Engaging Mathematics Games vs. Flashcards

Improving the Mathematics Fact Fluency of First Grade Students

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Abstract

The purpose of this study was to determine whether a mathematics flashcard or mathematics fact game intervention group would increase the mathematics fact fluency in students who needed mathematics fact intervention. The null hypothesis was that there would be no difference in achievement on mathematics fact fluency assessment scores for the flashcard group, and the game group of first grade students who need mathematics fact intervention. The null hypothesis was supported based on the results of this study. Both groups showed improvement even though there wasn't a significant difference between the rates of growth in each group. A pre- and post-test was used to determine student achievement and analyze data.

CHAPTER I

INTRODUCTION

Overview

Mathematics fact fluency is automatically recalling mathematics facts. It is an important skill for primary students because the lower-order skills of addition and subtraction help build confidence in students and prepares them for higher-order thinking (Sun & Zhang, 2001). Students learning to automatically recall facts can help students with more challenging mathematical work. For a first grade teacher, the first half of the year is spent on teaching students a variety of strategies to solve addition and subtraction problems. The goal is to teach them ways to find the answer when they don't have the automatic recall yet. For the remainder of the year, students should begin to automatically recall facts so that by second grade they have mastered addition and subtraction facts with answers up to 20.

If students have difficulty mastering these facts, they are likely to struggle with future mathematics curriculum. For example, students are likely to struggle with more advanced addition and subtraction problems involving multiple digits. It is important for teachers to provide high-quality computation instruction so that students are able to master these foundational mathematics skills (Miller, Stringfellow, Kaffar, Ferreira, & Mancl, 2011).

Two interventions that are frequently used at this age are strategy intervention and drill and practice intervention. Strategy intervention involves teaching students relationships among numbers so that they can quickly recall facts. For example, when solving 5 + 4, students may realize that the sum is one number away from the doubles fact of 5 + 5 = 10 to retrieve an answer of 5 + 4 = 9. Drill and practice intervention involves memorizing mathematics facts so that they are an automatic recall and is not based on number relationships. A popular example of drill and

practice is the use of flashcards. The repetition of using the flashcards or other uses of quick facts is supposed to help students memorize the facts.

Some interventions that have been used to increase addition and subtraction mathematics fact fluency are having students practice with flashcards, and having students participate in addition and subtraction themed small group games. These are the interventions that will be used with this group of students to determine which intervention improves mathematics fact fluency the most.

Statement of Problem

The purpose of this study is to determine which mathematics fact intervention (flash cards or mathematics fact games) will improve student scores on mathematics fact fluency assessments the most.

Hypothesis

There will be no difference in achievement on pre-test and post-test mathematics fact fluency assessment scores of two groups of first grade students who need mathematics fact intervention; one group will be receiving a flash card intervention and the other will be receiving a mathematics fact game intervention.

Operational Definitions

Mathematics Fluency: Mathematics fact fluency will be measured based on the scores of the pre- and post-tests. Students will receive 20 problems of addition and 20 problems of subtraction to complete in one minute for each. This gives students approximately five seconds per problem for solving.

Low Achieving: Low achieving students will be determined based on students who scored less than 50 percent on the pre-test.

Flash Card Intervention: Students in this group will meet 2 – 3 times per week to practice addition and subtraction facts using flash cards.

Mathematics Fact Game Intervention: Students in this group will meet 2 – 3 times per week to practice addition and subtraction facts by playing a variety of engaging mathematics games. Mathematics games will include board games, card games, and computer games.

CHAPTER II

REVIEW OF THE LITERATURE

This review of the literature explores the best practices and interventions to improve addition and subtraction fact fluency at the elementary level, focusing on first graders. Section one provides an overview of what mathematics fact fluency is, and the importance of it in education. The expectations for first grade mathematics fact fluency are described in section two. Section three focuses on the characteristics of students who have mathematics fact fluency difficulties. In section four, best practices for basic addition and subtraction fact instruction are reviewed. The final section describes intervention strategies to improve mathematics fact fluency for struggling students.

Definition of Mathematics Fact Fluency

The definition of mathematics fact fluency is being able to automatically recall facts, which strengthens "mathematical ability, mental mathematics, and higher-order mathematical learning" (Sun & Zhang, 2001 pg. 1). Fluency with basic addition and subtraction can be defined as "the efficient, appropriate, and flexible application of single-digit calculation skills and is an essential aspect of mathematical proficiency" (Kling, 2011, p. 82). Kling states that traditionally, mathematics fact fluency for addition and subtraction occurred from "rote memorization of basic facts, typically through the use of flash cards, repeated drilling, and timed testing" (p. 82). Many experienced teachers have found that this traditional way of teaching mathematics facts is not necessarily the best way for students to develop mastery. These teachers find that focusing on efficient strategies to solve basic addition and subtraction problems helps build stronger mathematical computation skills. Research suggests that fluent students use both the facts that they have memorized and efficient strategies to "derive facts that they do not know" (p. 83).

Mathematics Fact Fluency for First Graders

According to the Common Core State Standards, first graders should "develop understanding of addition, subtraction, and strategies for addition and subtraction within 20" meaning that they should know addition and subtraction facts whose answer is within 20. They use a variety of models and strategies to "add-to, take-from, put-together, take-apart, and compare situations to develop meaning for the operations of addition and subtraction" (Kling, 2011, p. 82). Students also focus on understanding the connection between addition and subtraction.

Characteristics of Students with Mathematics Fact Difficulties

There are many factors that determine whether or not students will struggle with mathematics. It depends on "characteristics of students and teachers, how and what students are learning, and how and what teachers are teaching" (Mazzocco, 2011, p. 7). Some characteristics of students which can result in difficulty learning mathematics fact are lack of recall and computational skills, lack of conceptual learning which leads to misconceptions, lack of motivation, and lack of home support for learning or practicing skills.

Many students struggle with lack of recalling mathematics facts because problems with, or limited capacity of, their working memory. According to Iguchi (2008), the "Working memory is thought to play a central role in the acquisition and use of basic educational skills" (p. 2). Working memory is "the mind's workplace" and can develop differently among students (Mazzocco, 2011, p. 7). For these students, drilling with flash cards isn't enough to help them attain fluency when completing mathematics problems. Lack of recall can also sometimes stem from a learning disability, which is to a neurobiological disorder in one or more of the basic processes involved in understanding spoken or written language (Iguchi, 2008). When students

are unable to recall a fact, they need to lean on strategies that they have learned in order to determine the answer.

Other students who struggle with addition and subtraction fluency have lack of conceptual learning. It is important that teachers focus on both procedural and conceptual learning. Procedural learning is teaching how to do the mathematics (in steps) and conceptual learning is teaching "why" those are the steps to use. Conceptual learning helps students understand the relationships among numbers. Students should "develop flexibility in thinking about numbers based on understanding the relationships among whole numbers and being able to decompose and recombine numbers easily" (Phillips, 2003, p. 2). Another step would be to talk about those concepts. When learning (or instruction) focuses on procedures (e.g., what to do) but not concepts (e.g., why you do it), students may develop misconceptions about mathematics" and "…eliminating student misconceptions should be a critical goal for successful mathematics instruction" (Mazzocco, 2011, p. 7). Reducing misconceptions can play a huge part in helping students understand how to solve problems, or why they obtained incorrect answers.

In addition, lack of motivation can be a characteristic of students who struggle with addition and subtraction fact fluency. Some students learn "helplessness" and believe that they are unable to do mathematics, which can lead to task-avoidance and disengagement. If students have low expectations for their ability to complete a task successfully, "they may be more likely to give up easily, attribute their failure to their lack of ability, and attribute their success to external factors, such as luck or ease of the task" (Hanich, 2011, p. 4). Breaking this pattern can be difficult; however, it is important so that it doesn't continue to grow throughout the rest of students' mathematical learning experiences. "Self-handicapping" is another form of avoidance behavior related to a lack of motivation. Self-handicapping involves a student making choices that can

hurt his or her learning based on his or her negative beliefs. For example, a student may think that he or she will not do well on a mathematics test because he or she is bad at mathematics, and as a result, he or she will choose not to study. Students who self-handicap often do so because they doubt their ability to perform adequately on academic tasks . According to Hanich, to improve student motivation, teachers should promote mastery goals and minimize performance goals in the classroom, minimize social comparison and rewards based on performance, help students understand the effect of negative attributions, teach students appropriate self-regulated learning strategies, and model their own value of mathematics.

Another characteristic of students who struggle with mathematics fluency is having lack of home support and poor school attendance. Not having support at home to help with mathematics homework may cause achievement to be delayed or decline. The involvement of parents does influence academic achievement, especially within the homework process (O'Sullivan, 2008). Also, if students are not attending school regularly, they will miss mathematics instruction, causing them to have extra work or miss key instruction.

Mathematics Addition and Subtraction Instruction

According to Isaacs and Carroll (1999), "[t]he traditional rote approach to the basic facts, with frequent drill and timed tests, has serious disadvantages" (p. 3). The need for quick performance implicit in fluency drills can cause mathematical anxiety and focuses more on the idea that "mathematics is more memorizing than thinking" (p. 4). Currently, there are several best practices supported by research for teaching addition and subtraction fact fluency, which begin by utilizing the natural thinking of students. These practices include student-centered instruction, teaching the Concrete Representational Abstract (CRA model) focusing on conceptual learning, teaching and using derived facts, and increasing engagement.

When teaching students basic addition and subtraction facts, the best way may be to ask students an easy question without telling them how to solve it. This can elicit discussion among students and demonstrate that there can be more than one way to solve a problem. This concept will continue as instruction and material gets more rigorous. Having students decide how to solve the problem on their own or collaboratively with peers uses student-centered learning, which increases their engagement. After multiple strategies are discussed, students should decide which strategy is the most efficient for solving the particular problem. For example, a student adding 13 + 10 should find it more efficient to just add a ten to the number 13 than to add 1 to 13 ten times. Gningue, Peach, & Schroder (2013) "discovered that teachers who employed a high level of student-centered, inquiry-based pedagogy tended to be more effective as mathematics teachers than those who used a low level of student-centered teaching" (p. 641).

Teaching using the Concrete Representational Abstract (CRA) model "helps students gain conceptual understanding related to addition and subtraction" (Miller et al., 2011, p. 30). This model focuses on using concrete manipulatives to facilitate conceptual understanding, and then moves to representational drawings to eventually help students understand the concept abstractly. It is important that each step is modeled repeatedly for students and that they are provided with ample practice. According to the CRA model, students will not be able to understand the addition and subtraction mathematics facts without first understanding the underlying concepts. Research on the use of concrete and representational models reveals "acquisition benefits for students with learning disabilities, students with intellectual disabilities, and students who are low performers in mathematics computation" (, p. 40). The CRA model focuses on conceptual learning because the students learn concretely "why" numbers have certain relationships and "why" particular strategies are used to solve procedural problems. With this model, students

must understand the concrete and representational stages before moving on to the abstract way to solve a problem.

Another best practice when teaching basic mathematics facts is to teach facts based on numbers' inter-relationships. Instruction should follow a logical sequence focusing on number relationships, such as facts being "grouped by strategy rather than by sum" (Isaacs & Carroll, 1999, p. 4). Here is an example of using a logical sequence focusing on number relationships . Perhaps a teacher teaches first graders their doubles facts. If a student knows that 7 + 7 = 14, he or she could use that fact to find the sum of 7 + 8 by just adding one more to the sum. Teaching number relationships is beneficial to students when they are unsure of a mathematics fact answer. If a student doesn't know a mathematics fact, he or she may be able to relate the problem to an already known fact (such as 7+7=14). Isaacs and Carroll state that "[c]lass discussion of such derived-fact strategies helps a student learn from their peers and also legitimizes the use of strategies, thus encouraging the invention of further strategies" (p. 3).

Lastly, student engagement plays a big part in students learning their basic addition and subtraction facts. There are three types of engagement: behavioral, emotional, and cognitive. There are many factors that go into these types of engagement as shown on the diagram in the appendix (Fredricks, 2011).

Teachers, staff, peers, adequate structure, and task characteristics all play a role in student engagement. Since this review focuses on addition and subtraction instruction, it is important to look closely at the task characteristics part of the diagram in order to relate the concepts to those skills. Instruction needs to be interesting, and the level of challenge should be appropriate. Instruction should also be relatable to the real world, flexible in terms of use of strategies, and must involve students actively.

Interventions for Improving Mathematics Fact Fluency

This review of literature suggests that there are two main types of interventions which are typically used for mathematics fact fluency. These are strategy intervention and drill-and-practice intervention. Both types of intervention have been proven effective for improving mathematics fact fluency for addition and subtraction. Strategy Intervention involves "methods that help children refine and extend natural strategies including counting to solve, using parts and wholes, and using derived facts" (Reynolds, 2010, p. 11). Using derived facts helps students use known facts and relationships among them to solve unknown problems. Mathematics fact interventions that focus on derived fact strategies "can lead children to abandon more immature counting strategies" (p. 22).

Drill-and-practice involves students committing basic mathematics facts to memory and automatically retrieving them from memory. The most common application of drill-and-practice is the use of flashcards. Using flashcards has benefits as they are easy to create and they can be used individually or in groups (Reynolds, 2010). Drill-and-practice can also be implemented through use of computer programs that provide practice of facts for automaticity and are highly engaging to students. Computerized flashcard programs have the opportunity to improve student mathematics fact fluency. Reynolds states that "sophisticated computer programs provide immediate correction procedures, allow educators to create individualized accuracy and fluency aims, and collect progress monitoring data for each student utilizing the program" (p. 23).

Summary

Learning basic addition and subtraction facts is a large focus in first grade. It is expected that students should become fluent in addition and subtraction of mathematics facts up to 20 (Common Core State Standards). If students are not fluent in this area, it can hinder their

academic achievement as they go into second grade and beyond.

Many teaching strategies and intervention programs can be utilized to help students who struggle with mathematics fact fluency. It is important for teachers to research these strategies and interventions to determine which will work best for each of their particular students.

CHAPTER III

METHODS

The purpose of this study was to determine which mathematics fact intervention (flashcards or mathematics fact games) would improve student scores on mathematics fact fluency assessments the most.

Design

The research was based on a quasi-experimental design. A mathematics fluency assessment was used to determine which students required fluency intervention in addition and subtraction. Students were assigned to one of two groups: flashcard intervention and mathematics fact game intervention. Students who scored showing the need for intervention were placed into a group. Students were assigned to a group based on scores so that the scores in each group were as equal as possible. The students who scored showing that they do not need intervention were placed in a third group who did not get any intervention. The third group's data was also compared to the intervention groups which helps make the experiment a better quasi-experimental design. Following the intervention a post-test was administered to all groups.

Participants

The participants are 6 – 7 years old and attend school in a suburban setting. The school has about 700 students, with about 130 being in first grade. On recent PARCC testing, students in grades 3 – 5 scored lower on the Mathematics section than on the ELA section. The School Improvement Plan has focused on improving students computational and problem solving skills for the past few years.

All students in the first grade class were given a pre-assessment on addition and subtraction facts. Based on student scores, 20 students who scored low were placed into two groups

(flashcards or mathematics fact games). Scores were used to evenly place students into the two groups so that both groups had that same amount of students with similar scores. Scores were matched and students were assigned as equally and randomly as possible. Students with the lowest scores were assigned to each intervention group first, and then students with the next two scores were assigned to each intervention group, and so forth. Students were also assigned which specific group by using random number assignments. Each intervention group had ten students assigned, which met three times for week for six weeks.

The first intervention group that used flashcards has four girls and six boys. The second intervention group that used mathematics fact games had six girls and four boys. The third group that didn't receive any intervention had four girls and three boys. None of the students had an Individualized Education Plan and none are English Language Learners (ELL) or in the English as a Second Language program (ESOL). Two of the students receive federal funding for meals (FARMs).

Instrument

The instrument being used to measure achievement was a pre- and post- assessment that includes addition and subtraction mathematics facts. The mathematics facts were randomly generated by using math-aids.com to include addition and subtraction facts up 20. All three groups took the same pre- and post- assessment in order to measure achievement based on the intervention that was used. When the website randomly generated the mathematics facts, the teacher reviewed the facts to make sure they included a representation of all facts with no duplicates.

Procedure

Once the intervention groups were formed, mathematics fact group time was implemented

into the daily schedule on Mondays, Wednesdays, and Fridays. For about 15 – 20 minutes, the two intervention groups would meet with a teacher to practice mathematics facts. The first three weeks students focused on addition facts, and the following three weeks students focused on subtraction facts.

The first intervention group used only flashcards. The teacher taught students how to use the cards and the goal of the practice being to answer the mathematics facts at a fast speed. Some days the teacher was leading the activity, and other days the students were quizzing each other with the flashcards, with teacher support as needed. Students would also help each other remember facts quickly, for example, using a doubles fact or friendly number to get the answer faster. If a student answered the question quickly, the card would be placed in a "yes" pile. If the student didn't answer the question quickly or correctly, the card would be placed in a "no" pile. Students would reuse the "no" pile to help practice facts they were struggling with.

The second intervention group met the same days for the same amount of time, but used mathematics fact games to practice mathematics facts. The teacher's intern met with this group of students to teach them the game and support them as they played. Each week the intern taught a new game, focusing on mathematics fact speed. Students played the new game for the week with a partner and then were taught a new game the following week.

One of the games was called "Addition Bump" where students rolled dice and had to say the addition fact as fast as they could to place a marker on the game board. If the partner's marker was already on that number, students could "bump" the marker off. The goal of the game is to get as many markers on the board as you could in the given time frame. Another example of a game played was matching Popsicle sticks that had mathematics facts on them to the correct popsicle stick that had a sum on it. Some of the other games included were: Around the World,

Fast Math, Addition and Subtraction War, and a subtraction race PowerPoint. The goal of this group was to find engaging games to help students practice their quick mathematics facts. Students also discussed strategies to remember mathematics facts quickly, such as using a doubles fact or a friendly number.

CHAPTER IV

RESULTS

The purpose of this study was to determine which mathematics fact intervention (flashcards or mathematics fact games) would improve student scores on mathematics fact fluency assessments the most.

The pre-test and pots-test results for students receiving the flashcard or game interventions were analyzed using a t-test for independent groups. The results of the analysis are reported in Table 1.

Table 1

Pre- and Post-test Results for First Grade Students

Receiving Flashcards or Games Mathematics Intervention

Test	Group	Mean	N	Standard Deviation	t	Significance
Pre-test	Flashcards	12.8	10	4.47	0.31	0.76
	Games	13.4	10	4.30		
Post-test	Flashcards	18.2	10	4.89	0.41	0.97
	Games	18.1	10	5.88		

The hypothesis that there will be no difference in achievement on mathematics fact fluency assessment scores for the flashcard group and the game group of first grade students who need mathematics fact intervention is supported.

CHAPTER V

DISCUSSION

The hypothesis that there will be no difference in achievement in mathematics fact fluency assessment scores for both groups (flashcard and game) is supported. There was no significant difference between the scores of both groups. Even though there was no significant difference between the group scores, both groups did show improvement. The mean of the scores for the flashcard group increased from 12.8 to 18.2. The mean of the scores for the game group increased from 13.4 to 18.1. For data purposes, students who didn't participate in either of the interventions were also given the same pre- and post-test as the students in the intervention groups. This group worked on mathematics seatwork (not related to mathematics fact fluency) while the researcher met with the intervention groups. The mean of this group's scores stayed the same; the mean pretest and post test scores were 26.29 and 26.71. The data from these students shows that their scores barely increased. The intervention groups were able to raise their scores closer to those who didn't need intervention, although the treatment groups did not differ significantly.

Implications of Results

The results of this study shows that both the use of flashcards and engaging mathematics games helps improve addition and subtraction mathematics fact fluency. The findings in the study are important because they will help educators choose successful intervention strategies to help struggling students. Students in first grade need to master addition and subtraction facts up to 20 to help them be successful in future grades, which shows the importance of the results of the study. Both the flashcard group and the game group improved on the post-test compared to the students who only worked on seatwork, although a significance test was not conducted on the

gains.

Threats to Validity

After completing action research, it is important to reflect on any threats to validity. The threats to validity for this study include maturity, parent support, and intern support. Maturity is a threat to validity because some students may be more mature than others causing them to be more focused during instruction. Another factor that could affect validity is parent support. Some parents may work with their child on addition and subtraction mathematics facts frequently at home while others may not. Additionally, this study involved an intern that helped lead some of the intervention groups.

Connections to Previous Studies/Existing Literature

The results of this study help support the research on mathematics fact fluency. The research in chapter two shares that drill and practice strategies and using forms of high engagement help students improve their mathematics fact fluency.

Even though drill and practice strategies were not popular stand-alone intervention strategies in several of the research articles, this study did prove that using flashcards helps improve mathematics fact fluency. It is important that students learn how to "emphasize the development and application of strategies" so that they can quickly solve unknown facts (Kling, 2011 p. 82). If a student doesn't know a fact by memory, the student can use a strategy (example: doubles facts). to help figure out the answer. These types of strategies were taught throughout the year in first grade, which helped them when it came to solving problems on flashcards. The fast pace and recall practice within the flashcard group showed results in improvement.

Another meaningful finding from the study and research is about the importance of engagement. When students are not engaged during mathematics instruction, it can affect the

child's learning (Hanich, 2011). This study discussed that finding engaging activities for students to practice mathematics with will help them better understand the concepts. These findings align with this idea because the group that played engaging mathematics fact games improved their scores from the pre-test to the post-test. The students that didn't get any intervention (seatwork) only improved with a mean of 0.42.

As a result, both the games group (engagement) and the flashcard group (drill and practice) showed improvement on the post-test, where the students who didn't get any intervention barely improved. The study results are important for mathematics instruction, especially for primary students learning their addition and subtraction mathematics facts, because it shows that both using games and flashcards help improve fluency scores.

Future Research

After completing this study and analyzing the results, there are a few things that could be done differently in future research. First, it would be interesting if a combination group of both engaging mathematics games and flashcards would be used to see if the change in scores showed any significant changes. Another change that could be made would be to use different intervention groups since the results of this current study used only flashcards and games. Lastly, the results could increase even more if one was able to complete the study over a longer period of time instead of just six weeks.

Another possible area of research could be a specific order to teaching students strategies to solve unknown mathematics fact problems. It would be interesting to read more research on this topic and implement the teaching order of specific strategies in the classroom.

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Appendix

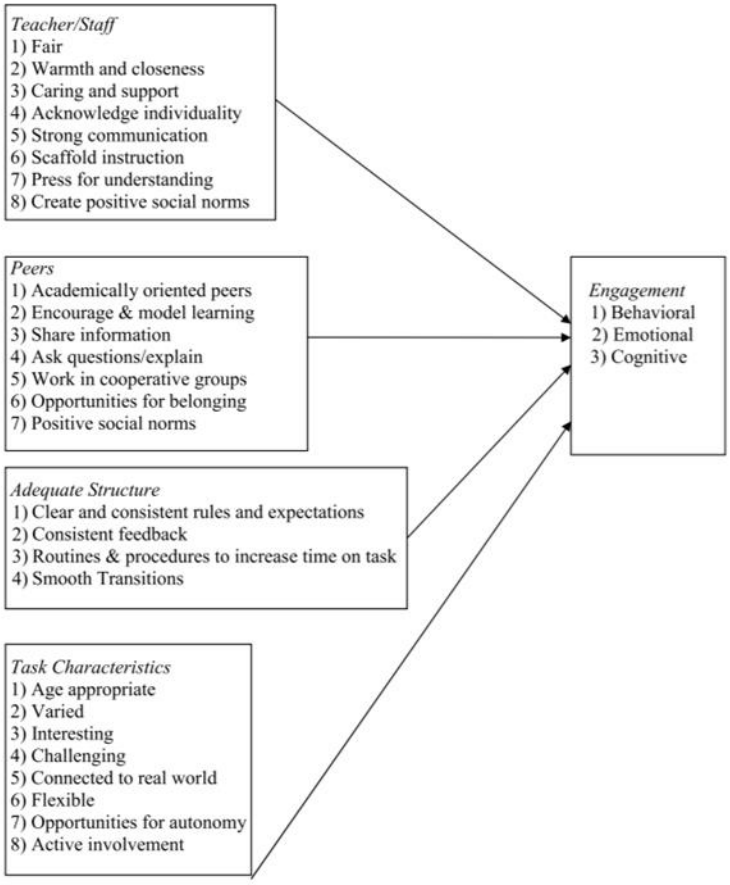

Figure 1. Conceptual Modeling of Engaging School and Out-of-School Contexts.