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Effects of online program vs. handheld flashcards on multiplication and division fact knowledge of 4th grade learners with exceptional needs

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EFFECTS OF ONLINE PROGRAM VS. HANDHELD FLASHCARDS ON BASIC MULTIPLICATION AND DIVISION FACT KNOWLEDGE OF 4TH GRADE LEARNERS WITH EXCEPTIONAL NEEDS

by

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Dedication

"When you get into a tight place and everything goes against you, 'til it seems as though you could not hold on a minute longer, never give up then, for that is just the place and time that the tide will turn." - Harriet Beecher Stowe

I dedicate this work to my wonderful husband, Elliot, whose unwavering love, support, encouragement, and patience guided me through this process. You never let me give up and truly are my inspiration to succeed.

Acknowledgments

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I would like to extend my gratitude to my family, friends, and colleagues who have been nothing but supportive and encouraging. I am fortunate to have such amazing people in my life and would not have been able to succeed without you.

Abstract

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This study utilized a time series design to investigate the effects of a computer-based math fact program called Xtramath.org vs. the use of traditional handheld flashcards. Students were given a baseline assessment before beginning the school district's method for learning basic math facts: Xtramath.org. They were tested again after 6 weeks and then began to use traditional handheld flashcards. Students were tested again to compare the results. Eight 4th grade students (5 male and 3 female) with special needs were included in this study. These students attend school in a wealthy, suburban area with a predominantly white population.

Fluency in basic math facts is a critical skill in furthering mathematical skills from elementary school through college. Without this important skill, students are certain to have difficulties throughout their schooling career and beyond. Some researchers have shown that technology-based programs are benefiting the growth of math skills, but has technology actually done away with an important factor in learning basic multiplication and division facts? The results showed that while both methods of acquiring math fact fluency were beneficial, there was a substantially greater increase with the use of the flashcards. The online program helped, but students were more successful with the flashcards.

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Chapter 1

Introduction

Fluency in basic math facts is a critical skill in furthering mathematical skills from elementary school through college. Without this important skill, students are certain to have difficulties throughout their schooling career and beyond. As early as 4th grade, students need fluency in their basic facts when completing multi-digit multiplication, long division, and multi-step word problems. Timed exams like the PARCC test do not allow for extra time to solve basic facts. As math programs become more difficult through middle school and high school, those students who are not adequate in their fact knowledge are sure to fall behind.

Significance of Study

Technology has come a long way in education. For math specifically, there are calculators, online manipulatives, online games, and even electronic flashcards. In many classrooms, flashcards are no longer needed to memorize facts, because it's so much more engaging for students to "play" with these facts on the computer. To many, this seems like such a big help in the classroom.

Since I began teaching special education five years ago, around the same time technology began making its way as an integral part of the curriculum, I have yet to find a class of students that is adequate in their basic math fact knowledge. While I see these students practice with math games on their chromebooks and iPads every day, I have not seen the same progress in their development or fluency of skills. Has technology replaced an important factor in learning basic math facts? If so, parents and educators need to begin implementing other strategies to prevent their students from falling behind. Some

researchers have shown that technology-based programs are benefiting the growth of math skills, but is it enough?

Purpose of Study

The purpose of this research study is to answer the following question: Does the use of online math programs improve the multiplication and division fact knowledge of 4th grade exceptional learners better than the use of traditional handheld flashcards? This researcher's hypothesis is that the use of handheld flashcards is more beneficial to the basic math fact performance of exceptional learners in elementary school because students have difficulty retaining the information in online programs as well as they would with handheld flashcards.

Defining Key Terms

Basic math facts. This term refers to addition, subtraction, multiplication, and division facts from 0-12. For the purpose of this study, this will represent only multiplication and division facts.

Exceptional learners. Exceptional learners are considered to be students with learning, cognitive, behavioral, physical, or sensory differences who require a different type of learning.

Flashcards. Flashcards refer to index cards or pieces of paper with a basic math fact on one side, and the answer on the other. There is a different fact and answer combination on each card.

Inclusion. An inclusion classroom is a classroom in which students with special needs work in the general education setting. There should be at least, a certified general education teacher, a certified special education teacher, and an assistant in each room.

Instructional assistant. An instructional assistant is an adult in the room to assist both teachers and students in daily routines. This person is sometimes, but not always, certified in teaching.

Math fluency. The ability to answer basic math facts quickly and accurately, without using drawings or fingers to count. The answers should come automatically to students with strong math fluency skills.

Resource room. A resource room is a special education classroom in which students are pulled out from the inclusion classroom for everyday learning in math, reading, or writing.

Implications for Study

One possible implication for this study is that if basic handheld math flashcards are found to be more beneficial in helping students develop math fluency skills, then parents and educators would reframe their approaches to teaching basic facts to children. Technology can be expensive. This would cause the school district to think twice before purchasing expensive online programs when students could simply make flashcards themselves. Technology is also known to cause difficulties. If the iPad is the only way the student can practice math facts, what happens when the battery dies or it stops working? Flashcards are always available in any situation. Additionally, students can always benefit from a break from screen time.

Another possible implication for this research study is that if online programs are found to have a greater impact on math fluency skills than regular flashcards then teachers who use more traditional practices would begin switching over to technology programs to teach math facts. This would allow schools to spend more time searching for

the best online programs and promoting them in the classrooms. Since many schools are already looking into individual devices for students for other subjects, they would be able to move confidently in the direction of online math curriculum.

The results of this study will help administrators, educators, and parents decide what the best course of action is to help their child. This evidence will offer a possible solution to the lack of math fluency skills seen in students today. No more counting on fingers or drawing pictures for basic facts. Students need to learn math fluency skills in order to succeed.

As in any study, there are some problems that may arise or alter the results. One barrier to this study could be the students' comfort level with technology programs they have been using. Another barrier might be that other factors could alter the results. For example, continuous reteaching of lessons, participation in class, completion of homework, outside tutoring, etc., are all things that need to be taken into consideration when analyzing the results of the study, as they may alter the findings.

Chapter 2

Literature Review

With the recent widespread progression towards technology, researchers and educators have welcomed any opportunity to add new technology into the classroom for their students. Research has been conducted on various kinds of technology, the unique mathematical programs, and the effect they have had on learning. This literature review will include five major sections: The Importance of Math Facts for Successful Performance in Math, Difficulties of Students with Disabilities, Computer Based Mathematics Programs, Handheld Flashcards, and Gaps in the Literature. This review is limited to studies targeting elementary and middle school students. Students in both the general education programs and special education programs have been included.

Importance of Basic Math Facts for Successful Performance in Math

Basic math fact knowledge becomes crucial by the time students reach fourth grade. Students in elementary school have struggled to maintain basic fact knowledge. One study shows that 21% of fourth graders in 2009 were performing below the basic levels of math (Codding, 2009), while this number increases as students get older. Another study stated that the National Assessment of Education Progress in the US assessed in 2013, a mere four years later, that 59% of fourth grade students were performing under the level of proficiency in mathematics (Zhang, Trussell, Gallegos, & Asam, 2015). In fact, it was quoted by the National Research Council that the performance of U.S. students on mathematical assessments in general evokes "both a sense of despair and hope" (Sood, 2007, p.145). Zhang (2015) completed an exploratory study that included a fourth-grade classroom of students mainly considered at-risk or

disabled. He found that the importance of basic skills becomes very apparent in the fourth-grade curriculum. In fourth grade, math begins to involve concepts that require multiple operations and steps to solve. Take multi-digit multiplication as an example. This process alone involves multiple sequences of single-digit multiplication and addition. Checking that problem for correctness would then require division and subtraction. All the while, students must be keeping numbers organized and lined up neatly - an executive functioning skill that can be challenging for many young and at-risk students. When figuring out a basic fact is still a process for a student, rather than instant recall, completing challenging multiplication and division problems, or those that involve fractions and decimals, becomes an agonizing and demoralizing process.

Robin Codding (2009) published a study that suggested the importance of basic math fact knowledge on all other elements of mathematical success. Math is considered to be a hierarchy, which stems from the basic knowledge of computation. She lists three main reasons why mastery of these facts is so important:

- these skills are required for independent living
- they are needed for things related to money, time management, abstract thinking, and problem solving
- finally, these basic computations are crucial for all other underlying mathematical concepts.

A preliminary study by Thurber, Shinn, and Smolkowski (2002), also supported the claim that basic math computation affects other areas of math. Their study was conducted by splitting math computations and applications into separate factors to analyze them. They found that even though these were different factors, the results

showed them as highly related (r = .83) constructs. Kroesbergen and Van Luit (2003) describe the domain of foundational math skills as very large and say that it should constitute a large part of the teaching in elementary school. After all, how do students move on confidently without this basic knowledge mastered?

Overall, the research has shown that there are two very important ideas about basic math facts or computation skills. One is that they are crucial in understanding all other elements of math. The other is that computation skills seem to be an area in which interventions can be effective for students (Kroesbergen & Van Luit, 2003). In the past, before technology was an option for students, paper-based methods and flashcards were used. Now, many teachers have decided to ditch the paper and switch to more contemporary methods of computer games and apps that students would find more appealing. Further research has been shared to consider the pros and cons of each method.

Difficulties of Students with Disabilities

Students with disabilities learn differently than those in the general education setting. These students have disabilities that can involve impairments of various cognitive domains: visual perception, knowledge and achievement, learning and memory, language, communication, reasoning, idea production, auditory reception, cognitive speed, and many more (Wehmeyer, Smith, Palmer, & Davies, 2004). Wehmeyer et al. (2004) note that students with disabilities may have a weaker working memory. This leaves implications for more efficient strategies to be put in place. It has been recommended to teach students with disabilities with direct, explicit instruction (Kroesbergen, 2003a) and plenty of opportunities for practice and repetition (Wehmeyer,

2004). One of the best scaffolding strategies that will help support student learning is to break down complex problems into smaller and more manageable steps as to not overwhelm students with executive functioning difficulties (Zhang, 2015).

Research shows that one of the critical elements for students with disabilities is effective instruction of basic math facts (Fries, 2013). Any student, whether in the general education or special education setting, who demonstrates challenges with mathematics will require extra attention (Kroesbergen, 2003a). In fact, it has been shown that math is one of the topics even teachers can find stressful (Hansel, 2017). For a subject that some teachers find difficult, surely students with special needs will struggle greatly in this area. Explicit instruction allows for teachers to model and supervise closely, frequently monitor student progress, and provide immediate feedback for students (Fries, 2013). All of these components are crucial to aide in the development of skills for special education learners.

Computer-Based Mathematics Programs

In a recent review of research and implementation guidelines; Hawkins, Collins, Herman, and Flowers (2016) describe the importance of math fact fluency on future applications of mathematics. While the results showed only small progress, the research suggests that computer-based instruction may work better in place of an existing program, rather than in combination with. She completed studies of CAI (Computer Assisted Instruction) programs that have been used over recent years in math instruction. Hawkins suggests that these programs are most helpful with students who are at-risk or have special learning needs. In her article, she runs through the careful planning, considerations, and steps needed to make decisions on which computer-based programs

to use. While computer-based programs are keeping up with technology and the interest of children, deciding on a computer-based math facts program is no easy task. Teachers and administrators must consider the cost, accessibility, ease of use, variety of skills practiced, etc. Technology requires time for training, both students and teachers (Wehmeyer, 2004), which can keep studies at a standstill while they wait. They must also consider the interest level of the students and how this new program will fit in with the current curriculum. However, many schools have already started incorporating personal technology devices for students, which would make new online math programs highly convenient and affordable (Hawkins et al, 2016). It takes a lot of time, money, and energy for a district to implement a completely new and expensive supplementary program into the district, so Hawkins suggests intense research.

Zhang et al. (2015) completed a research study in Urban City schools that showed the results after implementation of individual iPads and use of multiple apps to build math fact skills. The individual progress ranged from .5%-14%, and while it did reduce the achievement gap slightly, it did not bring any "struggling" students out of that category. Other research done in a quasi-experimental study of mathematics performance on standardized state tests both before and after the use of a multi-sensory computer-based program shows positive results as well (Xiong, 2010). This study also did not include students with disabilities or at-risk students. Mechling, Gast, and Thompson (2008) completed a study on the differences in effectiveness of using traditional flashcards and SMART Board, interactive whiteboard technology. The study showed that while learning took place in both methods, more students were able to benefit as a whole group from the computer methods.

The difficulties with using technology to enhance instruction, are that the ones who need the most help, students with disabilities, are not as likely to have access or benefit from technology resources (Wehmeyer, 2004). According to Kroesbergen and Van Luit (2003a), the studies show that all of the recent advances in technology do not lead to better mathematics performance for students with special needs. In this case, more traditional methods must be considered.

Handheld Flashcards

Handheld math fact flashcards are easy to use, can travel anywhere, and provide a visual during one-on-one time. While technology is new and exciting, the old-fashioned memorization of flashcards could prove to be beneficial. For students who have difficulties focusing or concentrating, technology might be hurting them. With flashcards there are no bright lights or loud noises, just a card to focus on.

In 2014, Michaelyn Bjordahl completed a study on the use of flashcards for the improvement of math fact fluency with a middle school student who had been diagnosed with Attention Deficit Disorder (ADD). Many students with special needs have a difficult time with attention, whether they are diagnosed with ADD or not. This student is a good example of some of the struggles many students in a resource room face on a daily basis. Bjordahl utilized direct instruction with handheld flashcards to look for improvement in basic fact fluency skills. At the conclusion of the study, her research suggested that handheld flashcards were effective in improving the student's basic fact fluency. What this study fails to tell us, however, is whether or not the student would have shown more improvement with a computer-based program.

It has been shown that traditional methods, that include contact with humans, as opposed to computers, is more beneficial for all student learning (Kroesbergen, Van Luit, & Naglieri, 2003). The computer cannot fix the most basic of difficulties that students face. In some cases, the studies that included computer-based instruction showed a lower effect than those that were actually instructed by a teacher. Kroesbergen et al. (2003) also shows that self-instruction - which is available through the use of flashcards, shows the highest increased of test scores when it comes to basic facts. Smith (2010) researched studies of students with disabilities using flashcards. Her study felt limited because her samples were mostly students with special needs. For this study, however, the implications lead to the notion that flashcards are more beneficial for students with special needs than for those in the general education program.

Gaps in the Literature

Many students who struggle with math fact fluency tend to focus on methods that waste their time and don't always work. Tablet computers can be great because they engage students in learning (Zhang, 2015). However, even with the use of computer games every day to build fluency, a resource room student can still be found drawing pictures or counting on their fingers. These methods are time-consuming, inefficient, and discouraging to students as they begin to learn more difficult concepts. The question that still remains is: are these online games and programs enough? Do students with special needs require more rote learning without the distraction of technology? Most technology devices are so new that there is little research to show how effective math apps are, especially for students with disabilities. Further research is required to determine which methods are the most appropriate for helping students with disabilities learn their basic

math facts, and in turn, find higher levels of success in mathematics.

Chapter 3

Research Methodology

The participants in this study were chosen based on this researcher's current position in education at the time the study was implemented. The participating students, their backgrounds, and their educational performance results were made accessible to this researcher throughout the course of the study. The researcher hypothesized that the use of handheld flashcards would improve student performance of basic multiplication and division facts more than the use of computerized techniques.

Setting and Participants

This study included eight fourth grade students with disabilities. Each student has an Individualized Education Plan (IEP) based on their specific needs. The students attend an elementary school in a suburban town in southern New Jersey. According to the New Jersey School Performance Report, 86.9% of the school population is Caucasian, 3.5% Hispanic, 2.8% Asian, 0.7% African American, and 6.0% are listed as being from two or more races. 100% of the students in the school listed English as their main language, 20% of the school's population is classified with disabilities, and 4% are listed as Economically Disadvantaged. The classroom these students attend is a pull-out resource room for math, reading, writing, and social skills with two teachers. In the classroom, during math, there is a student to teacher ratio of 3.5:1.

Student FD. FD is a ten-year-old student who receives fourth grade instruction for reading, writing, and mathematics in a replacement recourse room with a small group of other fourth grade students. FD tested consistently in the low average range for

cognitive and ability. His Dyslexia often causes low processing speeds, and he often interprets and expresses letters and numbers backwards.

Student JZ. JZ is a nine-year-old girl with Autism who receives fourth grade instruction in the resource classroom. She suffers from severe Anxiety and Obsessive Compulsive Disorder (OCD), both of which consistently affect her learning. JZ requires one-on-one assistance often, and feels so nervous about her work that it is hard for her to concentrate on the task at hand. She does well in math, but lacks instant recall of basic math facts.

Student KD. KD is a ten-year-old student who receives fourth grade instruction for reading, writing, and mathematics in a replacement resource room with a small group of same-aged peers. KD has a Specific Learning Disability and consequently struggles with reading comprehension and mathematical problem solving. According to his WJ-IV Tests of Cognitive Abilities, KD has an intellectual ability in the average range. KD enjoys math and finishing work as quickly as possible.

Student JG. JG is a ten-year-old student, who was kept back one year, and it now receiving instruction in the resource classroom. His classification as Other Health Impaired is due to a diagnosis of horizontal and vertical nystagmus and strabismus, which are difficulties with his eyes that adversely affect his educational performance. The need to focus on words or numbers for a length of time causes increased frustration and pain to JG, which is the reason for his struggles with math and reading. JG often shuts down and gives up when work becomes frustrating.

Student CH. CH is a nine-year-old student with Attention Deficit Disorder (ADD) who is receiving fourth grade instruction in the resource classroom. His cognitive abilities fall within the average range, but CH struggles with processing speed, quick execution of easy cognitive tasks, and auditory short-term working memory skills. CH has a low frustration tolerance and avoids new or challenging work.

Student AH. AH is a ten-year-old student with a Specific Learning Disability that affects her math calculations and problem solving. She spends her entire day in the Inclusion classroom and is only pulled out three times per week for extra math help. She is able to grasp new concepts with repeated demonstrations and reteaching, but her basic math fact knowledge is very low.

Student AC. AC is a nine-year-old student in the fourth-grade inclusion classroom. She receives mathematics instruction in the 4th grade resource room with a group of six other students. With a classification of Specific Learning Disability, AC struggles with mathematical calculations, mathematical problem solving, and both reading and listening comprehension. AC demonstrates a significant difficulty with number sense. Her scores on the WISC-V indicate that her abilities are within the low average range and are at the 16th percentile compared to her same-aged peers. The student's Individualized Education Plan (IEP) described that she has difficulty recalling and retaining information.

Student DE. DE is a nine-year-old student classified as Other Health Impaired due to a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD). His cognitive abilities are in the high average range. DE is very easily distracted and his ADHD affects

his processing speed and expressive skills. While he knows most of his basic facts, the instant recall is difficult to attain.

Procedure

Baseline data was charted to show growth in multiplication and division fact knowledge by just using computer methods over a period of six weeks. Three tests were given: one in the beginning, one after three weeks, and one after six weeks. Students in the school have memberships to Xtramath.org. As a district requirement, they practice their math facts online for at least ten minutes per day, if not more. This program is also available to them at home and during free time. Before baseline data was gathered, participants were briefly interviewed on their general feelings about their performance in mathematics. The questions were asked during week one, after week six, and after week 12. The interview questions were as follows:

- What is your favorite academic subject?
- How do you feel about math?
- Are you good at math? How good?
- Is math easy or hard for you?
- Is math fun or not-so-fun?
- Are you good at multiplication? How good?
- Are you good at division? How good?
- Do you know all of your basic math facts?

At the beginning of the six-week period, participants were given a test of 100 multiplication problems to complete in sixty seconds and another test of 100 division problems to complete in the same amount of time. These problems were basic facts

including numbers from 0-12. Students were instructed to complete as many problems as they could before the time went off. The only prompt they were given was that we were testing them to see how much progress they made over the months. These same tests were given after three weeks and again after six weeks. The only difference between the tests is that the problems were in a different order.

The intervention of traditional paper-based multiplication and division flashcards was implemented over a six-week period. The researcher met with each of the eight participants three times per week, for fifteen minutes each session. The intervention was delivered for a total time of 360 minutes. These sessions usually took place between 8:15 a.m. and 8:45 a.m. or 2:00 p.m. and 2:40 p.m., which is the students' "Go Time". During this time, all fourth graders are independently reading, finishing class work, completing enrichment activities, being retaught misunderstood concepts, or being pulled out for related services such as physical therapy, occupational therapy, counseling, or speech. If students had other "free" time during the day, sessions were completed at those times as well. The days that the students met depended on their related service schedule, need for review of lessons, and attendance. In this case, the specific days of intervention may have changed each week.

During the intervention time, participants no longer used computer-based practice methods in class. Students were given their own individual rings of paper math flashcards (one multiplication and one division) that the researcher kept. Participants started with 15 problems each. There were 30 cards because each problem and its reversal were given. For example, one card might read 3x8, while another reads 8x3. If an answer was correct on sight, without hesitation, a star was drawn on the back. If the answer was wrong or

there was hesitation, the student was corrected, asked to repeat the problem and answer, and nothing was drawn on the back. Once a card received three stars, it was taken off and replaced with a new problem.

The same assessments given during baseline data were given again, once after three weeks, and again after the final week. These assessments were put in place to evaluate student growth in the area of basic math fact knowledge. The amount of growth in the first six weeks was then compared to the amount of growth in the six-week period where the intervention took place. The participants were briefly interviewed again regarding their general feelings of math.

Variables. The independent variable in this study was the flashcards and the scheduling of practice. The intervention sought to increase knowledge of basic multiplication and division facts. The dependent variables in this study were the students' assessment scores, which indicate progress of math fact knowledge, and the students' general feelings about math.

Design. This study was a single subject research design. It investigated the effects of an independent variable - scheduled practice of the flashcards - on the dependent variable - the students' general feelings about math as well as their growth in basic multiplication and division fact knowledge. This was specifically a simple time-series design because the researcher could not control all of the variables (i.e. home practice, student attendance, motivation, etc.). Several observations were made over a period of time, while the intervention was introduced half way through. The baseline data was collected, while students were assessed before, during and after. The intervention was then put in place, with students being assessed before, during, and after. In the end, the

progress during the baseline data was compared with the progress during the intervention data, to determine if the intervention could be a possible cause for the increase of basic fact knowledge.

Chapter 4

Results

In this quasi-experimental time-series research study, the computer program *Xtramath* (xtramath.org) was compared with paper flashcards to determine which method was more successful in helping build the basic multiplication and division fact knowledge of 4th grade exceptional learners in Medford, NJ. Students were given 60 second multiplication and division questions, and well as interviewed before the beginning of the study, after six weeks with the online program and then again after six weeks with the paper flashcards. Individual student and whole class results are reviewed.

Individual Results

Student FD was a participant in the low average range for cognitive ability. Before practice with Xtramath.org began, FD attempted 8 multiplication problems in a 60 second session. He scored 5 of them correctly. In another 60 second quiz, he attempted 2 division problems and did not get either of them correct. During testing, the participant showed signs of being shy and unsure. He did not demonstrate confidence in his abilities to solve multiplication and division problems. The results of the beginning survey showed that FD listed writing as his favorite subject, and that he thought he was a little good at math, even though he said it was a little bit hard. He stated that math was not so fun, that he was not good at division, and that he did not know all of his basic multiplication and division facts.

After six weeks of independent practice with Xtramath.org, FD was tested again. His results showed that he attempted 13 multiplication problems and scored 11 of them correctly, he also attempted 5 division problems and scored 2 of them correctly. FD

demonstrated a little more confidence, but his work was still slow. It was also noted that he was counting on his fingers during the test. From the initial tests to this 6-week midway point, FD was able to attempt 5 more multiplication problems and 3 more division problems. He showed a score increase of 120% in multiplication and 200% in division. In his interview, FD still listed writing as his favorite subject but said he felt good about math. He stated that math was still hard but that Xtramath.org was fun. He still said that he was no good at division and that he knew some multiplication facts but not any of his division facts.

After six weeks with flashcard intervention, FD showed significant improvement on his 60-second quizzes. He correctly answered all 36 of the multiplication problems that he attempted and solved 19 out of 22 attempted division problems. This demonstrates an additional 23 multiplication and 17 division problems attempted. He scored 25 points higher in multiplication, which is a 227% increase over 6 weeks. He scored 17 points higher in division, which demonstrates an 850% increase in score. He showed interested and excitement in taking the quizzes. In his interview, FD stated that math was now his favorite subject. He also said that he felt awesome about math and that it was much easier now. When asked if he knew all of his multiplication and division facts, he told the examiner that he was able to figure them all out. FD showed a greater increase of 107% in multiplication with the flashcards than just Xtramath.org. He demonstrated a 750% more increase in division (see table 1 and figure 1).

Table 1

Results for Student FD

Student: FD	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	5	8	11	13	36	36
Division	0	2	2	5	19	22

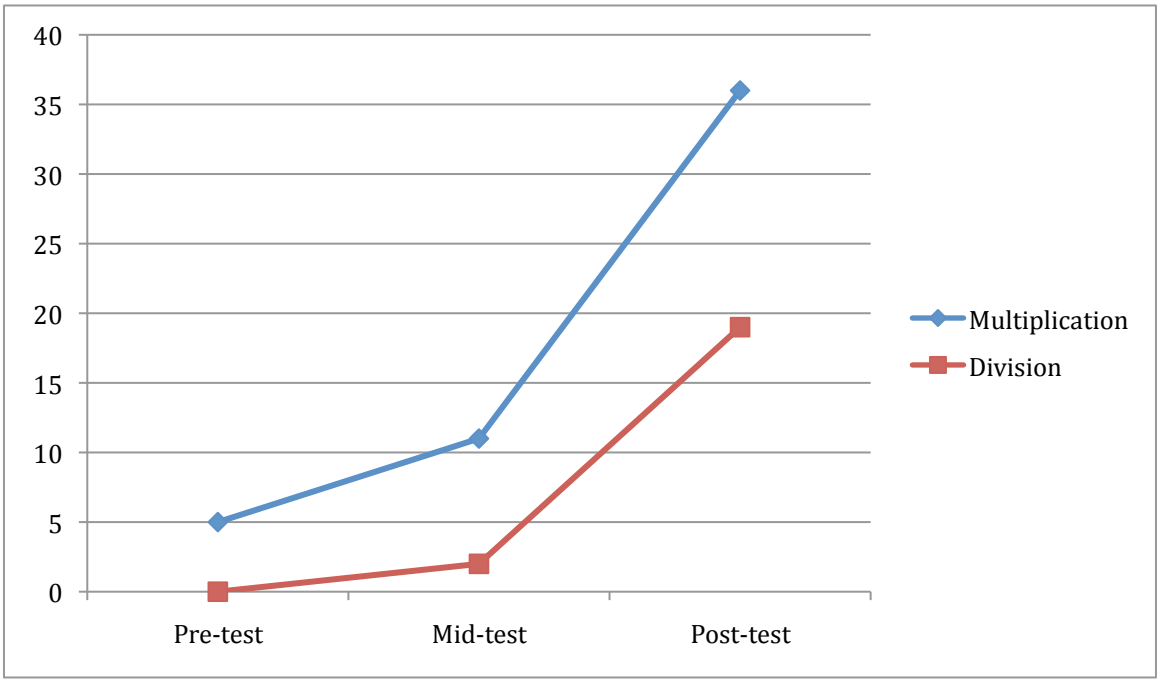

Figure 1. Results for student FD at three testing points.

The participant JZ a student on the Autism Spectrum with severe anxiety and obsessive-compulsive behavior. This has been known to affect her work and her instant fact recall. Before practice with Xtramath.org began, JZ attempted 12 multiplication

problems in a 60 second session. She scored 11 of them correctly. In another 60 second quiz, she attempted 4 division problems and got 2 of them correct. During testing, the participant showed physical signs of anxiety such as clenching her teeth, squeezing her pencil, and tightening her body. The results of the beginning survey showed that JZ listed writing as her favorite subject, felt okay about math, and that it was in the middle of easy and hard for her. She did state that math was fun, but when asked about whether or not she knew all of her multiplication and division facts, she declined.

After six weeks of independent practice with Xtramath.org, JZ was tested again. Her results showed that on the second set of tests, she attempted 12 multiplication problems, which was 2 more than before, and scored 13 of them correctly. This showed an 18% score increase. On her division quiz, she attempted 8 questions, which was twice as many as the previous test, and answered 7 correctly. Here, the data shows a 250% score increase. JZ continued to display the same physical signs of anxiety. In her interview, JZ stated that reading was her now favorite subject. The rest of her responses were similar to the first interview, stating that math was kind of hard for her and that she did not know all of her multiplication and division facts.

After a six-week flashcard intervention, JZ showed more improvement on her 60 second quizzes. She attempted 14 more multiplication problems than before and answered 27 out of the 28 correctly, presenting a 108% increase in score. In division, she correctly answered all 15 of the attempted problems correctly for a score increase of 114%. JZ still presented physical signs of anxiety, but less than before, allowing her to complete more problems. Overall, she showed a 145% score increase in multiplication and a 650% score increase in division. Her final interview indicated that reading was her

favorite subject, that she was a little good at math, and that she knew some of her multiplication and division facts (see table 2 and figure 2).

Table 2

Results for Student JZ

Student: JZ	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	11	12	13	14	27	28
Division	2	4	7	8	15	15

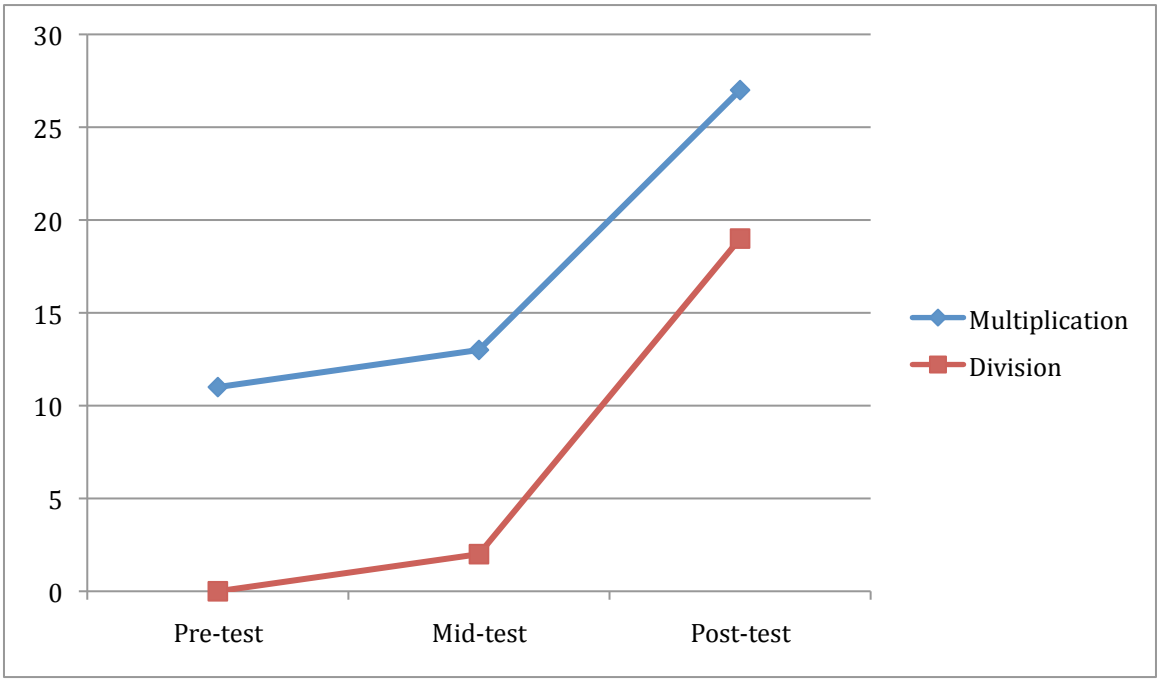

Figure 2. Results for student JZ at three testing points.

KD was a participant classified with a Specific Learning Disability. He tested in the average range for cognitive abilities, enjoyed math, and took pride in finishing his work quickly. Before practice with Xtramath.org began, KD answered all 23 of the multiplication problems he attempted correctly. On the other 60-second quiz, he attempted 8 division questions and scored 5 of them correctly. During testing, the participant worked as quickly as he could and would laugh and bounce when he couldn't find the answer right away. The results of the beginning survey showed that KD listed math as his favorite subject. He stated that math was his favorite subject because it was easy for him and he was really good at it. When asked if he knew all of his multiplication and division facts, he stated that he knew most of the multiplication but not all of them.

After six weeks of independent practice with Xtramath.org, KD was given the same two quizzes again. His results showed that he attempted 29 multiplication problems (6 more than before) and again answered all of them correctly. This showed a 26% increase in his abilities. KD also attempted 19 division problems and scored 13 of them correctly. This demonstrated a 160% increase in his score. KD approached the test in the same competitive manner, but appeared me concentrated during division this time. In his second interview, KD still listed math as his favorite subject. He had just as much confidence and noted that he was getting better at division, too.

After six weeks with flashcard intervention, KD showed even more improvement on his 60-second quizzes. He correctly answered all 49 of the multiplication problems that he attempted, and all 32 of the attempted division problems. This demonstrates an additional 20 multiplication and 13 division problems attempted. During the second 6

weeks, he demonstrated a 108% increase in multiplication and a 114% increase in division. This time, KD got himself "pumped up" to take the quiz and said he would ace it. In his interview, he again noted that math was easy and his favorite subject. He pointed out that even though he was good before, he got even better at his basic facts. Overall, KD's multiplication improved by 113% and his division by 540%. While he increased his scores consistently throughout, the flashcard method proved better in multiplication for KD (see table 3 and figure 3).

Table 3

Results for Student KD

Student: KD	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	23	23	29	29	49	49
Division	5	8	13	19	32	32

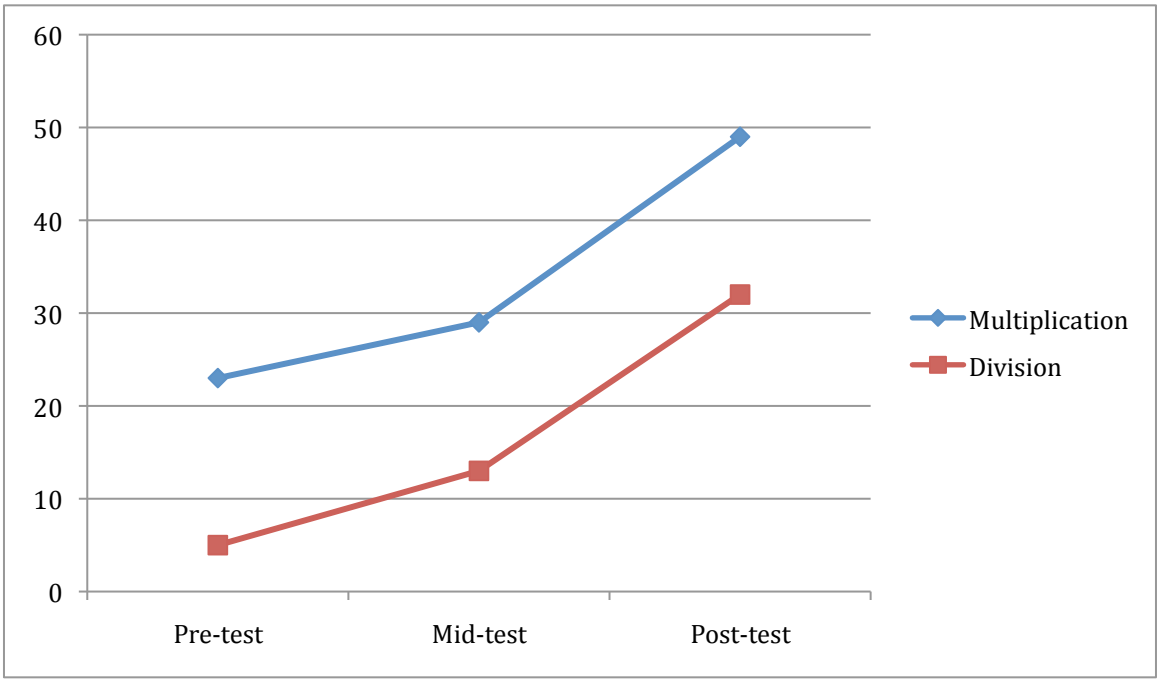

Figure 3. Results for student KD at three testing points.

JG was a student with visual difficulties that affect his performance in school. Focusing on words or numbers for even the shortest amount of time can cause frustration, resulting in the student shutting down. He was kept back for one year, so he is older than the rest of the class. Before practice with Xtramath.org began, JG attempted 16 multiplication problems in a 60 second session. He scored 13 of them correctly. In another 60-second quiz, he attempted 7 division problems and scored 2 correctly. During testing, the participant showed signs of frustration, like grunting and bouncing up and down, if he could not figure out an answer. The results of his first survey showed that JG listed social studies as his favorite subject, and that he thought he was pretty good at math. He also stated that math was easy and that he was good at multiplication and division.

After six weeks of independent practice with Xtramath.org, JG was tested again. His results showed that he correctly answered all of the 20 multiplication problems attempted. He also attempted 15 division problems and scored 12 of them correctly. JG approached the test with just as much confidence as before, but still became frustrated when he couldn't instantly recall a fact. From the initial tests to this 6-week midway point, JG was able to attempt 4 more multiplication problems and 8 more division problems. He showed an increase of 46% in multiplication and 500% in division. In the interview, JG still listed social studies as his favorite subject. He said that math was still easy and that he got a little better at it.

After six weeks with flashcard intervention, JG showed more improvement on his 60-second quizzes. He correctly answered 33 out of the 34 attempted multiplication problems correctly and solved 29 out of 29 attempted division problems. This demonstrates an additional 14 multiplication and 14 division problems attempted. He scored 13 points higher in multiplication, which is a 65% increase over 6 weeks. He scored 17 points higher in division, which demonstrates a 142% increase in score. JG demonstrated fewer signs of frustration during the final test, as he was able to complete the problems faster. In his final interview, JG stated that even though he was really good at math before, he had actually gotten better with his facts. In comparison with the computer and flashcard interventions, JG showed 19% more of an increase in multiplication with the flashcards. Overall, during the 12 weeks, JG increased by 154% in multiplication and 1350% in division (see table 4 and figure 4)

Table 4

Results for Student JG

Student: JG	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	13	16	20	20	33	34
Division	2	7	12	15	29	29

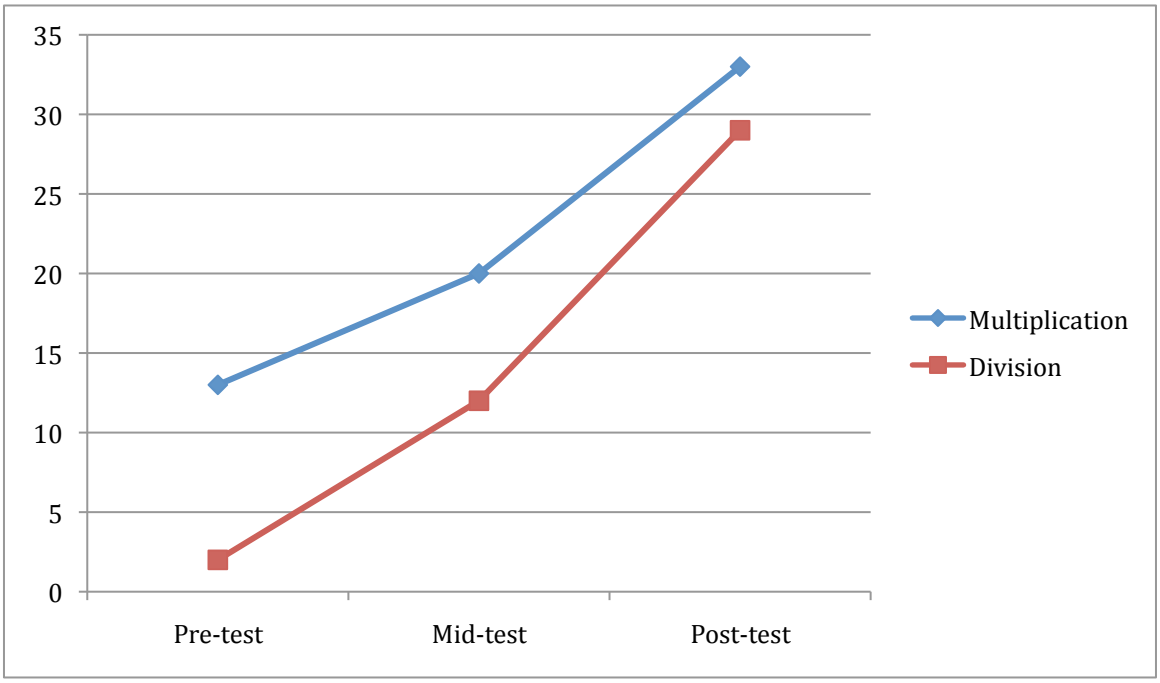

Figure 4. Results for student JG at three testing points.

CH was a student with attention deficit hyperactivity disorder (ADHD) who falls within the average range cognitively. He struggles with processing speed, quick execution of easy cognitive tasks, and auditory short-term working memory skills, and

has a low frustration tolerance. Before practice with Xtramath.org began, CH attempted 8 multiplication problems in a 60 second session. He scored 7 of them correctly. In another 60-second quiz, he attempted 3 division problems and answered 2 of them correctly. During testing, the participant worked slowly and showed signs of being shy and unsure. He did not demonstrate confidence in his abilities to solve multiplication and division problems. The results of the beginning survey showed that CH listed reading as his favorite subject, and that math was a difficult subject for him. He stated that math was only fun when he got to play games and that he did not know all of his multiplication and division facts.

After six weeks of independent practice with Xtramath.org, CH was given the same tests again. His results showed that he attempted 10 multiplication problems and scored 8 of them correctly, he also attempted 3 division problems and scored all 3 of them correctly. CH demonstrated a little more confidence on these tests, but his work was still slow. From the initial tests to this 6-week midway point, CH was able to attempt 2 more multiplication problems and the same number of division problems. He showed a score increase of 14% in multiplication and 50% in division. CH gave very similar answers in his second interview.

After six weeks with flashcard intervention, CH showed slight improvement on his 60-second quizzes. He correctly answered all 13 of the multiplication problems that he attempted, and solved 6 out of 8 attempted division problems. This demonstrates an additional 3 multiplication and 5 division problems attempted. He scored 5 points higher in multiplication, which is a 63% increase over 6 weeks. He scored 3 points higher in division, which demonstrates a 200% increase in score. CH still worked slowly on his

quizzes. In his interview, CH stated that social studies was now his favorite subject. He said he was starting to feel better about math but that it was still hard. CH showed a greater increase of 49% in multiplication with the flashcards than just Xtramath.org. He demonstrated a 50% more increase in division. Overall, CH increased in multiplication by 86% and in division by 200% over the 12-week period (see table 5 and figure 5).

Table 5

Results for Student CH

Student: CH	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	7	8	8	10	13	13
Division	2	3	3	3	6	8

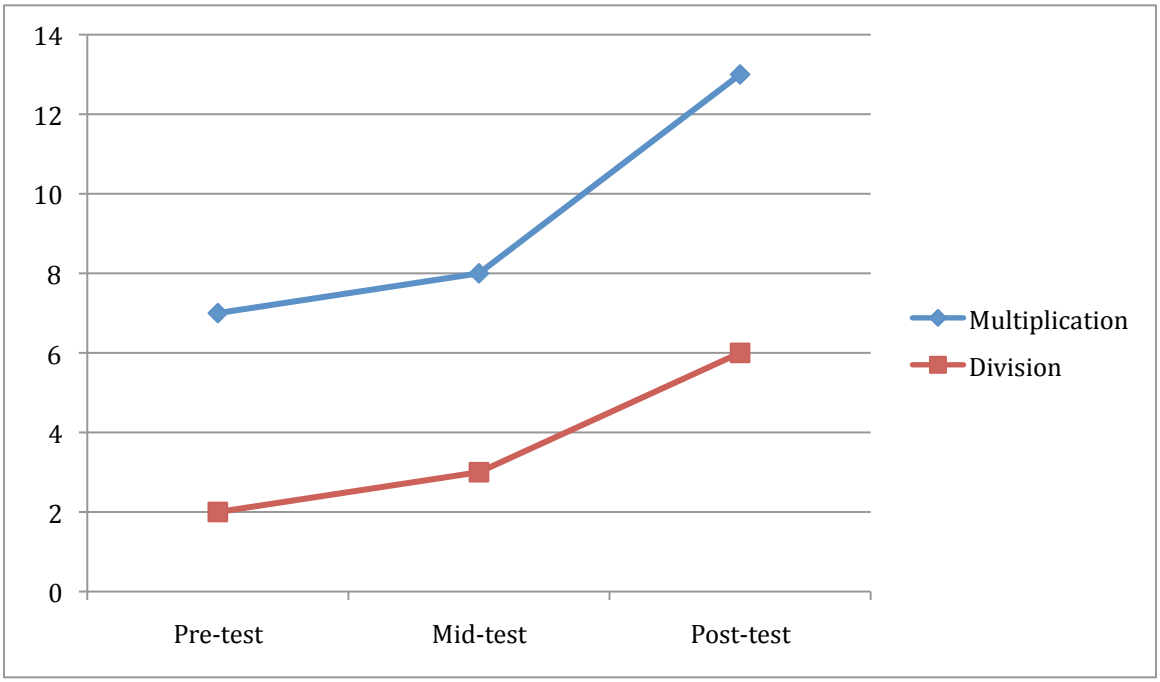

Figure 5. Results for student CH at three testing points.

Participant AH was a student with a specific learning disability who receives math instruction in the inclusive classroom and receives extra help from the special education teacher three times per week. Before practice with Xtramath.org began, AH attempted 15 multiplication problems in a 60-second session. She scored 14 of them correctly. In another 60-second quiz, she attempted 6 division problems and got 5 of them correct. During testing, the participant was using counting strategies with her hands. The results of her first survey showed that AH listed writing as her favorite subject, she was not good at math, and it was not so fun. She stated that she did not know her basic math facts and that she was not good at multiplication and division.

After six weeks of independent practice with Xtramath.org online, AH was tested again. Her results showed that on the second set of tests, she attempted 21 multiplication problems, which was 6 more than before, and scored 19 of them correctly. This showed

a 36% score increase. On her division quiz, she attempted 10 questions, which was 4 more than the previous test, and answered 8 correctly. Here, the data shows a 60% score increase. AH continue to use counting with her hand as a strategy but was able to remember some of the problems without it. She still felt that math was hard and that she was not getting much better with her facts.

After a six-week flashcard intervention, AH showed even more improvement on her 60-second quizzes. She attempted 17 more multiplication problems than before and answered all 38 correctly, presenting a 100% increase in score. In division, she attempted 12 more problems and answered 21 correctly, showing a score increase of 175%. AH only used counting on her hands a few times during the quizzes, which helped her increase her speed. Overall, she showed a 175% score increase in multiplication and a 320% score increase in division. Her final interview indicated that while writing was still her favorite subject, she felt that she was learning her facts, writing the answers faster, and getting better at math (see table 6 and figure 6).

Table 6

Results for Student AH

Student: AH	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	14	15	19	21	38	38
Division	5	6	8	10	21	22

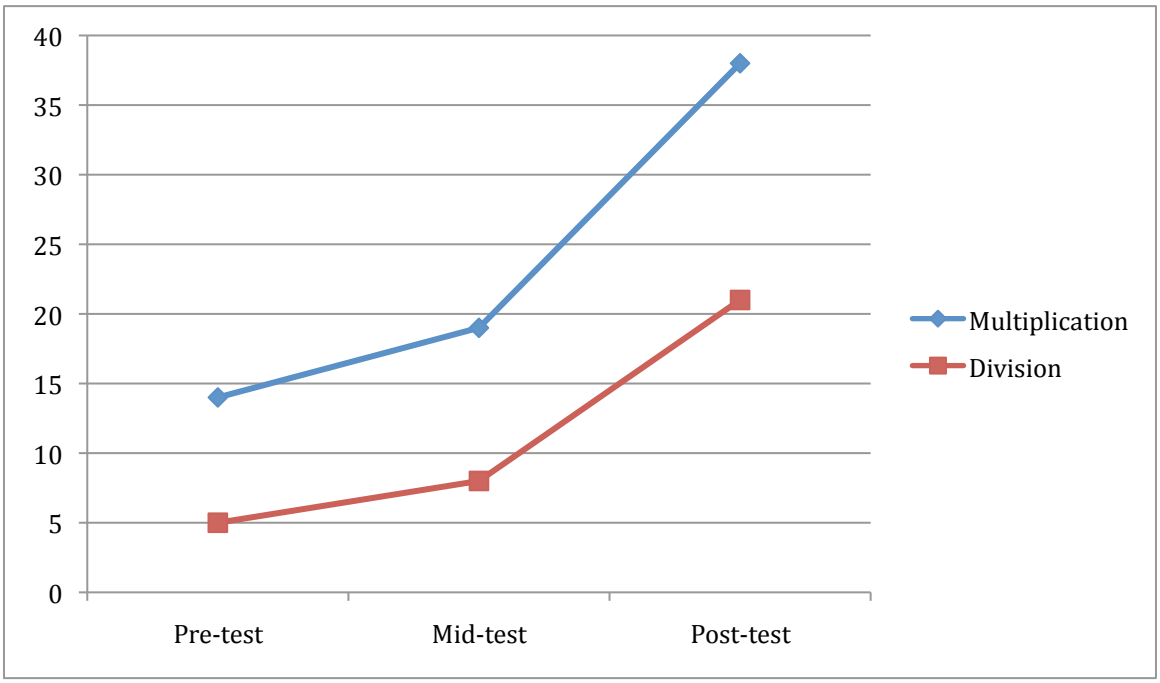

Figure 6. Results for student AH at three testing points.

Participant AC was a student with a specific learning disability who falls in the low average range cognitively and demonstrates a significant difficulty with number sense, as well as retaining and recalling information. Before practice with Xtramath.org began, AC attempted 3 multiplication problems in a 60 second session. She scored 0 of them correctly. In another 60-second quiz, she attempted 1 division problem and did not answer it correctly. During testing, the participant was visibly upset and kept looking up at the researcher for help. The results of the beginning survey showed that AC listed writing as her favorite subject, said math was fun but it was very hard for her. When asked about whether or not she knew all of her multiplication and division facts, she declined.

After six weeks of independent practice with Xtramath.org, AC was tested again. Her results showed that on the second set of tests, she attempted 11 multiplication problems, which was 8 more than before, and scored 10 of them correctly. This showed a 1000% score increase. On her division quiz, she attempted 4 questions, which was 4 times as many as the previous test and answered all of them correctly. Here, the data shows a 400% score increase. AC showed more confidence, and did not look to the teacher for help, but did work slowly. In her interview, AC stated that writing was still her favorite subject, but that she was getting better at her math facts.

After a six-week intervention with flashcards, AC showed significant improvement on her 60-second quizzes. She attempted 17 more multiplication problems than before and answered all 38 correctly, presenting a 100% increase in score. In division, she attempted 12 more problems and answered 21 out of the 22 correctly for a score increase of 175%. AC was much more confident during this test and said that she was proud of herself when she finished. Overall, she showed a 4500% score increase in multiplication and a 2700% score increase in division. Her final interview indicated that she loved writing and math. She felt that knowing her math facts made her faster at other math challenges (see table 7 and figure 7).

Table 7

Results for Student AC

Student: AC	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	0	3	10	11	45	45
Division	0	1	4	4	27	27

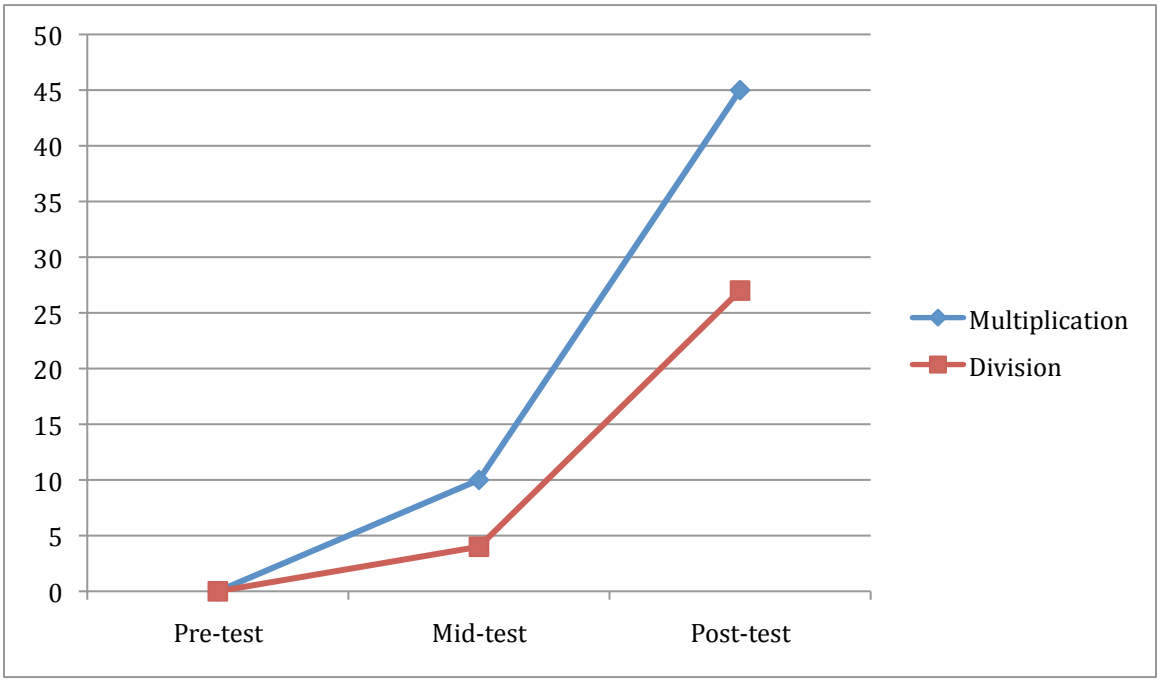

Figure 7. Results for student AC at three testing points.

DE was a student with ADHD whose inattention and inability to focus significantly impacted his classroom performance. Math has always been a strong subject for him. Before practice with Xtramath.org began, DE attempted 8 multiplication problems in a 60 second session. He scored 6 of them correctly. In another 60-second

quiz, he attempted 9 division problems and scored 5 correctly. During testing, the participant worked slowly and was often seen looking at other things around him. The results of his first survey showed that DE listed science and social studies as his favorite subjects, and that he thought he was pretty good at math. He also stated that he was okay at his basic math facts.

After six weeks of independent practice with Xtramath.org, DE was tested again. His results showed that he correctly answered all 9 multiplication problems that he attempted. He also attempted 9 division problems and scored 6 of them correctly. During testing, DE still seemed easily distracted. From the initial tests to this 6-week midway point, DE was able to attempt 1 more multiplication problem and the same number of division problems. He showed a score increase of 50% in multiplication and 0% in division. In the second interview, DE still listed writing as his favorite subject. He said that he felt fine with math but wanted to get better.

After six weeks with flashcard intervention, DE showed more improvement on his 60-second quizzes. He correctly answered all 30 of the attempted multiplication problems, and solved 23 out of 25 attempted division problems. This demonstrates an additional 21 multiplication and 16 division problems attempted. He scored 11 points higher in multiplication, which is a 233% increase over 6 weeks. He scored 18 points higher in division, which demonstrates a 360% increase in score. DE demonstrated fewer signs of distraction during the final test, and noted that he was proud of his focus. In his final interview, DE stated that math was getting more fun because he was challenging himself to get better. In comparison with the computer and flashcard interventions, DE showed 180% more of an increase in multiplication and 360% more in division with the

flashcards than the online program. Overall, during the 12 weeks, DE increased by 400% in multiplication and 360% in division.

Table 8

Results for Student DE

Student: DE	Pre-Test		Mid-Test		Post-Test	
	Correct	Attempted	Correct	Attempted	Correct	Attempted
Multiplication	6	8	9	9	30	30
Division	5	9	5	9	23	25

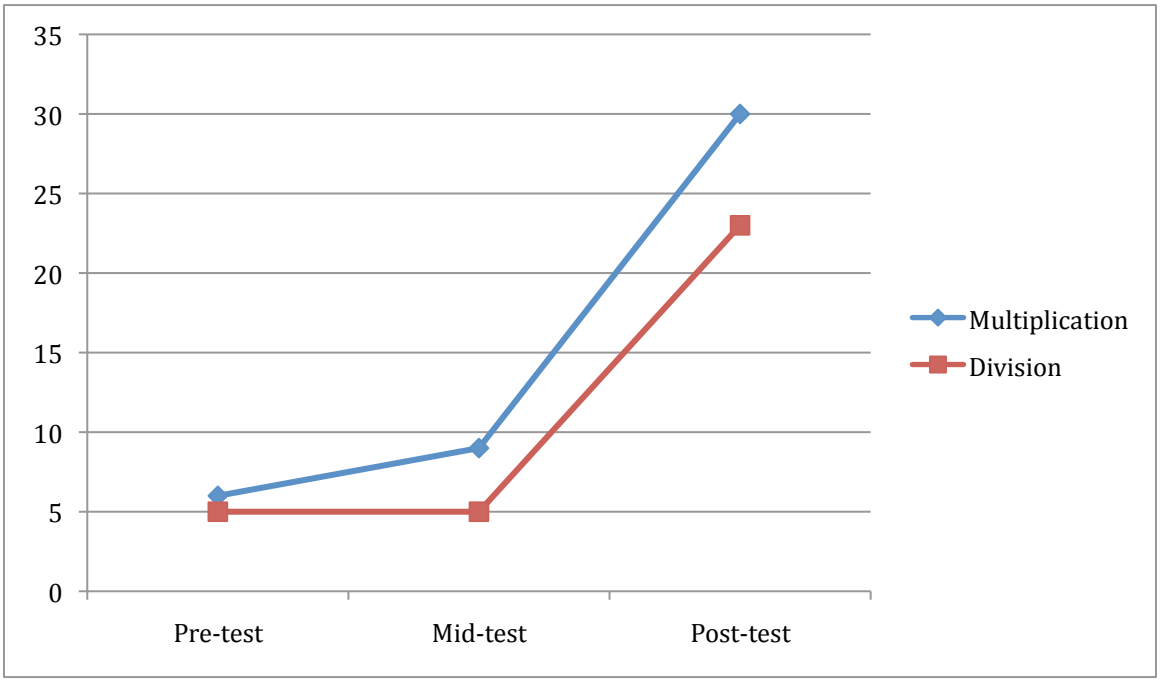

Figure 8. Results for student DE at three testing points.

Overall Results

At the conclusion of the study, all eight students showed an increase of both multiplication and division fact knowledge. A greater increase in skills took place as a result of flashcards rather than the use of the website. While division showed a greater skill increase, every student was able to answer more multiplication than division problems correctly on the post-test. Student AC showed the greatest increase throughout the study. On both pre-tests, she was not able to answer any questions correctly. On the post-test, she accurately answered 45 multiplication and 27 division problems correctly. While Student CH's scores were the lowest for both post-tests, he was still able to almost double his score in multiplication and triple his score in division.

Chapter 5

Discussion

This study examined two different methods of developing instant recall of basic multiplication and division facts. The goal was to determine if a computer based-program (Xtramath.org) or traditional paper flashcards resulted in more of an increase in basic math fact knowledge. This study included eight fourth grade students with learning disabilities form Medford, New Jersey. All but one of the students was instructed in the resource classroom for math, while the other was seen by the special education teacher three times per week for extra math help. The participants consisted of 3 white females and 5 white males, all ages 9 or 10. The study lasted for 12 weeks.

The students in this study had differing levels of ability. Some of the students preferred math, while others did not. Some students had slower processing speeds than other students. Some of the participants had anxiety or ADHD. Students are expected to master multiplication facts by the end of third grade but most do not. This explains why most students were stronger in multiplication than in division. The importance of these basic skills becomes drastically important in order to grasp new and challenging mathematical concepts that are introduced by the fourth grade math curriculum.

The results of this study showed that every student demonstrated a greater increase in fact knowledge and production of answers after the handheld flashcard method was used. There were only two students who showed a greater percentage increase with Xtramath.org in one of the subject areas but even that student favored the flashcards in the other. While there was an increase in performance after both methods, the handheld flashcards produced a greater increase in basic skill knowledge.

Relation to Previous Studies

Comparing the results of this study to the results of prior studies, the outcome is somewhat surprising. As technology advances so quickly, there are more and more studies being conducted to determine which methods (i.e. devices, games, apps, or websites) are the best to use. There are many studies that show personal devices being more beneficial than shared computers or promethean boards. What most studies don't compare is whether or not technology in general is a better method of learning new information than other ways. The few that do compare methods generally show technology to be a beneficial strategy for learning, but not necessarily better than traditional paper methods. For example, a study by Nelson (2009) was conducted to research which of three websites (www.funbrain.com, www.aplusmath.com, and www.multiplication.com) was the best method for acquiring basic fact knowledge. The study does not show how using flashcards would have compared with the websites. Many of these findings could have been the result of the students' increased interest in new technology that had never before been seen in school. An example of this is shown in a study conducted by Mechling et al (2008) comparing knowledge acquired through SMART board technologies with the same information presented with flashcards. In this study, the students who used the SMART board technology to learn the new information showed better results than those who used the flashcards. In 2008, when SMART board technology was just being introduced, the newness of the technology was still enough to engage students in a meaningful way. It is possible that this newness has warn off and the technology has lost its affect.

More studies are being conducted now to suggest that teachers should be reverting back to the ways of teaching before technology was readily available. This research demonstrates similar outcomes to this study. For example, Douglas Fisher and Nancy Frey (2018) summarized the results of three similar studies that were conducted to determine if digital or print methods were better for comprehension. In all three cases, print methods were shown to be more successful than digital methods. One of the studies in their article showed that while more information is able to be received and expressed in digital methods, less information is able to be truly comprehended and retained. Fisher and Frey place emphasis on the idea that learning with paper-based methods requires more effort from the students and without being able to physically handle materials, mental maps used for comprehension are disrupted.

As another example, in 2003, Kroesbergen and Van Luit conducted a study of about 60 elementary school students with exceptional learning needs, similar to the students used in this study. They looked specifically at basic skills in mathematics and how different types of instruction affected student learning. They, too, found that students who used computer- assisted technology were less effective than those without the use of technology. Somewhat contradictory results were shown by Plourde in 2008, when a similar study was conducted comparing flashcards to the use of SMART Board technologies. While this study looked to meet the needs of a whole group class, rather than individual skills, the results actually proved the SMART Board to be more effective than the flashcards. The five-year difference between the studies is to be noted. In 2008, we see a rise in use and interest of technology as Social Media networks become more popular.

Limitations and Future Studies

This study only examined a small population of students who were all of the same background and socioeconomic status. More students should be studied to provide more appropriate and accurate results. Additionally, this study was conducted over 12 weeks total-6 with the online program and 6 with flashcards. It would be more beneficial to review results over a longer period of time. It was also helpful for this to be an experimental design in which one group was given the flashcard intervention and one was not. This would help to determine the true cause of the increase in skills. Due to the requirements of the school district, such a design was not possible.

Practical Implications

The current study showed that there was more of an increase in instant recall of basic math facts after practicing with paper flash cards rather than using the program Xtramath.org. Teachers who have students with special needs that use this program may consider providing students with alternative options. Students gained confidence in math as a whole after learning facts, completed multi-step questions more quickly with less frustration, and were willing to attempt more difficult tasks. Students enjoyed the one-on-one teacher time over the time spent on the computer. While technology does wonderful things for education, the fact that students are now on technology more than not, shows that doing things off of the computer has become more of a novelty. As we move toward and even more technological world, teachers should not forge the importance of hands-on and face-to-face interventions.

Conclusion

This study was designed to answer the following question: Does the use of online math programs improve the multiplication and division fact knowledge of 4th grade exceptional learners better than the use of traditional handheld flashcards? The data showed that traditional handheld flashcards had a stronger impact on students with disabilities when it came to developing instant recall of basic facts. Using this technique (or other paper methods) would benefit students with special needs, and possibly even those without.

After reviewing the research and data throughout this study, it is clear that traditional handheld flashcards have more of an impact on students with learning disabilities than computer programs. Students enjoy the instant gratification and one-on-one time with the teacher, and they are less distracted by the bright lights and sounds of technology. In order for flashcards to make their full impact on students, teachers need to be implementing the intervention systematically and consistently. More research would give a clearer picture of the benefits of flashcards over technology.

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Appendix A

Multiplication Test

2	2	0	7	9	2	1	2	7	9
x5	x2	x3	x0	x4	x0	x9	x5	x7	x3
4	0	10	8	2	4	5	7	8	4
x0	x8	x6	x1	x6	x6	x8	x8	x3	x10
3	1	7	0	6	3	5	6	7	2
x9	x7	x2	x5	x6	x0	x9	x4	x6	x6
6	0	10	7	6	6	4	10	1	2
x0	x7	x2	x5	x8	x0	x7	x3	x6	x8
6	2	8	3	0	1	0	8	0	1
x7	x9	x4	x9	x3	x5	x9	x5	x0	x3
2	2	5	4	9	2	10	2	7	9
x3	x6	x3	x1	x5	x2	x2	x3	x4	x0
3	10	0	8	2	4	6	9	8	9
x3	x10	x6	x5	x10	x1	x8	x7	x9	x10
3	5	3	9	2	3	6	2	4	2
x2	x0	x4	x9	x0	x10	x8	x1	x5	x8
6	0	6	9	1	3	4	10	2	8
x0	x7	x7	x1	x1	x5	x7	x1	x1	x9
4	1	8	8	9	4	8	8	3	10
x0	x9	x0	x7	x3	x0	x7	x3	x6	x3

Name: _____

Date: _____

Score: _____ / 100

Set 1

Appendix B

Division Test

100 ÷10	2 ÷2	36 ÷3	7 ÷1	63 ÷7	2 ÷2	8 ÷2	5 ÷5	7 ÷7	9 ÷3
4 ÷2	2 ÷1	90 ÷10	16 ÷8	10 ÷5	4 ÷6	56 ÷8	6 ÷2	12 ÷2	24 ÷3
3 ÷3	49 ÷7	21 ÷3	15 ÷5	6 ÷6	3 ÷3	80 ÷10	6 ÷3	7 ÷1	24 ÷8
6 ÷1	70 ÷10	10 ÷2	18 ÷3	16 ÷8	6 ÷2	42 ÷7	10 ÷3	32 ÷8	20 ÷5
6 ÷1	25 ÷5	40 ÷8	35 ÷7	15 ÷3	15 ÷5	60 ÷10	8 ÷2	10 ÷5	3 ÷3
30 ÷5	2 ÷6	50 ÷10	4 ÷1	48 ÷8	2 ÷2	10 ÷2	12 ÷3	28 ÷7	9 ÷1
21 ÷7	10 ÷10	56 ÷8	35 ÷5	20 ÷10	40 ÷10	16 ÷8	9 ÷3	18 ÷9	9 ÷3
30 ÷10	5 ÷5	6 ÷3	9 ÷9	2 ÷2	30 ÷10	64 ÷8	2 ÷1	14 ÷7	40 ÷5
6 ÷3	7 ÷7	45 ÷5	9 ÷1	1 ÷1	3 ÷3	72 ÷9	10 ÷1	20 ÷10	18 ÷9
54 ÷6	10 ÷5	8 ÷4	81 ÷9	9 ÷3	4 ÷2	8 ÷4	8 ÷24	18 ÷6	12 ÷3

Name: _____

Date: _____

Score: _____ / 100

Set 1

Appendix C

Student Interview Questions

1. What is your favorite academic subject?

2. How do you feel about math?

3. Are you good at math? How good?

4. Is math easy or hard for you?

5. Is math fun or not so fun?

6. Are you good at multiplication? How good?

7. Are you good at division? How good?

8. Do you know all of your basic multiplication and division facts?