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Computer assisted instruction or mnemonic strategy instruction: which approach produces better outcomes with helping students develop multiplication fact fluency?

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COMPUTER ASSISTED INSTRUCTION OR MNEMONIC STRATEGY INSTRUCTION: WHICH APPROACH PRODUCES BETTER OUTCOMES WITH HELPING STUDENTS DEVELOP MULTIPLICATION FACT FLUENCY?

by
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ABSTRACT

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The purpose of this study was to examine the impact mnemonic strategy instruction and computer assisted instruction had on helping students gain multiplication fact fluency. Thirteen, third grade students were provided with either mnemonic strategy instruction or computer assisted practice for six weeks to see which instructional approach assisted the children with fluency gains with multiplication facts. The two groups were assessed weekly with timed fact probes to evaluate progress. Baseline scores and ending scores were analyzed with a percent of change formula to reveal either an increase or decrease in fluency. The results of the comparison between the two approaches support the view that computer assisted instruction contributes more to fluency than does mnemonic strategy instruction.

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Chapter I

Introduction

Math fact instruction has been at the core of primary grade math education for as long as most of us can remember. There is an important reason for this focus. The memorization and quick retrieval of all multiplication facts in early grades offers students future success in many areas of higher mathematics. Information-processing theorists believe that automaticity in math facts can relieve the "cognitive load" for performance with more complex tasks. The National Council of Teachers of Mathematics (NCTM) describes the following expectations regarding basic math fact acquisition for students in grades three to five:

- Develop fluency with basic number combinations for multiplication and division and use these combinations to mentally compute related problems, such as 30x50
- Develop fluency in adding, subtracting, multiplying and dividing whole numbers

Throughout the years, many teaching approaches have been used to help students memorize math facts. Many of these approaches have been shown by research to be effective in teaching fact acquisition. Do these methods also improve math fact fluency? Dan Willingham, a Cognitive Scientist at the University of Virginia, states that automatic fact retrieval is a building block skill for more advanced math ability, and that retrieving number facts from memory is a worthwhile process for repeated practice (Willingham, 2009). So, not only do we need to teach children to memorize facts but we must also teach them to retrieve them with automaticity.

In this research, I compare two very popular and highly regarded approaches to teaching multiplication facts: Computer Assisted Instruction and Mnemonic Strategy Instruction. The comparison will not only analyze the effectiveness for fact acquisition, but will also identify which approach helps students to have faster recall of facts. If elementary schools had access to both of these teaching methods, it would be beneficial to know which one produces better outcomes regarding memorization and automaticity.

Statement of the Problem

The overall question to be answered in this study:

Computer Assisted Instruction or Mnemonic Strategy Instruction: Which Approach Produces Better Outcomes with helping students develop Multiplication Fact Fluency?

In order to answer this question, the following specific questions will be answered:

Research Question 1:

Does Computer Assisted Instruction, when used to teach multiplication facts, increase the amount of facts learned and increase automatic recall after six weeks of instruction?

Research Question 2:

Does Mnemonic Strategy Instruction, when used to teach multiplication facts, increase the amount of facts learned and increase automatic recall after four weeks of instruction?

Hypothesis

The first hypothesis is that the students in the Mnemonic Strategy Instruction group will know more multiplication facts than unknown multiplication facts at the end of the study compared to the students in the Computer Assisted Instruction group.

The second hypothesis is that the students in the Mnemonic Strategy Instruction group will be able to score higher in timed tests than the students in the Computer Assisted Instruction Group.

Key Terms

Computer Assisted Instruction- The use of computers to present drills, practice exercises, and tutorial sequences to the student, and sometimes to engage the student in a dialog about the substance of the instruction. Also known as computer-aided instruction; computer-assisted learning (CAL).

Mnemonic Strategy Instruction- Mnemonic instruction is an instructional strategy commonly used with students who have disabilities as well as with their non-disabled peers. It is designed to improve memory of key information. Mnemonic instruction facilitates access to the general education curriculum by giving students the tools they need to better encode information so that it will be much easier to retrieve it from memory at later points. Mnemonics can be used in language arts (i.e., vocabulary, spelling, and letter recognition), mathematics, science, social studies, foreign language, and other academic subjects. Use of this instructional strategy does not require a wealth of additional materials or extensive planning and preparation time (Mastropieri & Scruggs, 1998).

Math Fluency-the ability to compute facts automatically and consistently. Students are expected to recall each fact within three seconds time. Math fluency can be assessed by using a correct rate per minute technique for monitoring progress over time.

Implications for Teaching:

Because successful math fact acquisition and fluency are key to a student's future math success, it is imperative that time is not wasted on ineffective approaches. This study's results could provide better direction for helping students memorize multiplication facts efficiently and fluently. Future math success relies heavily on this fundamental skill and so the importance should not be underestimated. Multiplication fact acquisition leads not only to higher ability with computation of whole numbers, but also affects work with fractions and algebra in secondary-school mathematics.

Teachers may recognize the importance to add or spend more time emphasizing math fluency when teaching multiplication facts.

Summary:

There are many methods of which to choose when teaching students to memorize multiplication facts. Even though many of these methods are backed by research, some are better than others. Two approaches, Computer Assisted Instruction and Mnemonic Strategy Instruction, will be analyzed. Both will be investigated to see how students respond with fact acquisition and automatic recall.

Chapter II

Literature Review

The Role of Fluency and Automaticity in Learning

Most people give very little conscious thought to walking because it is an automatic skill. Other skills like playing the piano or typewriting can become automatic with repeated opportunities for practice. These examples were taken from Benjamin Bloom's article on automaticity (Bloom, 1986). In it he explains that "once a skill has been developed to high level of automaticity, it requires frequent use but very little special practice to maintain at that level". Cognitive psychologist, Dan Willingham, in his writings maintains that the procedures needed to be an effective writer, mathematician, or reader must be learned to the point of automaticity so that they no longer consume working memory space (Willingham, 2004). Automaticity is not synonymous with fluency, but it could be considered a component of fluency. Fluency, according to Johnson and Layng, includes not only rate, but also retention after a significant period of no practice. They further expound on their definition by maintaining that true fluency is the availability of a skill so that it can be linked or combined with other behaviors thereby allowing students to perform complex asks and solve complex problems (Johnson & Layng, 1992). Binder, Haughton, and Bateman, in their article about fluency support the importance of fluency by pointing out that millions of students each year fail to achieve fluency on basic skills and therefore require later re-teaching on the same skills with students' and teachers' time is wasted as a result. They claim that rapid progress through curriculum can be achieved through the use of fluency in instruction and measurement (Binder, Haughton, and Bateman, 2002).

Carl Binder, in his compilation of discoveries in experimental psychology, outlines some of the work that comprises what is now known as fluency-based instruction (Binder, 2003). With their work on instructional measurement procedures, he and his colleagues revealed that measures that assess smooth, masterful performance versus accurate but hesitant responses were better at producing mastery outcomes. They were also able to conclude from their research that many learning programs inhibit true mastery due to the fact that not enough time is spent in practice for fluency stage of learning. His work demonstrated that achieving fluent performance produces dramatic results in both students with disabilities and students without.

Instructing students by teaching certain skills to mastery and fluency has been found to be effective with both math and reading instruction. The importance of reading fluency has always received much interest and attention. In April, 2000, The National Reading Panel released an evidence-based assessment of the scientific research on reading. In this report, the importance of reading fluency was investigated. It found that despite its importance, fluency is often neglected in the classroom. The panel established that "fluency is one of several critical factors necessary for reading comprehension" (NICHD,2000).

The Importance of Fluency Instruction with Math Facts

In April, 2006, President Bush created the National Mathematics Advisory Panel (National Math Panel, 2006). He did this so that the assigned experts would identify and propose the best use of scientifically based research to advance the teaching and learning of mathematics. The panel's final report was issued in 2008 and contained 45 findings and recommendations regarding instructional practices, materials, professional development and assessment. One of the core principles of math instruction was the emphasis that students should develop immediate recall of arithmetic facts to free the "working memory" for solving more complex problems.

The What Works Clearinghouse (WWC) released a report in April, 2009,that revealed eight scientifically researched recommendations for educators to use when implementing math interventions to struggling students. These recommendations are targeted for children in the elementary and middle school. Of the eight, the sixth recommendation stated the following, "Interventions at all grade levels should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts". The research that was used to support this recommendation indicates that many students with difficulties in math are not fluent in arithmetic facts. This recommendation, along with the others is a suggested intervention that should be used within the Response to Intervention, multi-tier framework. The typical student that is serviced within the different tiers is a struggling learner. WWC investigation into struggling math students has established the significance of teaching math facts to fluency level.

The National Counsel for Teachers of Mathematics (NCTM) math standards have become the basis for many state standards. NCTM's most recent revision in 2000, has included math fact fluency in two learning expectations in their teaching standards for students in grades three to five (NCTM, 2000).

Carl Binder, in his reflection of years of research on fluency-based assessment, worked with students who had slow recall of digits read, and written per minute. After sufficient practice, the students increased their correct digits per minute. The fact that their fluency increased had an effect on their smooth progress toward competence on solving the written math problems (Binder, 2003).

The need to teach arithmetic facts to a fluent level of understanding should not be underestimated. Several research studies indicate that weak recall of basic number facts is a common characteristic among students with math difficulties. Gersten, Jordan, & Flojo reviewed research on mathematical difficulties pertaining to early identification and intervention. In their investigation of research, it was concluded that "almost all students with mathematics difficulties demonstrate problems with accurate and automatic retrieval of basic arithmetic combinations". This correlation is one of several others that the researchers found as contributors to math difficulties. Their review also concluded that teachers need to identify the students that have not mastered the basic facts so that they can provide more time for instruction (Gersten, Jordan, & Flojo, 2005). It can be surmised that future math success is partially related to fluent knowledge of math facts.

Instructional Approaches That May Lend Themselves to Multiplication Fact Fluency

Before fluency is established, the multiplication facts must be taught. Understanding the concept behind multiplication is essential for the memorization of the facts to take place. Instruction of the concept usually involves the use of manipulatives to provide students with concrete examples of repeated addition. Showing students examples of arrays is one popular way of helping students see and manipulate a multiplication fact. Multiplication numbers sentences are paired with arrays to show relationship. Once the student demonstrates understanding, the facts can then be taught separate from the concrete/visual examples as a list of facts to be memorized.

There are, of course, many instructional methods used to teach students how to memorize multiplication facts. Which methods help students not only memorize facts but also help them to retrieve them quickly? Two approaches, Mnemonic Strategy Instruction and Computer Assisted Instruction will be explored.

Mnemonic Strategy Instruction

Nelly Tournaki focused on the importance of strategy instruction when instructing learning disabled. She conducted a study comparing strategy instruction versus the drill and practice method when teaching addition facts to second grade students. One of the goals of the study was to learn which method helped students become more automatic with fact recall. The results revealed that the students with learning disabilities that were provided strategy instruction improved more than the learning disabled students who were provided drill and practice. The accuracy pretest mean score for the students instructed using strategy instruction was 59.01 compared to the posttest mean score was 96.16. The response times of these students also increased significantly more than the drill and practice group and the control group. The accuracy pretest mean score of the students instructed using drill and practice was 60.80 compared to the posttest mean score of 76.16. The results of the students that were not classified with learning disabilities were a little different. These students improved using both strategy instruction and drill and practice. Although their response times also increased using both methods, the students who used the strategy instruction were faster at recall than those who were taught with the drill and practice method. The overall results indicate the importance of providing different approaches when teaching math facts and that strategy instruction is helpful with both accuracy and rate when teaching students with learning disabilities. Short time duration and restricted geographic area were some of the limitations noted by the author. She suggested that further research should examine the effectiveness of strategy instruction on the acquisition of other facts such as the subtraction, multiplication, and division facts. (Tournaki, 2003).

Another study that also explored using strategy instruction to teach automaticity for math facts was conducted by John Woodward. He included learning disabled students and non-learning disabled students who were academically, low-achieving. Woodward compared two instructional approaches for teaching students multiplication facts: an integrated strategy instruction approach and a timed practice approach. The integrated strategy instruction divided the multiplication facts into two groups: easy facts and difficult facts. The easy facts were grouped by 0s, 1s, doubles, perfect square, and times 5s, 9s, and 10s. The more difficult facts were taught by doubling and doubling again strategies and derived fact strategies. Number lines, arrays, and visuals were used in the instruction. These students were also given timed practice drills that were "integrated" with their strategy instruction. A direct instruction approach for teaching math facts was used with the students in the timed practice only group without instruction to use specific strategies. New facts were taught sequentially (i.e. start wit 1s, then 2s). These students were assessed through timed practice drills. Both groups were also taught extended facts, approximations, and algorithms. The results indicated that both groups improved considerably, but not to mastery in their knowledge of the harder multiplication facts. The students with learning disabilities lagged considerably behind their peers.

Results of the Hard Multiplication Facts Test

GROUP	Mean Pretest	Mean Postest	% Correct Pretest	% Correct Postest
STUDENTS WITHOUT LD				
Integrated	13.00	28.41	33	71
Timed Practice Only	19.24	28.23	48	71
STUDENTS WITH LD				
Integrated	6.57	15.71	16	39
Timed Practice Only	9.25	16.63	23	42

Looking beyond the improved performance with the basic facts, both groups of students in the integrated group performed higher on the Extended Facts and Approximation Tests. The author felt that although both approaches were found effective, the "educationally significant differences between groups found on the extended facts and approximations tests should encourage special educators to consider how strategy instruction can benefit students' development of number sense". Several limitations were noted with regards to this study. The author acknowledged that due to the group-administered measurement format, it was difficult to determine which form of retrieval the students used. Some of the students may have combined their knowledge of strategies with direct retrieval. Qualitative interviews could have been used to help determine which strategies the students used for retrieval. Another limitation was the limited time frame, so the need for a longitudinal research study was noted. Finally, the pacing of the instruction of new facts was based on the performance of 70% of the students and therefore the low-achieving students were not given the added time that they needed. It was suggested that future research should address this by exploring the effects of controlled added practice for this population (Woodward, 2006).

Mnemonics instruction can be considered as one type of strategy instruction. According to the Merriam-Webster Dictionary, the definition of mnemonics is "assisting or intended to assist memory; of or relating to memory". Regarding instruction, mnemonics are strategies designed to help individuals remember information. Margo Mastropieri, Thomas Scruggs, et. al., conducted many studies using mnemonics to help individuals with learning disabilities. In a two experiment study, mnemonics strategy instruction was compared to other methods to see which method helped both learning disabled and non-learning disabled students recall the most information. In the first experiment, 90 junior high, learning disabled students were taught ways to remember the hardness levels of minerals using three different instructional approaches: mnemonics, questioning and free-study. The students utilizing the mnemonic approach were provided first with pegwords to remember the hardness levels, then with key-words to help with remembering the mineral names, and then the complete mnemonic strategy was demonstrated by showing the combined pegword-keyword interactive pictures. The students included in the "questioning" group, were taught the hardness levels and minerals and then, using flashcards, were asked questions pertaining to each card when shown. The final group, were the students involved with the "free-study" condition. These students were provided with a lesson about the hardness levels of the minerals and then were given the choice of different methods they could use. These students were also provided with the appropriate materials, and were instructed on how to use the different methods by practicing them. All the students were provided time to study the hardness levels and mineral names, and then given a recall test. A 20-second response time was allotted for each item. Another recall test was administered 24 hours later with the same questions and procedures. The mean percent correct of the students using mnemonic strategies was 75.2 compared to 27.8 for the students in the "questioning" group, and 36.2 for students in the free-study group. The students using mnemonic strategies to recall hardness levels and mineral names took longer to answer, an average of 4.4 seconds compared to 2.3 and 2.7 seconds for the questioning and free-study subjects, respectively. 77% of the students using mnemonics reported it as the most effective. The second experiment was conducted in the same way as the first except it involved students that were slightly older and not learning disabled. The results in all three areas: recall, response time and strategy effectiveness, were very similar. Due to the large positive effects that were produced with both learning disabled and non-learning disables students, these experiments substantiate the powerful effects of a combined keyword-pegword pictorial mnemonic strategy for learning hardness levels of minerals (Mastropieri, Scruggs, & Levin, 2001). Mastropieri and her colleagues pointed out that "the uses of the keyword method are by no means limited to science-related materials"(Mastropieri, Scruggs, & Levin, 2001). The following two studies highlight the use of mnemonics instruction specifically when teaching the multiplication facts.

Mnemonics instruction, integrated with self-instruction techniques, were implemented with three students in a study conducted by Donna K. Wood, et al. The participants in the study were three students who attended special education programs for students with learning disabilities and were below grade level for both computation and problem-solving. The goal of the investigation was to first improve math fact accuracy which would then improve fluency. All of the 100 multiplication facts were taught utilizing six strategies: 0s, 1s, 5s, 9s, doubles, and pegwords. Five components were implemented: modified instructional sequence, associative learning, mnemonic procedures, strategic learning, and self-instruction training. The results of the study showed that after instruction was received, all three students' accuracy was often 100% and that they maintained this accuracy level during follow-up probes throughout the evaluation. Two of the three participants did not attain 100% accuracy on all of the probes after the pegword strategy instruction. The authors felt that this might be due to the fact that the pegword strategy was the last strategy taught and therefore had the least amount of follow-up tests. Their improvement, however, was substantially higher than any time during baseline. The participants, of which two were in fourth grade and one in the fifth grade, did not experience success when previously taught the multiplication facts through rote memorization. Their positive sentiments throughout the study implied approval of the instructional package. The authors note that the students appeared more enthusiastic about math instruction especially assignments involving multiplication facts. The students appeared to prefer the use of mnemonics strategies over memorization, which, the authors attribute, to their increased motivation. The authors pointed out that "the underlying mechanisms for why instructional strategies such as mnemonics are effective need to be evaluated" (Wood, Frank, & Wacker, 1998).

Gary Greene published a study that also investigated using mnemonic instruction to teach multiplication facts and compared it with traditional instruction. Twenty-three students with learning disabilities with ages ranging from 8 to 13 years participated. The students were recommended because they were having difficulty memorizing or failed to adequately memorize the multiplication facts. The author identified 14 multiplication as the ones of which the students would be instructed, as they were the most difficult to memorize. A prettest was administered to each student in the study to determine knowns and unknowns of the 14 facts. A week prior to the experiment, all twenty-three students participated in daily practice sessions to learn the pegwords associated with numbers included in the 14 facts. Flashcards used with mnemonic instruction contained one side showing the multiplication algorithm and answer with a cartoon illustration drawn below the numbers, and just the multiplication algorithm without the answer on the other side. The traditional flashcards had one side showing the multiplication algorithm with the answer and the other side without the answer. The students were divided into one group of 14 and one group of nine. The first group of fourteen students, were assigned to "Condition A" which studied the first seven facts through mnemonic instruction, followed by the second set of seven facts presented through traditional instruction. The group in "Condition B" studied the 14 facts in reverse order; first through the traditional method and then through mnemonic instruction. Each student in both groups were provided with one-on-one instruction in two separate learning trials using the approach described above. The students were required to repeat five times per card the multiplication algorithm, answer, and pegword phrase when flashed the mnemonic cards.

When flashing the traditional cards, the students were required to repeat just the algorithm and answer five times. The cards were then turned over and the students were then to say the entire fact five times, while providing the answer from memory. A review of all seven practice facts occurred at the end of each learning trial followed by a 90-second delay period. A posttest was then given to each student and while answers were recorded, the students were asked which method helped the most when remembering the answers. These answers were also recorded. Two additional posttests were administered: one, 24 hours later, and one, seven days later. Overall results showed that mnemonic training contributes more to the retention of math facts than do traditional methods of instruction. The retention of the 14 facts was exhibited over time. The fact that the two methods were provided in different orders provided additional findings. Although the authors recognize the need for more research regarding this discovery, they found that in this study, mnemonic instruction not only did not enhance the traditional method (verbal rehearsal) but actually interfered with it. The results indicated that a negative interaction occurred with the students who were taught the mnemonic instruction after the traditional method. The authors cautioned teachers to be aware of the use of mnemonic instruction in conjunction with traditional methods. There were several limitations to this study. The authors recognized that the group sizes should have been equal, and the amount of time the teachers invested with their students teaching pegwords was not controlled. There were also several other design problems some of which included: statistical regression, use of different special education teachers, and effects of repeated testing (Greene, 2000).

The research is clear on the benefits of strategy instruction and specifically, mnemonics strategy instruction. Mnemonics is effective with both students with learning disabilities and students without learning disabilities. Mnemonics can be used to help students remember in many different subject areas. Mnemonics instruction not only aids in the retention of multiplication facts, it also can be motivating to older students who have had difficulty learning them. Although mnemonics helps students remember multiplication facts, it may not help them become fluent.

Computer Assisted Instruction

Educational software for computers has improved a great deal in the last 10 to 15 years. Computer programs for math especially usually consisted of simplistic drill and practice opportunities with little visual stimulus. Now programs are involved and can include a variety of beneficial educational qualities. With the increase in availability and educationally relevant software, computer assisted instruction (CAI) is more popular than ever. This review will explore several studies that have been conducted on the effectiveness of CAI with helping students learn and remember math facts.

Fuchs, Fuchs, Hamlet, Powell, Capizzi, & Seethaler, assessed the value of CAI on number combination skills and story problem performance among first graders at risk for the development of math disability. In their study, thirty-three low achieving first grade students were assigned randomly in blocks within nine classrooms to receive math CAI or spelling CAI. For the students involved in the math CAI, a program that the authors referred to as "FLASH" was used. This program required the subjects to use their working memory to type a number combination after it appeared then disappeared from the screen. The duration that the stimulus remained on the screen corresponded to the student's performance during the session. This allowed for the appropriate amount of challenge and pressure on working memory. If the student was correct, he or she would receive positive reinforcement and if the student was incorrect, corrective feedback would be provided. The students worked for 10 minute sessions, three times per week for 18 weeks which added up to about 50 sessions total. Pre and posttests were administered for both addition and subtraction fact fluency and story problems. The results of the study showed that the biggest improvement was in the area of addition facts. The students' mean average on the addition fact pretest was 1.25 and 5.44 on the posttest with an improvement of 4.19. Improvement was evidenced in the other two areas as well. The subtraction fact fluency pretest was 1.56 and 5.00 on the posttest with an improvement of 3.44. The students showed the least amount of improvement with the transfer of knowledge to the story problems. The pretest mean average on the story problems test was 2.31 and 4.00 on the posttest with an improvement of 1.69. The study was able to produce results that suggest the potential for CAI to enhance arithmetic outcomes among high-risk first graders. The authors realized that future studies should incorporate larger samples and investigate longitudinal outcomes, in addition to increasing the number of weekly sessions to strengthen the effects (Fuchs, Fuchs, Hamlet, Powell, Capizzi, & Seethaler).

Another study that investigated the use of CAI with the acquisition of addition facts did so in comparison with peer tutoring. The purpose of Cates' study was to explore the relationship between the accurate response levels of students using two procedures:

peer drill and computer drill. Four girls, all with average standard math scores but low fluency levels, were recruited to participate. They were grouped in dyads for the peer tutoring sessions using flash cards and a three-minute time frame. Each student took turns being the tutor and the tutee. Experimenters kept track of all of the 21 sessions. A simple flash card program served as the computer drill component of the study. A timer was also used to keep track of the three minute sessions. The results of this study showed improved addition fact accuracy with both dyads except one dyad improved using computer drill and one dyad improved using peer drill. The authors relate these results to several explanations including, social variables, age, and knowledge of computer use (Cates, 2005).

When looking at how effective computer assisted instruction is when teaching children multiplication facts, it is important to review the following two studies. Wilson, Majstered, & Simmons, also compared CAI to a well-known instructional strategy. They looked at the acquisition of multiplication of four elementary students with learning disabilities using both CAI and teacher directed instruction. Both interventions were designed to result in fact automaticity. Acquisition of math facts was determined when the students were able to correctly answer within three seconds on two consecutive probes. Five facts were taught in each session in both interventions. The CAI that was used was the program called "Math Blaster" which enabled teachers to select specific facts to be studied. The first part of the program required the students to vocalize the entire problem softly as it appeared on the screen. These facts were then repeated. The second component of the program required the students to provide answers for the facts that appeared and they were given 3 to 10 seconds to respond. The teacher directed instruction was presented as a three-step procedure using flashcards. The procedure was repeated twice for each fact. The results of this study showed that both instructional formats can promote fact mastery and enhance automaticity. All four students did, however, benefited the most from the teacher directed instruction. The authors found that an important component to the teacher directed instruction was the amount of opportunities that the students had to respond. They felt that "the unexpected benefit of increase opportunities to receive, practice, and respond to problems could largely explain the achievement differences between the two conditions" (Wilson, Majsterek, & Simmons).

Computer assisted instruction software for learning multiplication facts is typically accomplished with drill-and-practice. Other available software is tutorial-based. Howell, Sidorenko, and Jurice compared the two in two different studies with one student with learning disabilities. One study investigated the effectiveness of the drill-and-practice software as the sole intervention, and the second study looked at the combined effectiveness of the tutorial-based software in conjunction with teacher intervention. They found that, although initial gains were noted with both the drill-and-practice software and the tutorial-based software, these gains were transitory. Long lasting change was noted with the combined intervention of teacher involvement along with the tutorial-based software.

Tutorial-based and drill-and-practice instruction are both available as a part of the entire multiplication component that is offered with CompassLearning's Odyssey Math computer program. The entire math program is available for students in grades kindergarten through the eighth grade. Odyssey Math is the computer program that will be provided to the subjects in this research. Recently, What Works Clearninghouse (WWC) published their report on the effectiveness of Odyssey Math. They reviewed fourteen studies and found that thirteen did not meet the WWC's evidence standards the one study that did, met their evidence standards with reservations. This study, which is unpublished, was conducted by DiLeo as a doctoral dissertation. 125 students participated in the treatment group and 82 students compiled the comparison group. All students were in the fifth grade. The Odyssey Math program was used in conjunction to the math curriculum with the students under research while the control group participated in math instruction the curriculum only. The yearly state test scores were used as the measure of improvement. The baseline data was from the students' third grade state assessment scores as their fourth grade score was unavailable (they did not take the fourth grade state assessment). After a year of supplemental computer assisted instruction using the Odyssey Math program, the students' math scores on the state assessment went up. There were positive differences and effect sizes that favored the intervention group with negative differences and effect sizes for the comparison group (DiLeo, 2007).

It seems that computer assisted instruction can be an important component of teaching multiplication facts and math instruction in general. The research shows that the most benefit comes not from its isolated use but from the combined use of teacher instruction and computer assisted instruction. CAI's effect on fluency was evidenced in one of the studies mentioned.

Chapter III

Methodology

The primary purpose of this study was to measure the effectiveness of two teaching strategies: Mnemonic Strategy Instruction and Computer Assisted Instruction in order to determine which contributes more to multiplication fact fluency. In this chapter, the subjects and setting, experimental design, interventions, and the method used for data collection are described

Participants

The participants were 14 third grade students (8 girls, 6 boys) enrolled in an elementary school located in a suburban school district in Southern New Jersey. The school district, which consists of two schools, serves approximately 906 students, Pre-K through 8th. The special education population in the district is currently at 7.3 %. Out of the 14 students, one student was classified as having a Specific Learning Disability, three are considered "at risk" in math and receive extra basic skills instruction, and one student has a 504 plan in place for general academic accommodations due to her seizure disorder. Students ranged in age from 8 to 9 years. Ethnicities included African American (2), White (10), White/African American (1) and Asian (1). Because of his frequent absences, one student was dropped from the study.

Experimental Design

The researcher used the quasi-experimental, on-going progress, within group design.

TABLE 1
Explanation of Experimental Design

Grouping	Treatment	Measurement
Experimental Group I	Multiplication fact instruction with mnemonic devices	Curriculum-Based (Weekly Timed Tests)
Experimental Group II	Computer Assisted Instruction	Curriculum-Based (Weekly-Timed Tests)

The participants were evenly divided into each intervention group; Group I or Group II. In an effort to promote balanced ability between the groups, assignment to each was based on the results from the initial baseline data that was collected at the beginning of the study. The scores were ranked from highest to lowest, and then every other score was assigned to each group. Because there was more than one highest score, each group included a top-scoring student.

During the implementation of the intervention, the students were provided with approximately 30 minutes of instruction everyday, four days a week for over six weeks. Fridays were reserved for progress monitoring. The researcher worked with Group I within the students' classroom and the classroom teacher worked with Group II in the computer lab.

A published program entitled "Multiplication in a Flash" by Alan Walker, was the primary curriculum source for the mnemonic instruction with Group I. This program utilizes a combination of pegwords, rhymes, and visual representations to help students remember the multiplication facts. The lessons were implemented in the following sequential fashion some lasting for several days:

1. Introduction to the meaning of multiplication (repeated addition) and the revelation that there are 100 multiplication combinations total to learn.
2. Commutativity was taught in several lessons to help the students realize that the 100 facts can be reduced by about half. All of the students were familiar with
3. Review of multiplication by 0 and by 1
4. Multiplication by 2, which consist of the "doubles" from addition was
5. Single-digit multiplication by 9 was taught by using a simplified pattern: in the product, the sum of the digits is 9. (For example, 9×7=63 and 6+3=9.)
6. Multiplication by 5 facts using the skip counting method. Other strategies were introduced to help reinforce multiplication by 5 such as using the clock to determine groups of five and also looking at the pattern of multiplying by 10 and then dividing by 2, since 5 is half of 10.
7. The remaining 15 multiplication combinations (and their commutative counterparts) were the focus of last half of the study.

It was with these 15 facts that the mnemonics instruction took place. The students were required to remember silly pictures of the numbers one through nine. Several lessons were devoted to remembering these pictures and included activities such as visualizing and acting out games. Once the students could demonstrate quick retrieval of the pictures, the facts were taught in a sequence (see Table 2).

TABLE 2

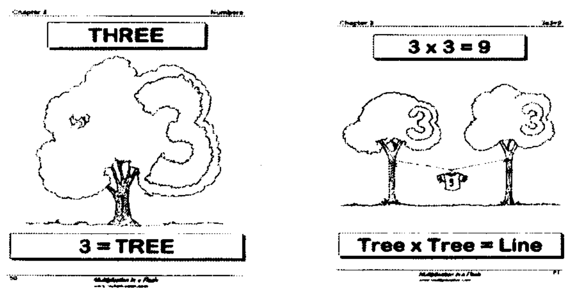
Multiplication Facts Taught in the Study

3x3	3x8	4x8	7x7
3x4	4x4	6x6	7x8
3x6	4x6	6x7	8x8
3x7	4x7	6x8	

Each fact to be learned involved introducing the children to the pegwords and accompanying picture. A script was read before each new fact was introduced. The script for 3x3 looked like this: "*The fact you will be learning with pictures and stories is 3x3. When I say 3, what picture pops into your head? The answer to 3x3 is a picture that fits with two trees. This is a picture that will help you remember 3x3=9. Whenever you see 3x3, you will see two trees. When you see those two trees, you will remember the line running between the trees. Line rhymes with nine. You will remember the answer even faster if you see the jersey with the number 9 on it. Remember, 3x3=9 or tree x tree = line.* (Walker, 2009)

FIGURE 1

Example of a Mnemonic Pegword and Picture



3=Tree, 9= Line; "3x3=9; Tree x Tree = Line

The "Tree x Tree = Line" picture remained on the Smartboard as the accompanying story was read out loud. After the children discussed the story and picture, they participated in rehearsal activities and games. After several days of lessons, games were played to help review the facts learned. These games were: multiplication bingo and flash cards.

Group II consisted of students that used computer programs and internet games and drills to practice multiplication facts. This group's instruction took place in the computer lab each day for over six weeks during the same time as their classmates' instruction took place. The students' teacher assisted them while they worked on a variety of computer programs, games and drills. During the first week of research, the students participated in the school's computer program called "Compass Odyssey". "Compass Odyssey" incorporates a combination of tutoring sessions and drill and practice in their third grade math component. For the remaining weeks of research, Group II went on the following web site: www.internet4classrooms.com . On this site, the students were provided with 42 multiplication fact websites that provided a combination of mini tutoring lessons, and drill and practice.

The measure used in this study was a progress monitoring system called Curriculum Based Assessment (CBM). For the purposes of this research, the CBM was used to monitor the students' acquisition and automaticity of learned multiplication facts. Baseline data and weekly monitoring data were obtained with the use of multiplication fact probes. The students were provided with a two minute time limit on each 100 fact-probe and were instructed to complete as many facts as they could within that time. An example of the directions for this task is as follows:

"It's time to take your weekly math test. As soon as I give you the test, write your first name, your last name, and the date. I want you to do as many problems as you can. Work carefully and do the best you can. Remember, start at the first problem and work left to right. Some problems will be easy for you; others will be harder. When you come to a problem you know you can do, do it right away. When you come to a problem that's hard for you, skip it, and come back to it later. Go through the entire test doing the easy problems. Then go back and try the harder ones. Remember that you get points for getting part of the problem right. So, after you have done all the easy problems, try the harder problems. Do this even if you think you can't get the whole problem right. When I say "Begin", start to work. Work for the whole test time. When I say "Stop", put your pencil down." (Wright)

At the beginning of the research, baseline data was collected by administering three consecutive fact probes to both Group I and Group II. The average of the three scores became the baseline and beginning point. After that, assessment occurred once a week.

When scoring the fact probes, the students received one point for each correctly answered digit. Graphs were created for each student in order to represent data and help determine progress. Progress was monitored using the weekly scores and comparing them to the baseline data that was collected at the beginning of the research. Individual and group progress will be analyzed to help determine responsiveness to the different interventions.

Chapter IV

Results

Thirteen third grade students were provided with either mnemonic strategy instruction or computer assisted practice for six weeks to see which instructional approach assisted the children with fluency gains with multiplication facts. The two groups were assessed weekly with timed fact probes to evaluate progress. Baseline scores and ending scores were analyzed with a percent of change formula to reveal either an increase or decrease in fluency. The percentage of change from the baseline score to the ending score was determined by dividing the difference of the two numbers by the original number. This method is a valid measure of growth between a beginning point and an ending point.

In Table 3, the mean level of baseline scores and ending scores for each group is shown for the six students in Group I and the seven students in Group II. In addition, the percentage of change is given.

TABLE 3

Comparison of Means and Percent Change
Representing Correct Digits of Each Group from the Beginning and Ending Scores

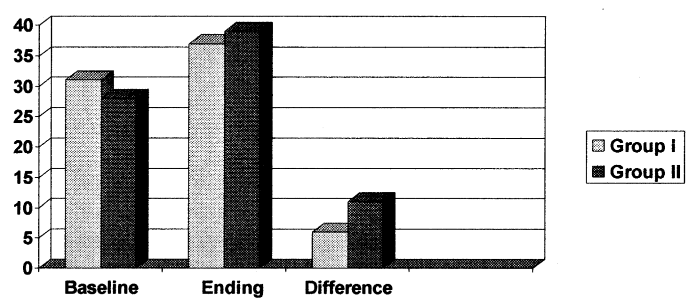
	Baseline Data M	Ending Score M	Mean Difference	% Change
Group I	31 CD	37 CD	6 CD	+20%
Group II	28 CD	39 CD	11 CD	+40%

Note. CD= Correct Digits/ Per 2 Mins.

Figure 2 illustrates both a numerical and visual comparison between the two groups and their fluency gains as a result of the different instructional approaches.

FIGURE 2

Comparison of Means for Each Group
Utilizing Beginning and Ending Scores



Each group's Correct Digit mean score showed a positive increase in fluency based upon baseline and ending scores. Figure 2 depicts the higher baseline average and lower ending score average of Group I whereas, Group II began with a lower average score and ended with a higher average score. As shown in Table 3, the percent of change increase in Group II was twice the growth of Group II indicating that, on average, the students who were provided with computer assisted instruction made more gains in fluency than the group provided with mnemonic strategy instruction.

Individual growth was analyzed to reveal fluency gains with each student. The students in Group I were given the labels A through F and the students in Group II were given the labels 1 through 7. Table 4 lists each student in Group I and their corresponding baseline and ending scores. Each score's conversion to percent of change illustrates how each student made either an increase or decrease in fluency.

TABLE 4

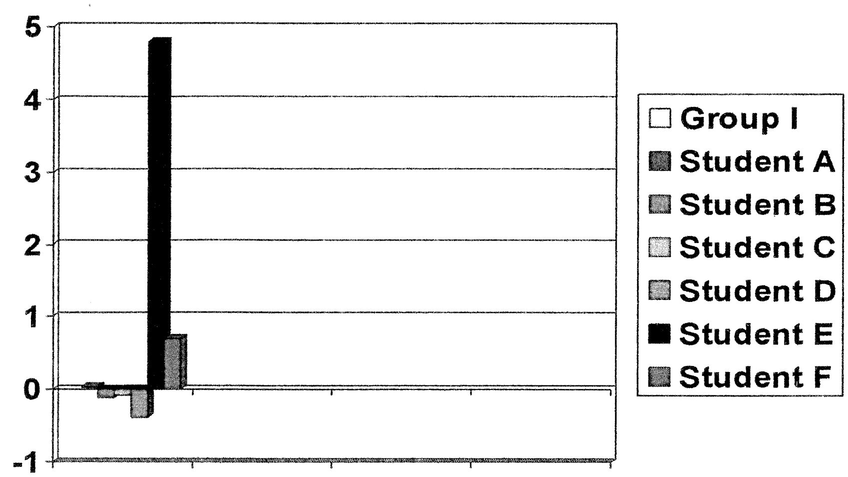
Individual Percent of Change between Baseline Score and Ending Score for Students in Group I (Mnemonic Strategy Instruction)

Group I	Baseline Score	Ending Score	Percent of Change
Student A*	32	33	+.03%
Student B*	25	22	-.12%
Student C	25	23	-.08%
Student D	36	22	-.39%
Student E	35	60	+4.8%
Student F	30	51	+.7 %

Note. An asterisk indicates students who receive basic skills instruction for math.

FIGURE 3

Students in Group I (Mnemonic Strategy Instruction)
Individual Percent of Change based on beginning and ending scores



Half of the six students in Group I showed evidence of improvement in fluency of multiplication facts with the other half showing a decrease. Students A and B were both considered "at risk" in math. Student A's performance resulted in a slight increase of fluency, while Student B's performance showed a slight decrease. Student E had the highest increase of correct digits (25 CD) which translated to the most growth in the entire class. (See Figure 3) The results from the data on the individual students in Group I indicate that two students had significant increase, with one student showing a slight increase in fluency. Fluency decreased with the other three students. Student D had a decrease of 14 correct digits, which translated to the lowest growth in the entire class (See Table 4).

TABLE 5

Individual Percent of Change between Baseline Score and Ending Score for Students in Group II (Computer Assisted Instruction)

Group I	Baseline Score	Ending Score	Percent of Change
Student 1	39	50	+.28%
Student 2	20	41	+1.1%
Student 3	30	30	NC
Student 4	35	52	+.49%
Student 5*	13	30	+1.3%
Student 6	28	28	NC
Student 7	31	40	+.29%

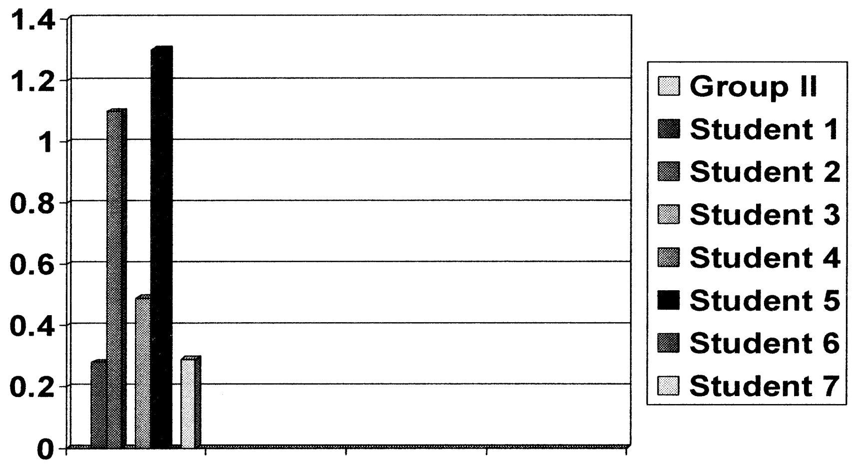
Note. An asterisk indicates a student with a 504 plan for academic medications.

NC=No Change

FIGURE 4

Students in Group II (Computer Assisted Instruction)

Individual Percent of Change based on beginning and ending scores



The students in Group II either had positive increases in fluency or no change at all. No student experienced a decrease in fluency. Student 5, who was considered to be "at risk" in math showed the greatest increase out of Group II (See Figure 4) This student exhibited the most growth out of all the students in Group II (See Table 5).

Chapter V

Discussion

In this study, I examined the impact mnemonic strategy instruction and computer assisted instruction had on helping students gain multiplication fact fluency. Thirteen third grade students, including several "at risk" in math, participated. The students were divided into two groups; Group I was instructed using mnemonic strategies, Group II was provided with daily multiplication fact tutorials and practice on the computer. The results of the comparison between the two approaches support the view that computer assisted instruction contributes more to multiplication fact fluency than does mnemonic strategy instruction. These results do not support the hypothesis which stated that mnemonic strategies would contribute more to multiplication fact fluency.

Quick and accurate recall of math facts is a fundamental skill necessary for performing and understanding basic, as well as advanced mathematical operations (Binder, 2003). Because deficits in math fact fluency are a common characteristic in students with math difficulties (Gersten, Jordan, & Flojo, 2005), teachers need to have strategies that they know are the most effective. Although there are many instructional strategies designed to help students learn multiplication facts it is not always known if these strategies also help students gain fluency. Gary Greene found that the use of mnemonic strategies help children with the retention of multiplication facts (Green, 2000), but he did not investigate its effect on fluency. In addition to assisting with retention, mnemonic strategies can also be more motivating than traditional methods like flash card drills (Wood, Frank, & Wacker, 1998). Several studies regarding computer assisted instruction that were investigated revealed positive results with increases in fact fluency. One study conducted by Wilson, Majsterek, & Simmons (1996), found that students who used a computer program to practice math facts had gains in fluency. At risk first graders were the subjects of a study conducted by Fuchs, et al. (2006) with computer programs used to help students with addition and subtraction facts. Again, improvement in fluency was shown as the students' scores were higher on posttests for both operations.

The results of this study imply that fact fluency can be enhanced by providing students with time to practice facts on the computer. Free multiplication fact practice web sites are available at www.internet4classrooms.com to help students achieve fluency. Because most students have access to computers either in school or at home, computer instruction or practice could be considered as another resource for teachers and parents when helping students with fact fluency. Using mnemonics to teach multiplication facts may enhance learning, motivation, and retention, but may not positively influence fluency. This study also implies that because basic math fact fluency has always been emphasized as an important skill, teachers' instruction in this area should be not only to building meaning and retention, but should also promote fluency.

Limitations of the Study

Results of this study should be interpreted with caution as several limitations were evident. First, this study was conducted with a small number of subjects from one third grade class. Future research may focus on a larger sample size. Second, an experimental design problem must be acknowledged. This study did not employ the inclusion of a control group and therefore did not provide insight on how other influences effect fluency improvement. Third, the students' in Group I were not provided with enough practice time. Further study is needed on the influence of repeated fact practice and how, when it is combined with other instructional approaches, has an impact on fluency.

Conclusion

In summary, lack of ability to acquire and maintain math facts at fluency levels is a common problem with many students, and may influence future math success. Multiplication facts, in particular, are taught in a variety of ways that may or may not affect fluency. The positive effects of mnemonic instruction to aid in the retention of information are well documented. How mnemonics instruction helps to improve fluency is less recognized. Computer assisted instruction is widely accepted as a supplement to teacher instruction and is commonly used to in math to help students practice specific skills. Fact practice on the computer has been found to be effective in enhancing fluency also. Results of the study revealed that mnemonic strategy instruction and computer assisted instruction both had a positive affect on multiplication fact fluency. However, the group of students who practiced multiplication facts on the computer daily for six weeks showed the most improvement on fluency. Additional research using larger samples and implemented for longer amounts of time are recommended.

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