Effectiveness of Paper-Based, Computer-Based, and Interactive Learning Strategies for Recall of Multiplication Facts

A Master's Research Project Presented to

The Faculty of the Patton College of Education

Ohio University

In Partial Fulfillment

of the Requirements for the Degree

Masters of Education

by

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May 2013

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Table of Content

Abstract

This research investigated three different mathematical strategies used for learning multiplication facts, one through ten, for students with and without learning disabilities who had not mastered their multiplication facts. The students were divided into three groups based on math quarterly assessments. Groups consisted of (1) interactive-based activities, (2) computer-based drill, and (3) paper and pencil-based (Cover, Copy, Compare: CCC) activities. Each group practiced multiplication facts for ten minutes every day for a month in addition to their regularly scheduled mathematics instruction. The interactive group practiced multiplication facts using manipulatives, songs, games, and other hands-on materials. The computer-based group completed problems on an internet website where they correctly completed as many quizzes as they could during the allotted time. The CCC group completed problems using a paper and pencil-based strategy. Data revealed that students who learn multiplication facts through interactive lessons experienced greater increases in their short term and long term recall of multiplication facts compared with students who learned facts through computer and paper and pencil- based strategies.

Multiplication facts are often difficult for elementary and middle school students to understand and remember. Students begin learning multiplication facts in third grade and continue front loading facts until fourth grade. In most schools, students learn their multiplication facts by rote memorizing of the product and taking timed tests; however, some students have a difficult time memorizing all the facts. Alternative interventions have been used when teaching multiplication facts in intervention settings that have consisted of using paper and pencil, computers, manipulatives, and calculators. A teacher needs to know the best way to teach multiplication facts to students, especially because “typically developing students are on their way toward automatic retrieval of number combinations by the beginning of third grade” (Powell, Fuches, Fuches, Cirino, & Flecher, 2009, p. 2). If fourth grade students have not retained the information and are having difficulty learning multiplication facts, three interventions that have demonstrated effectiveness to help students learn facts are cover, copy, and compare (CCC) –a paper and pencil intervention–, the use of a computer, and interactive learning through the use of hands-on manipulatives (Burns, Kanive, & DeFrande, 2013; Duhon, House, & Stinnett, 2012; Moch, 2001; Mong & Mong, 2010; Wong & Evans, 2007).

Students are usually drilled with multiplication facts for two years in school, and some students still have difficulty learning or retaining these facts. “When students still manifest large deficits with fact retrieval at the beginning of third grade, a pressing need exists for remediation” (Powell et al., 2009, p. 2). Students cannot learn multiplication if fact retrieval is not mastered. This is where intervention can help students catch up to peers who are on grade level. “Specifically in mathematics, researchers have noted positive findings for students who receive interventions” (Douglass & Horstman, 2011, p. 24). Students who struggle with recall of multiplication facts by fourth grade should receive intervention.

Three interventions examined below are CCC, computer-based, and interactive interventions. In many schools, students fall behind with the use of timed tests that determine if students master their multiplication facts. For students who cannot recall facts immediately, CCC is an intervention that provides the same medium of materials to work with and repeated practice of multiplication problem with timed tests. Students might receive greater benefits from the use of a CCC intervention because students are reflecting and giving themselves feedback on their own work. Throughout the CCC intervention, students are required to say the problem and then answer it by writing on their paper; so this intervention has the potential to can help learners automatically recall their multiplication facts. However, computer-based intervention allows multiplication facts to be practiced using a computer which might engage and encourage students to practice their multiplication facts because the delivery system is different and engaging. Typically, students are more excited to use technology when learning instead of always using paper and pencil. Finally, interactive interventions engage students and make math "fun," which encourages them to learn their facts. Each intervention has been demonstrated to help students learn their mathematics facts, but in the current study data will be compared to determine which intervention is more beneficial for recall of student's multiplication facts.

Literature Review

Students struggling with their multiplication facts need additional support learning their facts either at home or school. In school, facts are practiced for only small portions of the day; therefore, if students are failing to learn their facts they will fall behind because they will not be able to complete higher level math skill, such as division or fractions. "Students who fail to develop proficiency in math skills in the primary grades are more likely to experience difficulties in the math curriculum later on" (Pool, Carter, Johnson, & Carter, 2013 p. 2010). In order to prevent students falling behind, additional supports can be provided through intervention to help increase student achievement. “A key component in early intervention at the first sign of difficulties, with the result being the improvement in achievement of all students” (Douglass & Horstman, 2011 p. 23). These authors stress the importance of getting students involved in intervention as soon as the teacher notices difficulties. Putting students in intervention groups provides them with more exposure to multiplication facts which should result in an increase of their multiplication fact recall. Once students are caught up with the rest of the class and do not need additional support they can exit out of intervention.

Response to Intervention (RTI)

Response to intervention is a method used to help students who are struggling in an academic content area. Students are pulled out of the classroom and into another room for intervention at some point during the day. RTI consists of three tiers: Tier 1 is the core instruction which is provided in the general education classroom. Tier 2 is “supplemental instruction provided to those students who are struggling, at risk, or otherwise not meeting grade-level benchmarks in Tier 1” (Pool et al., 2013, p. 210). Tier 3 is designed for students with significant needs or disabilities where they receive intense interventions.

RTI is referred to quite often in relation to reading however it is for all academic subjects, especially math. Students need to have their progress monitored in math, just like they are in reading. Students who are not grasping the concepts and continuing to fall behind need more supplemental support, which would qualify them for Tier 2 of RTI. This would “reduce current cases of academic failure to prevent student problems from escalating to an intensity that requires individualized intervention and support” (Pool et al., 2013, p. 211). This helps students to learn the material before they fall so far behind that they could possibly qualify for special education services. When students participate in Tier 2 they might need explicit instruction where there are clear instructions, demonstrations, practice, and feedback. According to Douglass and Horstman (2011), “five to ten percent of students need a more targeted intervention (Tier 2)” (p. 28). This means teachers need to continue to progress monitor students and assess who might need additional support in Tier 1 that moves them to Tier 2 in RTI.

Cover, Copy, Compare (CCC)

CCC is a paper and pencil intervention that requires memorization of facts. CCC is best explained by Becker, McLaughlin, Weber, and Gower (2009). It is an intervention that displays a multiplication problem with the correct answer on the left side of the page and only an empty box on the right side of the page. The student reads the problem on the left side of the paper, then covers the entire problem with an index card (cover) and says the problem while writing it on the right side of the paper (copy). The student then removes the index card and compares the answer on the right to the correct answer on the left (compare). If the student answered the problem correctly then he/she moves onto the next problem, if not, then the problem is repeated until it is correct.

The CCC method of learning multiplication facts can easily be used in schools and has demonstrated its ability to increase students’ math fluency. In Wong and Evans, (2007), four classrooms from Year 5 classes at an inner city school were studied to compare pencil and paper instruction versus computer-based instruction. Using the CCC method, students had a higher increase of fact recall from pretest to posttest. Often schools determine that students know their multiplication facts if they can pass a timed test; by these results, the students would have a higher increase in math fluency. Students have the same medium for their pretest, intervention, posttest, and long-term test. This allows students to practice the same way they will be taking the posttest and other classroom tests (Duhon et al., 2012). In this case study, paper and pencil worksheets showed a large increase in multiplication fact recall from pretest to posttest; therefore, indicating- short term memory of fact recall.

There are a few negatives associated with the use of CCC. When students continually rewrite a problem, it becomes part of their rote memory. CCC increases students' short term memory, but their long term memory decreases (Wong & Evans, 2007). In school, teachers use short term memory to judge if a student has actually learned his/her math facts. However, teachers think that since students took a timed test, the facts are automatically in their long term memory which is not necessarily true. Students who practice fact after fact on a paper, memorize the facts, but do not actually learn them. There is not enough repeated practice of all the facts in CCC, with immediate reinforcement from another person (Becker et al., 2009). Some studies also require students to pass the same worksheet before moving onto the next set of problems (Mong & Mong, 2010). However, this strategy does not allow students to vary the order they are practicing their skills.

Computer-Based Interventions

A computer is another intervention for students to use when learning multiplication facts. There are several different programs schools can buy for students to work on their multiplication facts; yet, at the same time there are free multiplication practice problems, games, and worksheets for students to use online. One site for computer-based multiplication practice is multiplication.com; a site that has worksheets for students to complete online, as well as games to play. The computer allows students to practice facts repeatedly. It also allows students to complete problems at their own pace and repeat problems they struggle recalling, automatically with little to no effort.

Computer-based interventions can help students learn their multiplication facts quickly and retain the facts because they can be learned several different ways. “Four primary categories of computer-based instruction were identified: computer-assisted instruction, computer-enriched instruction, computer-managed instruction and computer-simulated instruction” (Duhon et al., 2012, p. 335). Computer-assisted instruction programs practice multiplication facts through drill. This would be the same as paper and pencil, only using the computer. Computer-enriched instruction includes games and game-like lessons for students; which would encourage students to learn the material while having fun. Normally, this method is only used during free time in schools. Computer-managed instruction evaluates students on their performance. Computer-simulated instruction includes real life application to math and shows how students can use multiplication in the real world (Duhon et al., 2012). Students can use all of these types of computer-assisted instruction or just one to learn their multiplication facts depending on their learning style.

Several studies using computer-based programs have shown an increase in math fluency after completing the program. In Burns, Kanive, and DeGrande (2012), 442 students in third and fourth grade participated in a study to evaluate the effects of a computer-based intervention. *Math Facts in a Flash*, a computer-based intervention designed to increase math fact fluency, was used as the intervention for the study. During this program, students used the computer to complete problems independently with little supervision. Students under the 25th percentile as determined by a pretest grew at the same rate as those who were above the 25th percentile on the pretest. This study demonstrates that *Math Facts in a Flash* increased student’s math fluency.

This program is similar to other programs because it presents one fact at a time. If a student gets the answer correct, it moves on. If the student answers incorrectly, it shows the student the correct answer before moving to the next problem. At the end of each session, it shows every problem the student completed and which ones were answered correctly and incorrectly, as well as the total amount of time it took the student to complete all the questions. This program provides students with immediate feedback on their multiplication facts.

There are several reasons why learning multiplication facts on a computer are beneficial for students. Learning multiplication facts using the computer can increase students’ fluency in fact recall. When students use math programs to learn facts, they receive immediate feedback on the problem (Burns et al., 2012). This helps them learn the correct answer to the problem rather than waiting until the end of the test or possibly days later. Computer intervention is also done independently so students can be working at individually appropriate levels rather than practicing facts that are too hard or too easy for them. Students also receive continuous practice during the intervention and do not waste time doing other things (i.e., waiting for their turn). They also work independently; therefore, the teacher can monitor large groups of students at one time instead of traditional small intervention groups (Burns et al., 2012).

Although there are many positives to using a computer to learn multiplication facts, there are also numerous drawbacks to using a computer. In computer interventions, students are not given additional help or support; it is completely individualized. This might be harder for some students to complete by themselves, and they will also need to have computer skills in order to complete the intervention. Students can only answer one question at a time or go from right to left on a page; they are not able to skip a problem and go back to it. There are several restrictions on a computer that students do not have with paper and pencil. If the problems are presented one at a time, students are not able to look back at previously answered questions for help. Computer intervention also take twice as long to implement because the program has to be introduced, explain its use, turn on computers, and shut them down (Wong & Evans, 2007). Typically, in math classrooms there are a limited number of computers thus students are required to move into a computer lab. Typically there are 3.2 students per instructional computer (Anonymous, 2005). This means that all students in school do not always have computer access. Changing the environment will also affect students because it is not their classroom where they will be taking pre, post and long-term tests (Wong & Evans, 2007). Computers have several benefits, but they also presented numerous challenges.

CCC Versus Computer Interventions

Research using CCC and computer-based instruction both demonstrates increases in students' multiplication skills however few studies have been done comparing the two. In the studies that have compared the two, there are varying results between which strategy is actually better for students because they compare different computer strategies with CCC; neither intervention is consistently reported as being better than the other. CCC shows a greater increase in learning facts according to Wong and Evans, (2007); however, the results indicate a difference in short term memory recall and long term memory recall between CCC and computer interventions. Mong and Mong (2010) indicate computer interventions were better than CCC for one of the three students in their study. The two other students had the same increase between CCC and computer intervention. Lastly, Duhon et al. (2012) show the medium used for assessment will impact which intervention results in the best student outcomes. When comparing all of these studies, there is no definitive intervention with clear supporting evidence of which best helps students recall multiplication facts.

Computer programs continuously practice all math facts previous learned with additional new facts, but at a rate where students can be successful. Students who learn using the computer are also reported to retain the information longer than those who use paper and pencil. Specifically, there was a larger increase from posttest to the long-term maintenance test (Wong & Evans, 2007). In another study, Mong and Mong, (2010) researched the difference between CCC and a computer intervention, *Math to Mastery*. The results showed students using the computer intervention had slightly more of an increase in fact recall than CCC. They explained computer intervention continually reviewed problems; however, CCC only reviewed certain problems on each worksheet rather than a continual mix of problems. The continuous practice of all multiplication facts helped students increase fluency and long term recall of facts.

Interactive Interventions

Interactive interventions have the connotation that when students use manipulatives they do not learn and they require a lot of "teaching" time. However, interactive interventions include more than manipultitves, they include songs, drawings, writings, movement, games, and other teaching tools. For instance, teachers need to explain "the concept of multiplication and how it connects to addition" (Burns, 2007 p. 16). When teachers make connections to students' prior knowledge it allows for deeper understanding and one of the best ways to make those connections is through manipulatives. "It is important to help students make connections among mathematical ideas so they do not see these ideas as disconnected facts" (Burns, 2007). Once students make connections they will be able to complete the problems with deeper understanding and allow them to store the information in their long term memory. If students see these as new, isolated facts, they will memorize them for the test, which will go into their short term memory, then after the test they will forget these facts and often struggle in math the rest of the year.

Manipulatives are the most popular material people think of when discussing interactive math. Manipulatives can be defined as “objects that can be touched, moved about, and rearranged” (Uribe-Flórez & Wilkins, 2010, p. 363). By using manipulatives teachers allow students to experiment and physically engage in abstract math in order to gain a concrete conceptual understanding of multiplication. This allows students to better understand the idea of multiplication which makes the concepts more clear. Uribe Flórez and Wilkins (2010) found that manipulatives were used the most by elementary teachers and the use of manipulatives decreased as students’ age increased. This particular study found that older teachers tend to use manipulatives less than younger teachers, and experienced teachers tend to use manipulatives more than novice teachers.

Additionally, it has been determined that the use of manipulatives in elementary classrooms improves performance for all students. Specifically, “activities that teachers planned using manipulatives not only benefited regular students but also met the needs of inclusion students without additional modifications” (Moch, 2001, p. 84). This provides evidence that manipulatives can help students with disabilities to gain a deeper understanding of multiplication and improve their recall of basic math facts. As a result, teachers have the same high expectations for all students during a lesson and include students with special needs in the lesson.

Although, research has demonstrated positive results that manipulatives work, there is also research demonstrating negative results with the use of manipulatives. “The reason teachers experience poor results when attempting to incorporate manipulatives may be because effective use of manipulatives is more difficult than most realize” (Puchner, Taylor, O’Donnell & Fick, 2008, p. 314). Therefore, teachers need to ensure they are using manipulatives the correct way. Teachers will know when students are not using manipulatives correctly because students will give the same answer to the teacher without being able to formulate it into their own words or ideas.

“The use of manipulatives for teaching mathematical concepts in the classroom may not work initially for everyone or for everything. Teachers must gain proficiency in using these devices” (Moch, 2001, pp. 81-82). The use of manipulatives requires teachers to put a lot of time into planning and thinking about the purpose for using the manipulative. Moch (2011) described the importance of using manipulatives as a pedagogical technique, not as reinforcement. The use of manipulatives are not as beneficial when they are used after direct instruction has occurred, rather, they must be used during instruction in order to obtain maximum benefit. This is one possible reason why teachers don’t use them in the classroom because they take up too much time and do not produce the greatest benefits.

Math games can also increase students learning. Games can provide students with the opportunity to visualize concrete ideas in order to develop a deeper understanding of the material (Lee, 2007). For struggling learners, math games allow students to become aware of their misunderstandings about the main idea of a math problem. Lee developed and used a fractions game to present material in an entertaining and educational way to help students expand their knowledge of fractions. The average and lower achieving students in the study rated the game as sometimes both “good” and “hard” indicating the game challenged them, but was still enjoyable. Overall, lower achieving students needed a lot of assistance during game play, which could be cause for concern. The teacher was required to provide a lot more assistance to the lower achieving students than other students. This finding might be due to the game being used following direct instruction and not during direct instruction which, as stated earlier Moch (2011) found to be less effective.

Interactive Versus CCC

A few students have evaluated the student achievement in mathematics using worksheets for instruction compared with using manipulatives. Cain-Caston (1996), studied third grade students to determine which strategy would increase student learning, when teaching addition, subtraction, multiplication and division. Students were evaluated using the California Achievement Test, which indicated students taught using manipulatives scored two grades above their current grade level compared to students taught using worksheets who scored on grade level. These findings indicate that students taught basic math skills developed a deeper understanding and carried out mathematical calculation tasks at a higher level than those who were taught using worksheets.

Given a lack of literature and research comparing all three methods of instruction (i.e., interactive strategies, computer-based drills, and paper and pencil), the current research was conducted to determine which intervention would result in the greatest increase in students' short-term and long-term memory recall of multiplication facts. This study examined the performance of both students identified as at-risk in mathematics, as well as students identified with special needs. The rationale for this student was that multiplication facts are vital for students to know in order to maintain grade level performance in math; therefore, all students need to improve their recall of facts.

Methodology

The purpose of this comparative study was to determine the best strategy for teaching fourth grade students multiplication facts when comparing interactive, computer-based drill, and paper and pencil (i.e., Cover, Copy, Compare) strategies. The following sections explain the methods used for data collection and include descriptions of the participants, demographics, procedures, instrumentation, and data analysis.

Demographics

The site for this study was an elementary school located in a rural Appalachian area of Southeastern Ohio. According to the 2000 Census Report there were 466 people living in the township, containing 175 households and 121 families. The majority of the people living in the area are white, with only 1.5% of non-white people living in the area. The median income for the school district in 2010-2011 was $25,401. The township has high levels of poverty and unemployment and both the township and the county have the highest poverty rates in Ohio. Currently there are 950 students enrolled in the school district, with approximately 67% of elementary students eligible for free or reduced lunches, the second highest in the county.

According to the School Year Report Card from 2011-2012 the school was rated as effective. The students in third grade and fourth grade scored at the proficient level in mathematics based upon the state indicators. The school consists of 97.8% white students, non-Hispanic, 67.7% economically disadvantaged, and 22.2% students with disabilities. The school itself is rated as having a medium-high rate of poverty.

The district's report card from 2011-2012 is similar to the elementary school's report card. The district is rated in "continuous improvement" and shows that fourth grade is below expected growth based on value-added measures. The district's proportion of students are similar as well with 1.3% of students classified as multi-racial, 98% of students white, non-Hispanic, 63.4% of students are economically disadvantaged and 23.6% of students identified with disabilities. All the teachers have a least a Bachelor's Degree and 70.8% of teachers have at least a Master's Degree.

Participants

The participants in this study included 20 fourth grade students. Students were from three different fourth grade classrooms consisting of 11 boys and nine girls; seven of whom had identified disabilities and had an Individualized Education Program (IEP), one had a 504 plan, and all other students were considered at-risk for math based upon a quarterly math assessment. Students were divided into three groups and participated in the study after lunch in a resource room during three separate ten-minute blocks of time. The time blocks were created with the students' classroom teachers during each class's individual reading time.

Students were from three different classrooms where they were taught multiplication facts using different methods. Students were placed in groups based upon the way their classroom teachers taught students multiplication facts at the beginning of the school year, so that students received a different intervention strategy than how they previously learned their multiplication facts during regular classroom instruction. All students with an IEP received math instruction together in the resource room.

Parents or guardians of participants signed and returned a consent form allowing the children to participate in the study. A few students who did not participate in the study still participated in the intervention for extra multiplication help however their data was not included in the study. In order to maintain confidentiality, every student was assigned a number. A master list containing names and number assignments was kept in a locked file cabinet in the classroom. All student data was also kept in a locked file cabinet within the classroom.

Instrumentation

All three groups of students were assessed exactly the same. Every student was given a pre-, post-, and delayed post-test, which are included in the Appendix. The paper and pencil pre-test had 40 multiplication problems and students were given two minutes to complete the facts to the best of their ability. The paper and pencil post- and delayed post-tests had the same multiplication problems arranged in a different order, and students were again given two minutes to complete the problems. The pre-test was given before the intervention began and the post-test was administered the day after intervention ended, one month after the pre-test. The delayed post-test was given to students one month after they took their post-test, two months after their pre-test.

The students in group one, the interactive group, were taught using a variety of different learning strategies and instruments. During the intervention, students used individual white boards to complete problems, base ten blocks, songs, dice and games, such as bingo, around the world and matching with multiplication facts. All these materials were used to help students deepen their understanding and allow for more practice with the multiplication facts.

Group two and three used very few tools. Group two, the computer-based intervention group, used a computer for practicing multiplication facts. This group completed online worksheets found on multiplication.com website. The third group, the CCC group practiced multiplication facts using researcher created pencil and paper worksheets. Groups had two and three set procedures that did not require different instruments for different days.

Procedures

Participating students were chosen based upon their quarterly math assessments and how well they were performing in the 4^{th} grade mathematics classroom. Once all three groups were assembled, each group completed the pre-test in the resource room. Each student was assigned a unique identification number and a worksheet face-down with 40 multiplication facts from 1-10. The students were asked to turn the worksheet over and begin once the timer started. Students were given two minutes to complete the worksheet and when the time was up, students wrote their unique identifying number instead of their name at the top of the paper. Students were instructed to turn the paper back over to ensure they didn't try to finish additional problems after the time expired. The papers were collected by the researcher after all worksheets were turned over. The same procedures were carried out for all three intervention groups.

All three groups had different intervention strategies which required different procedures. The interactive group was the only group that required different procedures for each day. The computer-based group and CCC group followed the same procedures every day.

Interactive-based intervention. Students in the interactive-based intervention group would come directly in from lunch and sit down at any desk in the resource room. Once all the students entered the room, ten minutes of intervention began. Students began the intervention by completing a question the white board, with help if needed. The question remained on the board the whole class period for students to visually see throughout the intervention period. Next, using direct instruction the researcher would teach them a trick about the multiplication fact, (i.e., the number one multiplied by any number always equals that number) or orally give them a multiplication problem and allow five seconds to respond. The researcher reminded them to try not to look at the board during the five seconds. Once the five seconds were over, students would respond with the answer. Lastly, students would then sing the facts with the answer in unison a class.

Once 3-5 facts were practiced in this manner, then students would engage in an activity, related to multiplication facts, either using base-ten blocks, games, or songs. The activity or manipulative would be explained, as well as its connection to previous knowledge. At the end of the intervention session students would be given an exit slip with two problems. The students wrote their unique identifying number at the top of the paper and completed the problems. Once students completed their problem they returned to their own classroom.

Computer-based intervention. The researcher gathered members of the second group, the computer-based intervention group, from classrooms during their reading time. These students were taken to a meeting room, which contained computers. All computers were set up ahead of time so that students could walk right in and begin. The multiplication.com page would be displayed on the computer screen so students only had to choose the corresponding multiplication fact for the day. As soon as students were seated, the researcher identified the fact to be practiced for that day. The students would click the identified number and begin practice. Once each student completed all the problems in the set, the researcher would check the page and review the missed problems with the student. After reviewing any missed problems, the student then would continue on to complete another page. This same procedure was followed each day for every student.

Cover, copy, compare (CCC) intervention. The final group was the CCC intervention group. Once students in the computer-based intervention group completed their intervention session, the researcher collected the last group of students in the CCC intervention group. Once in the resource room and students were seated, they were given a note card and a multiplication packet with their unique identification number written on them. The packet consisted of a box on the left that included a multiplication problem with the answer and a blank box on the right. The students would write their unique identifying number at the top and solve the multiplication problem using the cover, copy compare (CCC) procedure. Students would say the problem in their head, cover the problem and say it again, then write the answer in the blank box on the right. Once the answer was written down, students would compare their response with the problem on the left. If they were correct, they would move on to the next problem, but if they answered incorrectly they would redo the problem. This procedure would repeat for the entire ten minute intervention.

The multiplication facts were spaced out so that each day would allow for teaching of one multiplication fact, with several days allowed for review of several facts combined. Students practiced facts one through four on separate days, and then reviewed all the facts (1-4) for one day. The second week students practiced facts five through seven with a review day for facts five through seven and one through seven. The third week students reviewed facts one through seven, practiced eight, then reviewed six and seven, and one through eight. The final week, students practiced nine, ten, then reviewed seven through ten, and one through ten. On the last day of the final week, students took the post-test to evaluate their learning. A calendar of the mathematics facts practiced and reviewed each day is found in the Appendix.

Results

In the following section, tables for each group contain the pre-test, post-test, and delayed post-test scores (% correct) for each students. (See tables 1-3). In each table, students in italics are males and students in bold have a disability with an IEP or 504 plan. Graphs of students' scores for each group are also provided (See Figures 1-3).

Table 1

Pre-, Post-, and Delayed-Post Test Scores for Interactive-Based Intervention Group

Interactive Group	**Pretest % correct**	**Post-test % correct**	**Delayed post-test % correct**
Student 3	33	83	78
Student 4	50	95	95
Student 5	3	43	43
Student 6	48	88	95
Student 7	38	75	40
Student 8	33	48	38
Student 9	35	43	68
Mean	34.28571	67.85714	65.28571429

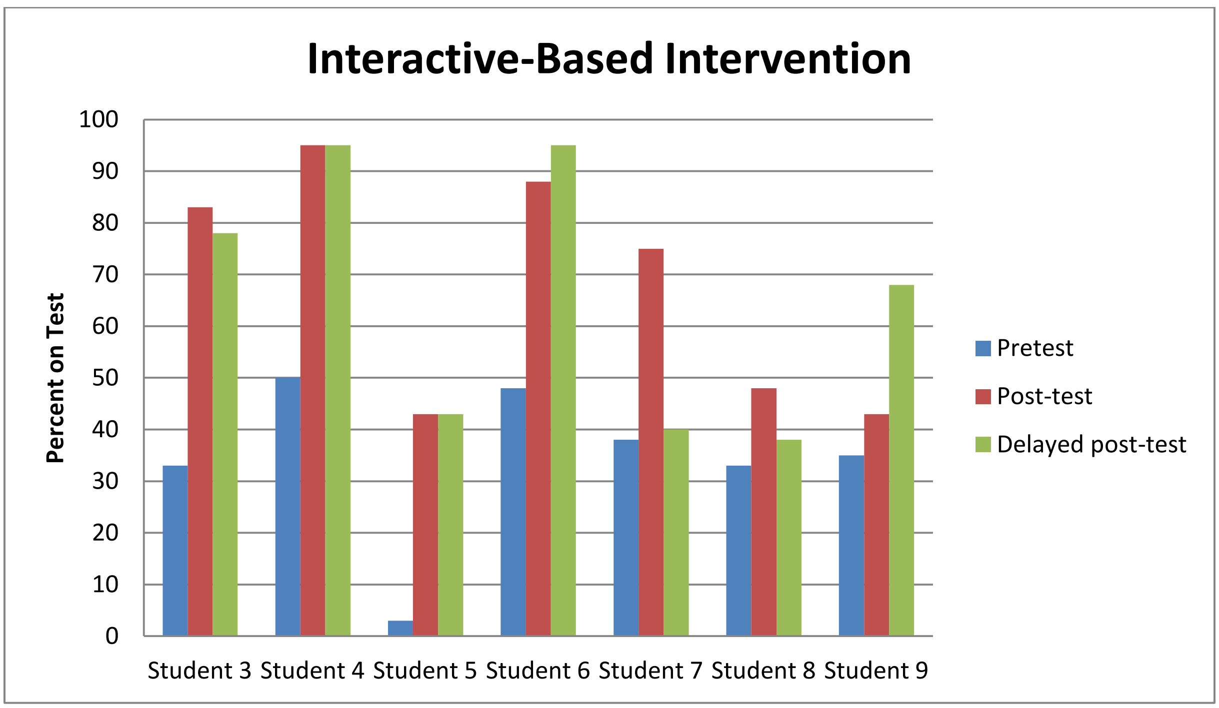

Figure 1. Pre-, post- and delayed post-test scores for students receiving interactive-based intervention.

Table 2

Percent Change for Interactive-Based Intervention Group.

Interactive Group	**Pre-test to Post-test**	**Pre-test to Delayed Post-test**	**Post-test to Delayed Post-test**
Student 3	50	45	-5
Student 4	45	40	0
Student 5	40	40	0
Student 6	40	47	7
Student 7	37	2	-35
Student 8	15	5	-10
Student 9	7	33	25
Mean	33.42857	30.2857143	-2.5714286

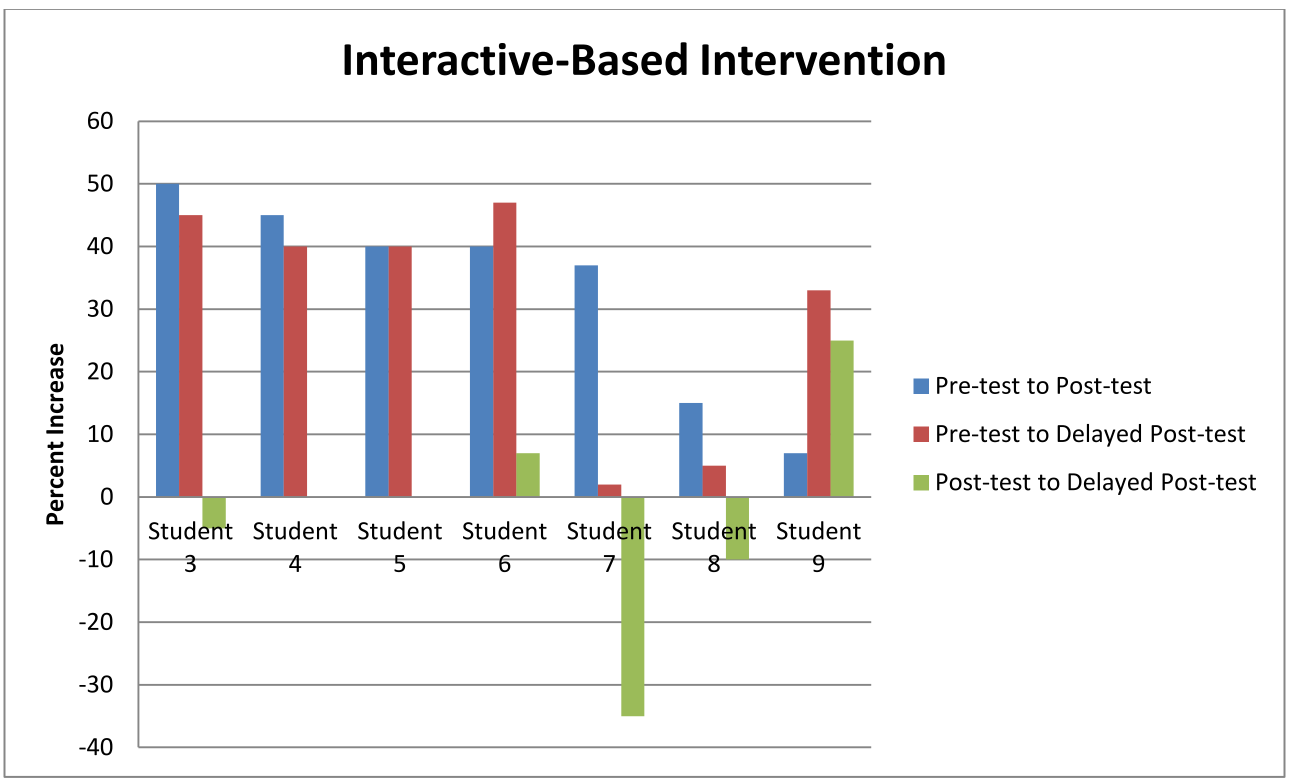

Figure 2. Percent change for students receiving interactive-based intervention.

Table 3

Pre-, Post-, and Delayed-Post Scored for Computer-Based Intervention Group

Computer Group	**Pretest**	**Post-test**	**Delayed post-test**
Student 10	38	90	85
Student 11	48	100	85
Student 12	23	35	35
Student 13	35	40	53
Student 14	55	65	65
Student 15	43	53	50
Mean	40.33333	63.83333	62.16666667

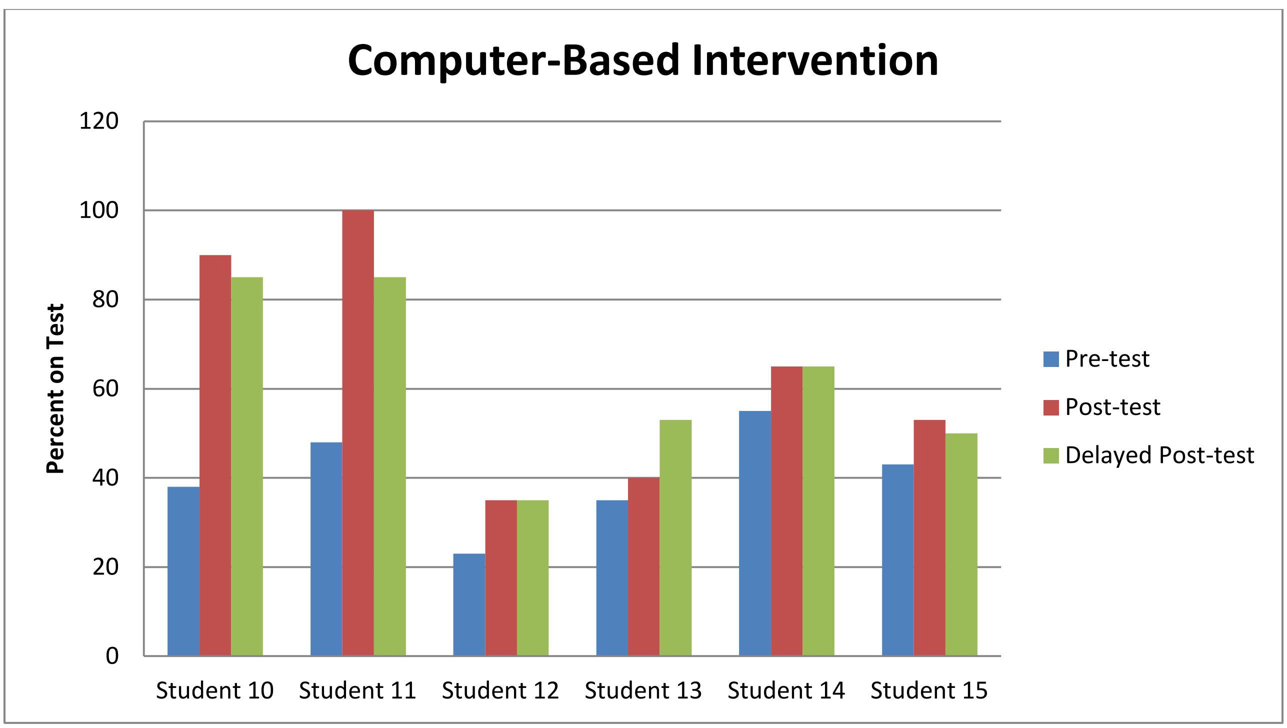

Figure 3. Pre-, post- and delayed post-test scores for students receiving computer-based intervention.

Table 4

Percent Change for Computer-Based Intervention Group

Computer Group	**Pre-test to Post-test**	**Pre-test to Delayed Post-test**	**Post-test to Delayed Post-test**
Student 10	52	47	-5
Student 11	52	37	-15
Student 12	12	12	0
Student 13	5	18	13
Student 14	10	10	0
Student 15	10	13	3
Mean	23.5	22.8333333	-0.6666667

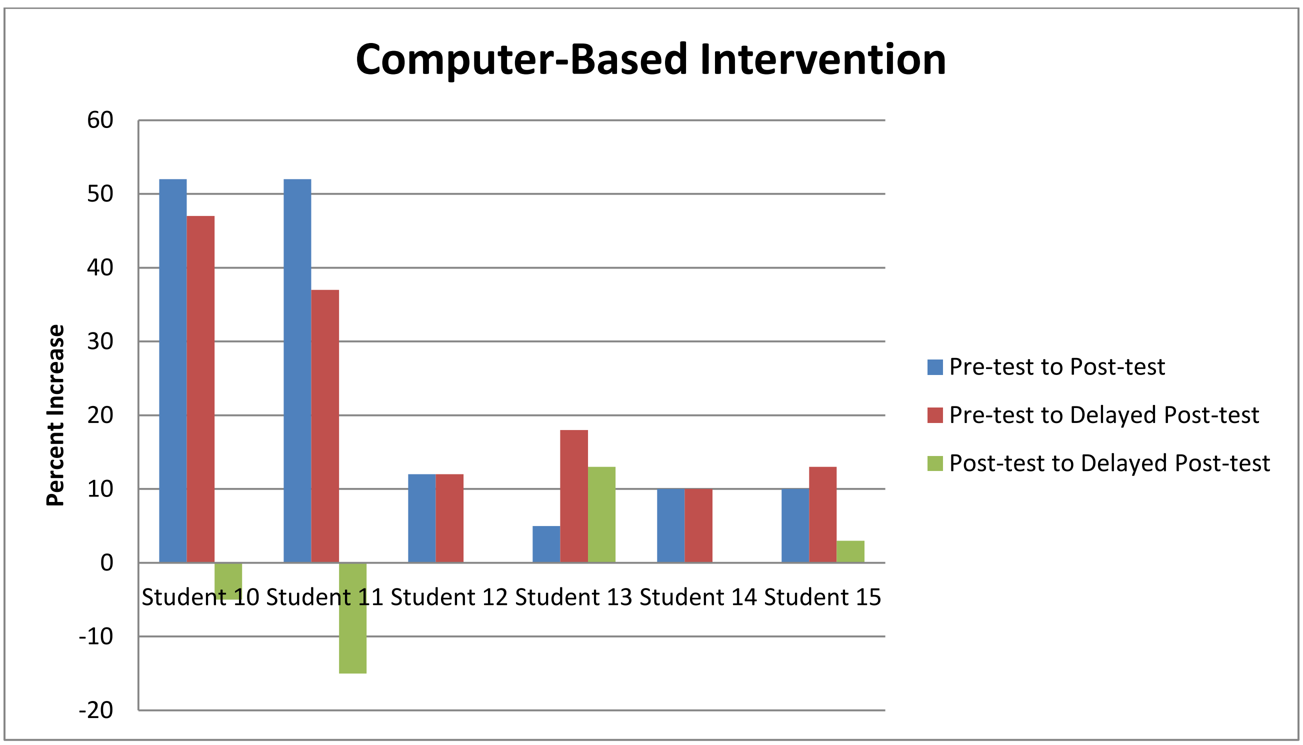

Figure 4. Percent change for students receiving computer-based intervention.

Table 5

Pre-, Post-, and Delayed-Post Test Scores for CCC Intervention Group

CCC Group	**Pre-test % correct**	**Post-test % correct**	**Delayed Post-test % correct**
Student 16	53	68	70
Student 17	50	73	93
Student 18	75	75	80
Student 19	70	68	75
Student 20	43	43	35
Student 21	55	65	70
Mean	57.66667	65.33333	70.5

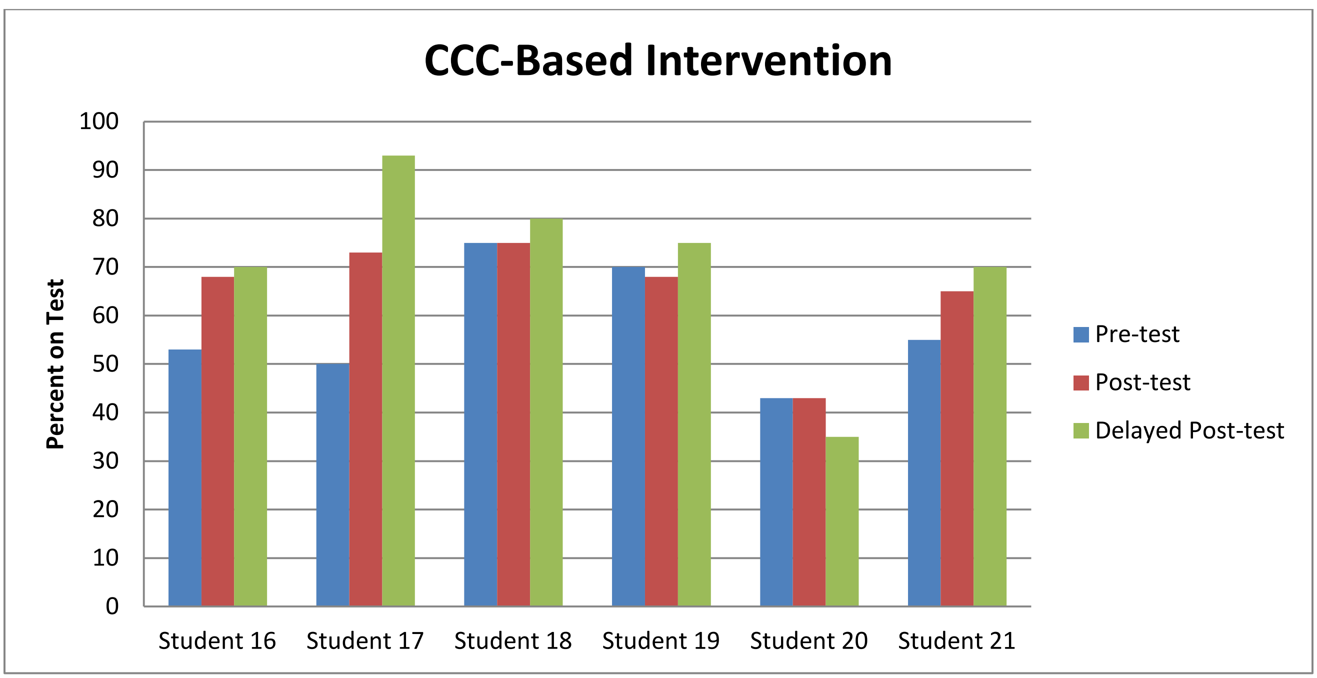

Figure 5. Pre-, post- and delayed post-test scores for students receiving CCC intervention.

Table 6

Percent Change for CCC Intervention Group

CCC Group	**Pre-test to Post-test**	**Pre-test to Delayed Post-test**	**Post-test to Delayed Post-test**
Student 16	15	17	2
Student 17	23	43	20
Student 18	0	5	5
Student 19	-2	5	7
Student 20	0	-8	-8
Student 21	10	15	5
Mean	7.666667	12.8333333	5.16666667

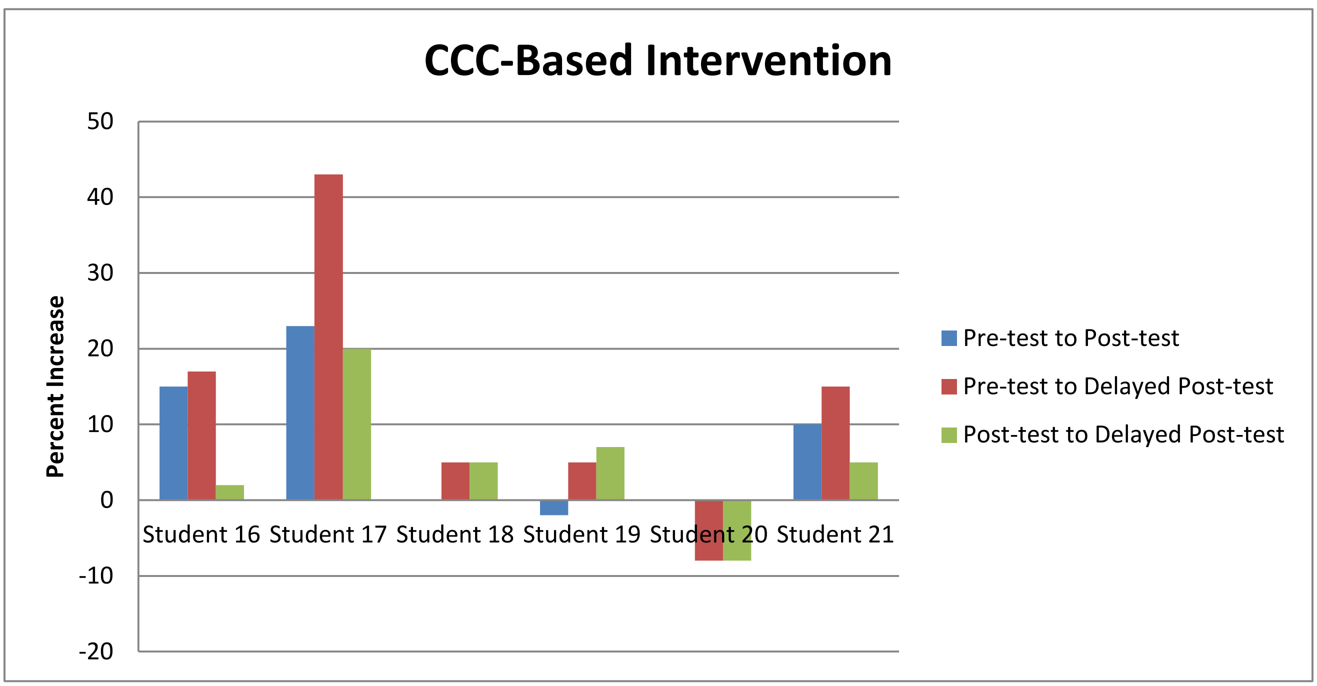

Figure 6. Percent change for students receiving CCC intervention.

The next section contains tables presenting the result of the t-tests. Results include short term and long term recall of multiplication facts compared by group, gender, students who have a disability and students who are at-risk.

Table 7

Group Differences for Pre- to Post-Test: Short-term Recall of Multiplication Facts.

Short term	t-value	p-value	Estimated difference
Interactive vs. Computer	1.8147	0.05975	9.929
Interactive vs. CCC	3.9117	0.003939*	25.7619
Computer vs. CCC	3.2468	0.008769*	15.83333

Table 8

Group Differences for Pre- to Delayed Post-Test: Long-term Recall of Multiplication Facts

Long term	t-value	p-value	Estimated difference
Interactive vs. Computer	1.4814	0.09451	7.452681
Interactive vs. CCC	2.381	0.02735*	17.45238
Computer vs. CCC	2.1822	0.03592*	10

*p< .05

Table 9

Group Differences for Pre- to Post-Test: Short-term Recall of Multiplication Facts by Gender: Males

Males: Short term	t-value	p-value	Estimated difference
Interactive vs. Computer	0.2638	0.4022	4.5833
Interactive vs. CCC	1.7472	0.07407	21
Computer vs. CCC	1.1148	0.178	16.4166

Table 10

Group Differences for Pre- to Delayed Post-Test: Long-term Recall of Multiplication Facts by Gender: Males

Males: Long term	t-value	p-value	Estimated difference
Interactive vs. Computer	0.5177	0.316	7.75
Interactive vs. CCC	1.2113	0.1364	17
Computer vs. CCC	0.5719	0.2972	9.25

Table 11

Group Differences for Pre- to Post-Test: Short-term Recall of Multiplication Facts by Gender: Females

Girls: Short term	t-value	p-value	Estimated difference
Interactive vs. Computer	1.1158	0.1899	16.6667
Interactive vs. CCC	3.7973	0.07932	32.5
Computer vs. CCC	0.9229	0.2131	15.8333

Table 12

Group Differences for Pre- to Delayed Post-Test: Long-term Recall of Multiplication Facts by Gender: Female

Females: Long term	t-value	p-value	Estimated difference
Interactive vs. Computer	0.4437	0.3436	7
Interactive vs. CCC	1.227	0.1592	18.6667
Computer vs. CCC	1.2336	0.1534	11.6667

Table 13

Group Differences for Pre- to Post-Test: Short-term Recall of Multiplication Facts for Students with Disabilities

Students with a disability: Short term	t-value	p-value	Estimated difference
Interactive vs. Computer	-0.2822	0.5966	-7
Interactive vs. CCC	0.8558	0.2386	11.5
Computer vs. CCC	0.8748	0.2696	18.5

Table 14

Group Differences for Pre- to Delayed Post-Test: Long-term Recall of Multiplication Facts for Students with Disabilities

Students with a disability: Long term	t-value	p-value	Estimated difference
Interactive vs. Computer	-0.1126	0.5396	-2.3333
Interactive vs. CCC	0.981	0.2144	11.6667
Computer vs. CCC	0.8221	0.2806	14

Table 15

Group Differences for Pre- to Post-Test: Short-term Recall of Multiplication Facts for Students at-Risk

Students who are at-risk: Short term	t-value	p-value	Estimated difference
Interactive vs. Computer	1.8904	0.07549	20.75
Interactive vs. CCC	5.7199	0.003537*	35.25
Computer vs. CCC	1.1724	0.1488	14.5

*p< .01

Table 16

Group Differences for Pre- to Delayed Post-Test: Long-term Recall of Multiplication Facts for Students at-Risk

Students who are at-risk: Long term	t-value	p-value	Estimated difference
Interactive vs. Computer	1.0898	0.1631	13
Interactive vs. CCC	1.3975	0.106	21
Computer vs. CCC	0.6339	0.2778	8

Discussion

When comparing the three different groups: interactive-based, computer-based and CCC there are some significant differences as determined by t-tests. A t-test evaluates if there is a significant difference between two populations. In this study, the comparisons of two populations consist of these sets: interactive vs. computer, interactive vs. CCC and computer vs. CCC. All three sets have subsets, which are created by separating students with IEP/504 plans, at-risk, and gender for long-term and short-term recall of multiplication facts.

Pre- to post-test differences. The first t-tests determined differences in short term memory recall of multiplication facts for all three groups. The results comparing the interactive group to the computer group displayed a p-value of 0.05975 or 94% confidence when the t-value was 1.8147. This gives us sufficient evidence that the mean of the interactive group was significantly greater than the mean of the computer group. When comparing the interactive group and CCC group there was a p-value of 0.003939 or more than 99% confidence with a t-value of 3.9117. This tells us that the interactive group was significantly different from the CCC group. Lastly, the results of the computer group and CCC group reached a similar conclusion to the previous results. The p-value of 0.008769 indicates with more than 99% confidence that a t-value of 3.2468 shows the CCC group was significantly different from the computer-based group and the least effective for short term memory recall of multiplication facts.

Pre- to delayed post-test differences. Long term memory recall of multiplication facts for all three groups was compared in the second t-test. When comparing the interactive group with the computer group, results revealed a p-value of 0.09451 or 90% confidence that the interactive group's scores were significantly greater than the computer group with a t-value of 1.4814. The results of the interactive group compared with the CCC group had a p-value of 0.0.2735 or a confidence of 97% and a t-value of 2.381, which indicates that the interactive group's scores were significantly greater than the CCC group. In the last comparison the computer group's scores were shown to be significantly greater than the CCC group, with a p-value of 0.03592 or a confidence of 96% and a t-value of 2.1822. Thus, confirming an identical hierarchy of effectiveness in strategies found for the short term memory recall of multiplication facts.

Students with identified disabilities. The three sets were divided into subsets of students who have an IEP/504 plan and those who are at-risk. Results of all t-tests for students who have an IEP/504 plan did not show any significant differences, thus showing that there is not sufficient evidence to demonstrate that one strategy is better than other for short and long term recall of multiplication facts in for students with identified disabilities.

Students at-risk. Students identified as at-risk displayed different evidence concerning which strategy is better for short and long term recall of multiplication facts. Comparison of short term recall of multiplication facts all three subsets showed varying significance. Results from the first t-test displayed a p-value of 0.07549 and t-value of 1.8904, which denotes that the interactive group was greater than the computer group, but the differences did not reach statistical significance.

The next t-test compared the interactive and CCC group producing a p-value of 0.003537 and t-value of 5.7199, this indicates the interactive group performed significantly better than the CCC group. There was a notable difference between the computer and CCC group. The p-value was 0.1488 and t-value was 1.1724, which indicates the groups' scores were different, but not statistically significant. Overall, this exemplifies that the strategies mattered for short term memory recall of multiplication facts in the students who are at-risk. However, the long term memory recall of multiplication facts did not produce the same significance differences. The only t-test that showed any difference was a comparison of the interactive group and the CCC group. These results indicated a p-value of 0.003537 and t-value of 1.3975, indicating the interactive group performed greater than the CCC group.

Gender. When examining group scores by gender and comparing each group to one another, there was only a slightly difference for males. The males displayed differences between the interactive group and the CCC group. The p-value was 0.1364 and t-value was 1.22113, showing minor differences for long term memory recall of multiplication facts.

Conclusion

The results of this study indicate that the interactive group increased students' short term and long term memory recall of multiplication facts the most. All t-test indicated that the interactive-based intervention group made larger gains than all other groups, which means that they had the greatest increase from pretest to post-test and pretest to delayed post-test. Results indicated the second group that increased students' recall of facts was the computer-based intervention group and the CCC intervention group was least effective.

All students in the interactive-based intervention and computer-based intervention group increased their short term and long term memory recall of facts. In the CCC intervention group there was one student who did not improve short term memory recall of facts and one student who did not improve long term memory recall of facts; however, all other students improved.

This research benefits elementary teachers who are teaching students multiplication facts. This study focused on the most effective strategies for teaching students with disabilities and students who are at-risk multiplication facts. The results did not determine which intervention is significantly better for students who have a disability. However, there was enough evidence to determine that the interactive-based intervention strategy was the most effective for short term memory recall of multiplication facts.

For long term memory recall of facts there was not a big difference between the interactive-based intervention and the computer-based group, however, there was enough evidence to determine that the interactive-based intervention was significantly better than the CCC intervention for improving students' recall of multiplication facts.

Recommendations

Additional research would benefit elementary math teachers teaching multiplication. Not many studies have been done comparing all three groups simultaneously; therefore, more research must be done to validate these conclusions. Only a few studies have researched interactive interventions for multiplication facts so more research needs done on this particular intervention. Within this intervention different types of strategies need to be researched more in depth to determine the most effective method for teaching multiplication facts.

Additionally, there has not been limited research conducted to determine the effectiveness of the computer-based strategy, which limits the validity of this strategy. Lastly, further research could be done comparing the effectiveness for students with disabilities in a group or students who are only at-risk, instead of grouping them together. This would determine which strategy is more effective for students with disabilities and those who are at-risk.

Implications for Practice

Limitations. The students who participated in the research are minors; therefore, consent must be given by parents or guardians. This causes some research to have a limited number of students involved, thus lessening its credibility. In Becker et al. (2009), only one student was used in the study. Although the study was successful for that student, it does not provide enough evidence to clearly demonstrate that CCC is the best method to use when teaching multiplication facts. Similar to this, Mong and Mong (2010), had three students participate in their study. Moreover, only one student experienced increased multiplication skills with computer intervention; whereas, the other two students increased multiplication skills at the same rate with computer-based interventions and CCC. These studies can be looked at for support, but there is not enough evidence in the research to clearly state which intervention would result in greater increases in memory recall for multiplication skills.

This study began in January and weather caused the research to be pushed back a few days due to snow days. This caused discontinuity in the day-to-day lessons and a break in the intervention for students. Students still completed all the necessary lessons; however it extended the intervention into February. More consistent intervention would need to be completed to show if students who did not increase their abilities would have a greater increase if the intervention was not interrupted.

Groups were created to be as equal as possible. Some groups had more boys than girls, while others had groups where their beginning abilities were higher than others. The groups were formed first by gender, students who had an IEP or 504 plan, so that each intervention could be compared. Next, students were divided into groups based upon their pre-test score and the method of learning in their individual classroom (students were put into a different learning strategy group than their classroom). Lastly, the at-risk students were divided into three groups based upon their gender, pre-test scores and individual classrooms. Groups were composed as evenly as possible based on the criteria.

Summary

This study compared interactive-based, computer-based, and CCC intervention for short-term and long-term memory recall of multiplication facts for fourth grade students. Each group completed ten minutes of intervention in the afternoon for one month. Results indicated that almost all students improved their short-term and long-term recall of multiplication facts. However, the interactive-based intervention showed the greatest increase in both students' short-term and long-term recall of multiplication facts. The students in this group learned their multiplication facts through hands-on activities, games and songs. The second group that showed the greatest increase in memory recall was the computer-based intervention group. The intervention for these students consisted of drill and practice on the computer with help from a teacher. The final group that demonstrated minimal improvement on multiplication facts was the CCC group, where students completed drill and practice worksheets. Findings indicate that students who are learning their multiplication facts, especially students who are at-risk in math, should be taught by songs, games, activities, and other engaging activities in order to learn and retain mastery of multiplication facts.

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Appendix

January 2013 Calendar

Sun	*Mon*	*Tue*	*Wed*	*Thu*	*Fri*	*Sat*
		1 No School	**2** No School	**3**	**4** Pretest	**5**
6	**7** One	**8** Two	**9** Three	**10** Four	**11** One - Four	**12**
13	**14** Five	**15** Six	**16** Seven	**17** Five - Seven	**18** One - Seven	**19**
20	**21** No School	**22** One - Seven	**23** Eight	**24** Six - Eight	**25** One - Eight	**26**
27	**28** Nine	**29** Ten	**30** Seven - Ten	**31** One - Ten	**1** Post-test	

Name: _________________ Date:_____________________

1 x 3	
1 x 5	
1 x 6	
1 x 1	
1 x 8	
1 x 9	

1 x 6	
1 x 2	
1 x 0	
1 x 4	
1 x 7	
1 x 10	