Improving Math Fact Fluency Using Digital Game-Based Interventions

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Abstract

This action research examines the use of digital game-based interventions on an iPad platform to improve the addition and subtraction fluency and automaticity skills of a classroom of 4th grade students in an urban public school. Students that participated included English Language Learners, learning support students, students in homeless situations, and many other challenging situations. Participants were given five weeks of interventions through the FASTT Math fluency program as well as weekly progress monitoring. The results indicated that every student showed some form of growth in multiple skill areas. Many participants showed significant growth in at least one skill area. Students also responded to survey questions about the intervention program with enthusiasm and positive comments. These findings have validated the use of apps as an effective intervention in the classroom setting.

Dedication and Acknowledgments

For my Grandma Renee, who always believed that I would succeed.

For John, who constantly supported my quest for this degree.

And for my students, who continually inspire me to become a better teacher.

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Chapter 1: Introduction

Background

Over the past hundred years, some feel that technology has become more prevalent the field of education. In fact, computer games are seen as a viable learning tool by both educators and developers (Ke, 2007). Students have moved from using slate and chalk to iPads, and teachers are now expected to incorporate technology into their daily lessons seamlessly. Mobile devises are often seen as "fundamentally altering the paradigm of traditional education," cites O'Malley et al. (p. 2). While some teachers have been resistant to change, many teachers see this as a boon. With the apps and hardware that are readily available in schools today, teachers can implement multiple lessons, all at differing levels, at the same time. Many teachers have been using diverse forms of technology to meet the needs of their students that are not covered in whole group instruction. However, it is unclear whether this is an inherently effective method.

In contrast to technology, elementary school math facts are the same as they were 100 years ago. The methods of teaching addition and subtraction may evolve, but 2 + 2 still equals 4. Many teachers as well as researchers equate the idea that students who have strong skills in basic math facts as well as rapid fact retrieval fluency will perform well when it comes to problem solving and complex computations as well as high scores on tests such as the SATs (Price et al., 2013). When a deficit in math fact retrieval is noted in a student today, a logical solution would be to use a technological approach; use an app or program that teaches basic math fact fluency. Hawkins et al. cited "many studies documenting positive effects of [computer assisted instruction] on math performance" (p. 142). It is a simple, and usually easy, solution, but instructors may not feel confident that an app, even one backed by independent research, will give the student the same quality of instruction that they can as an actual teacher. Putting your

trust, and your student's education, into the hands of a machine is daunting. School districts and every teacher within them need to be certain that this method will produce quality results for their students.

Problem Statement

This study investigates separate but related problems. The students targeted have, as a whole, shown a lack of fluency with basic addition and subtraction skills. While they are all in the 4th grade, they are often still seen counting on fingers and requiring paper and pencil for one and two digit problems. The national common core standards for mathematics expects students in the fourth grade to "fluently add and subtract multi-digit whole numbers" (Mathematical Standards, 2018). The use of concrete models (tokens, fingers, etc.) or drawings is only acceptable in the first grade standards (Mathematical Standards, 2018). The students in this class also face a host of external factors that have hampered their learning when it comes to math skills. The class includes English Language Learners, students with learning support needs (both diagnosed and those in the process of seeking services), students from high-poverty areas, displaced or homeless children, students with violent or traumatic backgrounds, and students that have been retained in previous grades. Though this group poses a host of challenges, it is still the responsibility of the teacher to increase the math fact fluency of the entire class. Meeting every need of each student can proffer many problems.

Using a program or application (henceforth referred to as an "app") would seem like a logical solution. Many apps boast that they will improve math abilities by simply setting the students in front of a device and having them follow the program. Most apps attempt to engage students through the use of game play as a part of the process. These apps are often designed to be used by students with minimal assistance from adults as well. The students in this study attend

an urban school that is in financial distress. The school is in a low-income area and does not have enough teachers, support systems, or programs to help all of the students that are struggling. There is no intervention program offered within the classroom either. The option of an app or program would pose an excellent solution. However, the teacher needs to be certain that the app will offer interventions and instruction that is on par with what the they can offer themselves. This study intends to show how effective digital interventions can be for this population.

Significance

This action research project will focus on a group of 4th grade students in a low-income, urban, public school setting. Overall, these students have shown a significant deficit in basic addition and subtraction fluency. Using iPad apps, the students will receive interventions designed to increase their math fact fluency without specific teacher intervention in this area. This research will be unique as the class includes English Language Learners, learning support students, children with significant trauma, and students that are displaced from their homes, many of these issues being hallmarks of low-income urban schools.

The impact of this study on these students, and this school district in general, could be dramatic. If the evidence shows that students are indeed able to grow in fundamental math skills using only technology and with little teacher interaction, this model could become a standard method of interventions across the district. While there are plenty of teachers available in the United States, there is an enduring shortage of teachers in low-income and minority schools (Malatras, Gais, & Wagner, 2017). This means that there are rarely teachers available for remediation in the areas that are in the most need. Any subject area that can be taught through technology frees up a staff member to fulfill an area that requires personal interaction. Teachers

who do not have access to math tutoring for their students can improve their skills without assistance.

Conversely, if this research shows that intervention through technology alone is not an effective method of improving math fact fluency, educators will need to know so that this method is not used as the sole intervention for children lacking in these skills. Teachers are committed to helping their charges grow in every way that they can and will want to be informed about which methods are not proving effective and should be altered or discontinued. As educators, we have a duty to know in what ways we can best help our classes.

Research Questions

This study seeks to answer two basic questions. The first is a quantitative question, which will be answered by the data gathered on the math fluency from the apps. The second question is a qualitative question, which relies on data gathered from the student interviews.

Question one: Is there a relationship between independent digital-based interventions and an improvement in student fact fluency in basic addition and subtraction? The researcher will monitor the student's math fact fluency throughout the process looking for any gains or losses of skill.

Question two: Is there a relationship between independent digital-based interventions for basic addition and subtraction facts and a change in the perception of the student's own skills? The researcher will poll random students throughout the process in regards to their feelings about their own mathematical skills as well as the effectiveness of the program.

Research Design

For this study, the researcher will inform the parents and guardians of every student in the class that they are being asked to participate in this study. Consent forms will be distributed in English and Spanish.

The researcher will administer two types of math pretests, a fluency test and an automaticity test. There will be a pretest for both addition and subtraction. The students will be given time daily to work in the FASTT Math app via iPad for a period of 4 weeks. The games offered in the app will be limited to addition and subtraction.

At the end of each week, the researcher will give a fluency and automaticity quiz to track growth in both addition and subtraction. The researcher will also chose 2-4 students at random each week to interview about their perceptions of their progress. At the end of the intervention period, tests that are identical in style and form to the pretests will be given to every student to show overall growth of both fluency and automaticity.

Definition of Terms

For the purposes of this research, the following terms will be used frequently with the associated definitions:

1. Numeracy – The ability to understand and deal competently with numbers, tables, graphs, and basic mathematical concepts (Parsons & Bynner, 2005).
2. Math Fact Fluency – The ability to complete basic mathematical equations quickly and efficiently. (Price, Mazzocco, & Ansari, 2013)
3. Math Fact Automaticity – The ability to complete basic mathematical equations automatically or reflexively, without thinking through the problem.

These are the key terms that inform the current study. The following chapter, consists of a review of the literature that informs this study.

Chapter 2: Literature Review

This review will look at why math fact fluency is important and how technology can assist teachers in growing these skills in a diverse student groups. Math facts are a part of numeracy and the review examines the importance of numeracy in children and adults. Mathematical automaticity in children is a known predictor of mathematical success in high school and adulthood (Parsons & Bynner, 2005). Building on this knowledge, this review will look at the successes and failures of digital tools in classrooms and how teachers have used technological adaptations for decades. Specific focus will be given to the use of iPads in the classroom and how technology can meet the needs of students with disabilities and special needs. Finally, I will dig deeper into how digital tools have been used in classrooms specifically to improve performance in basic math fact fluency.

The Importance of Numeracy

Teachers and scientists around the world will tell you that math skills matter (Arnold, 2012; Mazzocco, Feigenson & Halberda, 2011; Parsons & Bynner, 2005; Price, Mazzocco, & Ansari., 2013). Numeracy, what Parsons & Bynner (2005) refer to in their study of numeracy skills as people go through school and into adulthood as “being able to deal competently with numbers, tables and graphs” (p. 4) is a skill on par with basic literacy. Numeracy covers things like number recognition, pattern identification, math equation abilities, and the use of variables, among other things. Numeracy is what allows us to complete any mathematical problem, from 2+2=4 up to complex equations, and both the simple and complex are necessary in education and beyond.

Without numeracy skills, people in the adult world are severely hampered. A longitudinal study by Parsons & Bynner (2005) of 17,000 children, starting in 1958 and following them

through their lives found that “the majority of men and women with a poor grasp of numeracy and/or literacy left full-time education at age 16” (p. 5). Additionally, the rate of unemployment for people with poor numeracy was over two times the rate for people with competent numeracy by the time adults reached the age of 30 (p. 5). In this age group, the men had the lowest hourly pay (Parsons & Bynner). Moreover, Parsons and Bynner noted that low economic success showed a much stronger connection to poor numeracy than to poor literacy. Most shockingly, they also discovered that women specifically can feel the effect of poor numeracy in their adult lives even if they have capable literacy skills. Parsons & Bynner found that adult women with poor numeracy but capable literacy were less likely to engage in full-time work, more likely to occupy unskilled jobs, report poor physical health, become uninterested in politics, report low self-esteem, and feel a general lack of control over their lives (p. 6).

Adults with poor numeracy skills can feel these effects in many ways. Price et al. (2013) conducted a study of brain activation during mathematical computation and found that people who have low fluency in basic math facts will struggle to tell time or even be able to perceive elapsed time. Adults must use basic numeracy on a daily basis to make purchases, follow schedules, and meet deadlines, just to name a few examples. The areas of the brain responsible for the automaticity of math facts is the same that processes phonological awareness, suggesting a correlation between basic reading and mathematical skills (Price et al., 2013). Much of these mathematical deficits are attributed to cognitive effort. The goal of math fact fluency is to obtain automaticity, the ability to give a rapid response with the least amount of cognitive effort (Arnold, 2012). When a student is automatic with their responses to basic mathematical problems, times tables for example, then they free up cognitive processing for higher level math skills like problem solving. Neuroscientific studies such as the one conducted in 2013 by Price et

al. showed that arithmetic fluency plays a key role in the acquisition of higher math skills (p. 161).

It is clear that arithmetic automaticity leads to problem solving abilities (Arnold, 2012; Price et al., 2013). Once students have reached elementary school, they are often presented with problems involving the basic four math processes; addition, subtraction, multiplication, and division. While they are given years to master these four processes, Arnold explains in her study of mathematical drill and repetition that developing automatic responses to math fluency facts will allow the answers to be recalled from the memory faster and therefore strengthen the learning (p. 31). Once students move to higher-level math, this recall will reduce computation time and free up cognitive space for problem solving.

Many teachers believe that low scores in elementary math lead to low scores in high school math. This belief is backed up by science. Price et al. (2013) were able to show that "brain mechanisms associated with elementary arithmetic skills are related to performance on a broad ranging, educationally relevant measure of math competence at the end of high school" (p. 162). This means that teachers can predict student achievement in high school math, to some extent, based upon a student's math automaticity in 3rd grade. Furthermore, Price et al. (2013) were able to show that single-digit arithmetic computation abilities using automaticity as opposed to full computation with mathematical processing was a predictor of greater success on the PSAT Math Test (p. 160-161). The use of math fact fluency also proved significant in predicting higher scores on the PSAT Critical Reading, showing a correlation to automaticity and critical thinking skills in general (Price et al., 2013).

Automaticity with math facts is not the only part of numeracy that predicts future success in math. Mazzocco, Feigenson, and Halberda, (2011) found evidence that basic number sense in

preschool children (identifying numbers and what they represent) correlates to future formal math abilities. They noted that this number sense, called Approximate Number System (ANS) directly led to elementary math skills such as fact fluency and, from there, into secondary mathematical achievement.

Just as many teachers will tell you that math facts are important, they will tell you that this skill is on the decline. In fact, these skills have been waning since the 1970's (Arnold, 2012). While studying national trends and finding from the National Center for Education Statistics, Arnold (2012) notes that some of the skills that are dropping include math proficiency, especially with number sense and automaticity of math facts (p. 28).

Improving math skills can be accomplished in many ways. Direct instruction and practice at home are both established methods of improving math skills in students of all ages. Another option has always been tutoring after school or intervention within the classroom. Supekar, Swigart, Tenison, Jolles, Rosenberg-Lee, Fuchs, & Menon (2013) found a direct correlation between 8 weeks of one-to-one math tutoring and an increase in math fact retrieval. In a perfect world, every family could afford private tutoring for their children, but that is not the case.

Digital Tools in Education

No two students learn in the same way. Child psychologists such as Bloom, Piaget, Kolb, and many others have worked to find how children learn best. When a child fails to thrive at any subject, the teacher may intervene. Interventions are as old as formal education and have been proven to show their effectiveness time and time again (Goldina, Hermidac, Shaloma, Costaa, Lopez-Rosenfelda, Segretinc, Fernández-Slezakd, Lipinac, & Sigmana, 2014). They can range from the classic and simple (i.e. practicing math facts in small groups with the teacher) all the way to the newest digital tools. Goldin and her colleague's (2014) research demonstrates that

"intervention equalizes the academic outcome" in children that attend low-scoring schools, children with disabilities, and those who suffer from a number of other social and educational detriments (p. 6447).

According to Baker et al, there are three keys to increasing student's success. The first key is that the teacher and student both understand specifically how the student is performing (Baker, Gersten, & Lee, 2002). Secondly, Baker et al. (2002) found that interventions that utilize a peer as a guide or partner increase student success. The third key that they noted was clear guidelines and feedback for the students on their progress. This information could be applied to both conventional and technology-driven interventions in the classroom.

Interventions within the classroom are an important tool for every teacher. However, whole-group and small-group instruction is the foundation upon which teaching is built. To most people, this looks like a teacher and a group of student in a classroom, working on content in some way together. In recent years, it has been theorized that computer based instruction can be just as viable as traditional methods. In 2013, a research group led by S. Nusir was able to show that the group of students taught using computer based instruction with interactive multimedia not only achieved as much as the traditional group, but they "significantly outperformed" the traditional group (p. 313). Even more surprising, students that were diagnosed with learning disabilities (those who tend to need more hands-on help from an actual teacher) showed the most growth when using the interactive computer instruction method. Nusir's research does stipulate that programs that require interaction and some self-instruction were far superior to applications that simply gave instruction. This means that students show greater success when they are required to cooperate with the program and take ownership of their own learning instead of simply listening to lecture and repetition in a digital form.

Interactive self-instruction on a computer sounds like a teacher's dream. However, one may wonder what does the teacher actually does while the students learn on their own. Orouke, Main, and Ellis (2013) sought to answer this question in their study with year 4 students in Australia. They determined three categories of teacher involvement:

- "The guiding teacher (observes and encourages, does not participate)
- The facilitating teacher (assists, more enthusiastic, participates to an extent)
- The interactive teacher (intervenes when needed, fully participates with the kids)" (p. 741)

These distinctions were shown to match the level of teacher participation with the amount of instruction the students ended up receiving from the computer based intervention. However, Orouke et al. (2013) explained that, in the end, it is not the style of the teacher that is the key factor; rather, it is the choice of instructional tools for each individual students that the teacher makes. Any tool can engage a motivated student and any student can fail to benefit from an apparently engaging tool if they are not invested.

The concept of interactive technology in schools is not new. The first personal-use calculator hit the market in 1972, signaling the demise of the slide rule. The National Council for Teachers of Mathematics currently recommends that calculator use be taught to every student in the United States (Akpan & Beard, 2014). Adaptive technology for special needs or circumstances is integral to meeting the needs of every child. Adaptive technology is especially useful in teaching students with special needs. Akpan & Beard (2014) observe that students that have trouble with organization or data can use visual technology such as spreadsheets and databases. Visually impaired learners may use screens that enlarge the print or read aloud to them. Students that cannot write well may benefit from dictation software and number

processors. English Language Learners have many doors opened to them through technology such as translation services and visual aids. iPads allow for international keyboards with different characters on them (Prince, 2017). Many forms of technology also have translation programs that will speak to the student in their home language. Digital tools have proven to be valuable assets for differentiation across the curriculum to meet a wide variety of needs.

Digital Tools for Math Fact Fluency

Many people feel that computer-assisted instruction seems to work for almost anyone. Arnold (2012) found that students who are drilling math facts on a computer actually behave in a similar fashion to the computer. They acquire input in the form of sensory information and, using the computer's software, they provide output through either memory or calculation (p. 30). Just as with a computer, Arnold was looking for faster times to provide correct answers, showing less computational requirements. As stated previously, high level math builds upon a foundation of basic math skills such as math fact fluency. "Thus, low achievers seem not to do well at authentic problem solving and discussion of mathematical concepts without solid preparation in the underlying mathematical foundations" (Baker, Gersten, & Lee, 2002). Since students learn math facts in a fashion that is similar to a computer, digital learning is a successful way to develop basic math fluency.

Many studies have noted success in math interventions using programs or apps (Akpan & Beard, 2014; Baker, Gersten, & Lee, 2002; Bicer, & Capraro, 2017; Burns, Kanive, & Degrande, 2010; Cozad, & Riccomini, 2016; Hawkins, Collins, Hernan, & Flowers, 2016, Kaur, Koval, & Chaney, 2017; O'Malley, Jenkins, Wesley, Donehower, Rabuck, & Lewis, 2013; Prince, 2017). In fact, Cozad, & Riccomini (2016) identified eight studies pertaining to student success and mental math proficiency. Results of this synthesis indicate that digital-based interventions are an

effective instructional technique for increasing fact fluency with students demonstrating mathematics difficulties (p. 1).

There is a wide variety of options for teachers who are seeking digital interventions for numeracy skills. Bicer, and Capraro (2017) used a program called MathForward to increase the math performance in 7th and 8th graders. MathForward is a program that provides teacher professional development and integrates the use of technology as a tool in the classroom. Cozad and Riccomini (2016) looked at the success of six different programs: Math Facts in a Flash, Math Drills, Math Evolve, Magic Math, Math Blaster, and Fast Facts. Each study showed results that the intervention yielded some improvement in mathematics fluency. Many showed either mastery of the material or significant growth in the subject matter.

In a 2013 paper presented at the Council for Exceptional Children Annual Meeting, O'Malley et al. discussed the effectiveness of iPads in mathematical interventions. Overall, the paper indicated the iPad was an effective instructional tool for students with moderate to severe disabilities. Notably, when the ten teachers that participated in the study were asked if the iPad "program was worth the time and effort invested, 100% responded positively, rating this question either 4 (agree) or 5 (strongly agree)" (p. 10). Teachers that participated also noted that not only did the students rate of fluency show gains while the intervention was taking place, but that the students "regressed to baseline levels when the intervention was removed" (p. 10)

In contrast, Ke (2008) performed a study in Pennsylvania with 15 elementary students that were struggling in math. Though all of the students showed an increased positive attitude towards their own mathematical skills and learning, the study did not show any significant gains in said skills. The author notes "that game-based learning is a hybrid, systematic process" (p. 1619) and the most important aspect of a computer based intervention program is not the app

itself, but the role that the instructor plays. Ke stresses the importance of the teacher actively participating and regulating the games rather than simply observing.

Teachers are integral to digital interventions in other ways as well. Hawkins, Collins, Hernan, and Flowers (2016) expand on the notion of a teacher's ability to improve the students' computer based learning experience by analyzing how to choose the best app for the needs of your students. They noticed that the best success comes if the programs used are fast paced and engaging. Students benefit from immediate feedback. Teachers utilize the tools more often if the program offers some form of data management and progress monitoring.

iPads in particular are an incredible asset in the classroom. They are small and portable. They support countless apps, many either free or very inexpensive. Most of the larger elementary math textbooks have iPad apps that compliment them, such as Everyday Math and Engage NY Math. In 2013, O'Malley et al. examined the effectiveness of an iPad app called Math Racer in increasing the basic math fact abilities of students with cognitive needs. The results of the study showed that "the iPad was an effective instructional tool for students with moderate to severe disabilities" (p. 10) and 100% of participating teachers felt they had a positive effect as an intervention. iPads have also shown to be valuable resources for English Language Learners. A recent study cites an iPad's ability to engage ELL students using functions such as translation and pictures or video. ELL's can present their learning on an iPad using the same features, crossing the language barrier. The author also notes language growth that is attributed to the use of the iPads (Prince, 2017).

Assessing Math Fact Fluency Growth

No matter which platform and program is selected, in the end, teachers must assess the student's growth in math fact fluency. The traditional method of assessing a student's math

fluency is to give them a timed fact test in which the students will be given *x* number of minutes to solve a set number of problems. These assessments usually stick to one operation, addition, subtraction, multiplication, or division. However, there are a few pitfalls with this time-honored method. The first is the questions of what you are testing, speed or accuracy (Tait-McCutcheon & Drake, 2015). There is no way to know if a student is spending all of their time on a few problems and guessing the rest or if they are simply poor at their math facts. Without the ability to discern how much time is spent on each problem, you are limited in the information that you can obtain. Tait-McCutcheon and Drake also observed that math anxiety is triggered in students across the board when presented with a timed test (2015). This will again impact performance and taint your results.

Tait-McCutcheon & Drake instead came up with their own basic math fact test, the Individual Basic Facts Assessment (IBFA). This assessment is designed to be used as either a screening test or as part of the assessment base that the teacher already has in play. The basic format is as follows:

> Using a PowerPoint that only allows 4 seconds per question has ensured that students are not able to strategise [sic] across a collection of items or take a long time over any one item. Having the teacher read out the question alongside the visual prompt has made the assessment accessible to a broad range of students (p. 592).

The assessment can use any or all of the four basic mathematical operations. In this way, students are able to spent short bursts of time on their work, testing only automaticity and not computational skills. This 4-seconds per question method, notably, will be used as part of the pre- and post-test for the proposed research.

Conclusion

Math facts and automaticity are an important building block towards numeracy and higher problem-solving abilities. Tutoring and interventions are a proven way to increase math fluency in struggling students. Technology as an intervention platform in mathematical automaticity is well researched and shows many positive trends. Evidence points to technological intervention being just as good, if not better than, traditional methods as a math intervention tool. The possibilities with technology in the math classroom are endless. Students with cognitive disabilities, language needs, or gaps in foundational skills can all receive quality interventions, tailored to their needs. Digital tools also allow for a wider variety of interventions occurring simultaneously in the same classroom. iPads, in particular, function as an adaptive tool that can accommodate students while still providing an engaging learning environment. They provide the ability for student-program interaction, which is a proven way to enhance learning. Digital forms of intervention in mathematics offer a sound method for any teacher to improve the skills of their students with great success. This alternative to traditional interventions must now be analyzed in greater detail. Teachers need to know if digital interventions work on all forms of mathematical skills or only in specific areas. This study targets the numeracy skills of addition and subtraction through automaticity and seeks to find out if students will show growth in these areas with only digital interventions.

The current chapter provided a summary of the relevant literature, which informs this study. The following chapter will discuss the methodology used for this study.

Chapter 3: Methodology

Participants

All participants are elementary school students between the ages of nine and eleven. They are all enrolled in the same 4th grade general education classroom. They attend an inner city elementary school. This is a Title 1 school, defined as a school in an area with a high percentage of low income families (https://www2.ed.gov/programs/titleiparta/index.html). 100% of the participants qualify for the free or reduced lunch program.

All of the participants identify as non-white, either African-American, Latino, or mixed race. There are fourteen females and ten males in the group. Three of the participants are enrolled in an English Language Learner program at the school. These three students speak a language other than English as their primary language in the home. Two speak Spanish in the home and one speaks Swahili. There are five additional participants that speak Spanish as the primary language in the home but do not qualify as English Language Learners due to their fluency with the English language.

One participant has been identified as having learning support needs and has an Individualized Education Plan to receive special education services. This participant receives supplemental learning support in both language arts and mathematics. They are pulled out of the general education classroom for additional language arts and mathematic support. This participant will participate in the math game interventions and assessments within the general education classroom. They will receive additional support with signing onto the program and comprehension of the programs' instructions. They will receive no other modifications to the program.

Two participants are currently in the referral process to be tested for learning support needs. One of these is being referred for only language arts and has received testing identifying a learning disability in reading. The other is being referred for both language arts and mathematics and has a current 504 plan that includes accommodations for both subjects. These participants will participate in the math game interventions and assessments within the general education classroom with no modifications to the program.

Six of the participants are receiving pull-out mathematical interventions for 30 minutes twice every six-day cycle from a Title 1 math teacher in addition to general mathematical education. These participants have been identified as just below grade level on the Star Math assessment that was administered in both the fall and winter of the school year.

Selection Criteria

All of the potential participants are currently enrolled in the researcher's 4th grade classroom. As this is an action research study, the participants must all receive services from the researcher in mathematics instruction and there was no random selection process. Every student in the classroom was invited to become a participant. The entire class will be using the digital math intervention program, regardless of participation in the study. Only those students who have consent to participate in the research will have their data included in this study. As such, there is no incentive to participate in this study

Materials

The researcher created a consent document detailing the research as well as a cover letter with a brief explanation and important details (see Appendix A). This letter was translated into Spanish and back-translated into English by separate translators to ensure clarity. These

documents were sent to the families of every potential participant in both English and Spanish as every household has an adult that is literate in at least one of these languages.

The digital mathematical interventions will be accessed through an iPad application called Fluency and Automaticity through Systematic Teaching and Technology Math (FASTT Math). This program is licensed by the Houghton Mifflin Harcourt Publishing Company and offers different games that students will play to increase their mathematical automaticity and fluency in addition and subtraction. All participants will need individual access to iPads for 10-15 minutes of uninterrupted time each class day. The classroom has a bank of 10 iPad Air 1s. The participants have access to headphones as the FASTT Math games will read items and directions to students. The FASTT Math program will highlight the math facts that the participants are fluent in (see Figure 1) and use non-fluent facts as the targeted facts for fluency practice activities (see Figure 2) as well as game play (see Figure 3).

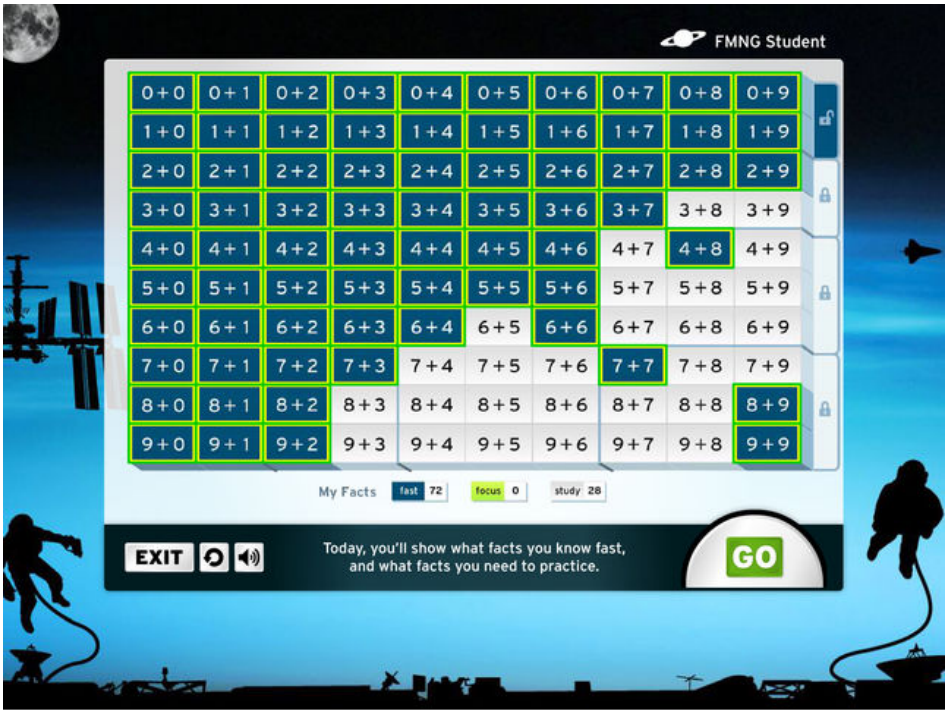

Figure 1. Math fact grid with the fluent facts highlighted in blue.

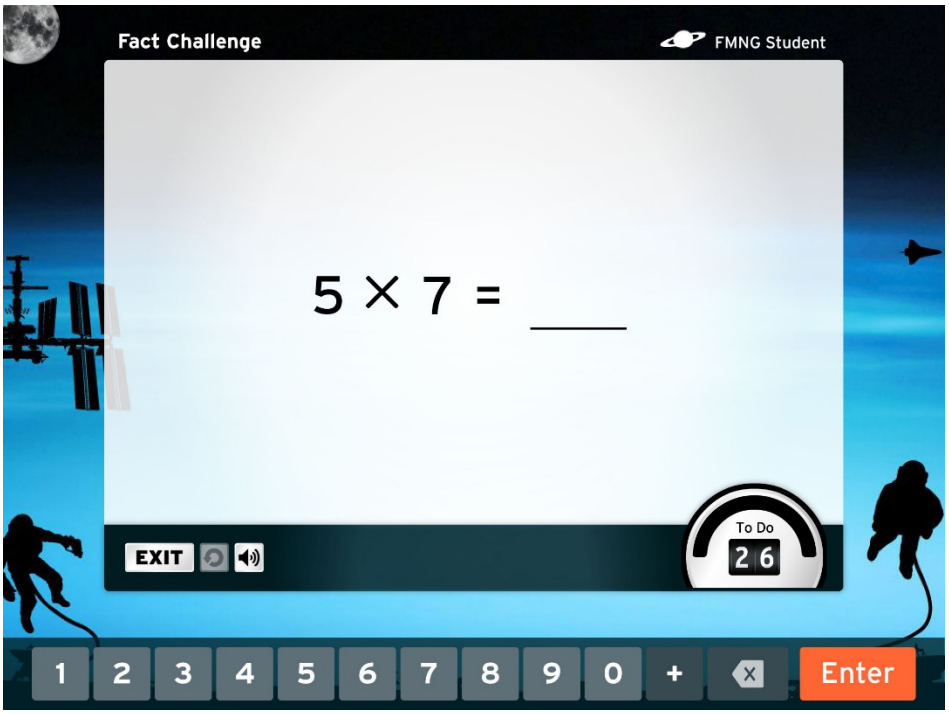

Figure 2. FASTT Math fluency practice screen.

Figure 3. FASTT Math game screen; Slime City.

The researcher created pre- and post-tests for both addition and subtraction facts to test fact fluency using http://www.math-aids.com (see Appendix B). There are three versions of each assessment. Each assessment has 60 addition or subtraction problems on it. The fluency tests are timed, giving three minutes to answer as many problems correctly as possible without skipping any problems. Participants will take one test at the beginning of the research and one at the conclusion. The same forms will be used to monitor progress weekly but the participants will only have one minute to take each assessment. Every students will need a pencil to complete both the pre- and post-assessments as well as the weekly progress monitoring.

The researcher also created two paced assessments, one to assess addition automaticity and one to assess subtraction automaticity (see Appendix C). These assessments are given via PowerPoint presentation. Each assessment has 20 questions and the slides are timed so that every problem is shown for four seconds. A sound plays each time the slide changes to alert the students to the new problem. The automaticity assessments will be administered at the beginning and the end of the research. Every student will need a pencil to complete the pre- and post-assessments in automaticity. The researcher created accompanying automaticity progress monitoring tools through the website www.kahoot.com (see Appendix C). The participants will need to access these progress monitoring tools using the chromebooks that are available in the classroom at a 1-to-1 ratio. The Kahoot assessments show a problem for ten seconds on the screen with four possible answers and students will choose the correct answer. Each version has a total of fifteen addition or subtraction problems to complete.

The researcher has also compiled a list of semi-structured survey questions that will be asked to random students at three times during the research period; once after the first week of interventions, once in the middle of the intervention timeline, and once at the conclusion of

interventions. Each interview session will include one participant that has been identified as on or above grade level in mathematics through the Star Math Assessment, one participant that has been identified as less than one year below grade level through the Star Math Assessment, and one participant that has been identified as more than one year below grade level through the Star Math Assessment. No participant will be interviewed on more than one instance.

Participants will answer the questions aloud and be recorded. The answers will be transcribed by the researcher after the interview is completed. The questions are:

1. Are you enjoying our math game time?
2. What part of these math games are you enjoying the most? Why?
3. What part of these math games would you like to change? Why?
4. Do you feel that these programs are helping you in your math facts? If so, how?
5. Is there anything about this experience that you would like to share?

Ethical Considerations

The proposed research was submitted to an Institutional Review Board (hereafter referred to as an IRB) on February 15th, 2018. The researcher was supervised by a university professor throughout the research process. The parents of each participant signed a consent waiver, as did each participant. The researcher will keep the original documents in a locked cabinet and, after three years, will shred them. The researcher also has scanned copies on their school-based computer which is password protected. All data, both identifiable and de-identified, will be kept in hard copy form in a locked cabinet for three years, then shredded. Electronic data will be kept on the researcher's school laptop and will be deleted at the end of their employment with the school district. The de-identified data will be shared with the supervising professor at the

University of the Arts. The researcher will also keep a log of activity on their computer. This log will not contain any identifiable data.

The potential risks to participants is very low. The only foreseen concerns with the study are the potential for students to become upset or discouraged with any problems while interacting with the FASTT Math program itself or if they perceive themselves as not succeeding. The potential benefits will be improved math fact fluency and automaticity as well as an improvement in basic numeracy skills and, potentially, an improved grade in mathematics as a result of these increased skills. There are no monetary benefits or extrinsic incentives to participating in this research.

Procedures

At the beginning of the research, participants will take an addition and a subtraction facts fluency test. They will have three minutes to answer as many problems as possible without skipping any. They will also take an addition and a subtraction facts automaticity test. They will be given 20 problems to solve with only four second per problem. The researcher will log this data for comparison at the end of the study.

Every participant will be given 10-15 minutes daily to log into the FASTT Math program on an iPad to complete the program elements and play the math games. The participants may play any of the math games available. The program begins with addition facts and then moves to subtraction facts. Participants will not be able to make up time missed due to absences. The researcher will also log into the FASTT Math program and play the games with the students in the same area.

At the end of each week of research, the participants will take an addition and a subtraction test, each a minute long, to see how many problems they are able to answer correctly without skipping a problem. They will also access the timed assessment on www.kahoot.com to answer fifteen addition and fifteen subtraction problems with ten second given for each problem. These progress monitoring assessments will be used to examine growth in both fluency and automaticity.

The researcher will use the results of the Star Math assessments that were administered by the school district in the fall and winter of the school year to divide the class into 3 groups; students on grade level, students less than one year below grade level, and students more than one year below grade level. At the end of each research week, the researcher will choose, at random, one student from each group to interview with the survey questions. These interviews will be conducted in a separate room and will be videotaped and transcribed.

Any student that are in the researcher's class that have not consented to participate in the research will still follow the same procedures. These students will not be interviewed and their data will not be included in the research.

The current chapter provided a summary of the methods and procedure for the research conducted in this study. The following chapter will examine the data collected for this study.

Chapter 4: Data Analysis and Results

Quantitative Findings

The quantitative research focused on four different data types; timed addition assessments, timed subtraction assessments, paced addition assessments, and paced subtraction assessments. Each type of assessment consisted of a pre-test, weekly progress monitoring assessments, and a post-test. The timed assessments were designed to show growth in math fact fluency and the paced assessments show growth in math fact automaticity. For the purposes of this study, statistically significant growth or loss will be defined as greater than one standard deviation of movement.

Timed Addition Assessment

Participants were given a 3-minute addition test to see how many problems they were able to answer correctly. At the end of each intervention week, they took a 1-minute timed addition test to monitor their progress. At the end of the research, they again took a 3-minute addition test to compare to the pre-test.

20 of the 23 students showed some form of growth on the timed addition assessment. One participant showed neither growth nor loss, scoring the same on the pre- and post-tests. Three participants scored lower on the post-test than on the pre-test. The standard deviation of the participant growth was 8.3 more questions correct on the post-test than on the pre-test. Of the participants that showed growth, 13, or 57% of them grew more than one standard deviation, showing statistically significant growth in timed addition fact fluency. One of the participants that showed a net loss was not below one standard deviation, the other two showed a statistically significant loss.

The average growth of the participant population was 7.7 questions on the 3-minute timed test or approximately three problems per minute, equating to an average growth of 52%.

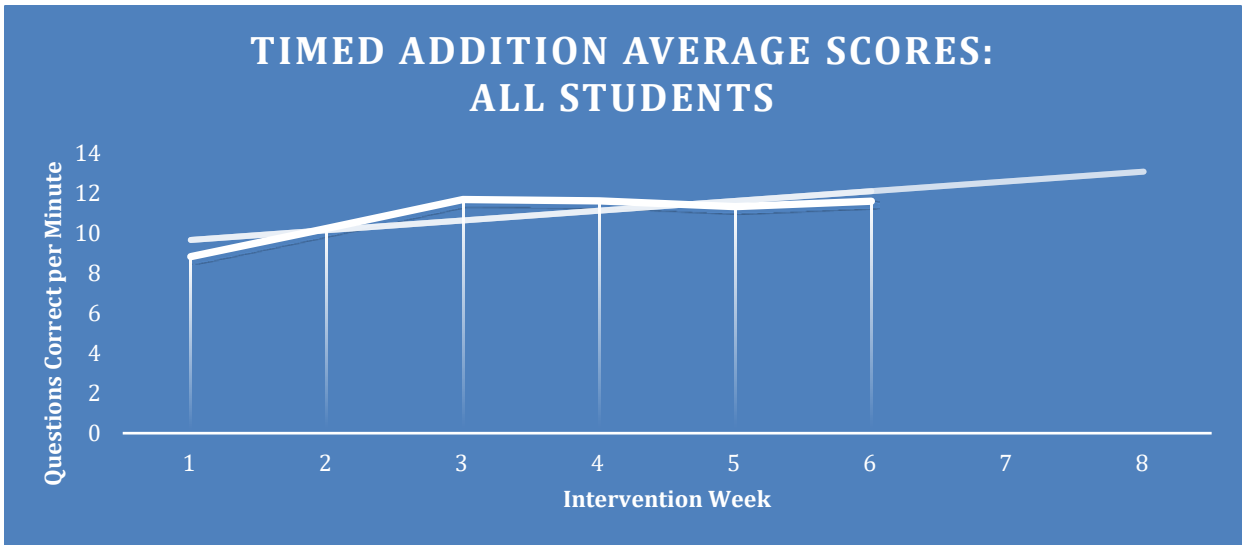

Figure 4

This ranged from -19 to 30 more questions on the post-test than on the pre-test, or a -49% to 500% growth. When the weekly progress monitoring data is included, the participants showed steady growth with a projected increase (see Figure 4).

Participants that were performing at less than 1 year below grade level on the Star Math assessment showed the most gains on the timed addition assessment. This subgroup showed an average of 79% overall growth. Within this group, that was an average of a 7 correct answer increase on the 3-minute timed assessment. When the progress monitoring was factored in, this set showed the fastest projected growth (see Figure 5).

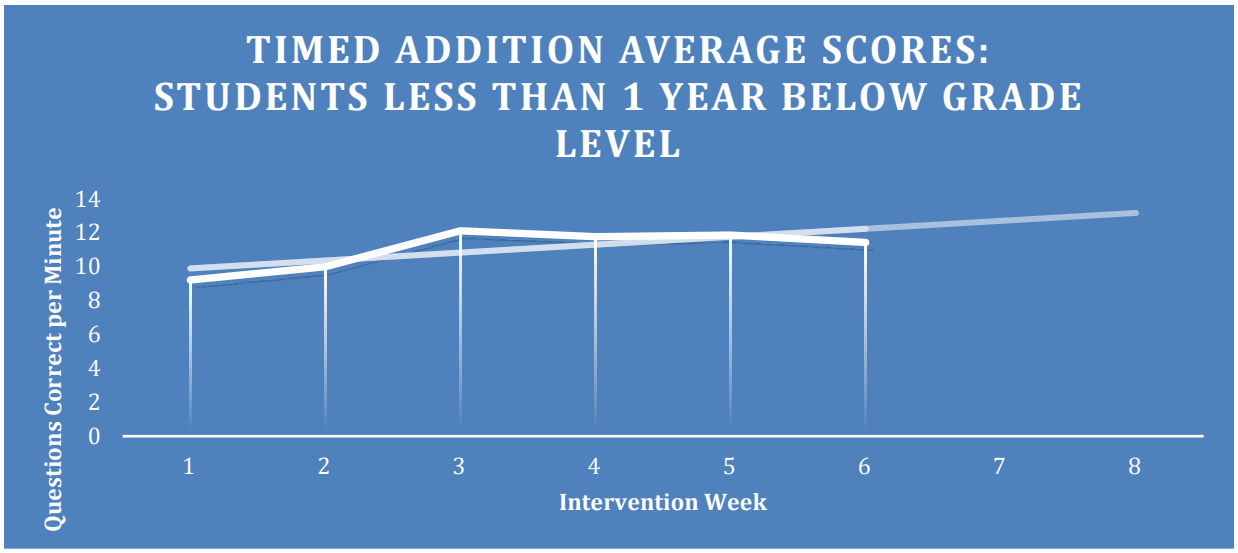

Figure 5

The participants that were identified as on or above grade level by the Star Math assessment also showed an average of 44% growth. For this set, the average increase in correct answers was 11. This grouping started off with the highest rates of fluency and the progress monitoring data projected quick growth for this grouping (see Figure 6).

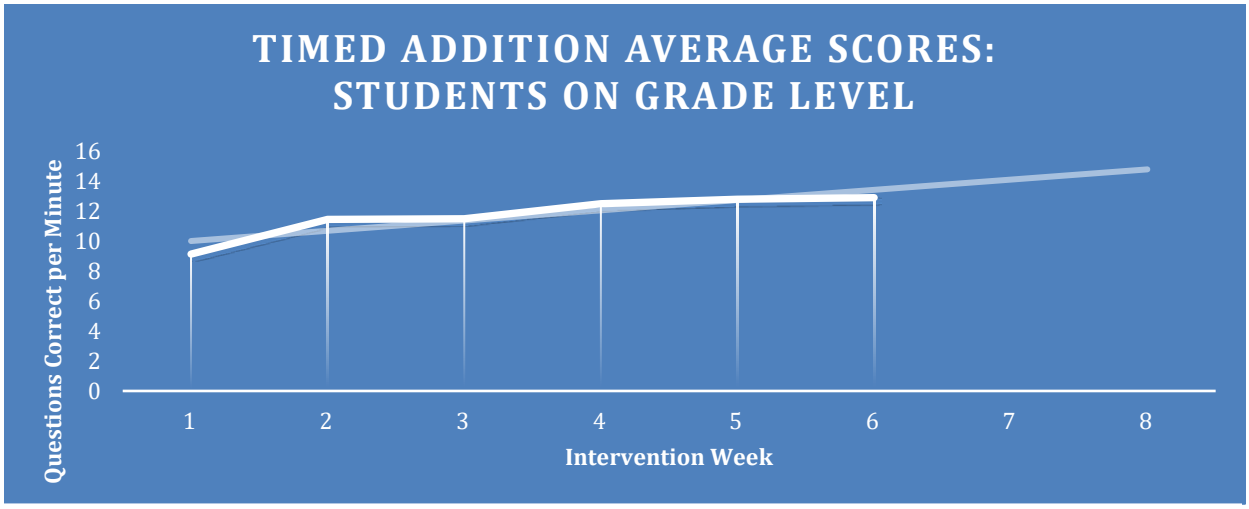

Figure 6

The next most notably performing group were the participants that were performing at more than a year below grade level according to the Start Math assessment. This set showed an average growth of 29% or 5.5 more correct answers on the 3-minute addition test. This cluster of

participants showed a projected slow but continued growth once the progress monitoring scores were factored in (see Figure 7).

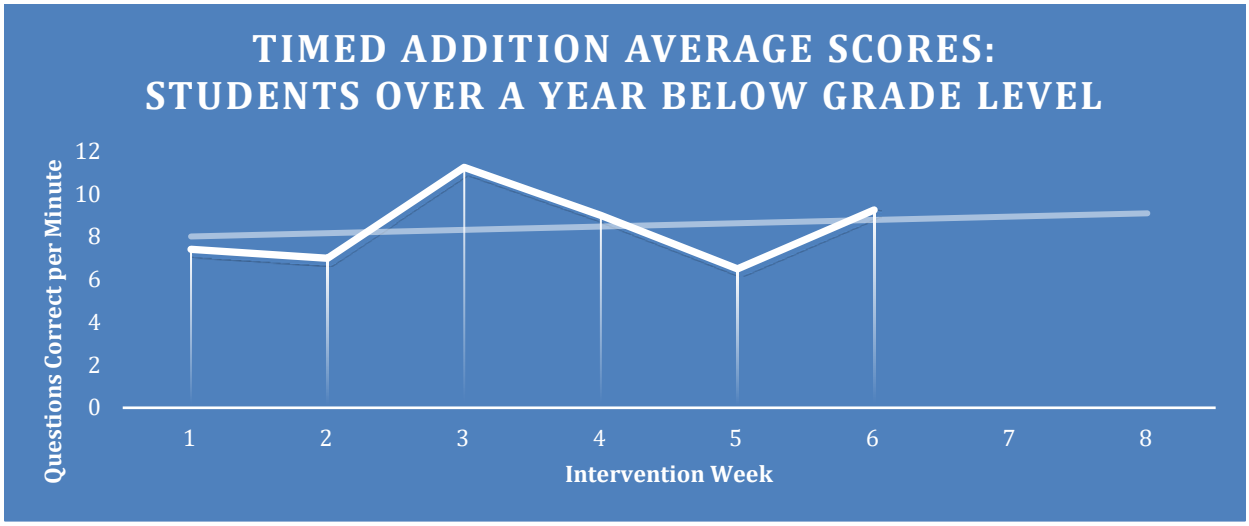

Figure 7

The participants that were English Language Learners showed an average growth of 26% which was approximately 7 more correct answers on the post-test for this set. Though it is the slowest rate of projected growth, this grouping is also projected to develop fluency with increased ability (see Figure 8).

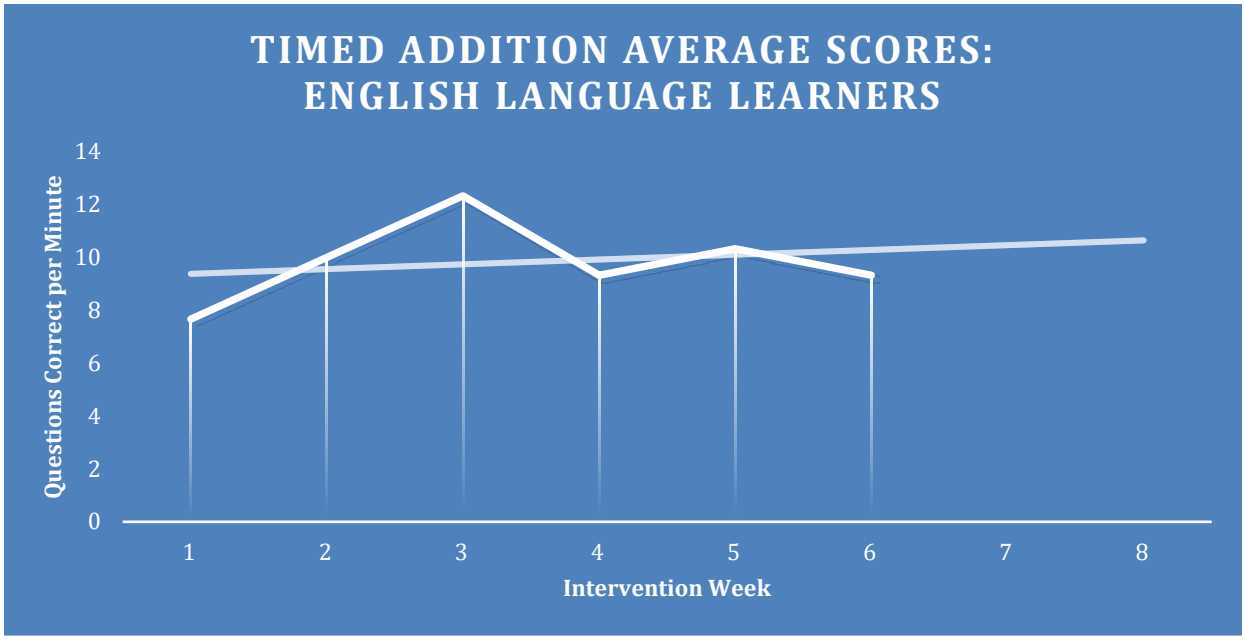

Figure 8

Timed Subtraction Assessment

The subtraction fact fluency was assessed in the same method as the addition, with a 3-minute timed pre-test and post-test and 1-minute timed progress monitoring assessments administered weekly. Though subtraction fluency was assessed throughout the study, none of the participants moved from addition fluency practice into subtraction fluency practice on the FASTT Math intervention program. 14 of the 23 participants showed growth on the subtraction fluency assessment. Two of the participants scored identically on both pre-test and post-test, showing no net growth or loss. Seven of the participants did not perform as well on the post-test as on the pre-test, showing a loss. With a standard deviation of 5.5, a total of eight participants, or 35%, showed statistically significant growth on the subtraction fluency assessment. Of the participants that showed a loss of skill, only two presented a loss greater than one standard deviation.

The average growth in timed subtraction fluency was 3.2 questions on a 3-minute assessment, a 42% increase. The post-test scores ranged from -10 to 19, or -37% to 200%. Weekly progress monitoring shows a projected increase of skills (see Figure 9).

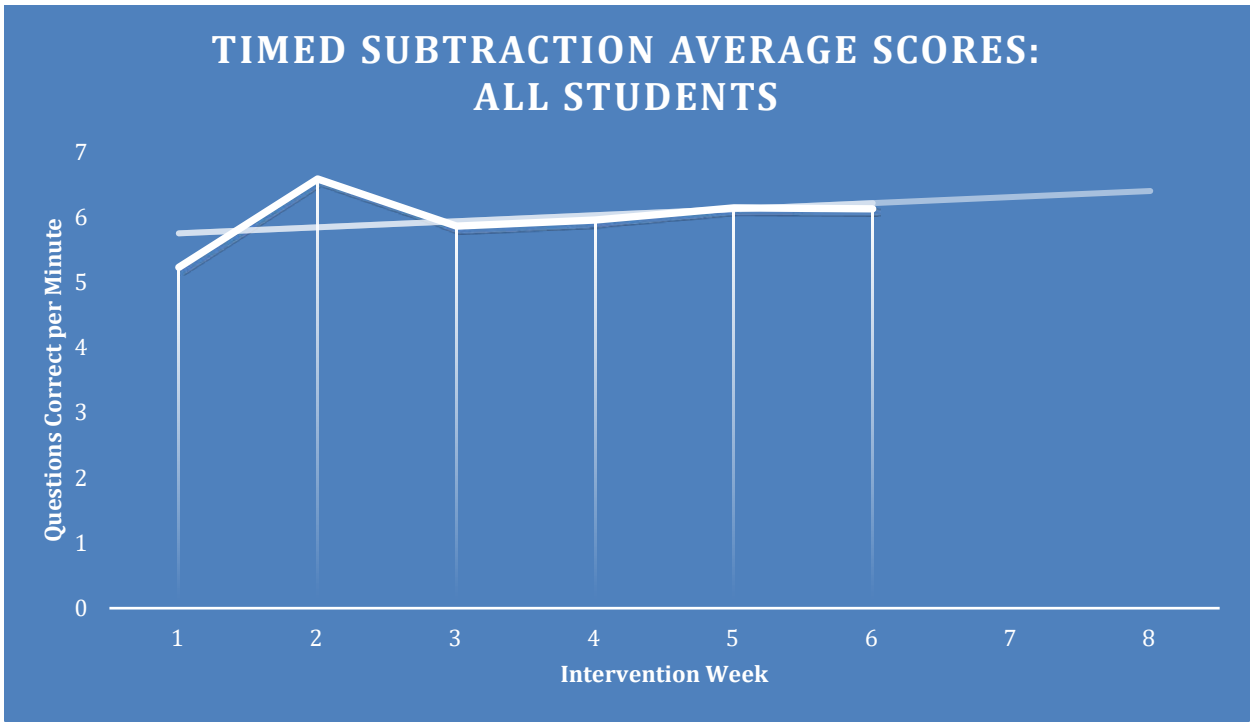

Figure 9

Just as with the timed addition assessment, the subset that showed the most growth were the participants that have been performing at less than a year below grade level on the Star Math assessment. This set showed an average growth of 70%, gaining approximately 4.3 correct answers on the post-test. This group showed slow projected growth once the progress monitoring data was applied (see Figure 10).

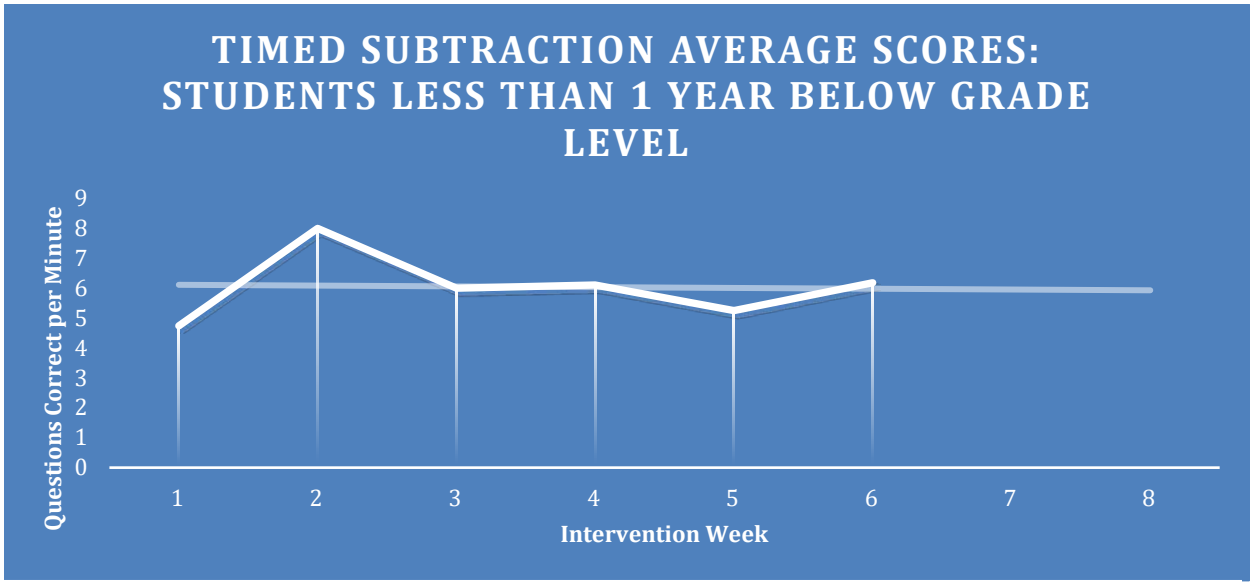

Figure 10

The second-best performing group were the participants that were identified as on or above grade level. They showed an average growth of 16%, increasing their post-test performance by approximately 1.6 correct answers. The progress monitoring shows rapid growth projected for this set (see Figure 11).

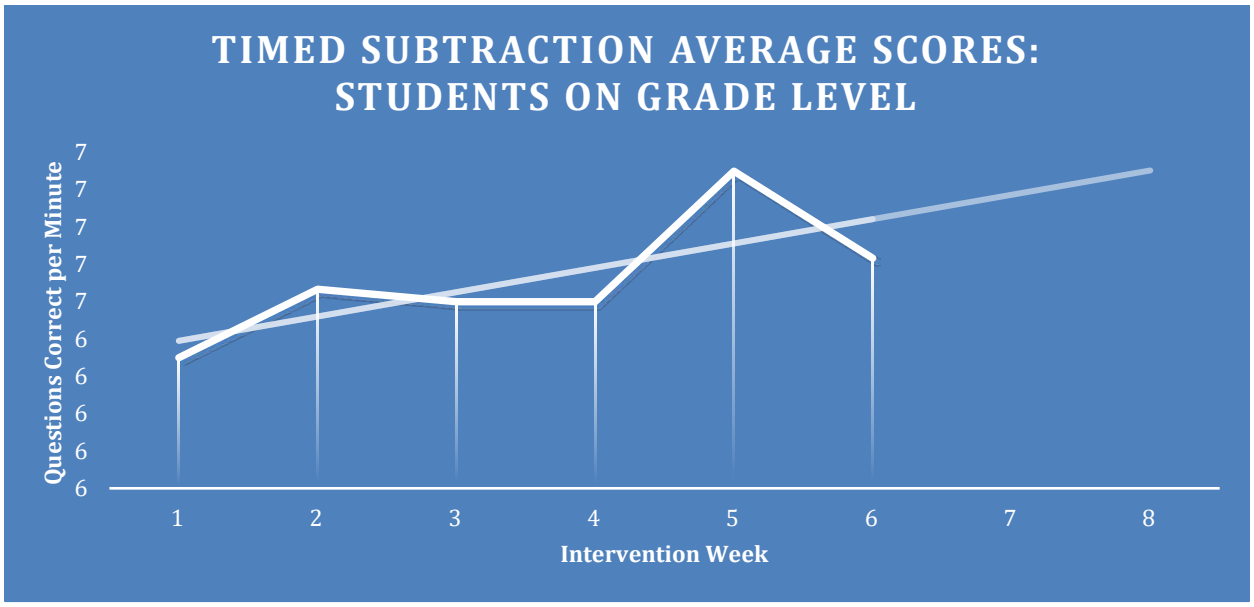

Figure 11

The grouping of participants that tested at more than one year below grade level showed a net gain of subtraction fluency skills at an average of 15%. This equated to an increase of 1.7 correct answers on the post-test. When the progress monitoring data is factored in, this group is still projected to make some slow gains (see Figure 12).

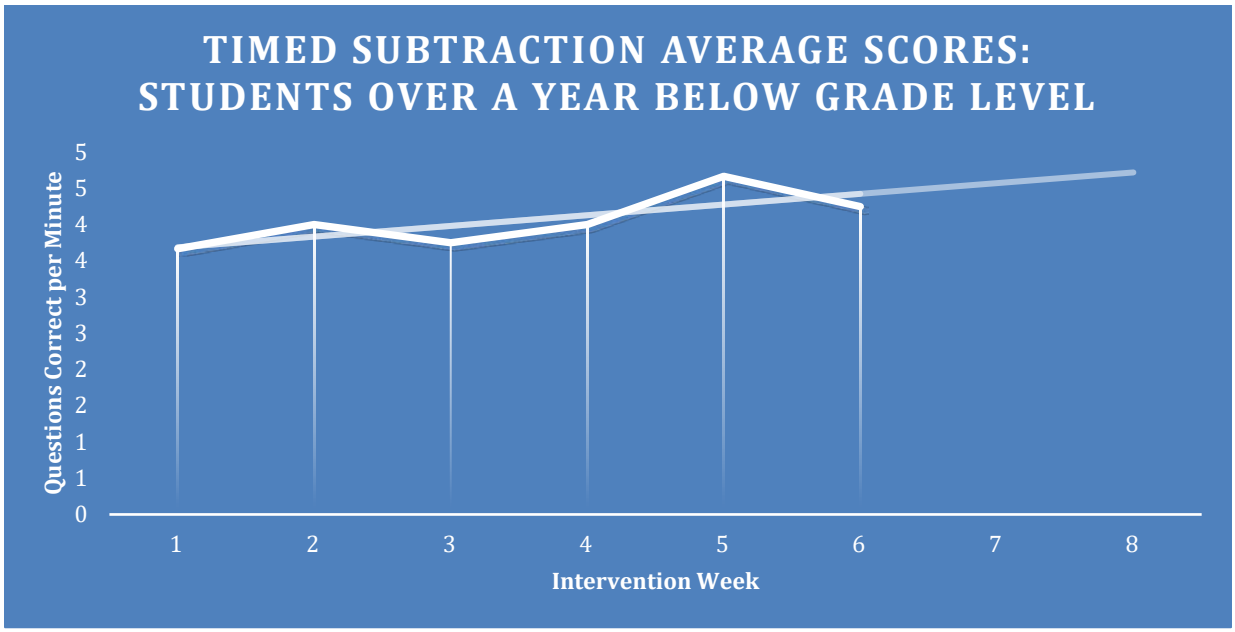

Figure 12

The English Language Learners showed an average growth of 4%, gaining less than one correct answer on the post-test. While this group has a very slow rate of growth in subtraction fluency, the progress monitoring shows that this set is expected to show gains within this skill set (see Figure 13).

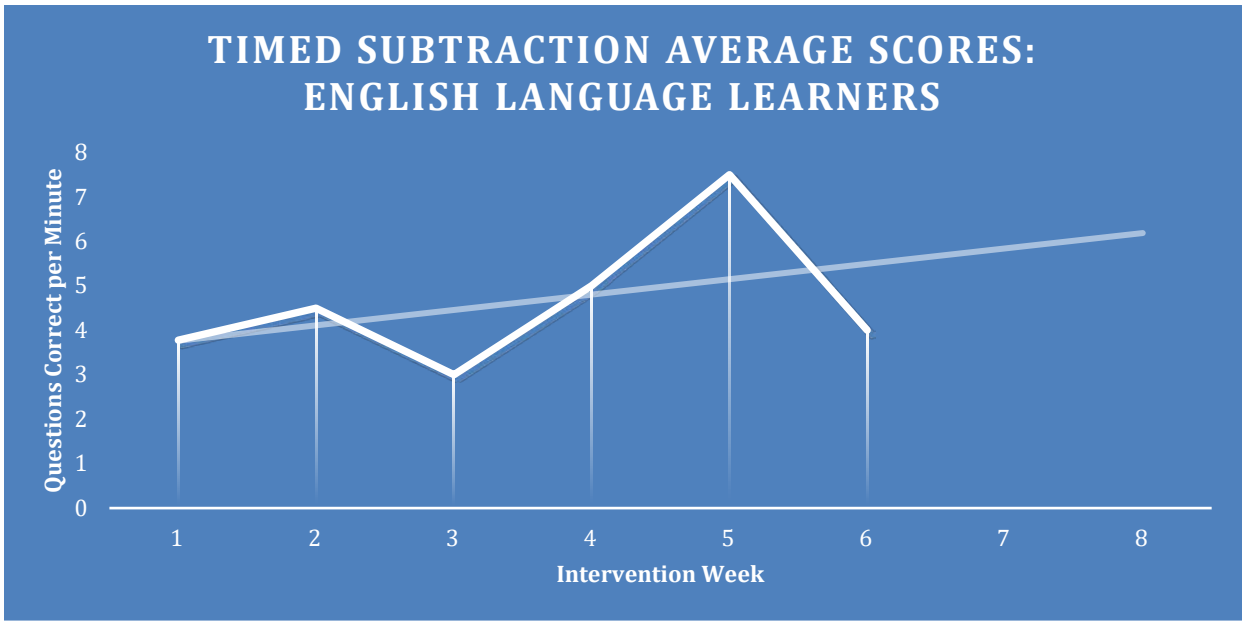

Figure 13

Paced Addition Assessment

To measure addition automaticity, participants were given an addition assessment that allowed them only 4 seconds to answer each question. There were 20 total problems. At the end of the research, the participants were given an identical assessment with different problems. Due to the limit of 20 total questions, the potential for growth was capped. Participants that started with a higher rate of automaticity were not able to show significant growth from pre-test to post-test. Progress monitoring was again used to help determine a trend for each participant and to project the future growth of the groupings. At the end of each week, all participants took a 15-question automaticity assessment that allowed them 5 seconds per problem before moving on.

Of the 23 participants, 13 showed some form of growth from pre-test to post-test. Four of the participants scored the same on the pre-test and post-test, neither gaining nor losing automaticity. Two of these participants started with competent automaticity levels, one scoring 80% and the other 100% on each assessment. The other two participants started with below average automaticity competence, one scoring 65% and the other 50%. Six participants showed a loss from beginning to end, but each was only a loss of 1 correct answer. The standard deviation was 3.4, so this loss was not statistically significant. Of the five participants that showed loss, four began with competent automaticity, all scoring 70%-100% on the pre-test. One participant had an initial score of only 20%, showing poor automaticity with no significant gain in the skill.

Of the 13 participants that showed growth, 11 grew more than one standard deviation from beginning to end. This means that 48% of the students showed a statistically significant gain in addition automaticity with 5 weeks of digital interventions. None of the participants showed a statistically significant loss. The average growth on the assessment was 2.0 questions

from pre-test to post-test, a 32% gain overall. The scores ranged from -1 to 11 more correct answers on the post-test. This is a range of -25% to 300% growth. With the progress monitoring factored in, the overall group is projected to maintain at a plateau, though many of the participants ended with levels of mastery (see Figure 14).

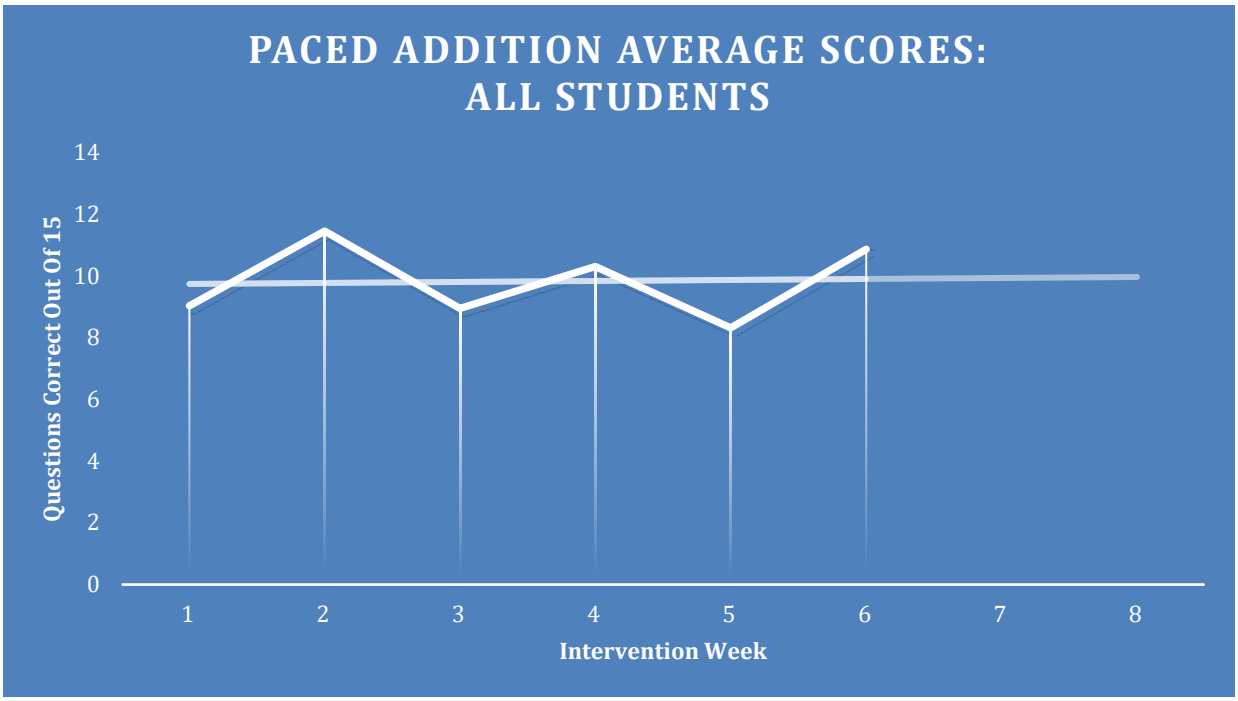

Figure 14

As with the timed addition and subtraction assessments, the participants that have been performing at less than a year below grade level showed the most gains on the addition automaticity tests. The typical growth for this set was 29% with a 2.6 questions gained as the average. Once the progress monitoring scores are accounted for, this set of participants has a projected rate of steady growth in addition automaticity (see Figure 15).

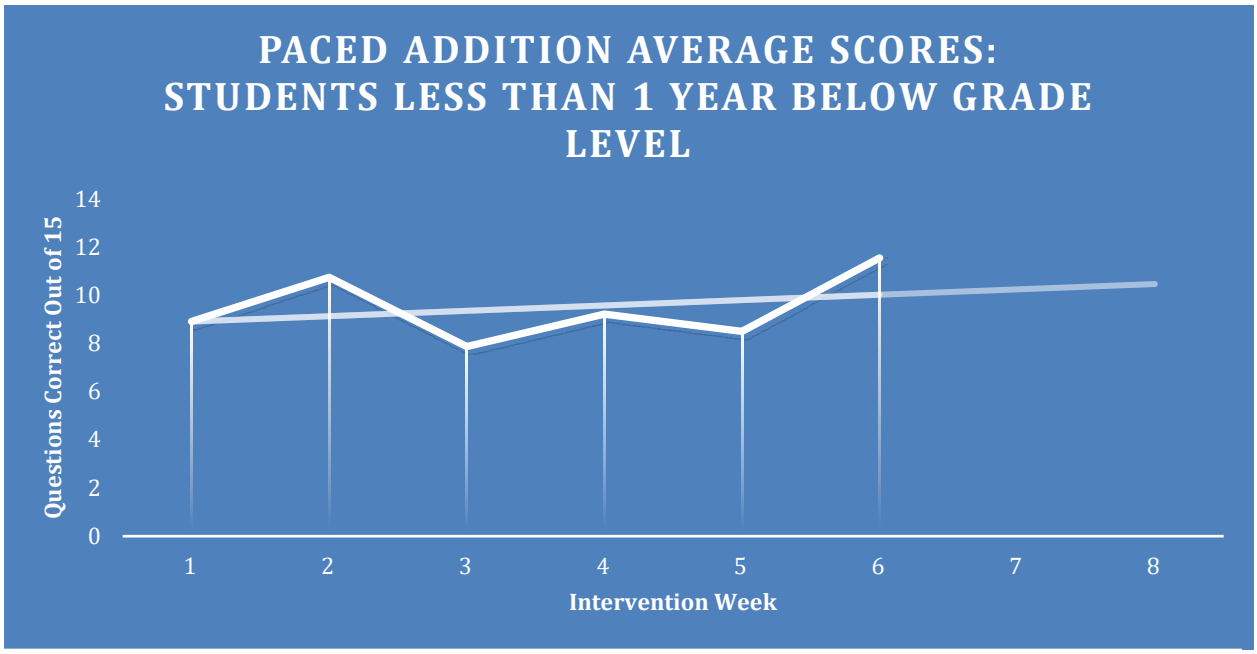

Figure 15

The next group was the English Language Learners, showing an average growth of 23% from pre-test to post-test. This was also approximately 1.1 questions of gain. However, once the progress monitoring scores are accounted for, this is the first grouping of any set of participants that shows a trend towards neither growth nor loss in automaticity. None of the participants in this grouping started or ended with automaticity scores higher than 60% and none made statistically significant movement towards growth or loss of the skill (see Figure 16).

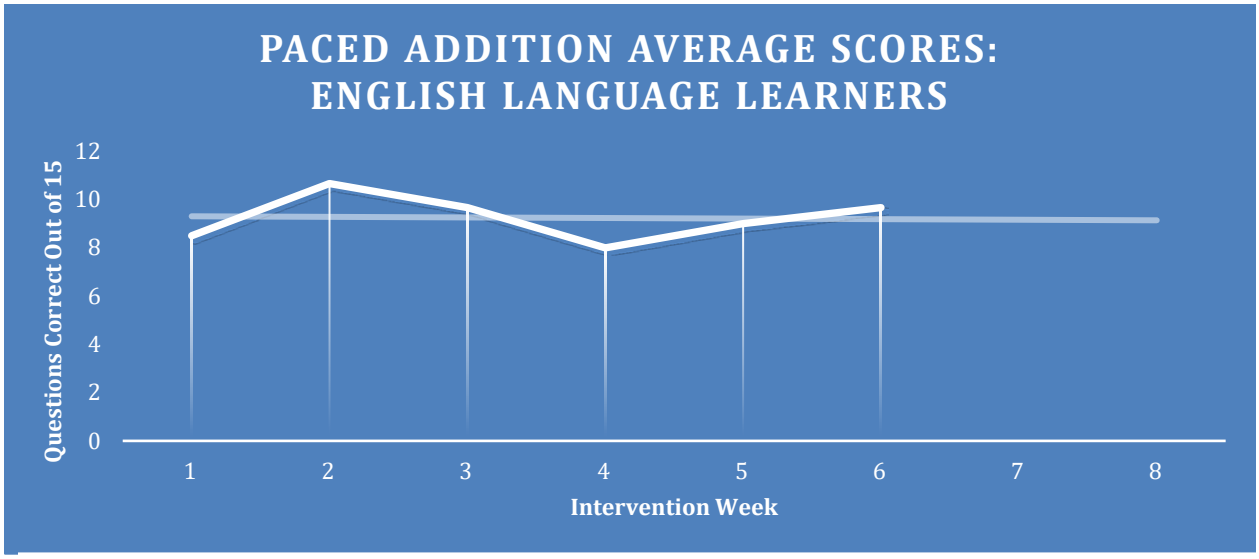

Figure 16

The next set was the group that started the strongest, the students that have been performing on or above grade level. This set showed an average growth of 21%, about 1.5 more correct answers from pre-test to post-test. However, four of the ten participants began with an automaticity ability of 80% or higher, showing a mastery of the skill already. Two more participants gained mastery by the end of the study and all participants in this group showed at least a 50% score on the post-test. When the progress monitoring scores are accounted for, this group shows a projected loss but this is due to a majority of the group achieving mastery and plateauing (see Figure 17).

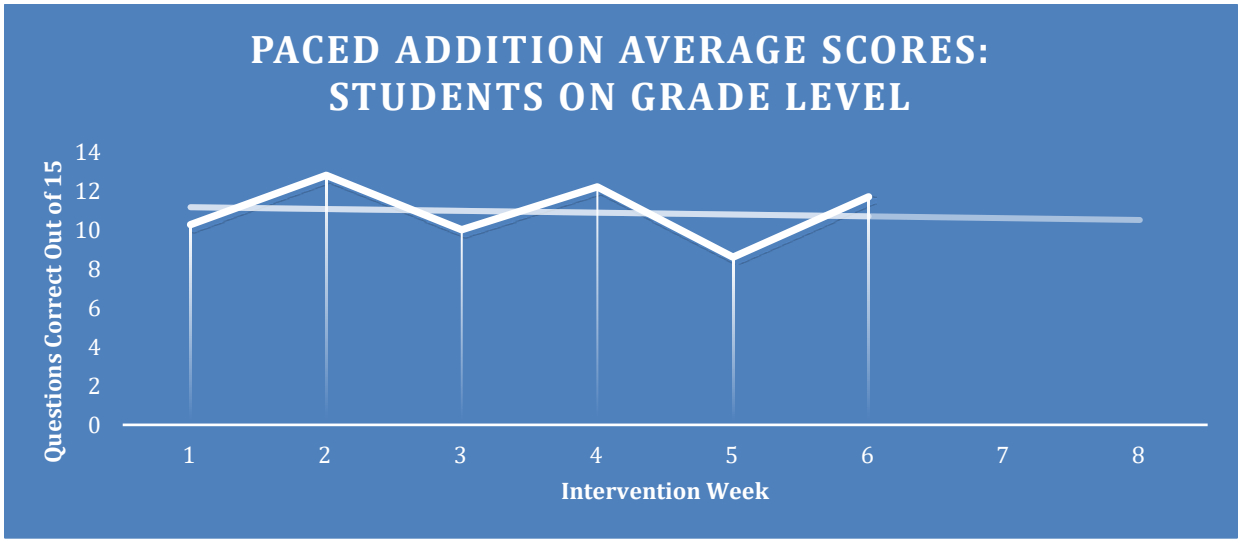

Figure 17

The participants that have been performing at more than a year below grade level showed the least amount of growth with an average of 19%, which was approximately 1.1 questions on average. This grouping also showed a projection of neither growth nor loss when the progress monitoring is factored in (see Figure 18).

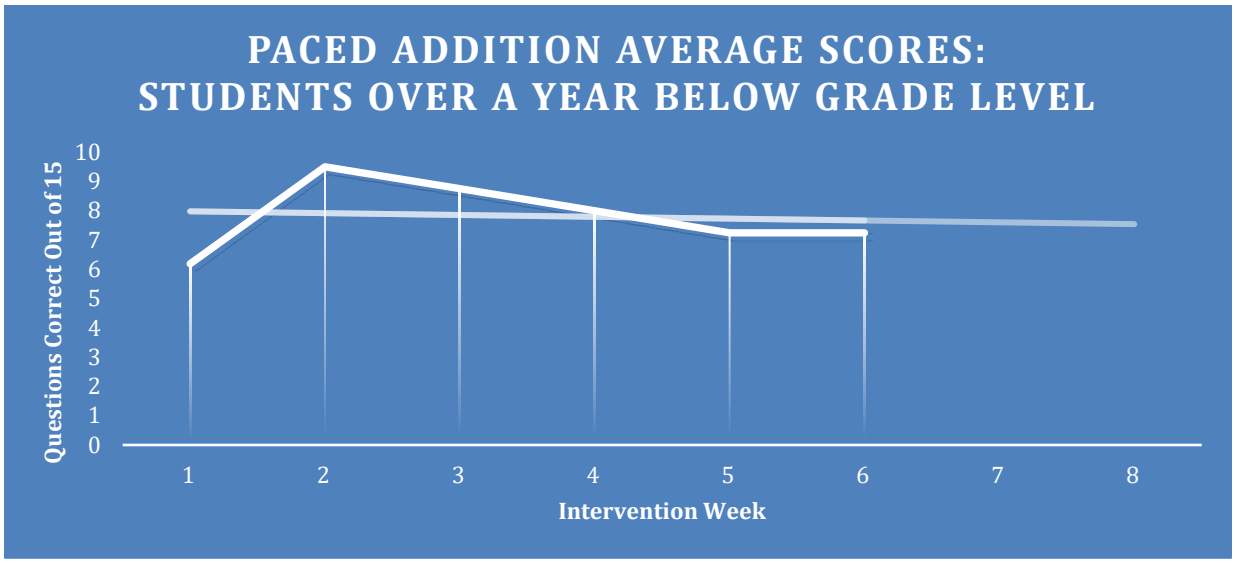

Figure 18

Paced Subtraction Assessment

The last quantitative data set was an assessment of the subtraction automaticity skills of the group. Just as with the paced addition, this was tested with a 20-question subtraction fact test that only allowed four seconds per problem. Progress monitoring was conducted at the end of each intervention week with a 15-question assessment allowing five seconds per problem. The research concluded with another 20-question assessment that allowed four seconds per question.

19 of the 23 participants showed some form of growth in this assessment. The standard deviation was 2.0 questions and, of the participants that showed growth, 10, or 44%, grew more than one standard deviation. The average rate of growth was 2.39 questions, a 27% gain, just slightly above the standard deviation. The three of the remaining four participants showed a net loss with one making more than one standard deviation of loss and the other two making no statistically significant loss. One participant showed neither growth nor loss, scoring the same on both the pre-test and post-test. The range of growth was from -3 to 8 more questions from pre-test to post-test, showing a gain of anywhere from -25% to 100%. Once the progress monitoring

scores were factored in, the participants are projected to grow in subtraction automaticity (see Figure 19).

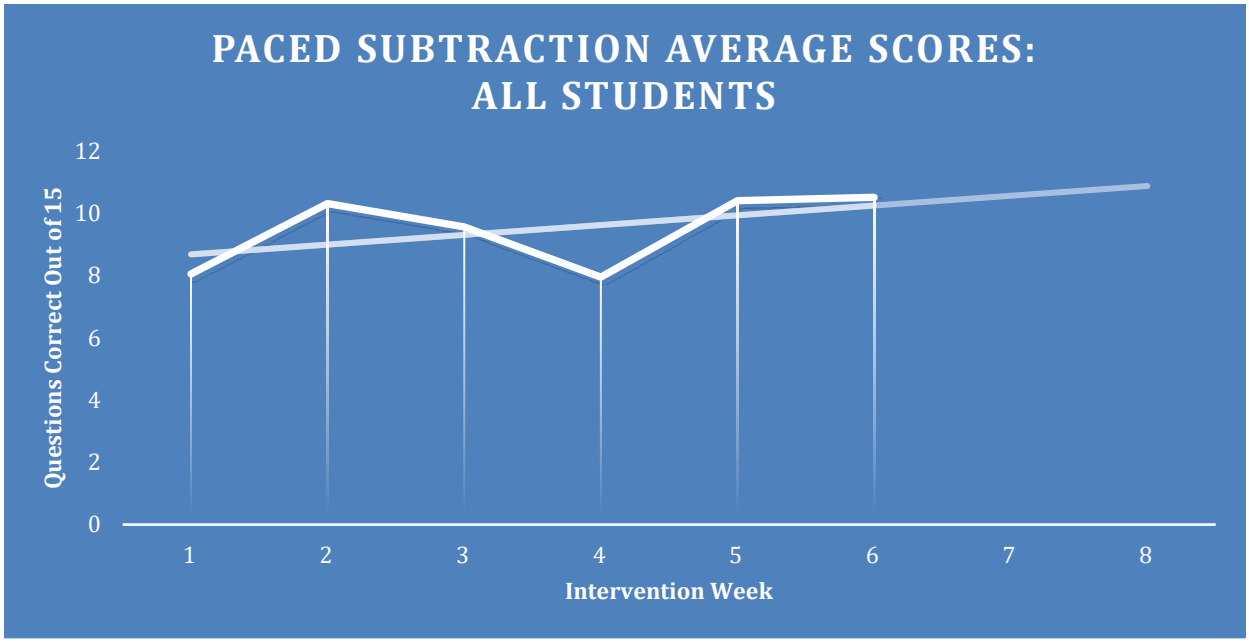

Figure 19

Remarkably, the participants that have been performing at less than one year below grade level again showed the most growth, sweeping every area as the highest performers. In subtraction automaticity, this set showed an average growth of 157%, gaining approximately 4.0 more correct answers by the end of the research period. The progress monitoring confirms that this group is expected to climb steadily in this skill area (see Figure 20).

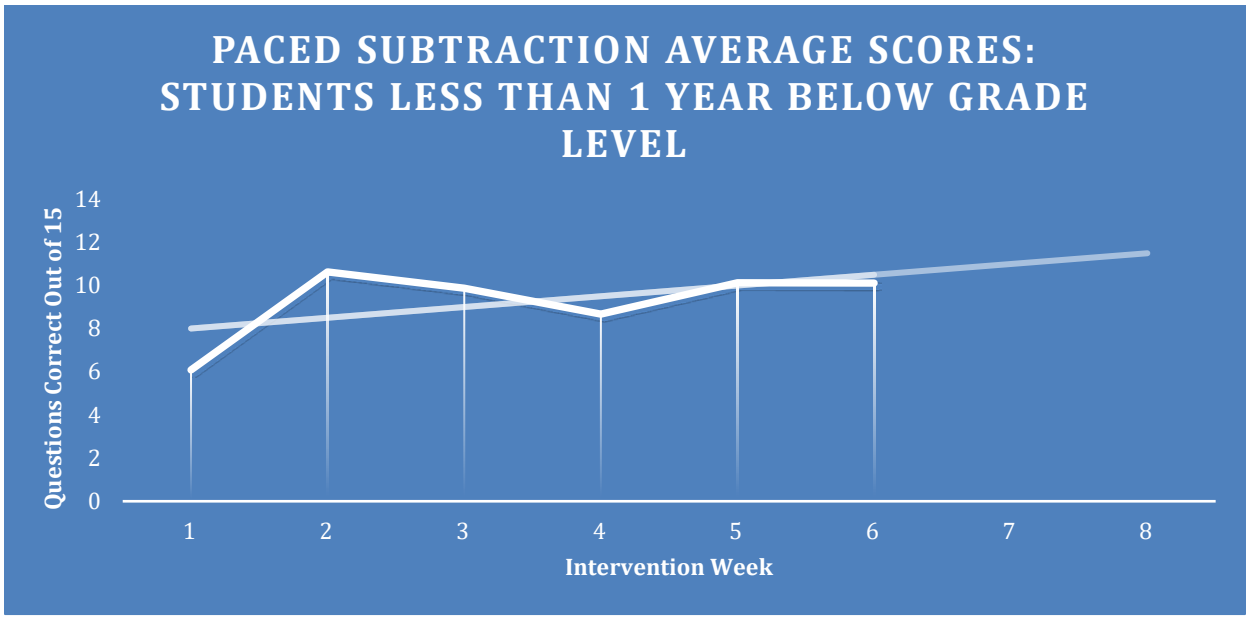

Figure 20

The next group of participants were those that are functioning at more than a year below grade level. They showed an average gain of 1.5 questions on the post-test, a 21% increase for this set. They are also showing a very slow projected rate of gain (see Figure 21).

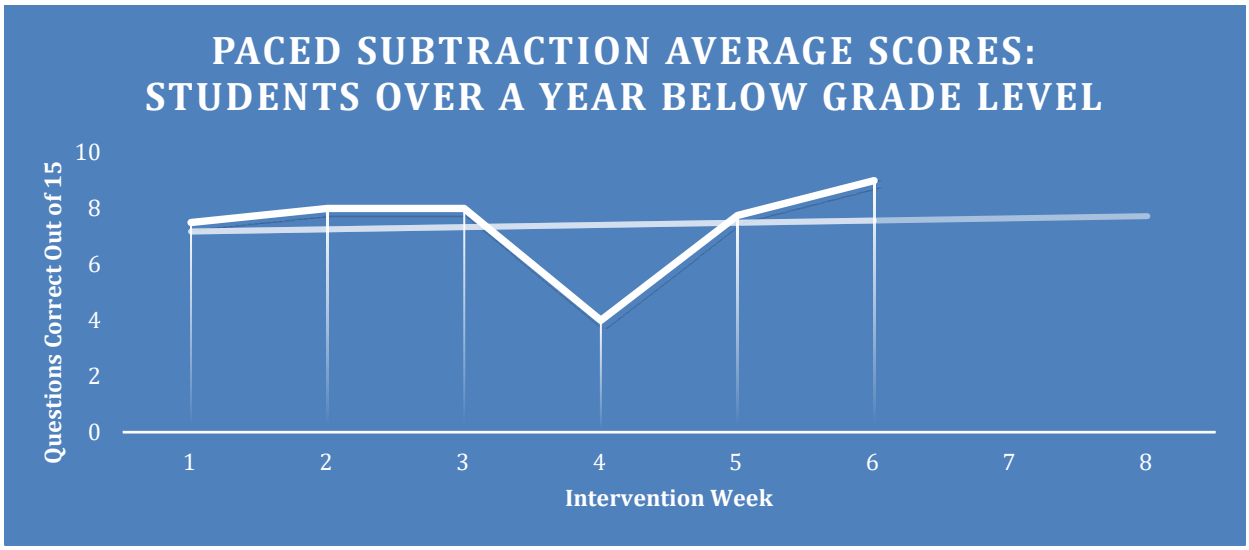

Figure 21

The participants that are on or above grade level were again the group that had the most initial success at subtraction automaticity. This set showed an average gain of 19%, which was 1.5 more answers that are correct. Just as with the addition automaticity tests, these participants

showed significant initial mastery. Four of the ten participants began with at least a 75% on the pre-test and another three more gained this mastery by the end of the intervention period. This left two participants at over 60% on the post-test and projected to achieve mastery quickly. One participant showed growth but did not achieve mastery by the end of the intervention period. Once the progress monitoring scores are applied, this group is projected to slowly grow until all participants have achieved mastery of subtraction automaticity (see Figure 22).

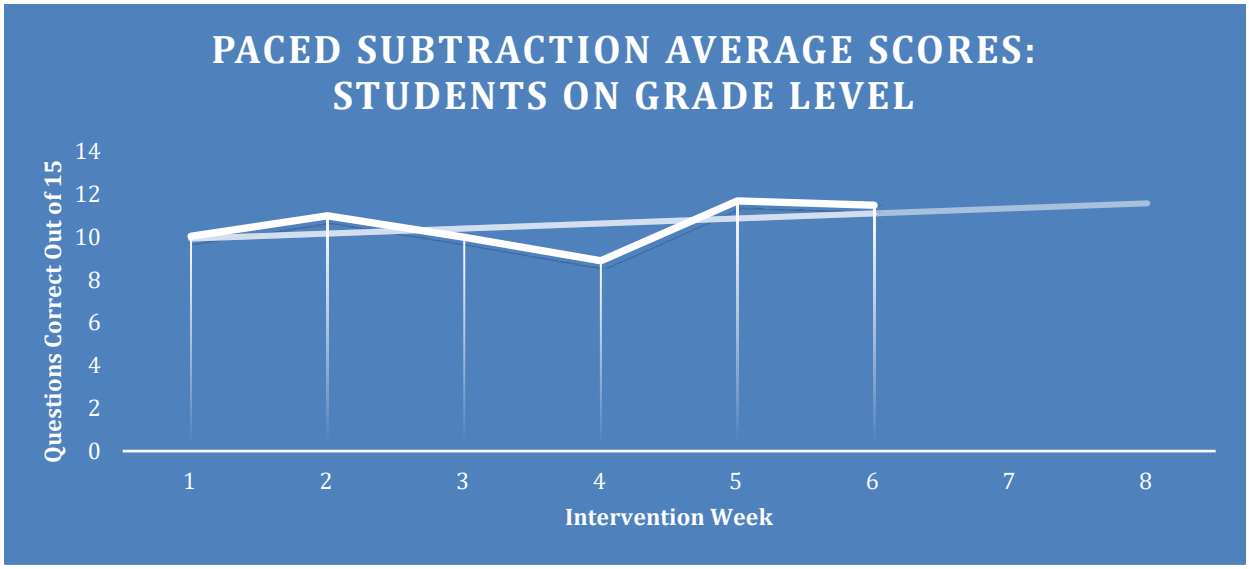

Figure 22

The English Language Learners showed the lowest rate of gain with an average of 18% for the group. This was a gain of 1.7 more questions per average for this set of participants. Contrary to their performance in addition automaticity, this group is projected to rise in subtraction automaticity once the progress monitoring assessments are factored into the data (see Figure 23).

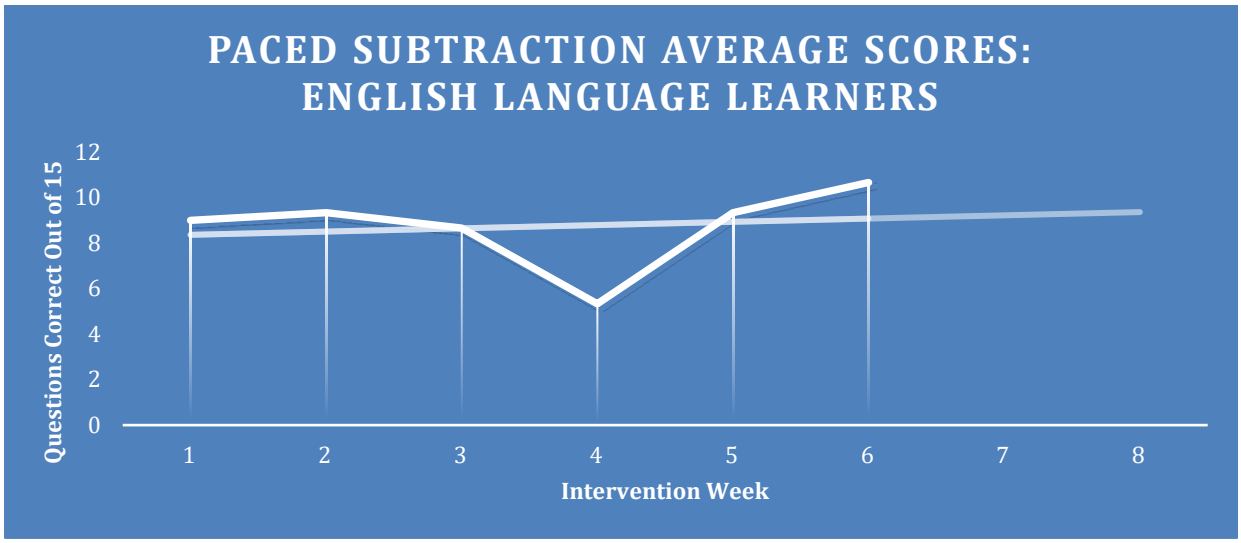

Figure 23

Quantitative Summary

Every participant in this study showed some form of growth. In fact, each participant grew in at least two of the four tested areas, addition fluency, subtraction fluency, addition automaticity, and subtraction automaticity. Four participants, 17% of the research group, showed growth in two of the four areas. 11 participants, or 48% of the research group, showed growth in three of the four tested areas. Eight participants showed growth in every single category, 35% of the research set. It should also be noted that overall growth or achievement of skill mastery was achieved by each subset of participants for every skill that was assessed. Figure 24 shows the ranking of each subgroup from greatest to least percentage of growth in each of the four tested areas.

Fluency and Automaticity Outcomes Ranked From Greatest to Percentage of Least Growth				
	Timed Addition	**Timed Subtraction**	**Paced Addition**	**Paced Subtraction**
1	<1 year below-79%	<1 year below-70%	<1 year below-29%	<1 year below-157%
2	On-44%	On-16%	ELLs-23%	>1 year below-21%
3	>1 year below-29%	>1 year below-15%	On-21%	On-19%
4	ELLs-26%	ELLs-4%	>1 year below-19%	ELLs-18%

Figure 24

It is worth noting that there was a noticeable dip in progress monitoring around week 4-5. This progress monitoring period was spread over two weeks that included spring break. This time was also used for an intense math focus on decimals before the participants took the PSSA and, therefore, may have been distracted or overwhelmed, possibly leading to lower scores in this time period.

The first research question was: Is there a relationship between independent digital-based interventions and an improvement in student fact fluency in basic addition and subtraction? Based upon the data provided, it can be said that overwhelmingly yes, independent digital-based interventions will improve student fact fluency in basic addition and subtraction for this set of participants.

Student Surveys

The student surveys focused on the perceptions of the participants. Will the interventions increase the participants' perception of their own skills? Will their perceptions match the actual increase in skill, or lack thereof? Participants were surveyed at three separate times during the interventions; once after the first week of interventions, once in the middle of the research period, and once at the end of the intervention period. Each time, three participants were chosen, one that is performing on or above grade level, one that is performing at less than one year below grade level, and one that is performing at more than one year below grade level. No participants were surveyed more than once. The participants were chosen randomly from within the groupings. The participants pulled included two English Language Learners (one Spanish speaker and one Swahili speaker), three participants that speak Spanish as the primary language in the home but do not qualify for language learner services, and four native English speakers.

All nine participants surveyed stated that they were enjoying the math intervention program. Seven of the nine participants independently stated that they felt the program was helping them increase either their math fact fluency or their growth in math skills. One participant noted that they like the program because, “I get to do math and have fun at the same time.” Another stated that, “sometimes I am slow in math and [this program] really helps me get faster and faster.” The participant that is a refugee from central Africa noted that their favorite part of the intervention program is getting onto it every day, “because then I can learn more.” Two of the participants only cited features of FASTT Math that they were enjoying such as playing the games.

When asked what parts of the math interventions they would like to change, one participant noted that they would like to decrease the number of problems required on the fluency checks that are part of the FASTT Math program. The five participants only stated that they would change styles or aspects of the games, such as stopping the slime monster from burping or increasing the number of possible background styles. Three said that there was nothing that they would change about the intervention experience.

In response to the question of whether the participants felt that the intervention program was helping them with their math facts, 100% of them stated that they felt it was. Every participant was able to give independent statements as to why they felt this way. Some reasons include:

- “It helps me get my subtraction and my addition faster so that I can get better at math.”
- “When you mess up, they let you do it again and again.”
- “First, when I was adding, I [added slowly] and I needed to count and now I don’t. Now, how FASTT Math is helping me, I am learning faster.”

- “Sometimes I get problems wrong and I am too slow for them and this helps me get faster and get them more right.”
- “I keep getting faster and faster with my math facts.”

In fact, when one participant was asked what they would like to share with others about this program, they independently responded with, “I would keep recommending it and I would say that it is a great program.”

Though the classroom as a whole was not surveyed, it is worth noting that, upon completion of the program, participants requested that the researcher purchase an extension on the licenses for the FASTT Math program so that they could continue the intervention until the end of the school year. Multiple participants asked if the researcher could help them download the app to their personal mobile devices so that they could access the FASTT Math program outside of school. One participant made numerous requests to get onto the program for additional time at recess because they enjoyed the games so much. Another requested paper to make flash cards to practice their fact fluency at home and improve their FASTT Math scores.

Student Survey Summary

The participants showed an overwhelming interest in the intervention program. The second research question was: Is there a relationship between independent digital-based interventions for basic addition and subtraction facts and a change in the perception of the student’s own skills? Every participant surveyed felt that they were making growth in math fact fluency and that it was due to the independent digital-based interventions. The participants showed enthusiasm for the program and were excited about the perceived effect it had on their learning. This perception was bolstered by the FASTT Math program showing them their growth

on a daily basis. Overall, the participants' views of their own growth matched the data, showing gains in all areas for the class as a whole.

The current chapter provided a detailed summary of the data collected for this study. The following chapter will examine the conclusions that can be made based upon this data.

Chapter 5: Conclusions

Whole Group Findings

The data from this research has been impressive. The initial hope was that this type of game-based, digital intervention would prove successful for at least half of the students that were participating. Any educator will tell you that an intervention is never expected to work on every student every time. There are too many variables in a classroom for that kind of outcome. But, within this research group, 100% of the participants showed growth in more than one tested area. That is incredible to hear as a teacher.

Compared to the studies cited in the literature review, this intervention program was more successful. This program produced more dramatic results than studies completed in areas of students with none of the mitigating circumstances presented with this research group. The participants are all minorities from an urban area, all living in an economically disadvantaged area, many with English language acquisition needs, some with learning support needs, with more than half functioning below grade level in mathematics, and all of them showed improvement. The results of this study proved consistent with the majority of the data out there. Digital interventions not only work, but they will work with equal or greater effectiveness on students who have special needs.

Even more impressive were the responses that the participants gave on the surveys regarding interventions. All surveyed participants were pleased with the interventions and expressed feelings of success when involved. They were able to articulate how the interventions were helping them with their math facts and asked for the interventions to continue after the study was complete. For students to be excited about learning basic math facts and asking for more time to work on their skills is incredible for any teacher to hear.

Subgroup Findings

By far, the most impressive growth was made by the participants that were functioning at less than one year below grade level. They made the most growth in every tested category. This could possibly be attributed to the participants working deeply in their zone of proximal development, being given the most room to grow and, therefore, showing the best performance. With this kind of a result, it is safe to say that these types of digital interventions are an incredibly successful tool for students that are slightly behind and need a targeted boost to catch up.

The participants that have been on or above grade level also benefited greatly from these interventions, but in a different way. In each tested area, this subgroup made progress, but the greater impact was in how many moved into an area of mastery. As the top performing participants from the start, they did not have as much room to grow. Many started at lower levels of mastery or very close. While this group did not show the rate of growth that the below level students did, the interventions proved to bring these participants well into mastery of both mathematical fluency and automaticity, showing that these types of apps can be very successful to close a gap in on-level students and to push them higher.

The participants that were performing at more than a year below grade level were the group that had the most challenges in front of them and, therefore, the least likely to show any growth. Within this group were two language learners, a student with refugee status, a student with significant motivational and behavioral issues that is often not willing to participate in school activities, and a student that speaks nothing but Spanish in the home and, therefore, is not able to receive much academic support from their family in the language spoken in the school. This was also the smallest of the three leveled groups with only four students making up the set.

It would be reasonable to see no growth or even a net loss of skill given the trials that face these children. However, this group also showed growth in every tested area, though it was lower than the other two groups. The impact of this finding is incredible. To know that students with these types of needs can be helped through digital interventions with steady success is unbelievable to the average teacher.

The groups of English Language Learners were included in the leveled groups but also examined on their own. This set included one participant that was less than a year below grade level and two that were more than a year below grade level. One of the greatest benefits of digital intervention apps is that they can read aloud and even translate for students that are not native English speakers and this proved impactful in this study. All three ELL students showed growth though none of them are able to read English on a native level. Because all instructions were read aloud, this did not interfere with the participants' ability to achieve success within this intervention period.

The participant that showed the least growth was the only student with identified learning support needs in mathematics, though they still showed growth. While the student has an IEP for mathematical instruction, there were other factors that hampered them. The participant has documented motivational and behavioral issues, often refusing to participate in classroom activities. They are pulled out of class daily for learning support services and therefore missed multiple progress monitoring sessions that they could not make up. Even so, they still showed growth in every tested area.

This study set out to answer two basic research questions.

Question one: Is there a relationship between independent digital-based interventions and an improvement in student fact fluency in basic addition and subtraction? The data points

overwhelmingly towards yes. The participants showed tremendous amounts of growth and the only presentation of the materials being tested were through the digital interventions. Addition and subtraction skills are not covered in the classroom in either whole-group or small-group instruction. All of the growth and mastery was a direct result of the digital interventions presented to the students.

Question two: Is there a relationship between independent digital-based interventions for basic addition and subtraction facts and a change in the perception of the student's own skills? Again, the data points overpoweringly to yes. The class as a whole loved the FASTT Math program. All of the surveyed participants stated that they felt themselves improving in their math skills and that they believed it to be a result of the digital interventions being provided. The participants were interested in the intervention games and were independently motivated to participate and succeed in the program. Not only that, they want to continue with the program after the research was complete. Students that are excited to learn are a boon to any classroom and this digital intervention created an entire classroom of them.

Limitations

There were some limitations to this study, the most impactful being the difficulty in assessing the true needs of the population being researched. While the students home language and free-lunch status are easy to find, there are no demographics on how many have support at home with academic work, what kind of access they each have to technology away from school, or even how many of them currently have a permanent home. There is an estimated rate of 10% of the population qualifying as transient homeless in the research district, living with friends and family members or in shelter situations. Through personal interactions and anecdotal evidence, the researcher has found that many families that are displaced from their homes in the research

district will hide this information from the school, choosing to maintain the illusion that they are still living in their former residence. Given this tendency of families to hide homeless status, there is no way to get accurate numbers for this population. The participants included at least one student that was known to be living in a homeless shelter at the time of the research, but there could be more.

Another significant limitation was the frequent absenteeism of some participants. Multiple students in the group were absent at least once every other week and many more were frequently pulled from class for learning support, language support, testing, band lessons, and other activities. It was not feasible to have make up sessions for every participant every time, so there are multiple participants that missed some interventions and some progress monitoring assessments. All of the participants received the pre- and post-tests.

Finally, because this group is so specialized, it is hard to make generalizations based upon their data. With so many needs to meet, it is not likely that another classroom will have the same demographics present. However, it is likely that many classrooms will have at least one of the demographics present in the participant groupings. It is also easy to repeat this study with the same parameters to see if the results are repeatable with a different student set.

Implications

The results of this research are impactful to every teacher in the country. Digital, game-based interventions will allow teachers to meet a wide variety of mathematical needs at the same times. Programs like FASTT Math, that cater to each student's needs, will permit teachers to help every child in their room at the same time. Students can improve their math skills that are not taught within the classroom through only digital interventions. This research shows that digital interventions are at least as effective as a teacher at improving math fluency skills.

Digital interventions have also been shown to hold relevance to children. By participating in intervention programs like this, the students are given control and power over their own learning. These types of apps let the students monitor their growth and, in doing so, increase their positive attitudes and confidence in their own abilities. Because these types of interventions can be completed by students independently, they are easily accessible for Language Learners, students with IEPs, children with special needs, and even students that are out of school for extended periods of time and must complete their studies on their own at home or in facilities like hospitals. Though this type of research needs to be repeated to show reliability, it is an impressive foundation to any mathematical digital intervention program.

In the end, teachers and administrators can justify programs like these because they are able to meet the needs of a wide spectrum of students, all at the same time, and all within a short period of the classroom day. This makes these interventions are more efficient than a single classroom teacher. When used in conjunction with mathematics instruction from a teacher, a single person is able to meet both grade-level needs (through instruction) and foundational needs (through digital intervention) in the same class period.

Conclusion

Digital game-based interventions through iPad applications will help a wide variety of students to improve in mathematical fluency and overall numeracy. These types of interventions have been pushed as a potential boon to teachers and this research reaffirms the faith that has been put into these programs. These high-tech tools are proving to be worth the high price tags. They can help more students at one time than a teacher can service on their own and they meet a diverse variety of needs that are presented in classrooms today. As the technology grows and improves, so too will its ability to help the students. Teachers must remember that, as with any

intervention, students will always need the guidance and support of educators. Implementing digital interventions as a part of a mathematical curriculum will bolster any teacher and improve the quality of education for every student in the classroom.

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Consent to Participate in Educational Research

Title: Improving Math Fact Fluency Using Game-Based Digital Interventions
Principal Investigator: Shannon Luciani, Teacher, Downey School
Capstone Research Project Advisor: Dr. Elana Betts, Instructor, University of the Arts

Study Overview: I am very excited to invite you to take part in a study on using math games in class to increase math fact fluency. This study is a part of my graduate research on using iPad games as a fun way to have kids learn basic math facts. To help with this, I am asking for your permission to have your child participate in this research.

Procedures: In January, students will take a set of math facts tests to see how good they are with basic addition and subtraction. These tests are no longer than 3 minutes. From January until March, students will be able to play math fact games on iPads for 10 minutes every day. These games will focus on addition and subtraction only. Once a week, random student will be asked about their thoughts on the games and if they are helping. There will also be weekly Kahoot games to see student progress. At the end of the study, students will take the math facts tests again to show any growth from the math games.

Video/Photographs: Students may be photographed and/or video taped as a part of the study. This is to ensure that their answers to questions are recorded correctly and may be used in the presentation at the University of the Arts. These images and recordings will NOT be in any published paper. No student image will be linked to their scores.

Other people in this study: Mrs. Luciani's entire class is invited to take part in this study.

Benefits and Risks: The tests and scores used will NOT be a part of your child's grades. They will only be used for the research paper and not for any academic placement or evaluation at the school. The only purpose for this research is to evaluate the impact of these math games.

Rewards: No rewards will be provided to participate in this research.

Confidentiality: Your child's results and responses will be anonymous. The research will use random numbers for each child, no names will be used. Some people other than the researcher may have access to study paperwork in order to ensure proper study conduct. No names will be included on this paperwork, only the random student number.

Voluntary Participation: Your participation in this research is voluntary. You can change your mind at any time. Simply contact Mrs. Luciani if you want to stop your child's participation in this study.

Contact Information: Please contact Shannon Luciani at sluciani@hbgsd.us, 717-703-1240, or through the Remind texting program if you have questions or concerns about the research. You may also contact Dr. Elana Betts at EBetts@UArts.edu, 484-888-9326.

Parent/Guardian Permission: Please indicate below if you provide permission for your child to participate in this educational research. A copy of this form will be provided upon request.

- ☐ I grant permission for my child to participate in in this education research.
- ☐ I DO NOT grant permission for my child to participate in this educational research.

_____ _____ _____
Print Parent's Full Name Parent's Signature Date

Student Permission: Please sign below if you are willing to participate in this educational research. Please keep in mind that this will not affect your grade in this course. A copy of this form will be provided upon request.

I, _____, am willing to participate in this education research.
Print Student's Full Name

_____ _____
Student's Signature Date

Consentimiento para participar en investigación educativa

Título: Mejorando la fluidez de hechos matemáticos usando intervenciones digitales basadas en juegos
Investigador Principal: Shannon Luciani, Maestra, Escuela Downey
Asesora de proyectos de investigación Capstone: Dra. Elana Betts, instructora de la Universidad de las Artes

Descripción general del studio: Estoy muy emocionado de invitarlo a participar en un estudio sobre el uso de los juegos de matemáticas en clase para aumentar la fluidez de los hechos matemáticos. Este estudio es parte de mi investigación de posgrado sobre el uso de juegos iPad como una forma divertida de que los niños aprendan datos básicos de matemáticas. Para ayudar con esto, estoy solicitando su permiso para que su hijo participe en esta investigación.

Procedimientos: En enero, los estudiantes tomarán un conjunto de pruebas de matemáticas para ver qué tan buenos son con la suma y resta básica. Estas pruebas no duran más de 3 minutos. Desde enero hasta marzo, los estudiantes podrán jugar juegos matemáticos de hechos en iPads durante 10 minutos todos los días. Estos juegos se enfocarán solo en la suma y la resta. Una vez a la semana, se le preguntará a los estudiantes al azar sobre sus ideas sobre los juegos y si están ayudando. También habrá juegos semanales de Kahoot para ver el progreso del estudiante. Al final del estudio, los estudiantes volverán a tomar las pruebas de matemáticas para mostrar el crecimiento de los juegos de matemáticas.

Video / fotografías: los estudiantes pueden ser fotografiados y / o grabados en video como parte del estudio. Esto es para asegurar que sus respuestas a las preguntas se registren correctamente y puedan usarse en la presentación de la Universidad de las Artes. Estas imágenes y grabaciones NO estarán en ningún documento publicado. No se vinculará ninguna imagen de estudiante con sus puntajes.

Otras personas en este estudio: toda la clase de la Sra. Luciani está invitada a participar en este estudio.

Beneficios y riesgos: las pruebas y los puntajes utilizados NO serán parte de las calificaciones de su hijo. Solo se usarán para el trabajo de investigación y no para ninguna ubicación académica o evaluación en la escuela. El único propósito de esta investigación es evaluar el impacto de estos juegos de matemáticas.

Recompensas: no se proporcionarán recompensas para participar en esta investigación.

Confidencialidad: los resultados y las respuestas de su hijo serán anónimos. La investigación utilizará números aleatorios para cada niño, no se usarán nombres. Algunas personas que no sean el investigador pueden tener acceso a la documentación del estudio para garantizar una conducta de estudio adecuada. No se incluirán nombres en esta documentación, solo el número de estudiante al azar.

Participación voluntaria: su participación en esta investigación es voluntaria. Puedes cambiar de opinión en cualquier momento. Simplemente póngase en contacto con la Sra. Luciani si desea detener la participación de su hijo en este estudio.

Información de contacto: comuníquese con Shannon Luciani en sluciani@hbgsd.us, 717-703-1240, o mediante el programa de mensajes de texto Recordar si tiene preguntas o inquietudes sobre la investigación. También puede comunicarse con la Dra. Elana Betts en EBetts@UArts.edu, 484-888-9326.

Permiso de padre / tutor: Indique a continuación si proporciona permiso para que su hijo participe en esta investigación educativa. Se proporcionará una copia de este formulario a pedido.

- ☐ Otorgo permiso para que mi hijo participe en esta investigación educativa.
- ☐ No concedo permiso para que mi hijo participe en esta investigación educativa.

_____	_____	_____
Imprima el nombre completo del padre	Firma del padre	Fecha

Permiso del estudiante: Por favor firme abajo si está dispuesto a participar en esta investigación educativa. Tenga en cuenta que esto no afectará su calificación en este curso. Se proporcionará una copia de este formulario a pedido.

Yo, _____, estoy dispuesto a participar en esta investigación educativa.
Imprimir el nombre completo del estudiante

_____	_____
Firma del estudiante	Fecha

2/26/18

Dear Parents and Guardians,

This spring, I am planning to complete my Master's degree and I need your help. I am asking all of the students in my class to participate in some research. Basically, I am going to have the class play math games and see how much it improves their math skills. The attached form that explains the entire process.

If you are willing to have your child participate, please sign the attached document and return it to me by no later than 2/28/18.

Sincerely,

Mrs. Shannon Luciani
4th Grade Teacher
Downey School
sluciani@hbgsd.us
717-703-1240

2/26/18

Queridos padres y guardianes,

Esta primavera, planeo completar mi maestría y necesito tu ayuda. Les pido a todos los estudiantes de mi clase que participen en algunas investigaciones. Básicamente, voy a tener los juegos matemáticos de la clase y ver cuánto mejora sus habilidades matemáticas. El formulario adjunto que explica todo el proceso.

Si desea que su hijo participe, firme el documento adjunto y devuélvamelo antes del 2/28/18. Por favor, póngase en contacto conmigo con cualquier pregunta. Gracias.

Sinceramente,

Sra. Shannon Luciani
Maestro de 4to Grado
Escuela Downey
sluciani@hbgsd.us
717-703-1240

Name : _____ Score : 64

Teacher : _____ Date : _____

3 Minute Drill

7 + 9	7 + 13	6 + 1	10 + 20	4 + 7	14 + 18
3 + 0	20 + 3	11 + 18	19 + 6	17 + 6	3 + 0
16 + 19	9 + 1	19 + 1	0 + 6	17 + 11	8 + 2
8 + 4	20 + 17	11 + 9	1 + 10	18 + 5	15 + 18
4 + 16	6 + 12	10 + 13	1 + 7	19 + 2	2 + 14
14 + 14	3 + 8	12 + 15	1 + 15	2 + 10	11 + 20
12 + 17	13 + 5	18 + 0	15 + 2	17 + 3	6 + 16
12 + 3	5 + 14	9 + 11	0 + 13	2 + 8	15 + 12
14 + 7	18 + 4	10 + 4	7 + 19	16 + 15	8 + 19
5 + 12	5 + 17	4 + 9	20 + 20	16 + 11	13 + 16

Name : _____ Score : 65

Teacher : _____ Date : _____

7 + 9 = 16	7 + 13 = 20	6 + 1 = 7	10 + 20 = 30	4 + 7 = 11	14 + 18 = 32
3 + 0 = 3	20 + 3 = 23	11 + 18 = 29	19 + 6 = 25	17 + 6 = 23	3 + 0 = 3
16 + 19 = 35	9 + 1 = 10	19 + 1 = 20	0 + 6 = 6	17 + 11 = 28	8 + 2 = 10
8 + 4 = 12	20 + 17 = 37	11 + 9 = 20	1 + 10 = 11	18 + 5 = 23	15 + 18 = 33
4 + 16 = 20	6 + 12 = 18	10 + 13 = 23	1 + 7 = 8	19 + 2 = 21	2 + 14 = 16
14 + 14 = 28	3 + 8 = 11	12 + 15 = 27	1 + 15 = 16	2 + 10 = 12	11 + 20 = 31
12 + 17 = 29	13 + 5 = 18	18 + 0 = 18	15 + 2 = 17	17 + 3 = 20	6 + 16 = 22
12 + 3 = 15	5 + 14 = 19	9 + 11 = 20	0 + 13 = 13	2 + 8 = 10	15 + 12 = 27
14 + 7 = 21	18 + 4 = 22	10 + 4 = 14	7 + 19 = 26	16 + 15 = 31	8 + 19 = 27
5 + 12 = 17	5 + 17 = 22	4 + 9 = 13	20 + 20 = 40	16 + 11 = 27	13 + 16 = 29

Name : _____ Score : 66

Teacher : _____ Date : _____

3 Minute Drill

18 + 6	18 + 14	19 + 1	15 + 3	4 + 16	11 + 5
16 + 17	19 + 11	13 + 14	3 + 19	19 + 18	17 + 3
9 + 3	4 + 13	14 + 1	15 + 8	9 + 8	12 + 2
11 + 4	2 + 18	12 + 9	1 + 15	0 + 1	17 + 19
6 + 7	0 + 17	8 + 17	16 + 7	3 + 13	12 + 20
5 + 10	14 + 14	20 + 15	1 + 10	7 + 5	5 + 2
1 + 8	17 + 12	2 + 10	4 + 0	6 + 9	9 + 9
13 + 11	18 + 15	10 + 0	16 + 12	5 + 11	3 + 0
8 + 2	8 + 5	14 + 19	0 + 20	11 + 18	10 + 4
2 + 12	6 + 7	7 + 16	20 + 20	20 + 13	15 + 6

Name : _____ Score : 67

Teacher : _____ Date : _____

18 + 6 = 24	18 + 14 = 32	19 + 1 = 20	15 + 3 = 18	4 + 16 = 20	11 + 5 = 16
16 + 17 = 33	19 + 11 = 30	13 + 14 = 27	3 + 19 = 22	19 + 18 = 37	17 + 3 = 20
9 + 3 = 12	4 + 13 = 17	14 + 1 = 15	15 + 8 = 23	9 + 8 = 17	12 + 2 = 14
11 + 4 = 15	2 + 18 = 20	12 + 9 = 21	1 + 15 = 16	0 + 1 = 1	17 + 19 = 36
6 + 7 = 13	0 + 17 = 17	8 + 17 = 25	16 + 7 = 23	3 + 13 = 16	12 + 20 = 32
5 + 10 = 15	14 + 14 = 28	20 + 15 = 35	1 + 10 = 11	7 + 5 = 12	5 + 2 = 7
1 + 8 = 9	17 + 12 = 29	2 + 10 = 12	4 + 0 = 4	6 + 9 = 15	9 + 9 = 18
13 + 11 = 24	18 + 15 = 33	10 + 0 = 10	16 + 12 = 28	5 + 11 = 16	3 + 0 = 3
8 + 2 = 10	8 + 5 = 13	14 + 19 = 33	0 + 20 = 20	11 + 18 = 29	10 + 4 = 14
2 + 12 = 14	6 + 7 = 13	7 + 16 = 23	20 + 20 = 40	20 + 13 = 33	15 + 6 = 21

Name : _____ Score : 68

Teacher : _____ Date : _____

3 Minute Drill

3 + 9	0 + 1	10 + 6	20 + 15	2 + 6	18 + 7
1 + 11	3 + 12	2 + 2	0 + 5	15 + 15	16 + 11
6 + 18	7 + 9	4 + 1	8 + 0	15 + 2	9 + 20
13 + 12	0 + 2	19 + 13	17 + 4	8 + 16	16 + 5
10 + 19	10 + 5	6 + 17	1 + 17	19 + 8	16 + 14
12 + 7	14 + 4	12 + 3	5 + 6	14 + 18	5 + 19
3 + 15	18 + 14	11 + 10	20 + 17	7 + 13	9 + 20
4 + 12	12 + 13	13 + 14	9 + 8	19 + 16	18 + 3
5 + 8	15 + 20	8 + 0	11 + 3	13 + 1	14 + 11
1 + 10	4 + 7	6 + 16	17 + 4	11 + 9	20 + 10

Name : _____ Score : 69

Teacher : _____ Date : _____

3 + 9 = 12	0 + 1 = 1	10 + 6 = 16	20 + 15 = 35	2 + 6 = 8	18 + 7 = 25
1 + 11 = 12	3 + 12 = 15	2 + 2 = 4	0 + 5 = 5	15 + 15 = 30	16 + 11 = 27
6 + 18 = 24	7 + 9 = 16	4 + 1 = 5	8 + 0 = 8	15 + 2 = 17	9 + 20 = 29
13 + 12 = 25	0 + 2 = 2	19 + 13 = 32	17 + 4 = 21	8 + 16 = 24	16 + 5 = 21
10 + 19 = 29	10 + 5 = 15	6 + 17 = 23	1 + 17 = 18	19 + 8 = 27	16 + 14 = 30
12 + 7 = 19	14 + 4 = 18	12 + 3 = 15	5 + 6 = 11	14 + 18 = 32	5 + 19 = 24
3 + 15 = 18	18 + 14 = 32	11 + 10 = 21	20 + 17 = 37	7 + 13 = 20	9 + 20 = 29
4 + 12 = 16	12 + 13 = 25	13 + 14 = 27	9 + 8 = 17	19 + 16 = 35	18 + 3 = 21
5 + 8 = 13	15 + 20 = 35	8 + 0 = 8	11 + 3 = 14	13 + 1 = 14	14 + 11 = 25
1 + 10 = 11	4 + 7 = 11	6 + 16 = 22	17 + 4 = 21	11 + 9 = 20	20 + 10 = 30

Name : _____ Score : _____ 70

Teacher : _____ Date : _____

3 Minute Drill

20 - 12	25 - 15	18 - 17	10 - 3	11 - 10	11 - 3
23 - 15	11 - 2	27 - 9	10 - 9	16 - 1	14 - 3
25 - 17	12 - 6	16 - 1	17 - 16	21 - 9	13 - 7
12 - 0	22 - 17	26 - 19	11 - 7	12 - 7	12 - 2
5 - 4	26 - 7	6 - 3	22 - 0	22 - 4	13 - 10
21 - 5	21 - 15	18 - 15	20 - 3	3 - 2	23 - 14
15 - 1	14 - 0	19 - 5	20 - 9	27 - 14	19 - 19
5 - 2	7 - 4	20 - 4	13 - 7	8 - 2	16 - 13
5 - 4	24 - 11	17 - 6	10 - 5	17 - 13	15 - 8
6 - 0	6 - 1	9 - 1	16 - 8	8 - 0	19 - 12

Name : _____ Score : _____ 71

Teacher : _____ Date : _____

3 Minute Drill

20 - 12 = 8	25 - 15 = 10	18 - 17 = 1	10 - 3 = 7	11 - 10 = 1	11 - 3 = 8
23 - 15 = 8	11 - 2 = 9	27 - 9 = 18	10 - 9 = 1	16 - 1 = 15	14 - 3 = 11
25 - 17 = 8	12 - 6 = 6	16 - 1 = 15	17 - 16 = 1	21 - 9 = 12	13 - 7 = 6
12 - 0 = 12	22 - 17 = 5	26 - 19 = 7	11 - 7 = 4	12 - 7 = 5	12 - 2 = 10
5 - 4 = 1	26 - 7 = 19	6 - 3 = 3	22 - 0 = 22	22 - 4 = 18	13 - 10 = 3
21 - 5 = 16	21 - 15 = 6	18 - 15 = 3	20 - 3 = 17	3 - 2 = 1	23 - 14 = 9
15 - 1 = 14	14 - 0 = 14	19 - 5 = 14	20 - 9 = 11	27 - 14 = 13	19 - 19 = 0
5 - 2 = 3	7 - 4 = 3	20 - 4 = 16	13 - 7 = 6	8 - 2 = 6	16 - 13 = 3
5 - 4 = 1	24 - 11 = 13	17 - 6 = 11	10 - 5 = 5	17 - 13 = 4	15 - 8 = 7
6 - 0 = 6	6 - 1 = 5	9 - 1 = 8	16 - 8 = 8	8 - 0 = 8	19 - 12 = 7

Name : _____ Score : _____ 72

Teacher : _____ Date : _____

3 Minute Drill

19 - 13	17 - 1	15 - 9	19 - 13	16 - 11	14 - 11
20 - 8	25 - 6	18 - 4	2 - 2	13 - 0	17 - 14
19 - 9	7 - 0	20 - 2	11 - 5	22 - 18	20 - 17
19 - 9	19 - 18	24 - 14	19 - 4	13 - 2	18 - 12
3 - 3	23 - 5	11 - 3	21 - 2	27 - 10	14 - 14
17 - 15	27 - 20	24 - 1	3 - 1	7 - 0	9 - 4
22 - 14	25 - 12	24 - 16	11 - 1	21 - 12	23 - 11
17 - 8	12 - 1	16 - 15	10 - 6	7 - 7	16 - 1
23 - 4	26 - 9	17 - 6	7 - 0	27 - 15	13 - 4
22 - 3	13 - 0	26 - 10	10 - 5	15 - 5	8 - 5

Name : _____ Score : _____ 73

Teacher : _____ Date : _____

3 Minute Drill

19 - 13 = 6	17 - 1 = 16	15 - 9 = 6	19 - 13 = 6	16 - 11 = 5	14 - 11 = 3
20 - 8 = 12	25 - 6 = 19	18 - 4 = 14	2 - 2 = 0	13 - 0 = 13	17 - 14 = 3
19 - 9 = 10	7 - 0 = 7	20 - 2 = 18	11 - 5 = 6	22 - 18 = 4	20 - 17 = 3
19 - 9 = 10	19 - 18 = 1	24 - 14 = 10	19 - 4 = 15	13 - 2 = 11	18 - 12 = 6
3 - 3 = 0	23 - 5 = 18	11 - 3 = 8	21 - 2 = 19	27 - 10 = 17	14 - 14 = 0
17 - 15 = 2	27 - 20 = 7	24 - 1 = 23	3 - 1 = 2	7 - 0 = 7	9 - 4 = 5
22 - 14 = 8	25 - 12 = 13	24 - 16 = 8	11 - 1 = 10	21 - 12 = 9	23 - 11 = 12
17 - 8 = 9	12 - 1 = 11	16 - 15 = 1	10 - 6 = 4	7 - 7 = 0	16 - 1 = 15
23 - 4 = 19	26 - 9 = 17	17 - 6 = 11	7 - 0 = 7	27 - 15 = 12	13 - 4 = 9
22 - 3 = 19	13 - 0 = 13	26 - 10 = 16	10 - 5 = 5	15 - 5 = 10	8 - 5 = 3

Name : _____ Score : _____ 74

Teacher : _____ Date : _____

3 Minute Drill

4 - 0	26 - 16	15 - 3	26 - 17	18 - 12	13 - 10
23 - 5	17 - 12	19 - 0	27 - 10	24 - 10	9 - 0
24 - 20	19 - 11	25 - 5	3 - 3	16 - 15	20 - 1
25 - 19	20 - 8	11 - 8	9 - 4	21 - 6	17 - 7
19 - 13	9 - 9	21 - 7	2 - 2	7 - 2	0 - 0
15 - 5	4 - 0	27 - 6	6 - 2	9 - 6	16 - 5
19 - 14	16 - 13	12 - 1	23 - 20	25 - 17	7 - 4
24 - 12	26 - 18	14 - 8	12 - 5	6 - 4	10 - 8
22 - 18	17 - 13	16 - 11	13 - 9	18 - 1	14 - 2
15 - 6	7 - 3	18 - 15	19 - 17	10 - 8	23 - 20

Name : _____ Score : _____ 75

Teacher : _____ Date : _____

3 Minute Drill

4 - 0 = 4	26 - 16 = 10	15 - 3 = 12	26 - 17 = 9	18 - 12 = 6	13 - 10 = 3
23 - 5 = 18	17 - 12 = 5	19 - 0 = 19	27 - 10 = 17	24 - 10 = 14	9 - 0 = 9
24 - 20 = 4	19 - 11 = 8	25 - 5 = 20	3 - 3 = 0	16 - 15 = 1	20 - 1 = 19
25 - 19 = 6	20 - 8 = 12	11 - 8 = 3	9 - 4 = 5	21 - 6 = 15	17 - 7 = 10
19 - 13 = 6	9 - 9 = 0	21 - 7 = 14	2 - 2 = 0	7 - 2 = 5	0 - 0 = 0
15 - 5 = 10	4 - 0 = 4	27 - 6 = 21	6 - 2 = 4	9 - 6 = 3	16 - 5 = 11
19 - 14 = 5	16 - 13 = 3	12 - 1 = 11	23 - 20 = 3	25 - 17 = 8	7 - 4 = 3
24 - 12 = 12	26 - 18 = 8	14 - 8 = 6	12 - 5 = 7	6 - 4 = 2	10 - 8 = 2
22 - 18 = 4	17 - 13 = 4	16 - 11 = 5	13 - 9 = 4	18 - 1 = 17	14 - 2 = 12
15 - 6 = 9	7 - 3 = 4	18 - 15 = 3	19 - 17 = 2	10 - 8 = 2	23 - 20 = 3

Addition Facts Quiz

YOU WILL HAVE ONLY **4 SECONDS** FOR EACH QUESTION.

PENCILS READY…GOOD LUCK!

Addition Facts Quiz

YOU WILL HAVE ONLY **4 SECONDS** FOR EACH QUESTION.

PENCILS READY…GOOD LUCK!

10 + 12 =

8 + 20 =

1 + 2 =

16 + 19 =

$$2 + 9 =$$

7 + 6 =

13 + 0 =

9 + 4=

12 + 6 =

$$0 + 5 =$$

11 + 13 =

$$7 + 7 =$$

14 + 6 =

20 + 4 =

6 + 9 =

17 + 1 =

5 + 3 =

14 + 8 =

$$6 + 8 =$$

10 + 9 =

Subtraction Facts Quiz

YOU WILL HAVE ONLY **4 SECONDS** FOR EACH QUESTION.

PENCILS READY…GOOD LUCK!

Subtraction Facts Quiz

YOU WILL HAVE ONLY **4 SECONDS** FOR EACH QUESTION.

PENCILS READY…GOOD LUCK!

10 – 10 =

$$9 - 3 =$$

$$4 - 2 =$$

$$18 - 12 =$$

6 − 1 =

27 – 0 =

$$15 - 11 =$$

13 – 6 =

$$8 - 2 =$$

$$24 - 2 =$$

$$20 - 18 =$$

5 − 3 =

25 – 9 =

$$4 - 0 =$$

$$20 - 11 =$$

$$11 - 2 =$$

16 – 7 =

$$7 - 6 =$$

14 – 13 =

$$1 - 0 =$$

Kahoot Addition Progress Monitoring Questions

Addition Progress Monitoring 1

Q1	5+6=	Q2	10+10=	Q3	10+6=	Q4	9+9=	Q5	8+9=
Q6	8+7=	Q7	5+7=	Q8	6+6=	Q9	9+6=	Q10	5+4=
Q11	3+5=	Q12	9+3=	Q13	12+2=	Q14	13+5=	Q15	20+5=

Addition Progress Monitoring 2

Q1	8+2=	Q2	12+4	Q3	9+8=	Q4	5+11=	Q5	13+7=
Q6	15+0=	Q7	16+1=	Q8	8+6=	Q9	7+8=	Q10	7+3=
Q11	12+5=	Q12	14+19=	Q13	9+3=	Q14	7+15=	Q15	14+9=

Addition Progress Monitoring 3

Q1	5 + 5 =	Q2	9 + 7 =	Q3	9 + 5 =	Q4	3 + 7 =	Q5	10 + 8 =
Q6	25 + 7 =	Q7	6 + 4 =	Q8	2 + 8 =	Q9	13 + 7 =	Q10	9 + 2 =
Q11	9 + 9 =	Q12	9 + 8 =	Q13	12 + 12 =	Q14	14 + 14 =	Q15	15 + 15 =

Addition Progress Monitoring 4

Q1	12+5=	Q2	8+2=	Q3	7+5=	Q4	9+5=	Q5	7+9=
Q6	9+9=	Q7	9+6=	Q8	7+6=	Q9	13+5=	Q10	12+7=
Q11	7+4=	Q12	15+3=	Q13	9 + 12 =	Q14	7+11=	Q15	8 + 5 =

Kahoot Subtraction Progress Monitoring Questions

Subtraction Progress Monitoring 1

Q1	9 - 4 =	Q2	4 - 3 =	Q3	6 - 3 =	Q4	10 - 3 =	Q5	12 - 6 =
Q6	15 - 5 =	Q7	11 - 4 =	Q8	3 - 0 =	Q9	6 - 2 =	Q10	5 - 5 =
Q11	8 - 4 =	Q12	5 - 3 =	Q13	7 - 2 =	Q14	15 - 6 =	Q15	21 - 14 =

Subtraction Progress Monitoring 2

Q1	2 - 0 =	Q2	17 - 1 =	Q3	9 - 1 =	Q4	11 - 3 =	Q5	10 - 2 =
Q6	12 - 7 =	Q7	15 - 8 =	Q8	26 - 2 =	Q9	22 - 8 =	Q10	25 - 10 =
Q11	10 - 6 =	Q12	12 - 11 =	Q13	9 - 4 =	Q14	16 - 3 =	Q15	18 - 5 =

Subtraction Progress Monitoring 3

Q1	26 - 6 =	Q2	23 - 9 =	Q3	21 - 4 =	Q4	21 - 6 =	Q5	9 - 5 =
Q6	10 - 4 =	Q7	14 - 7 =	Q8	16 - 8 =	Q9	9 - 3 =	Q10	8 - 5 =
Q11	5 - 2 =	Q12	12 - 7 =	Q13	13 - 8 =	Q14	23 - 19 =	Q15	14 - 2 =

Subtraction Progress Monitoring 4

Q1	6 - 5 =	Q2	10 - 7 =	Q3	15 - 8 =	Q4	11 - 6 =	Q5	8 - 8 =
Q6	9 - 3 =	Q7	7 - 2 =	Q8	5 - 2 =	Q9	14 - 7 =	Q10	7 - 2 =
Q11	5 - 0 =	Q12	6 - 3 =	Q13	7 - 4 =	Q14	8 - 7 =	Q15	10 - 5 =