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The effects of iPad applications as an instructional tool for mathematical achievement and motivation

Anne E. Zabel

The Effects of iPad Applications as an Instructional Tool for Mathematical Achievement and Motivation

By

Anne E. Zabel

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Marian Graeven Peter, Ed.D.

Dr. Marian Graeven Peter

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ABSTRACT

The purpose of this research and intervention was to determine if the use of iPad technology during mathematical instruction would increase student achievement and motivation. During the five-week intervention, the participant was taught strategies for solving double and triple digit addition and subtraction equations. Those strategies were paired with the use of iPad technology. By the end of the five-week intensive intervention, the participant made large gains on the post-test as well as maintaining more consistent scores on the progress monitoring probes throughout the length of the study. Furthermore, the participant's motivation and excitement of learning mathematics also increased by the end of this five-week study. Increasing the intensity of the intervention, adding engaging iPad technology and providing immediate feedback were some of the strengths of this study. Some of the limitations were providing a clear understanding of the Math Attitudes Survey to the participant as well as only working with one student in the study. Some of the recommendations made for classroom teachers in general from this study were coupling traditional mathematic instruction with specific technology and giving students a second chance to answer problems that were solved incorrectly the first time. Some of the recommendations made for teachers working with the participant specific to this study included allowing the student to use his own dry/erase whiteboard to solve problems, encouraging him to pay careful attention to the problems instead of focusing on how fast he can work, providing immediate feedback for the student and working to build a good relationship with him so he feels supported and confident with his work.

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CHAPTER ONE

INTRODUCTION

This case study aims to increase academic achievement and motivation in the subject of mathematics through the use of technology. Developing a strong fundamental understanding of numbers and math is critical for students to reach a level of proficiency in their later years. Fluency of basic facts in mathematics is essential for mastering higher level thinking skills (Smith, March-Martella and Martella, 2011). Mathematic instruction that is engaging is a sure way to help student achievement levels rise. The research by Singer (2015) found that the use of iPads during math instruction enhanced learning for the children who were unmotivated and for the children who did not normally put forth much effort.

In the following thesis, there are five chapters. The chapters include an introduction to the study, a review of literature, procedures and methodology for the study, results and conclusions. The first section of this thesis provides an introduction of the participant in this case study. The next section describes how the law mandates that students must be educated in the least restrictive environment. The third section discusses connections this case study has to the Common Core State Standards.

Introduction to Child

The participant in this case study was one third grade African American boy at a public charter school in Milwaukee, Wisconsin. At the time of the intervention the participant was eight years and ten months old. The 2014-15 school year was the first year that the student attended the school in this case study. When he talked about his school experience before attending the current school he did not have positive feelings about school. He was constantly in trouble with his teacher. He and his brothers missed a lot of school. He was happy to be at his new school.

His attendance was good and overall he looked forward to coming to school and wanted to be there.

The participant wanted to please the teacher. When he felt as though he had disappointed the teacher or adult in charge he would shut down, refuse to do his work and pout. Sometimes he would leave the classroom or hide. The work in third grade was difficult for this student and he struggled a lot academically. Not being able to complete the same work as his peers led to lack of motivation and engagement. Many of his behavioral difficulties and lack of engagement were due to the work being difficult for him to complete. Prior to this study the researcher had been working with this student for five months and had built a relationship with him. This established relationship with the student helped the researcher cater to the needs of the child. The researcher found ways of talking to the child that were motivating and uplifting to him.

The participant was referred for the Response to Intervention (RtI) Program because he was performing at least one grade level below grade level in the subject of mathematics. The participant began the Response to Intervention program in November of the 2014-15 school year. Response to Intervention focuses on the early identification and support of students with learning and behavior needs. Students who do not achieve the desired level of progress during RtI are then referred for a comprehensive evaluation and considered for eligibility for special education. At the time of the case study, the participant did not have an Individual Education Plan (IEP).

The participant's instructional level was at the second grade level. Prior to this case study, I worked with this child two times a week for thirty minutes. We focused on basic addition and subtraction facts and skip counting. As the sessions progressed the focus shifted to double and triple digit addition and subtraction. While working with this student during the RtI sessions from November to January it came to my attention that the student struggled to stay on task and engaged in instruction that was taking place. He was very easily distracted and would wander to various areas in the classroom or begin talking about things that had nothing to do with what we were doing. The student also showed inconsistency in his comprehension of the mathematic material that was being focused on. Every week the student completed a progress monitoring probe and his scored fluctuated between 15 and 30 points out of 50. He lacked motivation and that was evident in the effort that he put into completing his assessments.

Connection to the Law

Although the participant in this case study did not have an Individualized Education Plan (IEP) and he was not in the Special Education program, he was involved in Response to Intervention (RtI) which is included in the Individuals with Disabilities Education Improvement Act of 2004 (IDEA 2004). RtI must be high quality, researched-based instruction in general education. RtI is used as a universal screening for academic and behavior problems. RtI must include continuous progress monitoring. RtI must consist of multiple tiers of progressively more intense instruction. Students who do not achieve the desired level of progress in response to the targeted interventions are then referred for a comprehensive evaluation and are considered for eligibility for special education services under IDEA. The participant in this study participated in a tier three intervention. Tier three is the most intensive, one-on-one intervention in the RtI model. The progress monitoring during RtI determined if the student would be referred for special education.

Connection to Common Core State Standards

The participant in this study received one on one RtI sessions in the subject of mathematics. He lacked the fundamental skills to add and subtract single digit numbers. Without the skills to add and subtract single digit numbers it is difficult for students to move on to adding and subtracting double and triple digit numbers. The Common Core State Standards (CCSS) emphasize the importance of building a solid foundation and understanding of numbers in the subject of mathematics. In second grade students should be able to fluently add and subtract within 20 using mental strategies. Students should also use addition and subtraction within 100 to solve problems. This study was designed so that the student would acquire the fluency with single digit numbers. Additionally, this study focused on understanding the concept of taking apart and putting together in order to build a solid foundation for the understanding of numbers when adding and subtracting double and triple digit numbers. Therefore, this study satisfies the Common Core State Standards at the second grade level.

Conclusion

The participant in this case study is a third grade student who struggles with math fluency. Math fluency of basic facts is fundamental to the progression of mathematical studies. If a student lacks the fundamental skills of adding and subtracting single digit numbers it is difficult to progress to more difficult levels of mathematics. Therefore, an individualized intervention was designed for the participant in this study and implemented over a five week period to increase his mathematical achievement and motivation. In the next chapter a review of literature will be discussed about the following areas; mathematical frameworks and strategies, motivation and engagement in mathematics, combining traditional math instruction with technology and Response to Intervention programs focused on mathematics. This review of literature will set the stage for the intervention that was implemented in this case study.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

Mathematics is a core subject taught in public schools in the United States. Developing a strong fundamental understanding of numbers and math is critical for students to reach a level of proficiency in their later years. Competence in mathematics is critical for schooling as well as daily activities, and employment later in life. The goal of mathematical competence is not being reached in the United States. Many schools have been focused on creating interventions for students to help improve the mathematical achievement level of our country as a whole. In order to design an effective intervention in math, a wealth of knowledge centered on raising student achievement and motivation is vital.

The purpose of this chapter is to examine effective ways of teaching mathematics to students who are significantly under the grade level norm in school. The literature reviewed in this chapter has been divided into four parts. The first section will explore math frameworks and strategies that other researchers have implemented to improve mathematic achievement in elementary aged students. Many of the interventions discussed in the first part of this chapter are centered on building mathematical fluency. The article by Smith, March-Martella, and Martella (2011) explains that fluency of basic facts is essential to master the higher level thinking skills in algebra and calculus. The second section of this chapter serves to determine ways to keep students focused and on task during the teaching of mathematics in school. Students who are functioning at a lower level than their peers often tend to give up more quickly when faced with challenging content. It is crucial to build motivating factors into interventions to keep those students engaged and moving forward. The third part of this chapter examines how technology can be used to keep students engaged and raise student achievement. The final part of this chapter will discuss effective intervention designs that can be implemented in Response to Intervention (RtI). Practitioners need to discover how to produce the most meaningful results for students and that often involves deciding how to change the intervention in order to help students reach their highest potential.

Section One: Math Frameworks/Strategies for at Risk Students

This first section of literature reviewed will examine frameworks used to teach mathematics to students who were in the lower 25% on a norm referenced assessment or were at least one year below grade level on curriculum based measures. These three research studies included samples of students who were both regular education and special education. Two out of three of the studies focused on building mathematic fluency while one of the studies focused on increasing the working memory capacity of students on mathematic word problems.

The study by Skarr, Zielinski, Ruwe, Sharp, Williams and McLaughlin (2014) aimed to determine whether or not a typical third grade boy and a fifth grade girl and boy with a learning disability could benefit from the combined use of Direct Instruction Flashcards and the Math Racetrack procedures to increase math fluency in an after school program.

The sample consisted of three participants. Participant 1 was an 8-year old, third grade boy. Participant 2 was a 10-year old, fifth grade girl. Both of these participants attended a private, parochial school in Spokane, WA, and were brother and sister. Participant 3 was an 11-year old, fifth grade boy at an urban public school in Spokane, WA. He had been diagnosed with a learning disability and received special education services since second grade in the areas of math, reading, writing and social behavior.

The researchers administered a pretest and a posttest in order to measure growth in the participants. The participants were given five minutes to complete 100 basic multiplication facts in mixed order as a pretest. At the end of the study the participants were given a similar posttest with 100 written multiplication facts and they were given five minutes to complete it.

The researchers used the pretest to establish a baseline from which to work with all three of the participants. They then presented the mastered facts using the Direct Instruction Flashcards and Math Racetrack procedure to familiarize participants with the procedures. Fifteen Direct Instruction Flashcards were presented to each child. Six to seven of the cards were target cards while the others were previously mastered facts based on their pretest. The student had to say the entire statement and answer correctly within two seconds. If this did not happen, the researcher modeled the statement and answer and the student had to repeat it back. The card was then put back into the pile two to three cards back so that it came up again quickly. The researcher continued to put that same card back two to three cards until the participant answered it correctly three times in a row. Then it was placed in the back of the pile and reviewed again minutes later to assess the retention of that fact. The researcher praised and encouraged each participant all the way through this process.

The Math Racetrack is a game board with 28 segments forming a racetrack. Each segment had a math fact written on them. Fourteen of the facts were mastered and five to seven segments had target facts on them. The child had to say the entire statement and answer correctly before moving to the next fact. The entire racetrack was timed and the child completed the racetrack two to three times every session. If the fact was answered incorrectly, the researcher modeled the correct statement and answer and the participant had to repeat it before moving on. When Set 1 of the facts was mastered, they moved on to Sets 2 and 3.

All of the participants showed immediate results and at the end of the study the mean number of correct answers increased greatly. Participant 1 increased from 2.5/7 to 6.8/7 in the first set of facts. In Set 2 he increased from 1.8 to 6.3 out of 7 and in Set 3 from 0.9 to 6.3 out of 7. Participant 2 also showed a lot of growth in all three sets. In Set 1, she went from 2/6 to 5.8/6, in Set 2 she increased from 0.6/6 to 3.8/6 and in Set 3 from 1.4/6 to 5/6. In Set 1 Participant 3 went from 0.7/7 to 6.5/7, Set 2 increased from 1.4/7 to 6.6/7 and in Set 3 he went from 1.3/7 to 6.4 out of 7. From the pretest to the posttest Participant 1 showed 141% growth, Participant 2 had 82% growth and Participant 3 had 63% growth.

Ultimately this study showed that skill and drill strategies do help build mastery with math fluency. The student's confidence levels also increased and they became excited about learning and mastering their multiplication facts.

The purpose of the second study in this section related to mathematical strategies for at risk students by Smith, March-Martella, and Martella (2011) was to examine the effects of the Rocket Math Program on the math fluency skills of a first grade student who was at risk for school failure. Rocket Math gives a sequence of learning facts that students' master. Twenty-six different worksheets, progressing from simple to more difficult, are provided consisting of four levels of addition, subtraction, multiplication, and division problems. The problems include already mastered problems and a new set. Students progress from one level to the next when their pre-determined fluency goal is reached. No published studies could be found assessing the effects of Rocket Math. The purpose of this study was to assess the effects of Rocket Math on a first grade student at-risk for school failure.

The sample consisted on one first grade boy. He attended a suburban elementary school in eastern Washington State. This child, John, was diagnosed with Attention Deficit, Hyperactivity Disorder and qualified for special education services under the category of Developmental Delay with social/adaptive deficits. He scored 62% on the Woodcock-Johnson III Assessment, placing him in the average range of basic intelligence. He was unable to focus on specific math tasks like story problems because he had a great deal of difficulty with math fact fluency.

The researchers used a Curriculum Based Measurement (CBM) pretest and posttest to measure growth over the course of the study. He was given a one minute, timed pretest to determine the rate per minute of single digit addition problems completed correctly. At the end of the study he was given a similar post test. Rocket Math Fluency Checks were administered every lesson. These Fluency Checks were also one minute timed assessments.

Rocket Math was administered over a four month period. After John took his one minute pretest, an individualized goal was determined. His goal was to get 26 problems correct. He kept track of his own progress with a progress monitoring sheet that he kept in his folder. Each time he passed a level he was able to color in a section of a rocket ship picture. Each level introduced two new addition problems. As he passed his goal for each level, he proceeded to the next. John began by putting his finger on the first problem and when he was told to begin he practiced as many problems as he could by whispering the answers aloud for one minute. Then, using the same problems, when he was told to begin he used a pencil to write as many correct answers as possible in one minute. Finally, they followed the same procedure using a new set of problems for one minute. At the conclusion of the process the student turned in his folder to the educator who scored the assignment. If there were consistently missed problems, the student was given additional opportunities to practice before the next fluency checks. When John reached his goal, the test was replaced with the next level sheet. If the student did not reach his goal, the same sheet was given. John completed 13 of the 26 levels of the Rocket Math Program.

The Curriculum Based Measure (CBM) showed that John increased his rate of problems correctly completed per minute from 10 on the pretest using a number line to 21 on the posttest without using the number line. Twenty-one is considered mastery. The Rocket Math Fluency Check scores improved as well. He began at Level A and completed 19 problems correctly in one minute. John ended at Level M and completed 26 problems correctly in one minute. On average, John took 2.6 times on each level before he met mastery to continue to the next level. As well as showing growth with math fluency, John remained on task for the entirety of the lesson. He was excited about his growth and he took pride and ownership in the process. The engaging design, along with the ability for John to track his progress, made Rocket Math a successful program in this study.

The purpose of the third research study in this section by Swanson, Moran, Lussier and Fung (2014) was to investigate the effectiveness of explicit, direct and generative strategy training and Working Memory Capacity (WMC) on mathematical word problem solving accuracy in elementary school children.

The sample consisted of 82 third grade students from 12 classrooms across four elementary schools in two Southwest California school districts. There were 46 boys and 36 girls. Eleven percent of the students were Caucasian, 87% were Hispanic and 2% were of Asian descent. All of the students selected for this study were in the lower twenty five percentile on a norm-referenced assessment.

The students were randomly assigned to one of four conditions for this intervention. These conditions included, restatement of a question, restatement of a question with relevant propositions, restatement of a question with relevant and irrelevant proposition (complete), and a control condition. The first treatment condition, the restate condition, targeted the recall of two propositions; the question and the goal. This required the student to read the problem, find the question, restate the question, write the question in their own words and then solve the problem. The second treatment condition, the relevant condition, targeted the paraphrasing of three propositions; the question, goal and relevant or needed numbers. In addition to the above steps the student had to verbally identify other important information in their own words. The third treatment condition, the complete condition, directed the student to restate the question as well as both the relevant and irrelevant propositions. In addition to the previous steps mentioned, the student was asked to state the necessary information and the sentences that included the unnecessary numbers. The control condition received small group instruction of the week's "business as usual" math work from their classroom teacher. Three working memory measures were administered before the intervention from a normative measure (S-Cognitive Processing Test; Swanson, 1995) that captured the Working Memory Capacity (WMC) of each of the participants.

All of the students received supplemental instruction from the MacMillan McGraw-Hill's Curriculum. The word problems used were taken from their classroom text. The sessions for this study were 30 minutes twice a week for 10 weeks for a total of 20 lessons. Each participant was given a booklet containing that session's lesson where their work was recorded. The tutors follow a script in the presentation of word problems. The four phases of each lesson included a warm up, modeling, guided practice and independent practice.

The warm up for the lesson was five minutes long and the participants completed problems requiring the use of calculation to find missing numbers or geometric shapes to complete a series of puzzles. Next, the tutor modeled the specific treatment problem-solving strategy. The modeling portion of each lesson only took five minutes to complete. In the guided practice part of the lesson, the tutor read the question twice, and the participants were directed to restate it in their own words without looking back at the problem. They used the targeted propositions specific to their treatment group and recorded their answers in their wordbook. They then shared with the group and solved the problem. They only progressed to the next part of the lesson when they had mastered the guided strategy steps demonstrated by their tutor. Finally, students spent the last 15 minutes of the lesson independently solving word problems similar to previously modeled and guided practice problems. Each student's workbook was assessed after every session to determine strategy implementation and problem solving accuracy. The control group received small group instruction on the week's "business as usual" math work from the classroom teachers for the designated time.

Results of this study showed that the effectiveness of generative treatment conditions were dependent of the level of Working Memory Capacity. When compared to the control group, the results showed all of the other groups to have an advantage when attempting to paraphrase all propositions. When a Tukey test compared all of the condition groups, it indicated a significant posttest score advantage for the complete treatment with compared with the other conditions. Children at risk for Math Difficulties, but with a relatively higher Working Memory Capacity were better able to utilize cognitive strategies then children with a lower Working Memory Capacity.

There has been a lack of focus in general education on the memorization of mathematic facts. Recent methods of math instruction have taken the emphasis off of fluency to concentrate on problem solving and high level questions. Both of these skills are vital to student achievement in mathematics and later in life. It is important to spend the time it takes for students to build fluency of facts so they are set up for success in their future. Students who struggle to conceptualize word problems need the time and intensity that it takes to clearly identify what problems are asking and deciding how to solve the problem. Designing effective interventions such as the ones discussed in section one of this chapter is a way to help students performing below grade level norms increase their achievement levels.

Section Two: Keeping Students Interested and Engaged in Mathematics

Students who are below grade level in mathematics are often struggling learners. When students' confidence is low, they often tend to give up more quickly when working in a subject area that is challenging for them. Keeping students interested in learning is an important element to an effective intervention. This section of literature review will identify ways previous researchers have built in incentives and motivations, encouraging students to want to learn. When students feel confident they are more willing to complete assignments on their own and their grades and achievement levels are reflected by this new found confidence.

The research study by Gilbertson, Witt, Duhon, and Dufrene (2008) used an assessment to select math fluency and on task behavior interventions for four students in a regular education, math classroom. The study aimed to determine if performance is related to incentives.

The variables used in this study were two fold. Math computational fluency was measured by the number of digits correct per minute on brief math probes administered at the end of each session. Specifically, any correctly placed digit was scored as a correct digit (e.g., 6x2=12 would be scored as two digits correct, whereas 6x2=22 would be scored as one digit correct). The total number of digits correct was divided by the number of minutes to determine DCPM (Digits Correct per Minute).   Direct observations were also conducted to estimate the percentage of time the participants exhibited on-task behavior while working independently on a math assignment.

The sample consisted of four elementary students, two boys and two girls. Brandon and Kiara were first graders and Chris and Jasmine were third graders. All were African American, general education students who had been referred for math intervention services. All participants were receiving a D or F in math class and they rarely completed their assignments.

First, baseline observations for on-task behavior and math computational fluency were established. On-task behavior was observed for six minutes, for four consecutive days during math class. Five Second Whole Interval Times Sampling Procedures were used to estimate the time on-task during independent work time on math problems. Then a baseline for math fluency was determined. Probes were administered to monitor participants' progress on instructional level math skills. Progress monitoring probes were conducted in each participant's classroom for four to eight sessions. Assessments were corrected and returned to the participants the next day. No incentives were offered during baseline.

The Contingent Reward portion of the study was next and it determined if performance was related to incentives. Prior to testing, the participants were told that a reward could be earned by meeting or exceeding their goal. Goals were determined on an individualized basis and were equivalent to a 10% increase in the medial score on the probes given during baseline testing. The probe was scored immediately and the results were shared with the students. The students only received rewards if their goal was met.

The Contingent Reward combined with Instruction portion was the last individually administered part of this study. This part of the study was designed to examine if performance was related to both practice and incentives. This section gave the participants immediate opportunities to practice skills. After presenting the same goal and reward options as in the previous section, the researcher spent three minutes guiding the participant to practice the target operation using flashcards. If the participant failed to say the correct answer within three second, the researcher told the participant the answer and the next flashcard was presented. Immediately after the three minute flashcard instruction, the researcher administered and scored a six minute probe and rewarded the student if he or she met or exceeded the goal.

After this assessment process, the researcher met with the student's math teacher to discuss acceptable treatment options based on assessment results. With input from the classroom teacher, the contingent reward instruction strategy was modified in three ways for classroom use. The instructional steps were implemented in the back of the classroom with a peer tutor and research assistant to ensure integrity of the procedures. The six minute probe was administered with the class during independent seatwork and the students earned a star on a chart if they exceeded their best score on the probe. Once the student earned three stars, he or she chose a reward from a class "treasure chest." The intervention was implemented in the classroom for 15 minutes per day. The probes were returned to the students on the following school day and the teacher reported to the student whether he or she had earned a star and a reward.

Contingent Reward produced a Digit Correct per Minute score improvement of 23% or more for all students. Contingent Reward combined with practice showed greater gains, ranging from 42%-86% increases. All four of the participant's performances were influenced by a combination of a skill and performance deficit requiring instructional and motivational interventions. The behavioral data shows that the level of on-task behavior increased when the intervention was introduced in the classroom setting. The combination of skill and drill combined with incentives are effective for students who struggle with on-task behavior and motivation.

In the next study Schweinle, Meyer and Turner (2006) explored the relationship between motivation and affect in upper elementary mathematics classes from the perspective of flow theory. They also investigated the relationships between students' motivation and teachers' instructional practices. The researchers asked two research questions: Study 1: What are the conceptual relationships between motivation and affects in students' reports during mathematics instruction? Study 2: How do instructional environments differ in classrooms with various factor patterns of student affect and motivation?

The research was conducted in three predominantly white public elementary schools in a middle-class town in rural Pennsylvania. They sampled six students by gender in each of seven fifth-and-sixth grade classrooms. To achieve a representative sample, teachers selected high- average, and low-achieving students of each gender from their classes, for a total of 42 students (21 girls and 21 boys). By selecting a small subset, the possibility of students working together to compare answers was reduced.

The researchers investigated the relationship between motivation and affect, as reported by students on the Experience Sampling Form (ESF). They asked students to generalize about the entire class experience since they used a small sample from each class. The researchers adapted the ESF for the fifth and sixth grade students. The adapted forms contained 12 semantic differential items (happy—sad, alert—sleepy) measured on a nine point scale. One affective item (relaxed—uptight) did not load significantly on any factor so they removed it from all analyses that followed. Two questions directly related to children's perception of challenge and skill: "How challenging was math class today?" and "How did you feel about your skills in math today?" Also, two items measured perceived importance: "Was this math class important to you" and "Was this math class important to others?" Finally, one item measured students' perceived success: "Were you successful in math class today?" Other questions measured on a 10-point scale from one (low) to 10 (high) examining students' motivation.

In the first study observers distributed the Experience Sampling Forms (ESF) during the last five minutes of mathematics class. Each of the selected students completed a form on each of four days in the fall and 4 days in the winter. 275 ESF forms were completed effectively in all.

The researchers found close relationships between affect and motivation for Study One. Whether students believed that they had skills to perform mathematics tasks appeared to be related strongly to affect—social and personal. The importance of a task to self and to others was more predictive of students' motivation than was the challenge itself. Greater efficacy was associated with more positive affect. The greater the challenge and importance, the greater was the positive affect. They found that importance, but not challenge, was related significantly to social and personal affect. The correlations between challenge and social and personal affect were lowest in classrooms where "important to you" was lower and higher where "important to you" was higher. This pattern suggests that students were more tolerant of challenge when the material was valued.

Seven fifth-and-sixth grade teachers participated, however for the second study, researchers selected three classrooms to discuss. On the same day the students completed the ESFs, the second author audio-taped classroom instruction and took detailed notes on the lessons and teacher-student interactions. The researchers examined how teacher discourse patterns might be related to students' perceptions of the classroom. They coded the discourse into the following categories: affective and social support; autonomy, feedback and evaluation; challenge, competence support and task importance. Then they examined student responses during instruction to evaluate these categories. Three classrooms were selected to discuss the terms. One classroom in which students reported above-average efficacy and above-average challenge and importance (Ms. Benjamin), one class in which students reported efficacy and challenge and importance in the average range (Ms. Adams), and one class in which students reported below-average efficacy and below-average challenge and importance (Ms. Duncan).

In the first classroom the students reported above-average efficacy and above-average challenge and importance. Ms. Benjamin's class discourse offered numerous examples of supporting students' efficacy with promoting understanding and student autonomy. She offered moderate challenges with sufficient teacher support. She devoted most of the time in her lessons stressing the importance of understanding and justifying mathematics. Her instruction was embedded in a positive climate. In the second classroom the students reported efficacy and challenge and importance in the average range. Ms. Adams was skilled at engaging her students in class participation. She seemed to create a positive class climate by initiating humor and allowing her students to comment freely when they chose. That may have relieved some students' frustration and increased students' sense of cooperation, but maybe not their sense of positive affect. She appeared to convey a strong value for mathematics which she demonstrated by remaining on a topic until students understood. Ms. Adams preferred to lead students to understanding by using questions, hints and calls for student explanations and justifications. Her clarifications were brief and infrequent. Because of the high level of challenge and her strong encouragement of students deriving their own explanations, students may have felt uncertainty about whether they understood the instruction, and thus reported lower efficacy. In the third classroom students reported below-average efficacy and below-average challenge and importance. Ms. Duncan seemed initially to encourage problem solving, but when students did not quickly devise a solution, she resorted to an emphasis on correct procedures and correct answers. This approach may have implied that she doubted her students' competence to solve the problems. She tended to send the message that mistakes were not learning opportunities but rather the basis for evaluation. Occasionally, she probed for clarification but not as often as Ms. Benjamin or Ms. Adams. Students may have reported low efficacy because Ms. Duncan provided few supports for autonomy, gave minimal feedback about progress, and treated mistakes in an evaluative manner. Finally, telling students what to do and failing to ask to explanations and justification could have reduced the level of challenge and sent the message that mathematics was not important.

In the third study of this section, Abrams (2008) investigated the effects on mathematical achievement and motivation of 33 urban elementary and middle school students as a result of their having played topical computer games prior to receiving direct instruction. The participants in this study were required to attend an extended day period twice a week because they were below their grade standards in mathematics.

Questionnaires designed by the researcher and approved by the school's principal, assistant principal, mathematics coach and two middle school mathematics teachers were presented to the experimental students, their teachers, and their parents prior to and at the conclusion of the study. The responses from the questionnaires provided information on the effect of playing computer mathematics games on students' motivation, attention and participation during traditional instruction, and students' ability to apply concepts and construct solutions on follow- up mathematics assignments. All students in the study took a pretest prior to the first lesson in the mathematic unit, and a posttest at the conclusion of their mathematics unit. Assessments were made based on results from the Everyday Mathematics and Impact Mathematics assessment test for the units studies.

The study was conducted in a small middle class public school on the east coast with one general education class per grade, and one additional special education third grade class. Sixty-five students out of a possible 76 students who attended a 37-minute extended day period in grades 1,2,3,5,6 and 7, and a special education third grade class, took part in this study. The sample consisted of 33 students in the experimental group and 32 students in the control group. The experimental group consisted of 14 girls and 19 boys. The control group consisted of 14 girls and 18 boys.

The study lasted four weeks. The researcher, along with four teachers and four paraprofessionals, met twice a week during the extended day period with the 33 students in the experimental group. The students in the experimental group played games for 25 minutes, twice a week prior to receiving mathematics instruction from their teachers, over the four-week study. The control group received traditional instruction on the same mathematics topics without access to computers from their teachers. All students in the study received their regular mandated classroom instruction during the school day. The games selected provided instructions and objectives and were listed in order of difficulty for each grade. All of the games were aligned with strands of the standards of the National Council of Teaching Mathematics.

Teachers filled out a form every Friday indicating which mathematics topics they would be covering on Tuesday and Thursday the following week. The researchers created a list of developmentally appropriate games for each grade for the students to play prior to the day the teacher would be presenting instruction on a specific mathematic topic. Teachers filled out an attitude questionnaire at the end of the study to help the school administration decide if the computer games had instructional benefits and should remain unblocked from the students' computers.

Results in the study did not support higher mathematical achievement as a result of students having played computer games prior to receiving direct instruction. Posttest results did not indicate a difference in achievement for the students who played the games and students who continued to receive traditional instruction. Results indicated that there was no significant difference on students pretest scores between the groups. Each group made significant progress from the pre- to the posttest and there was no significant progress made from the experimental group over the control group.

Results on the attitudes about learning mathematics survey showed a slight increase in positive responses among the experimental group. Prior to the study for the first question, "How much do you like mathematics?" 39.4% of students responded that they liked math a lot, 36.4% responded a little and 24.2% responded not at all. On the survey given after the student 54.5% indicated that they liked mathematics a lot, 36.4% responded a little and only 9.1% responded to not like mathematics at all. The second questions asked "How much do you know about mathematics?" Before the study 36.4% said they know a lot about math, 63.5% said they knew a little and no students said they knew nothing. After the study 39.4% indicated to know a lot, 57.6% indicated to know a little and 3% indicated to know nothing at all about mathematics. The third question on the questionnaire asked "How important is it to learn mathematics?" Prior to the study 60.6% said a lot, 24.2% said a little and 15.2% said not at all. After the study 63.6% indicated a lot, 27.3% indicated a little and 9.1% indicated not at all. The final question asked "How do you feel about yourself as a mathematics learner? Before the study 39.4% of students responded that they felt good and after the study that number rose to 78.8%. Thirty-six point four per cent said they felt fair about being mathematics learners, and that number dropped to 6.1% after the study. Finally 24.2% of students indicated that they felt not too good about themselves as math learners before the study and this number dropped to 15.2% after the study. The answers for the final question indicated that a significant change did occur in students' perceptions of themselves as good mathematics learners after playing the mathematics computer games. A comparison of pre- and post study responses on the questionnaires indicated that computer games did affect students' motivation for learning mathematics.

Rewarding students for a positive academic outcome proved to be successful way to motivate students in the study reviewed in this section. When the intensity of the skill and drill intervention was increased and external rewards were given students performed at a higher level because they had a better comprehension of the material and there was a prize involved.

Section Three: Math Instruction Partnered with Technology

Mathematic instruction that is engaging is a sure way to help student achievement levels rise. In this next section the researchers have intertwined technology into mathematic interventions. Students took ownership of their own learning and did so in a fun and engaging way. These studies demonstrate the potential of how technology can improve achievement levels and help maintain engaged learners.

The purpose of this quasi-experimental study by Carr (2012) was to examine the effects of iPad use as a one-to-one computing device on fifth grade students' mathematic achievement in two rural Virginia elementary schools. The theoretical foundation of this study was based on John Dewey's belief that learners gain knowledge through their individual experiences. He believed that creating student-centered learning experiences that were not only valuable and relevant but also flexible for student needs encouraged students to be more active in their learning.

The sample consisted of 104 fifth graders from two rural schools in Virginia. The experimental group included 56 fifth grade mathematics students from Grace Hannah elementary school and the control group had 48 fifth grade mathematics students from Lucas Robert elementary school. For one academic quarter of nine weeks, the experimental group used iPads daily during mathematics class while the control group did not.

The fifth-grade mathematics Scott Foresman Addison Wesley (SFAW) Assessment was given as a pretest and posttest. This assessment was specifically designed to align with the Virginia Standards of Learning (SOL). The test included 50 multiple choice questions. It was cumulative test and was reflective of the curriculum that the participating teachers had followed for the school year.

The students completed the SFAW Virginia SOL aligned assessment pretest before the iPad intervention. This data was collected and recorded as the baseline data for this study. One of the district's instructional technology resource teachers (ITR) trained the participating teachers in iPad use and after that training the iPads were distributed to the experimental group. During this study, both teachers covered mathematical content from the Virginia fifth-grade 2009 standards of learning using the SFAW fifth grade textbook series. Both teachers followed the district's fifth grade mathematical benchmarks covering the remaining instructional content from the fifth grade mathematics 2009 curriculum. The skills that were covered included fraction concepts, fraction operations, measurement, integers and equations. The participating teachers' lesson plans were collected for the duration of the study and the researcher compared the lesson plans to the instructional methods used throughout the study. The participating teachers were asked to complete the Lesson Plan Accuracy Rubric (LPAR) everyday. Several, experienced colleagues were also asked to use the LPAR to confirm the validity of the instrument for this study. The participating teacher recorded information about iPad usage, lesson plan implementation, external events or circumstances and additional related notes. For one academic quarter, the participating teacher and students in the experimental group used the iPads as a one-to-one ratio computing devices for at least one mathematical activity daily during math class. These iPad Activities included, but were not limited to, playing game-based learning applications, reviewing presentations, accessing online video tutorials, or using interactive manipulatives. The control group did not use iPads but instead incorporated other activities into math class. Some of the non iPad activities included, but were not limited to, playing collaborative learning games, completing worksheets and projects, or using physical manipulatives. After the academic quarter was complete the same SFAW fifth grade mathematics assessment was given as a posttest to measure mathematical growth.

The control group completed the pretest with the mean pretest score of 55.58%. At the end of the academic quarter, the control group had a mean posttest score of 62.25%. This is a positive difference of 6.67%. The experimental group completed the pretest with a mean score of 61.05% and 67.79% on the posttest. This is a positive difference of 6.74%. There was not enough evidence to reject the null hypothesis and it was assumed that no difference in mathematics achievement would exist between the experimental and control groups as measured by the SFAW assessment. The reported data indicated that the experiences with iPads in this study were not meaningful enough to significantly influence students' mathematical achievement.

The next study in the section about incorporating technology into math interventions was conducted by Herro, Kiger, and Prunty, (2012). It adds to the literature by examining the influence of a Midwestern elementary school's Mobile Learning Intervention on third grade math achievement. This research study aimed to answer two research questions. The first question is; does participation in the MLI (Mobile Learning Intervention) explain a significant amount of variation on a post intervention multiplication test controlling for several covariates including prior student achievement? If so, what is the influence of the intervention relative to the control variables? The second question that the researchers pose is; does participation in the MLI explain a significant amount of variation of the most difficult post intervention multiplication items controlling for several covariates, including prior student achievement? If so, what is the influence of the intervention relative to the control variables?

Park Elementary is part of a Midwestern PK-12 school district in the Midwest. Park Elementary serves more than 500 students between grades Pk-4th. There are 22 students in an average class. The school wide student to computer ration is 5:1. Eighty-seven students consented to participate in the study. Forty-one were in the Mobile Learning Intervention classrooms and 46 in the comparison (business as usual) group. The sample represented 97% of the school's third grade population.

All participants completed a pre-intervention survey to help identify and control the existing group differences. They also collected a variety of pre-intervention data including student test scores, report card data, and attendance. To measure mathematical achievement, the classroom teachers administered a 50 item multiplication pretest to all students. At the end they then administered a 100 item multiplication test to all students to measure growth at the conclusion of the intervention.

The Mobile Learning Intervention (MLI) was a nine week long intervention that was incorporated into two classroom's daily math lesson. On the first day of the intervention, each of the students received an iPod touch to use in class. The students were introduced to the Pop Math app, shown how to change the settings to multiplication and given ten minutes to spend using the app. The goal of Pop math is to earn points by popping the factors and correct product. A new application was introduced every day. Some of the applications included, Math Magic, Multiplication genius lite, Multiplication flashcard logo, Math Tappers, Math drill lite, Mad math lite, Flow Math and Flash to pass. Each day the teacher followed a similar procedure. The instructional technology research teacher rolled the cart into the classroom, introduced an application to the students by doing an overview for the application on the document camera to project the screen of the iPod touch. She always emphasized the goal of the application and showed them how the application worked. Students then retrieved their iPod touches from the cart and started working on the application as soon as they got to their desks. The teacher walked around the room assisting individual students. They looked at the student's progress to determine if they were working on multiplication tables that were too difficult or too easy and adjusted the program according to what each student needed. Students worked on the iPod touches for ten minutes. After using the iPod touch to practice multiplication tables, the students engaged in a formal math lesson using the Everyday Math curriculum. Teachers used whole group instruction to introduce concepts, followed by small group or individual instruction. In the comparison classroom, the students practiced multiplication for 10 minutes each day using "business as usual" techniques such as flash cards, math games, fact triangles and number sequences. This was followed by a formal math lesson using the Everyday Math curriculum.

On average, the MLI students answered more items correctly on the post intervention multiplication test than the Comparison students. The mean number of items answered correctly for the MLI students was 54.5 with a Standard Deviation of 14.8. The mean number of items answered correctly for the Comparison Group was 46.3 with a Standard Deviation of 12.5. There was a significant difference between the experimental and control groups showing MLI participation as the most influential reason for the progress. They repeated the analysis using double digit multiplication and found that the MLI students answered a greater number of these items correctly with a mean of 11.6 and a Standard Deviation of 4.9. The Comparison students scored a mean of 8.2 with a Standard Deviation of 4.4. The MLI students outperformed the Comparison students on a post intervention multiplication test controlling for prior student achievements and several other covariates. The findings suggest that coupling business as usual curriculum with a mobile device may be a cost-effective lever to improve student achievement.

The third study of this section reports on the effects of the combined use of an interactive whiteboard (IWB) with a virtual learning environment (VLE) on mathematic performance and motivation. Heemskerk, Kuipert and Meijer (2014) explored the following research questions: 1. To what extent is students' exposure to IWB lessons and the availability of these lessons on the VLE related to students' learning outcomes in mathematics in one school year and motivation for mathematics over three years? 2a. How do students evaluate the VLE for mathematics, and how often and in what way do students use the IWB lessons and other mathematics learning materials that are available on the VLE? 2b. How are these perceptions and use related to perceived and factual effects on students' learning outcomes and motivation for mathematics? For the first research question the researchers formulated the hypothesis: students with higher exposure to IWB lessons are more strongly motivated to study mathematics and achieve better learning results in mathematics than students with lower exposure to IWB lessons. Because the research questions 2a and 2b were of a descriptive and explorative nature, no hypothesis was formulated.

The first sample group in 2007-2008 consisted of 286 students but only 214 took part both times in the questionnaire. There were 173 boys and 98 girls. The second sample in the 2008-2009 school year was much larger and consisted of 849 students. One hundred ninety one students had been involved in the first phase of the project. There were 367 boys and 406 girls in this sample. Finally, the third sample participated in 2010 but only completed the MEQ once. This sample consisted of 183 students; 146 of these also took part in samples one and two. Based on the availability of IWB's and the arrangement of classrooms, it was possible to divide students into three groups: 1. Those who were exposed to mathematics lessons with an IWB approximately one-third of the time during the three year time span. 2. Those that were exposed to mathematics lessons with an IWB approximately two-thirds of the time over the three year time span. 3. Those who were almost always taught mathematics using the aid of an IWB, more than two-thirds of the time during those three years.

Specific motivations for mathematics were measured by the Mathematic Experience Questionnaire (MEQ) which has shown to be a reliable and valid indicator of students' motivation. The MEQ consists of four scales that cover specific aspects of mathematics including relevance, effort, anxiety and pleasure. The MEQ was administered as a pre-test at the beginning of each year and as a post-test at the end of the year. It was only possible to compare students' academic performance in the 2007-2008 school year because performance comparisons were only possible for students with different exposure to IBW lessons who had identical mathematic tests. Eleven teacher constructed mathematics test were used to measure mathematic achievement.

The study lasted for three consecutive school years. One math teacher introduced the interactive whiteboard in the school year 2007-2008. He always used it during his mathematics lessons and always made the content of his lessons available on the virtual learning environment so the students could consult this content at any time or place. During the following school year (2008-2009), another IWB was introduced. More math teachers started using the board and the number of students who had never experienced mathematics with IWB decreased quite dramatically. In the last school year of the research project (2009-2010) the two classrooms with an IWB were used as much as possibly by the six math teachers. There were hardly any students left who had never experienced the use of an IWB in their mathematics lesson.

There was no evidence that the use of an IWB in mathematical lessons was associated with better learning results. The measurement of mathematical achievement in the 2007-2008 school year revealed only one mathematics test with a better average result for the sample that had IWB exposure. The effect was not statistically significant. All in all there was no evidence that the use of an IWB in the mathematics lessons, as implemented in this experiment, contributed to the students' learning results in this school.

However with regards to the long term study on motivation, they found partial support for their hypothesis. For relevance, there was a significant effect of time but not of condition. Average relevance scored declined after the fourth measurement. Although the group who was always taught with an IWB consistently scored the highest on average in each measurement moment, statistically speaking on average all three groups scored equally. They showed no significant effects of experience with IWB math lessons on average effort scores. This implies that the hypothesis concerning effort should be rejected. The test on the effect of time on average anxiety scores was not significant. However, the group that was always taught with an

IWB scored higher (less anxiety) than the group that was frequently taught with IWB in their mathematic lessons. Time had a significant effect on average pleasure scores. IWB condition appeared to have an impact on average pleasure. The motivation of students declined during both school years 2007-2008 and 2008-2009 compared to the end of the previous school year 2007-2008. A similar increase at the beginning of the school year 2009-2020 did not occur as it did with the previous year.

In the second study the researchers described how students evaluated the virtual learning environment (VLE) for mathematics as well as the frequency and the nature of its use during the research period. Students appeared to appreciate the IWB lessons available on the VLE. Students who were always taught with IWB and had the option of using the VLE after lessons consistently showed higher average scores compared with the other groups. Most students reported positive perceptions about the effects of VLE on their understanding of the content and on their feelings of security on this matter. A *t-test* showed that boys perception of VLE were more positive that girls' perception. Most students reported using the VLE for mathematics to prepare for tests and examinations (55%). Another large group of students used the VLE when they had difficulties understanding mathematical content (44%) and when they had been absent from lessons (43%). Use of the VLE to search for information, to improve understanding of assignments (36%) or other reasons (6%) was reported less often. Ultimately students appreciated the VLE for mathematics because the IWB lessons were made available. The VLE was evaluated more positively by students who held the opinion that mathematics is highly relevant in society and by students who said they exerted a lot of effort on mathematics.

The purpose of the final study in this section by Singer (2015) was to examine and understand the effects of mobile technology devices, as an individual learning tool on third grade students' mathematics achievement and attitudes at a predominantly minority, lower socioeconomic school. There were two sub-questions addressed in this study. Sub-Question 1 asked how third grade students' math achievement differs when using an iPad compared to the traditional-textbook based education for a unit of study. Sub-Question 2 asked how do students' attitudes towards mathematics differ when using iPad devices compared to the traditional means of instruction.

This research took place in a kindergarten through fifth grade elementary school, referred to for this study as NPS Elementary School, located 25 miles east of New York City in a suburban setting. For the 2013-14 control class of students, there were 19 third grade participants and for the 2014-15 experimental class of students, there were 19 third grade students that participated. Third grade classes were the only grade level that received iPad devices for the 2014-15 academic year. For the sample of students used in the control class during the 2013-14 year, receiving traditional instruction was comprised of 12 female and seven male students. Twelve students were classified as African American and seven were considered Hispanic. Fifty percent of the students received free lunch while 18% of the students received a reduced price lunch. The class of students used for the experimental group in the 2014-15 academic year that received instruction with the integration of the tablet devices consisted of 11 female and eight male students. Four students were classified as African American, 13 were considered Hispanic and two were Filipino. Fifty-four percent of these students received free and/or reduced price lunch. Both the control and experimental groups were taught by the same teacher who had 12 years of experience teaching and incorporating technology in her lessons.

The learning outcomes for both groups of students were measured based on a pencil-and-paper test instrument using a Pearson SussessNet benchmark assessment. The test corresponded with the mathematic curriculum purchased by the district. The test intended to measure student proficiency on the knowledge and skills of the third grade curriculum. All of the students in third grade would have taken this mathematics pretest and post-test regardless of the study. The assessment included two types of questioning, multiple choice and short answer questions where students were required to show their work of how they came to the answer.

Students in both the control and treatment groups completed an Attitudes Towards Mathematics Inventory (ATMI) to determine the effects of the tablets on the student attitudes towards mathematics. This tool was used to measure how several areas related to mathematics attitudes including self-confidence, value, enjoyment, and motivation. The ATMI survey consisted of 40 questions using a five-point Likert-type scale. Participants were asked to read each statement aloud and respond on a scale from strongly agree to strongly disagree. A pictorial representation of a face was pictured over the words to adapt the ATMI to the needs of elementary aged students.

The first phase in the data collection process was to seek school approval to ensure that the research did not compromise the privacy of the students, or disrupt the work of students, teachers, and administrators. The date to administer the pretest and post-test that all the students took was determined by the district wide assessment calendar.

The control group followed the district approved curriculum map and assessment calendar for mathematics. The experimental group followed the same curriculum map and assessment calendar for mathematics, completed the same Pearson SussessNet pretest at the beginning of the school year, and the same SussessNet benchmark assessment at the end of the year.

The control group of students utilized textbooks, workbooks and worksheets as a form of instruction for the 2013-14 academic school year. The experimental group received mathematics instruction that included the integration of iPad devices for the 2014-15 school year. In order to limit threats in this study, both classes were taught by the same instructor who had twelve years of experience teaching elementary aged students. She had experience as a third grade teacher and proficiency with the use of technology. The teacher also received professional development opportunities to learn how to use the devices in alignment with their instruction. The teacher was given a class set of iPads, pre-loaded with applications that were to be used with the students. The installation of applications was managed by the district technology department. The iPads helped to increase the opportunities for differentiation, using applications that were selected to meet students at their individual learning levels. The teacher constantly circulated throughout the classroom to monitor all activity.

In the experimental classroom, the tables were arranged in a horseshoe layout centered around an Interactive Whiteboard. Each day, students were called to the iPad cart by number to retrieve their iPad and at the end of the day students were again called to the cart by their number to plug the iPad in so they were ready for the following school day. The eBackpack program was used in this study. eBackpack is a cloud-based learning management system that makes it easy to assign, annotate, collect, and grade on any internet-connected device. Everything that the teacher uploaded on eBackpack was accessible to the students. She used the eBackpack program to upload assessments that the students needed to complete. They followed along with the lesson and submitted their work electronically. The students downloaded their assignments from eBackpack, completed the work on their iPads and then turned the work into the applications submissions area. The teacher was able to grade, comment on students’ work, and return it back in that same application. Working with iPads also allowed for easy differentiated instructions that reached all of the different academic levels of students. The approach of the teacher was more focused on student problem solving and using the device to learn rather than a teacher directed environment.

At the end of the allotted time for the study, students were given an attitude towards mathematics inventory (ATMI). After the post-test an attitudes inventory by the experimental group of students was completed, all data was collected and organized.

It was found that the students that received instruction using iPad devices did not experience significantly different results in academic achievement compared to students who received traditional means of instruction. There were also no statistical difference in the Attitudes Towards Mathematics Inventory between the control and experimental group. However, during the interview with the participating teacher, it was revealed that the iPad devices increased student motivation and attitudes during mathematics lessons. It was noticed that the students were very motivated and self-stimulated when the teaching incorporated technology. The iPads enhanced learning for the children who were unmotivated and for the children who did not normally put forth much effort. The teacher spoke of the increase in attitudes towards mathematics explaining that students were more actively involved with the lesson and seemed more willing to do mathematics when the iPads were incorporated. The students liked having the responsibility of guiding their own lessons and being in charge of their learning. The teacher also commented that the iPads were not an end all, be all. The low level students still functioned at a low level while the higher level students still learned the new knowledge at a quicker pace. The devices were just a tool that met all students exactly where they were academically.

The data showed that the results from the post-test and the Attitudes Towards Mathematics Inventory did not show statistically significant difference between the control and experimental groups. However the interviews the participating teacher created a picture of noticeable increases in student engagement, attitudes and productivity for students that used iPads for instruction compared to students who did not use the devices.

Utilizing game-based learning in technology has gained popularity as an effective instructional strategy among math teachers. Elementary students enjoyed academic games and were excited and interested in learning about math while playing them. However, classroom teachers need to be sure that the technology and applications that they implement are effective and specific to the learning needs of all the students in the class. Incorporating specific technology with mathematics instruction has proven to be effective in raising student achievement and student motivation.

Section Four: Response to Intervention in Mathematic Instruction

Response to Intervention (RtI) is a multi-tiered model that aims to provide struggling learners with interventions at increasing levels of intensity to speed up their rate of learning. Progress is closely monitored to assess the learning rate and the level of individual students' performance. The articles in the final section of this chapter work with the Response to Intervention model to determine how students learn best.

The purpose of the study conducted by Atkins (2008) was to investigate an RtI model in mathematics where an effective general education intervention was implemented with students in second grade. There were two research questions explored in this study. The first research question asked; does rate of learning vary in a normative sample of students? The second research question stated; Can increasing intensity reduce the difference between the slope of average rate learners and low rate learners?

The dependent variables in this study were subtraction fluency and responsiveness assessments. Fluency is defined as the number of total digits completed accurately during the two minute assessment. Fluency was assessed using single digit subtraction probes. Responsiveness was examined to determine if slope could discriminate between learners. The author wanted to determine if increasing intervention intensity could reduce the difference between the slope of average rate learners and low rate learners. Calculating the slope of each student's fluency allowed the experimenter to specify a normative profile of growth and determine how the students' growth compared to the normative profile.

Participants in this study were five teachers and 71 general education students from an elementary school in a southwest rural community, serving students in kindergarten through fourth grade. The first intervention phase included all of the students from the five second grade classrooms. The second intervention phase included four students who exhibited low response rates during the first intervention phase.

The pre-intervention phase involved screening procedures to determine the sample of students used for the study and baseline procedures. School-wide screening procedures were used to identify a group of students in which a single fluency intervention was deemed appropriate. Second grade was targeted for remediation in subtraction from nine because of significant deficits in calculation fluency in all class sections. All five classrooms were selected to participate in this study, thus allowing the experimenter to work with the full population of second grade students from the rural community. During baseline all second grade students were given two minutes to complete a subtraction from nine probe. Within the same 24 hour period the probes were scored for digits correct per two minutes and fluency scores were entered into a database. Three data points for each student were used to establish performance rates prior to implementation of the fluency intervention.

Phase One intervention procedures were conducted by the experimenter and research team members in the classroom setting, across the entire sample during the scheduled mathematics instruction. This phase was designed to evaluate students' response to the fluency intervention. To establish a rate of response all participants were exposed to the fluency intervention once daily for 24 sessions. Each student received an individualized probe containing his/her name and the goal for the session. The goal was derived from the previous day's performance. If the students improved their previous score, they would be able to pick out a reward from the reinforcement box. The reinforcement box is similar to a prize box in a typical classroom. Within the same 24 hour period the probes were scored for digits correct per two minutes and fluency scores were entered into a database. If the student exceeded their goal listed he/she would receive a sticker on his/her probe the following day. The stickers served as a daily reinforcement, and the number of stickers was tallied each week to determine each student's access to the reinforcement box. Each week students were able to choose rewards from the reinforcement box for improving upon their scores.

Data from the subtraction from nine probes were scored for digits completed accurately in two minutes and entered into an Excel database. These scores were graphed to display fluency growth rates for each student. Students whose slopes were greater than one standard deviation above the mean were classified as high rate responders. Students whose slopes were within one standard deviation of the mean were classified as average rate responders. Students whose slope fell below one standard deviation from the group mean were classified as low rate responders. The students in the low rate responders group were then moved to the second phase of the study.

Phase Two intervention procedures were conducted by the experimenter and team members in the Title 1 Reading Room, a small classroom with a single table and chairs. The purpose of this phase was to increase the growth of the low rate responders to that of the average responders. The experimenter followed the same procedures implemented during the first intervention phase. Differences in the delivery involved location of delivery and the absence of classroom peers. Intensity of the intervention also changed, by increasing daily frequency to occur two times a day for approximately eight minutes a day. The performance goal for the intervention was the highest score from the previous day's performance. If the student exceeded the goal listed he/she would receive a sticker on his/her probe the following day. Stickers were tallied and reinforcements were delivered each Friday. The highest score for each session was also recorded as the dependent variable for this phase. Student's slopes were calculated daily. Once the student finished the first phase of two sessions daily, intensity was doubled to four sessions a day. The previous conditions remained the same except the intervention intensity was approximately 15 minutes. Once the performance criterion was met participation was systematically discontinued for each student. When Phase Two was completed the experimenter advanced to the post-intervention phase. During the post-intervention phase maintenance data was collected on two sessions from all second grade students to evaluate how well the students maintained fluency rates post intervention.

The first intervention phase was conducted for 24 sessions. When this responsiveness evaluation was completed, average performance had increased from 18 digits correct per two minutes to a mean performance of 56 digits correct per two minutes for all participants. Overall the group increased their fluency scores by 311%. Slope data was used to classify students into proficiency groups. The mean slope for the high rate responders group (n=11) was 2.29. Students whose slopes were within one standard deviation of the mean were classified as average rate responders. The mean slope for the average rate responders (n=45) was 1.10. Students whose slope fell below one standard deviation from the group mean were classified as low rate responders. The mean slope for the low rate responders group (n=13) was 0.20. On average, high rate responders advanced two digits each intervention session and average rate responders advanced one digit each session. Low rate responders, on average, took five sessions to advance by one digit.

The second phase of this study included four students who exhibited low response rates during the first intervention phase. When the intensity was two sessions daily two of the participants' slopes exceeded the performance criterion with a slope of 1.12. Colton's slope increased to 3.19 and Mallory's slope increased to 1.99. Zeke's slope increased from -1.50 to 0.00 but it did not meet the performance criterion. Kenneth's performance did not show improvement during this phase, with his slope dropping to 0.30. When the intensity of the intervention increased to four sessions each day all of the students' slopes exceeded the performance criterion. Both Kenneth's and Zeke's slopes exceeded that of the average rate responders. Kenneth's slope increased to 3.89, while Zeke's increased to 3.71. Mallory's slope also increased during this intervention phase, climbing to 2.80. Colton's slope decreased slightly to 2.29. By the end of the intervention phases, all students had met criterion and their response rates exceeded that of the average response.

During the post-intervention phase, after the removal of the intervention, the students had maintained their previous gains from the intervention. The students involved in the second part of the study also maintained their previous performance although their post-intervention gain was smaller than those included in only the first part of the study.

Data from this study indicated that the intensity of an intervention improves the majority of students' performance. When the amount of time in the intervention increased from once a day to two times a day, it resulted in increased achievement levels for the participants. Furthermore, when the intensity for those students increased from two times a day to four times a day the achievement of the participants increased even more.

The purpose of the next study in the section about Response to Intervention conducted by Mong (2008) was to evaluate the effects of the *Math to Mastery* intervention package to improve fluency rates of identified elementary school students who were performing at least one year below grade level as measured by curriculum-based measurement procedures. Four research questions were explored in this study. The first research question was will *Math to Mastery* increase the number of digits corrects per minute on a single skill instructional level probe for elementary school students experiencing the intervention in a school setting? The next question asked if this intervention would decrease the number of errors per minute on single skill instructional level probes. The third research question asked if *Math to Mastery* would increase the number of digits correct per minute on multiple skill grade level probes. Finally, the last research question that was explored asked if there would be a decrease of the number of errors per minute on multiple skill grade level probes.

The components of the *Math to Mastery* intervention package served as the independent variables for this study. These components included instructional level materials with previewing, repeated practice, immediate corrective feedback, performance feedback, self charting of progress, mastery-based progression, reinforcement, and limited time for instruction.

The dependent variables for this study were the three measures of mathematical fluency; total digits produced per minute (TDPM), digits correct per minute (DCPM), and errors per minute (EPM) on both single skill instructional probes and mixed skill grade level probes.

Participants in this study included 12 third grade students from a school district in the Southeastern United States. Students ranged from 8.4 to 9.4 years of age with a mean age of 8.5. None of the participants had ever received special education services or have had previous diagnoses. Seven of the participants performed at a first grade level. Five of them performed at a second grade level, one of which was dropped from the study due to his frequent absences from school during the time in which the data collection was taking place.

Prior to beginning this study written parental consent was obtained for all of the students participating. The interventionist used curriculum-based assessment procedures to identify each student’s instructional level. Multiple skill curriculum based assessment probes were administered to determine the current grade level performance of each of the students. The student attempted to complete one worksheet at his/her current grade placement in school. Each student was given 60 seconds to complete each worksheet. If performance was determined to be in the instructional level range, a worksheet at the same grade level was given. If the student performed at a frustrational level, a worksheet at a lower grade level was administered. These procedures were followed until a median instructional level performance was obtained on three worksheets within the same grade level. Once the instructional level was identified, the session continued until a minimum of three data points at that level were obtained to establish a baseline. These data points were, total digits produced per minute (TDPM), digits correct per minute (DCPM), and errors per minute (EPM). Only students performing at least one year below their current grade level were included in the study.

The intervention sequence was conducted three times a week for eight weeks. Each student received individual interventions via a pull out method in a one on one setting. The following steps of the intervention were based on the *Math to Mastery* manual developed by Doggett, Henington, and Johnson-Gross. The first step of the intervention was *math probe previewing* where the interventionist completed each math problem on the probe while the student followed along. Step two was the *repeated practice* step where the student practiced completing each math problem on the math from in a series of one minute trials until a mastery criterion of 20 digits correct with fewer than two errors were obtained. Sessions did not last for more than 30 minutes and were typically conducted from seven to 10 trials. While the student was completing each problem, the interventionist followed along, marking digits and errors and giving immediate corrective feedback. Immediately after each one minute trial the interventionist calculated and informed the student of his or her digits correct per minute for the trial. This score was recorded on the *Math to Mastery* intervention documentation form. The student completed the self-monitoring chart at the end of each one minute math trial. This process continued until the student reached the mastery criterion for math fluency or up to ten trials each day. Students were required to master three different single skill math worksheets consecutively before they progressed to the next skill. Grade level probes were administered once per week to determine the student's progress. The multiple skills on the grade level probes were not all taught to the students during this intervention. Students only advanced to a new skill if mastery criterion was reached on a three consecutive single skill assessments.

Four research questions were explored in this study. The first question was, will *Math to Mastery* increase the number of digits correct per minute on a single skill instructional level probe for elementary school students experiencing the intervention in a school setting? All 12 of the students increased their mean in digits correct per minute over baseline levels. The mean level of performance was at or above the mastery criterion for three out of 12 of the students and within one digit correct per minute for four of the other students. The next question asked if this intervention would decrease the number of errors per minute on single skill instructional level probes. All 12 of the students showed a decrease in their errors per minute as compared to baseline levels. The mean level of performance was at or under the master criterion for all 12 students. The third research question asked if *Math to Mastery* would increase the number of digits correct per minute on multiple skill grade level probes. All of the students showed an increase in their mean of digits correct per-minute, however none of the students' mean level of performance was at or above the mastery criterion of 20 digits correct per minute. The final research question that was explored asked if there would be a decrease of the number of errors per minute on multiple skill grade level probes. For 11 out of 12 of the students there was a decrease in the mean of errors per minute. One participant did not make any errors across either the baseline or the intervention phases. Additionally, the mean level of performance was at or under the mastery criterion for all 12 students. In order to master a skill, a student was required to reach the mastery criterion on three consecutive intervention sessions before progressing to the next benchmark. This strict requirement may have been why four of the 11 students were only able to master one to two skills during the eight week intervention period. Seven students were able to master three to five skills during the same eight week time frame. The twelfth student in the study was unable to master any skills due to absences from school. Overall, the 11 students that received the full eight week intervention mastered an average of 2.9 new mathematics skills. During the course of the eight week intervention, the students were only exposed to addition skills. They received no interventions geared towards subtraction. This would explain their inability to reach the mastery criterion of subtraction equations.

There is a continued need to examine response to intervention models in mathematics. It is necessary to understand how time and intensity can help or hinder a student from reaching their highest potential. In the final section of this chapter, the authors determined that the amount of time spent with a student has a dramatic effect of their achievement. Response to Intervention is a fluid and constantly changing process that educators and practitioners have to be willing to work with to find the way each student learns best.

Conclusion

In conclusion, the first section of this chapter talked about strategies other researchers have incorporated into mathematic interventions to increase student achievement. Mathematical fluency of basic facts is an area that needs a lot of time and attention. If students have not mastered those facts at the fundamental stages it makes it much more difficult to stay on pace with the mathematical content presented later in their academic lives. Most of the researchers in the first section implemented ways to help struggling students improve their automaticity in identifying single digit addition, subtraction and multiplication facts. Students must have a strong foundation of those skills in order to move into mastering words problems and other mathematical skills. The final authors, Swanson, Moran, Lussier and Fung (2014) in the first section focused on improving the Working Memory Capacity to better understand and solve word problems. The deconstruction of the word problems helped students comprehend the information provided within the problem as well as how to find the important information they were looking for to solve the problem. All of the studies in the first section provided immediate feedback to the participants; allowing them to see where they made mistakes and helping them identify ways of fixing those mistakes.

In the second section of this chapter the studies focused on building incentives into interventions to motivate students who were uninterested in excelling in mathematics. The participants in one study did not complete assignments regularly because they did not understand how to do the work. When students feel unsuccessful on a regular basis they lose motivation and excitement about learning. The use of short and frequent assessments with immediate feedback paired with external rewards helped the participants feel successful in their learning thus increasing their motivation and excitement about learning mathematics.

The third part of this chapter identified additional ways to increase student achievement and motivation through the use of technology. Students in this day and age get excited about using iPads and computers. When the interventionists taught mathematics in the usual, day to day way and added the use of computers and iPads, student motivation and excitement around learning improved. The participants were especially interested when engaging mathematical games were introduced. Students wanted to play the games and improve their mathematical skills.

The final section of this chapter focused on mathematical instruction in the Response to Intervention model. For Response to Intervention to be effective it has to be ever changing and ever evolving to best serve the needs of the individual students participating in the interventions. The research conducted was very specified and individualized to the needs of each student. The researchers found that the more often they met with the participants the greater increase in achievement they observed.

The research collected from the literature reviewed in Chapter Two has driven the case study methodology discussed in this paper. This case study will use some of the strategies outlined in the first section and combine the use of technology to improve student achievement and motivation in the subject of mathematics. All of this is incorporated in the Response to Intervention model with one third grade boy, and will address the research questions of "Will the use of iPad applications during mathematical instruction increase student learning/ achievement?" and "Will student use of technology when coupled with direct instruction increase motivation and self-confidence?"

CHAPTER THREE

METHODOLOGY

Introduction

This chapter details the procedures used with the target student in an effort to improve his academic achievement and motivation in mathematic fluency through the use of iPad applications focusing on single, double and triple addition and subtraction. The participant will be referred to as John in this chapter. The first section, Methodology, provides a detailed student description, information about the setting, and student population. The second section includes this case study's setting, sample population, and data collection. Finally the third section, Overview of Procedures, provides an explanation of the intervention used with the target student in an effort to increase his mathematical fluency and motivation, as well as information relevant to data collection.

Student Description, Setting, and Sample Population

Student Description

John was a third grade student at a public charter school in the Midwest. It was his first year at this school. John did not have an individualized education plan (IEP); however his classroom teachers noticed early in the year that he was not performing at grade level. Response to Intervention began within the classroom and small groups. When adequate progress was not being made with those interventions, his teachers worked with the school psychologist to intensify his interventions tier three of the Response to Intervention (RtI) model. John received two one-on-one interventions a week with me, the researcher in this case study.

Through my own observations, I learned that John was easily distracted and tended to give up quickly when work was challenging. When the one on one intervention began in

November, John struggled to add and subtract single digit numbers. He did not know the difference between even and odd numbers. At the beginning of the intervention he worked on skip counting by 2's, 5's and 10's. He worked hard to add and subtract one and zero from single digit numbers. He worked to create automaticity with adding and subtracting one from numbers. As John's automaticity improved he was taught the strategy of counting on to assist him in both single digit addition and subtraction equations.

As I got to know John better I noticed an excitement for learning that I had not seen early on. As his fundamental skills increased his confidence increased. At the end of our 30 minute sessions two times a week, John would ask to play a game on the computer for five minutes before returning to class. On the days that he had put in great effort and shown improvement in his fluency he was allowed five minutes to play math games on the computer. It was then that I noticed an excitement for video games and decided to use that to try to improve his skills.

Setting

This study took place in an elementary, urban, charter school in the Midwest. The student was pulled from his regular education classes for thirty minutes three times a week to work on mathematical computation skills in a one on one intervention. The intervention took place in a private classroom with the target student and the interventionist.

Sample Population

This case study focused on one African American male student attending a charter school in an urban Midwestern city in the United States. The student was in third grade and was new to the school. He had been referred for Response to Intervention Tier three. This means that the interventions that had taken place previously in the classroom and small group did not help this student make adequate progress. Tier three interventions are the most intense intervention offered through Response to Intervention. The student had been referred for RtI because he was performing at least one year below grade level in mathematic fluency. This student had been participating in RtI for four months prior to the beginning of this case study. Prior to this case study, the student met with the interventionist two times a week for 30 minute sessions. The intervention prior to the study did not include technology in any way.

Overview of the Procedures

After a review of research regarding mathematical fluency, automaticity and motivation, procedures were developed which focused on improving automaticity in the process of adding and subtracting larger double and triple digit equations. I chose to use technology in combination with direction instruction because the findings of the study conducted by Herro, Kiger, and Prunty, (2012) suggest that coupling business as usual curriculum with a mobile device may be a cost-effective lever to improve student achievement.

As the protocol was developed for this case study I decided to increase my weekly meetings with John from two sessions of 30 minutes each to three sessions of 30 minutes each. The intensity and focus of the intervention would increase to set the stage for larger gains in academic results. I chose to use progress monitoring probes and the spring benchmark test from the aimsweb assessment. Aimsweb is a Curriculum Based Measurement (CBM) used for universal screening, progress monitoring and data management for Grades K-12. It is a norm referenced assessment which is produced by Pearson. I worked in collaboration with the school psychologist for Response to Intervention. She requested that I use the aimsweb progress monitoring probes in my research study.

The data that was collected from the progress monitoring probes was used to determine if a special education referral is needed for this student. Prior to the intervention I administered the aimsweb Third Grade, Benchmark Three. This assessment includes single, double and triple digit addition and subtraction as well as basic multiplication and division. I used the third grade benchmark in order to compare the participant to other students who are his same age around the United States. Throughout the intervention, I administered aimsweb Progress Monitoring second grade probes. In the third session of every week, the student spent eight minutes completing one of these Progress Monitoring probes. I administered the second grade probes because that was the instructional level that the student was currently working at. After the intervention I gave the same aimsweb benchmark assessment that was given prior to the intervention as a posttest to measure growth of mathematical achievement. This also allowed me to again compare his results to other students his age. The participant also completed a student survey before the intervention and after the intervention to measure motivation and confidence in mathematics. The survey asked questions about his attitude towards math.

Intervention Design

The intervention took place over a five week period. Each week was broken down into three sessions of 30 minutes each. The participant worked on two different mathematical applications on the iPad for 10 minutes each, as well as received 10 minutes of direct instruction from me. Direct Instruction was a part of each session for 10 minutes. I demonstrated modeling to work through the equations by thinking aloud for the student to hear. I provided scaffolds by asking guiding questions such as, “What do you do first?”, “Where does that number need to go?”, “If you’re borrowing what needs to happen to the number you’re borrowing from?” I also provided supportive feedback to encourage participant to take his time and try his best. IPad application work was a part of each session.

The order of applications alternated between sessions. Direct instruction was taught first in the first session of each week to review the functionality and make sure the participant had a clear understanding of how to complete the problems. During the second and third sessions of each week direct instruction was taught after the use of the apps to go through equations that were answered incorrectly in Mad Math. This allowed the participant the chance to see where his mistakes were made and work through the equations correctly with help and support from me. The mathematical function alternated between addition and subtraction. In the last week of the intervention the participant worked with both addition and subtraction at the same time. Separating the functionality allowed the participant to focus and work towards mastery on one kind of problem at a time. In the final week the two functions were combined to assess the participant's security and mastery of both types of problems.

The quasi-experimental study by Carr (2012) examined the effects of iPad use to drive student learning. The theoretical foundation of Carr's study was based on John Dewey's belief that learners gain knowledge through their individual experiences. Both iPad applications that were used in this case study were student centered and flexible for student needs. I believe that the design of these apps would encourage the participant to be more active in his learning thus improving his opinion and attitude about math. "Math Evolve" is a fun math game for kids. This app was the winner of the Best Educational Game of 2011 in the Best App Ever Awards. This game helps build automaticity with numbers as the player attacks the correct answers with their spaceship. An equation appears at the top of the screen and the player is given four numbers to choose from as the answer. If the player answers the problem incorrectly a number pad appears and the game is paused so the player can take their time and answer the question correctly. The difficulty of the numbers, function and time is adjustable and at the end of the game the app provides stats about the percentage of accuracy and the equations per minute. "Mad Math" is an app that can focus on single, double or triple digit addition, subtraction, multiplication, division or mixed functions. A flashcard is shown and the participant has to type in the correct answer. For double and triple digit equations, the participant can draw the numbers in with their fingers so they are able to carry or borrow as necessary and then type the final answer. After the participant has completed the set number of flashcards the stats show how many questions they answered correctly, and the amount of time it took. This app also provides all of the equations the participant answered correctly and incorrectly or they can see exactly where their mistakes were made.

Weekly Sessions

In the first session of each week the participant received direct instruction first to review the operation that they were focusing on that week. We reviewed the methodology of carrying or borrowing as is applicable that week. Next he worked on the app "Math Evolve" for 10 minutes and then "Mad Math" for 10 minutes. In the second session each week, the participant first worked with "Math Evolve" for 10 minutes and then "Mad Math" for 10 minutes. We spent the remaining 10 minutes going through equations that the participant answered incorrectly and we practiced how those should have been solved correctly. During the third session of each week the participant worked with Mad Math for 10 minutes, received Direct Instruction for 10 minutes and then completed an aimsweb Progress Monitoring probe for the remaining time of the session.

Week 1 / Week 3—Addition

Session 1/Session 7

- 10 min Direct Instruction
- 10 min Math Evolve
- 10min Mad Math

Session 2 / Session 8

- 10 min Math Evolve
- 10min Mad Math
- 10 min Direct Instruction

Session 3/Session 9

- 10min Mad Math
- 10 min Direct Instruction
- 10 min Progress Monitoring Probe

Week 2 / 4—Subtraction

Session 4/Session 10

- 10 min Direct Instruction
- 10 min Math Evolve
- 10min Mad Math

Session 5/Session/11

- 10 min Math Evolve
- 10min Mad Math
- 10 min Direct Instruction

Session 6/Session 12

- 10min Mad Math
- 10 min Direct Instruction
- 10 min Progress Monitoring Probe

Week 5—Addition and Subtraction Combined

Session 13

- 10 min Direct Instruction
- 10 min Math Evolve
- 10min Mad Math

Session 14

- 10 min Math Evolve
- 10min Mad Math
- 10 min Direct Instruction

Session 15

- 10min Mad Math
- 10 min Direct Instruction
- 10 min Progress Monitoring Probe

Data Collection

Prior to the intervention, the participant completed the aimsweb third grade benchmark to set a baseline for mathematical achievement as well as a survey to measure his baseline attitude and feelings towards math. The participant's responses to questions regarding his attitude towards mathematics were audio recorded. The intervention took place over a five week period. In the third session of each week, an aimsweb progress monitoring probe at the second grade level was administered. The progress monitoring probes were given at the second grade level because that was the student's instructional level for mathematics. After the intervention was complete, the same third grade benchmark assessment and attitude survey that were given prior to the intervention were administered again.

The aimsweb third grade benchmark three included mathematical equations ranging from single, double and triple addition and subtraction as well as simple multiplication and division facts. This assessment allowed the interventionist to assess where the student scored on a norm referenced assessment compared to students his same age.

The survey that was administered both prior to and after the intervention asked questions regarding the student's feelings about mathematics in general as well as how he felt he performed as a student of mathematics. The purpose of this survey was for the researcher to determine if playing mathematical games would help build the student's motivation and overall feelings about mathematics.

Conclusion

This chapter detailed the procedures used with the target student in an effort to improve mathematical achievement in the area of fluency and automaticity in mathematics as well as student motivation and feelings about mathematics through the use of iPad applications focusing on single, double and triple addition and subtraction. The first section provided a detailed student description. The second section included this case study's setting, sample population, and data collection. Finally the third section, Overview of Procedures, provided a detailed explanation of the procedures used with the target student in an effort to increase his mathematical fluency and motivation.

In the following chapter, Chapter Four: Results, samples of student work and assessment results will be presented. These results will then be discussed in Chapter Five: Conclusion.

CHAPTER FOUR

RESULTS

Introduction

The purpose of this research and intervention was to determine if the use of iPad technology during mathematical instruction would increase student achievement and motivation. The intervention took place over a five week period. Each week was broken down into three sessions of 30 minutes each. The participant worked on two different mathematical applications on the iPad for 10 minutes each, as well as received 10 minutes of direct mathematical instruction from the interventionist. This case study focused on single, double, and triple digit addition and subtraction equations. This chapter consists of the collected data, including figures and tables, and a summary of the results.

Overview and Data Collection

Assessment Data

One type of data collected was assessment results. The participant completed two versions of Aimsweb assessments throughout this study. Aimsweb is a Curriculum Based Measurement (CBM) used for universal screening, progress monitoring and data management for Grades K-12. It is a norm referenced assessment which is produced by Pearson. Aimsweb assessments were used by the participant's school to monitor progress during Response to Intervention sessions. Prior to the case study, the interventionist administered the Third Grade Benchmark Three Assessment (Appendix A). This assessment was given at the third grade level because the participant was in the third grade during the intervention. The mathematic equations on this assessment included single, double and triple digit addition and subtraction as well as basic multiplication and division. The Benchmark Assessment was given as a norm referenced assessment to compare the participant to other students his same age across the United States. After the intervention, the same Benchmark Three Assessment was administered again to determine and measure mathematical academic growth.

Aimsweb Progress Monitoring Assessments were administered weekly at the second grade level (Appendix B). The Progress Monitoring probes were administered for eight minutes at the end of the third session of every week. The participant had been performing at the second grade instructional mathematical level which is the reason why the Progress Monitoring Probes were given at that level. These probes included single, double and triple digit addition and subtraction equations. These were the kinds of mathematic problems that were focused on during this intervention.

The second type of data collected was to determine if incorporating iPad technology with mathematic instruction would affect the opinion and attitude of the participant. A survey (Appendix C) was administered prior to the intervention in which the participant indicated how much he agreed with each question about math. At the end of the survey, the interventionist asked short answer questions about mathematics and recorded his answers. After the five week intervention was complete, the same survey was administered again.

Benchmark Assessment

The pretest was administered prior to the beginning of the intervention. The Aimsweb Third Grade Benchmark Three consisted of thirty-seven mathematical equations. The student was given fifteen minutes to complete the assessment. Twelve of the problems on the Benchmark Assessment were single, double or triple digit addition, 12 were single, double or triple digit subtraction, nine equations were single digit multiplication and four were single digit division. The participant answered eight of the 12 addition problems correctly, one of the 12 subtraction problems correctly, one out of nine multiplication equations correctly and zero out of four of the division equations correct. There were a total of 37 problems on the Benchmark Assessment and he answered 10 of those accurately. Aimsweb assigned a possible 1, 2 or 3 points for each question on the Benchmark Assessment according to the difficulty of the problem. Out of a possible 68 points, he earned 13 points on the pretest taken prior to the intensive five week intervention.

The same Benchmark Assessment was administered after the five week intervention. Out of 12 addition problems he answered all 12 correctly. Out of the 12 subtraction problems he answered all 12 correctly. He answered two out of nine multiplication equations correctly and 0 out of four division equations. Out of a possible 68 points, he earned 44 points on the post test taken after the intensive five week intervention. Pre-test and Posttest worksheets are available to view in Appendix A.

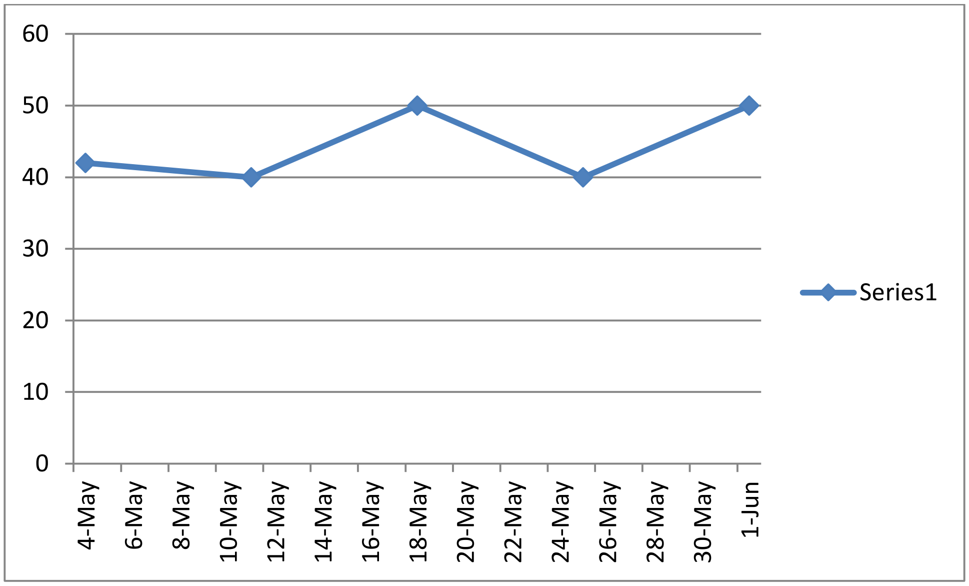
Progress Monitoring Probes

The Aimsweb Progress Monitoring Probes are intended to track the progress of student's academic achievement on a regular basis to analyze improvements from week to week. The school psychologist oversaw the Response to Intervention program at the school in this study. The data collected from the progress monitoring probes was used to determine if a special education referral was needed for the student.

The progress monitoring probes were administered at the student's instructional level which was second grade. The academic focus of this study was to increase mathematic fluency when working with single, double and triple digit addition and subtraction equations. Five progress monitoring probes were given in total, one each week of the intervention. There were 28 questions on each of the probes. Every probe consisted of different equations however each probe had 17 addition equations and 11 subtraction equations. There was a possible 50 points on each progress monitoring probes.

TABLE 4.1

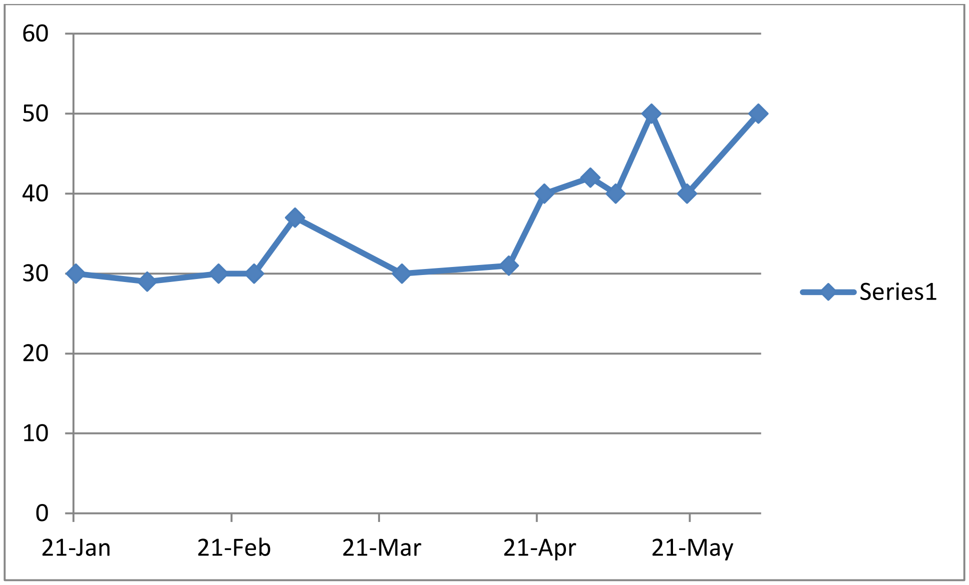
Progress Monitoring Scores during 5 week intervention



As shown in Table 4.1, on the first progress monitoring probe that was given during this study, the participant correctly answered 17 out of 17 addition problems and eight out of 11 subtraction problems for a score of 42 out of 50. During the second week he correctly answered 17 out of 17 addition problems and seven out of 11 subtraction problems with a score of 40 out of 50 points. In the third week of the intervention he answered 100% of the problems correctly for a score of 50 out of 50. In the fourth week he answered 16 out of 17 addition problems correctly and eight out of 11 subtraction problems correctly for a score of 40 out of 50 points. In the final week of the intervention he answered 100% of the problems correctly with a score of 50 out of 50. All progress monitoring mathematics worksheets are available to view in Appendix B.

TABLE 4.2

Progress Monitoring Scores January 21 through June 6



As shown in Table 4.2, prior to the intensive intervention the student had completed progress monitoring probes and earned scores between 29 and 40 each time. When the intensive intervention of three times a week began his weekly scores increased to between 40 and 50 points each week.

Attitude Survey

The Attitude Survey (Appendix C) was administered prior to the beginning of the study. The survey was given to measure motivation and confidence in mathematics. There were six statements on the survey for the student to respond to ranging from strongly disagree to strongly agree about his feelings and attitude toward the subject of mathematics in school. The student indicated that he liked math a lot but that he often gets discouraged in math class. After completing the survey the interventionist asked question about specific aspects that he liked or didn’t like about math class. When talking about what he did not like about math he said that he received consequences for talking during class and he felt like the teacher did not trust him. The interventionist asked if there were ways that she taught math that he enjoyed. He said that he enjoyed the number song, rolling numbers and working with his individual whiteboard. He was asked what he thought would make math class more fun and he answered by saying that he didn't want to get consequences for talking. He wanted to be allowed to talk more and help people. He also identified that using an individual whiteboard to complete his work would make math class more enjoyable. Finally when asked what was hard for him in math, he began by saying everything was easy but then changed his response and identified that carrying and borrowing were difficult when he had to put numbers on top of the equations.

After the five week intensive intervention, the participant completed the same attitude survey. When answering the six questions ranging from strongly agree to strongly disagree, he indicated that he enjoyed math class and never gets discouraged. After circling his answers to the questions the interventionist asked him questions for him to respond to. When asked what some things that he did not like about math, he answered that he didn't like when people told him the answers. He said that math class would be more fun if people let him figure out his work and did not give him the answers. Next he was asked if there were aspects of how the interventionist taught him that he liked. He said that he enjoyed taking the progress monitoring tests each week. He also indicated that he liked using the iPad during the sessions. Finally he was asked what areas of math were hard for him and he identified that multiplication and division were difficult.

The results from the surveys show an increase understanding and motivation for the subject of mathematics. The participant's responses on the survey after the intervention showed that he strived to be more competent in math and did not want other students to tell him answers.

His answers indicate that his confidence in mathematics increased since the intensive five week intervention began.

Conclusion

This chapter displayed the data collected during the five-week research study. The purpose of the data was to determine if the use of iPad technology during mathematical instruction would increase student achievement and motivation. In order to prove this hypothesis, pre and posttest scores from the five-week intervention period along with progress monitoring assessments were discussed and analyzed. Before the five-week intensive intervention began, the participant was performing at the thirteenth percentile for his age on the Benchmark Assessment. After the five-week intensive intervention the participant performed at the forty-fourth percentile for his age. In addition to the assessment scores, the participant completed an attitude survey to measure his confidence and motivation in the subject of mathematics. The results showed an increase in his confidence and motivation in math. He enjoyed taking the progress monitoring probes each week and seeing his progress. He wanted to be more independent when completing his work and did not like when other students tried giving him answers, instead he wanted to figure the answers out by himself. While this chapter discussed the data collected to measure academic and intrinsic advances, Chapter Five presents conclusions drawn from this data.

CHAPTER FIVE

CONCLUSION

Introduction

The purpose of this research and intervention was to determine if the use of iPad technology during mathematical instruction would increase student achievement and motivation. During the five-week intervention, the participant was taught strategies for solving double and triple digit addition and subtraction equations. Those strategies were paired with the use of iPad technology. By the end of the five-week intensive intervention, the participant made large gains on the post-test as well as maintaining more consistent scores on the progress monitoring probes throughout the length of the study. Furthermore, the participant's motivation and excitement of learning mathematics also increased by the end of this five-week study. In this chapter, connections to existing research, an explanation of the results and the strengths and limitations of the study will be reported. Finally, recommendations for future research in the field of pairing mathematic instruction with technology will be presented.

Connections to Existing Research

Research has shown that incorporating skill and drill strategies have been effective when teaching mathematic facts to elementary students (Skarr, Zielinski, Ruwe, Sharp, Williams and McLaughlin (2014); Smith, March-Martella, and Martella (2011). It has been shown that when technology is paired with traditional mathematical pedagogy (Herro, Kiger, and Prunty, 2012; Singer (2015) students make greater academic gains along with showing increasing motivation and engagement during math lessons. When students lack motivation and confidence their academic achievement suffers. In order to determine effective mathematical instruction, research on the best methods was conducted. The rapidly increasing popularity of using one-on-

one iPad devices to support academics has led to a need to study the impact they have on students' learning and attitudes. Chapter Two focused on four areas to improve mathematic achievement and engagement. These areas included mathematical frameworks and strategies for at risk students, keeping students interested and engaged during math class, incorporating technology in math instruction, and response to intervention implementation for math instruction. These research based areas were then the basis for the design and implementation of this action research study.

One research-based practice in mathematics was implementing strategies and frameworks to increase academic achievement in the area of mathematics for students at risk of school failure. Skarr, Zielinski, Ruwe, Sharp, Williams and McLaughlin (2014) combined the use of the program Math Racetrack with Direct Instruction Flashcards to increase math fluency in an after school program. Ultimately their study showed that skill and drill strategies do help build mastery with math fact fluency. The students' confidence levels increased and they became excited about learning and mastering their multiplication facts. Another research study conducted by Smith, and March-Martella, and Martella (2011) examined the effects of the Rocket Math Program on the math fluency skills of a first grade student who was at risk for school failure. In utilizing skill and drill practices along with progress monitoring tools, the participant showed mastery of 13 levels of math facts along with increased attention and engagement by the end of this study. Findings from these studies showed that when educators practiced skill and drill tasks with students consistently, over time their achievement levels increased. With the increased mathematical achievement, their confidence and motivation towards mathematics also improved. The results from these studies were the basis for incorporating a flashcard based iPad application into this action research study. Through the use of that particular app the student in this research study improved his mathematic fluency which resulted in an increased level of confidence and excitement for learning math. The usage of progress monitoring in the study by Smith, March-Martella, and Martella (2011) was the basis for which the progress monitoring probes were implemented in this research study as well. When students are able to monitor their own progress and see improvement and growth they gain confidence and motivation thereby improving their academic achievement and their enthusiasm for learning.

The second research-based area of mathematic instruction focused on keeping students interested and engaged during mathematics class. The research study by Gilbertson, Witt, Duhon, and Dufrene (2008) determined that the combination of skill and drill instruction and incentives were effective for students who struggled with on-task behavior and motivation. In this research study the incentive was the use of technology after practicing skills during the direct instruction portion of the session. The use of games and technology enticed the participant to do well during the direct instruction portion of the session so he could use the iPad. As the sessions continued the incentive became the participants' achievement. Over time he became more interested in seeing his improvements on his progress monitoring probes and did not need that carrot so to speak dangled in front of him. The study by Schweinle, Meyer and Turner (2006) found that whether students believed that they had skills to perform mathematics tasks appeared to be related strongly to affect—social and personal. The importance of a task to self and to others was more predictive of students' motivation than was the challenge itself. In this research-based study the researcher found that the participant's motivation and attitudes about mathematics improved as his skills in solving double and triple digit addition and subtraction improved. Thus academic success and motivation and attitude directly affect one another.

The third research-based area of mathematic instruction focused on the combination of technology with mathematic instruction. Prior literature reveals there are several possible benefits with integrating technology with mathematic instruction. In today's day and age students are generally motivated and interested in using computers or hand-held devices to do just about anything. Herro, Kiger, and Prunty, (2012) sought to identify if combining the use of a Mobile Learning Intervention (the use of iPods) with regular classroom instruction would help students increase mathematic achievement. There was a significant difference between the experimental and control groups showing MLI participation as the most influential reason for the progress. The findings suggest that coupling business as usual curriculum with a mobile device may be a cost-effective lever to improve student achievement. The apps used were very specific to what the students were working on in class each day. The usage of the app as well as the goal of the app was explained each time the students used them. An adult showed students exactly how to use the app and then monitored the class to make sure students were staying on task. The study done by Herro, Kiger, and Prunty (2012) influenced this case study to combine one on one instruction with the use of specific mathematical iPad apps. The participant in this case study knew the goal of each app and the equations that were practiced were consistent with what was focused on during the direct instruction portion of each session. The study by Singer (2015) combined the use of mobile technology devices with math instruction to determine if students would experience a significant difference in mathematical achievement and their motivation and attitudes towards math. The use of the Attitudes Towards Mathematics Inventory, a survey measuring student attitudes and motivation about math class was the basis for the Math Attitude Survey in this case study. Although there was no significant difference between the control and experimental groups in Singer's study, the participating teacher noticed that the students were very motivated and self-stimulated when the teaching incorporated technology. The participant in this case study showed increased engagement which resulted in academic gains as the study progressed.

The final research-based area implemented in this study was the use of Response to Intervention strategies. There is a continued need to examine Response to Intervention models in mathematics. For Response to Intervention to be effective it has to be ever changing and ever evolving to best serve the needs of the individual students participating in the interventions. It is necessary to understand how time and intensity can help or hinder a student from reaching their highest potential. One of the questions explored in the study conducted by Atkins (2008) asked if increasing intensity reduced the difference between the slope of average rate learners and low rate learners. Data from this study indicated that the intensity of an intervention improves the majority of students' performance. When the amount of time in the intervention increased from once a day to two times a day, it resulted in increased achievement levels for the participants. Furthermore, when the intensity for those students increased from two times a day to four times a day the achievement of the participants increased even more. The research conducted was very specified and individualized to the needs of each student. The researchers found that the more often they met with the participants the greater increase in achievement they observed. In this case study the intervention sessions increased from twice a week to three times a week. Being exposed to the mathematic content three out of five school days a week resulted in greater and more consistent gains in mathematic achievement. The intensity of the intervention in this case study contributed to the participant's increased achievement and motivation.

Connections to Common Core State Standards

The Common Core State Standards (CCSS) emphasize the importance of building a solid foundation and understanding of numbers in the subject of mathematics. In second grade students should be able to fluently add and subtract within 20 using mental strategies. Students should also use addition and subtraction within 100 to solve problems. This study was designed so that the student would acquire the fluency with single digit numbers. Additionally, this study focused on understanding the concept of taking apart and putting together in order to build a solid foundation for the understanding of numbers. Therefore, this study satisfies the Common Core State Standards at the second grade level.

Explanation of Results

An intervention was designed to determine if the use of iPad technology in combination with traditional mathematic instruction would increase student achievement and overall attitude about mathematics. In order to analyze the effectiveness of the intervention, data from a pre-test and posttest was collected to measure academic achievement from before the intervention. The interventionist administered the third Grade Benchmark Three Assessment (Appendix A). This assessment was given at the third grade level because the participant was in the third grade during the case study. The mathematic equations on this assessment included single, double and triple digit addition and subtraction as well as basic multiplication and division. The Benchmark Assessment was given as a norm referenced assessment to compare the participant to other students his same age across the United States. After the intervention, the same Benchmark Three Assessment was administered again to determine and measure mathematical academic growth. Every week during the duration of the study the participant completed a progress monitoring probe (Appendix B) to measure growth from week to week. Progress Monitoring

Assessments were administered weekly at the second grade level. The Progress Monitoring probes were administered for eight minutes at the end of the third session of every week. The participant had been performing at the second grade instructional mathematical level which is the reason why the Progress Monitoring Probes were given at that level. These probes included single, double and triple digit addition and subtraction equations which were consistent with the kinds of mathematic problems that were focused on during this intervention. Finally, data from an attitude survey (Appendix C) was collected prior to the intervention and after the intervention to determine if the use of iPad technology in the intervention affected the participant's attitude and feelings about mathematics.

Pre and Posttest Data

The first type of data analyzed was the Aimsweb Third Grade Benchmark Three Assessment (Appendix A). Aimsweb is a Curriculum Based Measurement (CBM) used for universal screening, progress monitoring and data management for Grades K-12. It is a norm referenced assessment which is produced by Pearson. The Aimsweb Benchmark Assessment was used in this case study to collect pre-test and posttest data and measure growth from the beginning of the intensive intervention to the end of the intervention.

On the Pre-test, the participant answered eight of the 12 addition problems correctly, one of the 12 subtraction problems correctly, one out of nine multiplication equations correctly and zero out of four of the division equations correct. There were a total of 37 problems on the Benchmark Assessment and he answered ten of them accurately. Aimsweb assigned a possible 1, 2 or 3 points for each question on the Benchmark Assessment according to the difficulty of the problem. Out of a possible 68 points, he earned 13 points on the pretest taken prior to the intensive five week intervention.

The same Benchmark Assessment was administered after the fifth week of the intervention. Out of 12 addition problems he answered all 12 correctly. Out of the 12 subtraction problems he answered all 12 correctly. He answered two out of nine multiplication equations correctly and zero out of four division equations. Out of a possible 68 points, he earned 44 points on the post test taken after the intensive five week intervention.

The focus of this case study was on double and triple digit addition and subtraction equations. When analyzing the data it is evident that the participant improved his understanding of how to solve addition and subtraction problems. On the pre-test he answered eight out of 12 addition problems correctly while on the posttest he answered all 12 correctly. In addition on the pre-test he answered one subtraction equation correctly and on the posttest he answered all 12 subtraction problems correctly. That demonstrates that the focus of the case study was effective and the participant showed mastery when solving double and triple digit addition and subtraction equations. Conversely, he answered one out of nine multiplication equations correctly on the pre-test and two out of nine on the posttest. He did not complete any of the division problems correctly on either the pre-test or posttest. This illustrates that there was no emphasis placed on multiplication or division during this intervention. When compared with other third graders across the United States, the participant began at the second percentile and increased to the thirtieth percentile. These scores indicate that the case study was effective.

Progress Monitoring Probes

The next type of data that was analyzed in this case study was the Aimsweb Second Grade Progress Monitoring Probes (Appendix B). Although the participant was in third grade at the time of this study, he completed Progress Monitoring Probes at his instructional level which was a second grade level. The academic focus of this study was to increase mathematic fluency when working with single, double and triple digit addition and subtraction equations. Five progress monitoring probes were given in total, one each week of the intervention. There were 28 questions on each of the probes. Every probe consisted of different equations however each probe had 17 addition equations and 11 subtraction equations. There was a possible 50 points on each progress monitoring probes.

On the first progress monitoring probe that was given, the participant correctly answered 17 out of 17 addition problems and eight out of 11 subtraction problems for a score of 42 out of 50. During the second week he correctly answered 17 out of 17 addition problems and seven out of 11 subtraction problems with a score of 40 out of 50 points. In the third week of the intervention he answered 100% of the problems correctly for a score of 50 out of 50. In the fourth week he answered 16 out of 17 addition problems correctly and eight out of 11 subtraction problems correctly for a score of 40 out of 50 points. In the final week of the intervention he answered 100% of the problems correctly with a score of 50 out of 50.

The data from the progress monitoring probes indicates that the instruction delivered during this case study was effective. By the third week of the intervention he answered 100% of the problems correctly. In the fourth week of the intervention his score dropped to 40 out of 50. This was because the participant was rushing and racing to get the probe done. His focus was on beating the time and his attention to detail suffered. In the final week of the study, the interventionist reminded the participant prior to taking the probe to focus on his steps and to work slowly and accurately. This mindfulness allowed the student to complete 100% of the equations correctly once again. Each week after the progress monitoring probes were completed, the interventionist scored the assessment and went through the results with the participant. The participant liked to see what he got wrong and what he answered correctly. This motivated him to answer accurately. When he answered questions incorrectly he liked working through the problems again to identify his mistakes and find the correct answer. This process showed him that when he took his time and focused on what the questions were asking he was able to answer correctly.

Prior to the intensive intervention the student had completed progress monitoring probes during Response to Intervention sessions and earned scores between 29 and 40 each time. The participant attended RtI sessions two times a week prior to this case study. When the intensive intervention of three times a week began his weekly scores increased to between 40 and 50 points each week. This indicates that increasing the number of sessions each week had a positive effect on the participant's academic achievement. This also shows that the use of iPad technology was effective. The use of technology helped the participant remain engaged and active in the processes necessary to complete the equations correctly, resulting in great gains in his mathematic achievement.

Attitude Survey

The final type of data collected was to determine if incorporating iPad technology with mathematic instruction would affect the opinion and attitude of the participant. A survey (Appendix C) was administered prior to the intervention in which the participant indicated how much he agreed with each question about math. At the end of the survey, the interventionist asked short answer questions about mathematics and recorded his answers. After the five week intervention was complete, the same survey was administered again. The survey was given to measure motivation and confidence in mathematics. There were six statements on the survey for the student to respond to ranging from strongly disagree to strongly agree about his feelings and attitude toward the subject of mathematics in school.

On the survey given prior to the intensive intervention, the student indicated that he liked math a lot but that he often gets discouraged in math class. The response of the participant on the attitude survey prior to the five week case study was more positive than anticipated by the researcher. A reason for this might have been because the student responded with the answers that he perceived as correct or the answer that he thought the "teacher" wanted to hear. He responded that he often gets discouraged during math class. This was the only answer where he indicated that math was difficult for him. The researcher had to explain the question so that he understood it. He seemed to be confused by some of the wording on the survey. After completing the survey the interventionist asked question about specific aspects that he liked or didn't like about math class. When talking about what he did not like about math he said that he received consequences for talking during class and he felt like the teacher did not trust him. This response indicated to the researcher that he was not focused on the mathematic content but rather the social interaction with other students and his teacher. The interventionist asked if there were ways that she taught math that he enjoyed. He said that he enjoyed the number song, rolling numbers and working with his individual whiteboard. He was asked what he thought would make math class more fun and he answered by saying that he didn't want to get consequences for talking. He wanted to be allowed to talk more and help people. The participant had a difficult time understanding why he was not allowed to "help" people and did not fully realize that he did not understand the content being taught therefore would not be permitted to help anyone else. He also identified that using an individual whiteboard like he did in the one-on-one sessions to complete his work, would make math class more enjoyable. Finally when asked what was hard for him in math, he began by saying everything was easy but then changed his response and identified that carrying and borrowing were difficult when he had to put numbers on top of the equations.

After the five week intensive intervention, the participant completed the same attitude survey. When answering the six questions ranging from strongly agree to strongly disagree, he indicated that he enjoyed math class and never gets discouraged. This was an improved attitude from the survey given prior to the intervention. He displayed more confidence when responding to the questions and seemed to answer more truthfully as opposed to just responding with his perceived correct answer. After circling his answers to the questions the interventionist asked him questions for him to respond to. When asked what some things that he did not like about math, he answered that he didn't like when people told him the answers. He said that math class would be more fun if people let him figure out his work and did not give him the answers. This response was very different from his answer before the intensive intervention. He wanted to work through the answers by himself which indicated more confidence and motivation in math as a whole. Next he was asked if there were aspects of how the interventionist taught him that he liked. He said that he enjoyed taking the progress monitoring tests each week. He liked being able to see what he got wrong immediately after completing the probes. He then wanted to rework the equations to identify his mistakes and solve the problem correctly. He also indicated that he liked using the iPad during the sessions. Just as with the progress monitoring probes, he liked that the iPad apps told him if his responses were accurate immediately. On the problems he answered incorrectly, he was able to rework them to answer them correctly. Finally he was asked what areas of math were hard for him and he identified that multiplication and division were difficult. This response again shows that the purpose of this case study was effective. Prior to the case study he indicated that borrowing and carrying in addition and subtraction equations were difficult for him. After the case study he sets his sights on the next function of math that he needed to master, multiplication and division. Now that he has mastered the addition and subtraction functions he was ready to move on to the next step in his mathematic journey.

The results from the surveys show an increase understanding and motivation for the subject of mathematics. The participant's responses on the survey after the intervention showed that he strived to be more competent in math and did not want other students to tell him answers. His answers indicate that his confidence in mathematics increased since the intensive five week intervention began.

Conclusion: Explanation of Results

This intervention was designed to determine if the use of iPad technology in combination with traditional mathematic instruction would increase student achievement and overall attitude about mathematics. Three data points were collected to determine if the case study was effective. The Aimsweb Third Grade Benchmark Three (Appendix A) was administered as a pre-test and posttest to measure academic achievement during the study. The Aimsweb Second Grade Progress Monitoring Probes (Appendix B) were administered each week to measure growth and consistency throughout the study. A Math Attitude Survey was given prior to the intensive intervention and after the intervention to determine if the design of the case study had an effect on how the participant felt about mathematics. All of the data points analyzed showed improvement and growth during this study. This indicates that increasing the intensity of the intervention and the use of iPad technology in the intervention had a positive effect on the participant's academic achievement and attitude towards math.

Some key findings from this study indicate that combining traditional mathematic instruction with engaging iPad applications led to gains in academic achievement and student attitude and motivation. The immediate feedback provided from the progress monitoring probes and the iPad applications increased the understanding of processes used to solve addition and subtraction equations correctly. This immediate response helped the student take pride in his work, giving him the motivation to identify mistakes or missteps while solving the equations. Ultimately increasing the frequency of the intervention from two times per week to three times per week led to greater gains academic of the participant. With those academic gains the participant felt more confident in his abilities resulting in increased positive attitude and motivation towards mathematics.

Strengths of the Study

The overall gains of the student in mathematics can be attributed to the strengths of this study. The first strength of this study was increasing the intensity of the intervention. Atkins (2008) found that increasing the number of sessions in a week resulted in higher gains by the students. By increasing the intensity of the intervention from two times a week to three times a week allowed the participant to be exposed to the mathematic content in a one-on-one setting three times as often as prior to the case study.

The second strength of this study was addition of engaging iPad technology into a Response to Intervention program. The use of technology increased on-task performance time during the intervention. Herro, Kiger, and Prunty, (2012) identified that coupling business as usual instruction with technology resulted in higher academic gains and increased levels of motivation. The participant in this case study enjoyed using the mobile device and he looked forward to that time. Combining direct instruction with technology provided an engaging and fun experience for the student. The increased amount of time on-task led to higher achievement gains. The use of technology also allowed the participant to have more fun learning which resulted in higher motivation and engagement.

The third strength of this study was the implementation of immediate feedback for the participant. Smith, March-Martella, and Martella (2011) found that when students were involved in monitoring their own progress their motivation and achievement improved. The iPad applications used in this study allowed the student to rework equations that he answered incorrectly the first time. The use of the progress monitoring assessments also gave the student instant feedback and understanding of where mistakes were made. The student enjoyed monitoring his own progress. He also took pride in going back and reworking problems that he got incorrect. Identifying his mistakes allowed the student to gain a higher level of understanding of the work.

Finally, the data was easily comparable since the students were given identical pre-test and posttest during this case study. Because both assessments contained the same format, it was easy to compare the raw data. Likewise, the Math Attitude Survey was also easy to compare.

Limitations of the Study

This study was limited to a single elementary student in one Midwestern city in the United States. Therefore, the results cannot be generalized to all students within the school or in the city. A larger sample size would have helped for the results of this study to be more a representative of the population. Using the methodologies in this case study in several RtI sessions would have proven the validity of this study.

The Math Attitudes Survey used was another limitation of this study. When the survey was given prior to the intervention, the participant answered with his perceived correct responses rather than how he may have truly felt. This data point did reveal positive gains however the gains may have been greater if the student had responded more truthfully to the survey prior to the intervention.

Recommendations for Classroom Teachers

Based on this research study, there are some recommendations to be made to classroom teachers in general. Coupling traditional methods of teaching mathematics with engaging technology (Herro, Kiger and Prunity, 2012) is one recommendation for classroom teachers. Continuing to teach math in a traditional method maintains familiarity and consistency for the students. This style of teaching has proven to be effective over the decades. Enriching the traditional mathematic pedagogy with technology keeps the learning current, relevant and engaging to the students. When students enjoy how they are learning, they are more likely to retain the information and show academic gains along with increased confidence and motivation.

Another recommendation for classroom teachers is to give students the opportunity to correct their mistakes. Encouraging students and even giving partial credit to students who look at problems answered incorrectly, identify their mistakes and give them another chance to find the correct answer is a great way for students to monitor their own progress and not feel defeated in the process. This also allows students the opportunity to identify missteps that they took when solving math problems. Allowing students a second chance helps build confidence and awareness when working with numbers.

A final recommendation for classroom teachers is to have specific apps for students to work on when working with technology. Simply giving a student a mobile device with generic applications is not always effective. The use of technology allows for more individualized interventions for all students (Singer, 2015). Make sure students understand the goal of each program and assign students specific apps to meet the needs of that particular student. This makes the use of technology intentional and individualized rather than generic and broad. Every student in each classroom has different needs. Using technology that is targeted to the needs of each child allows for that individualized attention for each student and greater gains in their academic achievement.

A recommendation for this particular student is providing him with immediate feedback regarding correct and incorrect answers on assignments and assessments. This student thrived on immediate feedback and being able to rework problems to identify mistakes and try to solve them accurately. He loved being able to monitor his own progress and identify his strengths and weaknesses. This was much more effective when the feedback was given almost instantly instead of waiting until the next session. He had difficulty remembering things from one session to the next. Giving him that opportunity right away was helpful for the participant.

Another recommendation for this student is to use individual whiteboards during traditional instruction. On the Math Attitudes Survey given after the intervention, the student identified that he enjoyed working with his own whiteboards during the RtI sessions. He liked having his own dry/erase marker and board to use when solving math problems. This simple tool may help keep the student motivated when being taught mathematics in a traditional way.

Another recommendation for the participant in this study was encouraging him to work slowly and find correct answers rather than racing through and finishing fastest. He needed the reminder every time he completed an assessment to take his time and really pay attention to what each question was asking. He is naturally very competitive and wants to be first with everything. Constantly reinforcing the idea that being correct is more important than being fast is essential to the success of this student.

Another way to reach the participant used in this research study is to provide engaging and fun methods of teaching math. The use of the iPad was effective with the participant in this study. He remained engaged and active in his learning. The applications used in this study also provided immediate feedback and allowed him to try incorrectly solved problems again.

Finding ways of increasing this child's confidence and motivation will help him be more successful in his academic ventures in the future. Working one-on-one with a teacher will help this child make greater gains in achievement and motivation. He also needs to feel like the teacher genuinely cares about him. Having a great relationship with this child is essential to his success. If he senses that the teacher is unhappy with him, he shuts down and is not productive. This student also needs to have good relationships with the other students in the classroom. He is easily thrown off by negatively perceived social interactions with other students. The teacher should be very aware of the students who sit around this child as well as the interactions that are taking place between him and his peers. Being able to meet the student where he is, both academically and socially, and work towards mastery of skills rather than focusing on what the other students in the class are learning will help this individual student be more successful in the future.

Recommendations for Future Research

The findings from this study are particularly relevant to the times and the ways in which elementary students are currently educated. Since this study solely focused on one participant from one school, it is recommended that future studies investigate the use of iPads in elementary schools. Furthermore future studies should investigate the use of iPads in Response to Intervention programs. Researchers should focus on districts that have implemented iPads into mathematic instruction or a few years to explore whether the devices have transformed the educational experience for students.

The discipline of mathematics was the only content area assessed in this study. Further studies into other elementary subject areas including English Language Arts, Science and Social Studies would be valuable.

Another recommendation for further research is the exploration of effective iPad applications. There are thousands of applications available for mobile devices and not all programs are effective. Searching through and trying out applications can be a waste of valuable learning time. Future research in this area would benefit teachers and students by providing valuable assessment data of potential, effective applications to implement in the classroom.

Conclusion

This chapter summarized my action research study, *The Effects of iPad Applications as an Instructional Tool for Mathematical Achievement and Motivation.* The purpose of my study was to determine if the use of iPad technology during mathematical instruction would increase student achievement and motivation. The sample population for this study was one third grade boy who was receiving Response to Intervention services in an elementary school in a Midwestern city.

During the five-week intervention, the participant was taught strategies for solving double and triple digit addition and subtraction equations. Those strategies were paired with the use of iPad technology. During each RtI session the participant received 10 minutes of direct instruction from the interventionist and spent time working on two math applications for the iPad. By the end of the five-week intensive intervention, the participant made large gains on the post-test as well as maintaining more consist scores on the progress monitoring probes throughout the length of the study. Furthermore, the participant's motivation and excitement of learning mathematics also increased by the end of this five-week study

In order to measure the effectiveness of this study, the participant was administered an identical pre-test and posttest (Appendix A) to measure mathematic achievement. The participant also completed a Math Attitudes Survey (Appendix C) prior to and after the duration of the study. During the third session of each week the participant completed Progress Monitoring Probes (appendix B) to measure growth from week to week.

The analysis of the data revealed that the study was effective. The participant grew from the second percentile to the thirtieth percentile on the Benchmark Assessment in mathematic achievement. The Math Attitude Survey also showed improvement and a greater understanding for mathematics as a whole. Overall, the findings from this student demonstrated that the use of iPad devices in a Response to Intervention program promoted student motivation, engagement, and attitudes towards mathematics along with increased successes with mathematical academic achievement.

References

Abrams, L. (2008). The effects of computer mathematics games on elementary and middle school students' mathematics motivation and achievement. Retrieved from http://search.proquest.com.csu.ezproxy.switchinc.org/docview/304813914?accountid=9367.

Atkins, M. (2008). Response to intervention: Incorporation of an increasing intensity design to improve mathematics fluency. Available from ProQuest Education Journals. Retrieved http://0-search.proquest.com.topcat.switchinc.org/docview/304381395?accountid=9367

Carr, J. (2012). Does math achievement h'App'en when iPads and game based learning are incorporated into fifth-grade mathematics instruction?, *Journal of Information Technology Education,* 11, 269-285

Dufrene, B., Duhon, G., Gilbertson, D. Witt, J. (2008). Using brief assessments to select math fluency and on-task behavior interventions: An investigation of treatment utility. Education & Treatment of Children, 31(2), 167-181. West Virginia University Press., URL http://0-search.proquest.com.topcat.switchinc.org/docview /202675430? Accountid =9367

Heemskerk, I., Kuipert, E., Meijer, J. (2014). Interactive whiteboard and virtual learning environment combined: effects on mathematics education. *Journal of Computer Assisted Learning, 30 (5)*, 465-478 http://dx.doi.org.csu.ezproxy.switchinc.org/10.1111/jcal.12060

Herro, D., Kiger, D., Prunty, D., (2012). Examining the influence of a mobile learning intervention of third grade math achievement. *Journal of Research on Technology in Education.*, 45(1), 61-82. http://0-search.proquest.com.topcat.switchinc.org/ docview /1448763675

Mong, M. D. (2008). Evaluation of the effects of the math to mastery intervention package with elementary school students in a school setting. Available from ProQuest Education Journals. Retrieved from http://0-searchproquest.com.topcat.switchinc.org/docview /230813162?accountid=9367

Schweinle, A., Meyer, D. K., & Turner, J. C. (2006). Striking the right balance: Students' motivation and affect in elementary mathematics. *The Journal of Educational Research, 99*(5), 271-278,280-293. Retrieved from http://search.proquest.com.csu.ezproxy. switchinc.org/docview/204199291?accountid=9367

Singer, J. (2015). *The effects of iPad devices on elementary school students mathematics achievement and attitudes* (Order No. 3730747). Available from ProQuest Dissertations & Theses Global: Social Sciences. (1734457388). Retrieved from http://search.proquest. com.csu.ezproxy.switchinc.org/docview/1734457388?accountid=9367

Skarr, A., Zielinski, K., Ruwe, K., Sharp, H., Williams, R., McLaughlin, T. (2014). Education & treatment of children: The effects of Direct Instruction flashcard and Math Racetrack procedures on mastery of basic multiplication facts by three elementary school students. West Virginia University Press. URL: http://0-search.proquest.com. topcat. switchinc.org/ docview/1503120991?accountid=9367

Smith, C., March-Martella, N., Martella, R. (2011). The effects of Rocket Math program with a primary elementary school student at risk for school failure: A case study. Education & Treatment of Children, 34(2), 247-258 West Virginia University Press. URL: http://0-search.proquest.com.topcat.switchinc. org/docview/ 868177144?accountid=9367

Swanson, L., Moran, A., Lussier, C., Fung, W. (2014). The effects of explicit and direct generative strategy training and working memory on word problem-solving accuracy in children at risk for math difficulties. Learning Disability Quarterly, 37(2), 111-123. doi: 10.1177/0731948713507264

APPENDIX A

Student: Teacher: Date:

1. $2 + 6$	2. $13 + 3$	3. $9 - 1$	4. $11 + 7 =$
5. 2×2	6. $18 \div 6 =$	7. 4×3	8. $13 + 15$
9. $19 + 14$	10. 5×7	11. $11 - 9$	12. 8×6
13. $14 + 16$	14. 9×1	15. $67 - 42$	16. $53 + 58$
17. $19 - 10$	18. $3\overline{)9}$	19. $6\overline{)12}$	20. $16 - 13$

AIMSweb® Math Computation

Benchmark Grade 3, Probe 8, Page 1

Student: Teacher: Date:

21. 3×5	22. $2\overline{)22}$	23. 7×9	24. $320 + 138 + 304$
25. $15 - 14$	26. $95 - 79$	27. 8×8	28. $4\overline{)20}$
29. $345 + 92$	30. $238 - 36$	31. $2 \; 90 - 5$	32. $247 - 50$
33. $1 + 8 + 9$	34. $460 + 139$	35. 10×2	36. $394 - 285$
37. $482 - 171$			

Student: Teacher: Date:

Reminder: There is **no** partial credit when scoring. The answer must be correct **in its entirety** to obtain the correct score value. Note that the answer key provides the correct answers for each problem, but is not exhaustive. For more information and examples of alternative correct answers, please refer to the Scoring section of the M–COMP manual.

Grade 3, Probe 3 Answer Key

Item No.	Answer	Correct	Incorrect	Item No.	Answer	Correct	Incorrect
1.	8	1	0	20.	3	2	0
2.	16	1	0	21.	15	1	0
3.	8	1	0	22.	11	3	0
4.	18	2	0	23.	63	2	0
5.	4	1	0	24.	762	2	0
6.	12	1	0	25.	1	2	0
7.	12	2	0	26.	16	3	0
8.	28	1	0	27.	64	3	0
9.	33	1	0	28.	2	2	0
10.	35	1	0	29.	427	2	0
11.	3	2	0	30.	202	2	0
12.	48	1	0	31.	97	1	0
13.	30	2	0	32.	197	3	0
14.	9	1	0	33.	18	1	0
15.	25	2	0	34.	599	2	0
16.	111	2	0	35.	20	3	0
17.	9	2	0	36.	109	3	0
18.	3	3	0	37.	311	2	0
19.	2	3	0				

Subtotal 1 ☐ Subtotal 2 ☐

TOTAL = Subtotal 1 + Subtotal 2 ☐

APPENDIX B

Student: Teacher: Date:

1. $8 + 1$	2. $6 + 4 =$ ____	3. $3 + 9$
4. $12 + 16$	5. $15 + 4$	6. $7 - 2 =$ ____
7. $6 + 6 =$ ____	8. $10 - 3$	9. $3 + 2 + 7$
10. $11 + 15$	11. $2 - 2$	12. $51 + 88$
13. $38 - 12$	14. $20 + 24$	15. $12 + 2$

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Progress Monitor Grade 2, Probe 5, Page 1

Student: Teacher: Date:

16 2 8 + 4	17 16 − 0	18 4 6 + 9
19 28 − 22	20 34 + 27	21 88 − 78
22 18 − 12	23 36 − 30	24 1 9 + 2
25 14 − 5	26 30 − 25	27 85 + 66
28 81 − 73		

Student: ______________________ Teacher: ______________________ Date: ______________________

Reminder: There is **no** partial credit when scoring. The answer must be correct **in its entirety** to obtain the correct score value. Note that the answer key provides the correct answers for each problem, but is not exhaustive. For more information and examples of alternative correct answers, please refer to the Scoring section of the M–COMP manual.

Grade 2, Probe 5 Answer Key

Item No.	Answer	Correct	Incorrect
1.	9	1	0
2.	10	1	0
3.	12	1	0
4.	28	1	0
5.	19	1	0
6.	5	1	0
7.	12	1	0
8.	13	1	0
9.	12	1	0
10.	26	1	0
11.	0	2	0
12.	139	2	0
13.	26	3	0
14.	44	1	0
15.	14	1	0
16.	14	2	0
17.	16	2	0
18.	19	2	0
19.	6	2	0
20.	61	3	0
21.	10	3	0
22.	6	2	0
23.	6	2	0
24.	12	2	0
25.	9	3	0
26.	5	3	0
27.	151	3	0
28.	8	3	0

TOTAL [ ]

APPENDIX C

Name____ Date____________

Math Attitude Survey

1. I like math.

   

Strongly Agree | Agree | Somewhat Agree | Do Not Agree

2. I sometimes find it hard to pay attention during math class.

   

Strongly Agree | Agree | Somewhat Agree | Do Not Agree

3. At school, I look forward to math.

   

Strongly Agree | Agree | Somewhat Agree | Do Not Agree

4. I always try my best in math.




Strongly Agree | Agree | Somewhat Agree | Do Not Agree

5. I often get discouraged in math or think I can't do it.




Strongly Agree | Agree | Somewhat Agree | Do Not Agree

6. Math is fun!!




Strongly Agree | Agree | Somewhat Agree | Do Not Agree

Are there some things you don't like about math? What?
Is there anything you like about the way I teach math? What is it?
What do you think would make math class more fun?
What are some things that are hard for you in math?