Using Mobile Technology to Increase the Math Achievement and Engagement of Students with Disabilities

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USING MOBILE TECHNOLOGY TO INCREASE THE MATH ACHIEVEMENT AND ENGAGEMENT OF STUDENTS WITH DISABILITIES

By

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ABSTRACT

USING MOBILE TECHNOLOGY TO INCREASE THE MATH ACHIEVEMENT AND ENGAGEMENT OF STUDENTS WITH DISABILITIES

by

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The advent of advanced technologies provides new opportunities for delivering instruction to students with disabilities. Many classrooms have access to mobile devices, such as iPads and Kindles, and educators utilize these devices to differentiate instruction and augment teacher-led instruction. This delivery method, known as blended learning, can create an enriched learning environment where students are exposed to individualized lessons that are self-paced and provide multiple modes of presentation. However, there is little empirical investigation into how students interact with digital devices or what components of online learning directly impact student learning and engagement with the content. In order to design authentic learning experiences that support students with disabilities and provide access to the general education curriculum, it is critical that researchers thoroughly examine the design on digital lessons and how students navigate digital environments.

The focus of this study was to investigate how students use mobile devices in a classroom setting and how they interact with academic content delivered in a digital format. The math achievement and engagement of students with disabilities was compared in two conditions - teacher-led math instruction (Traditional Math Instruction, TMI) and instruction delivered on a mobile device (Mobile App Instruction, MAI). Additionally, teacher and student perceptions of
math knowledge and engagement were collected for both conditions using surveys. The surveys were administered after the intervention was completed.

The results of the study indicate neither instructional method was significantly more effective in increasing the math achievement or the engagement of students with disabilities. Survey data revealed the teacher did not feel one condition was more effective at increasing math achievement or engagement. Data from the student surveys indicated that students in the TMI condition felt they learned more and were more engaged than the students in the MAI condition. Observational data indicated there was no significant difference in engagement for students in the TMI group and the MAI group. Data collected from the online learning platform suggested students easily accessed the lessons and completed embedded activities and questions. However, data from the learning videos indicate students accessed the videos but did not watch them through to completion, and did not answer the embedded questions.
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Dedicated to my beautiful daughters Cassandra Leigh and Lindsey Grace.

Never stop reaching for your dreams!
TABLE OF CONTENTS

ABSTRACT ................................................................................................................................. iii

ACKNOWLEDGEMENTS........................................................................................................... v

LIST OF TABLES...................................................................................................................... x

LIST OF FIGURES..................................................................................................................... xi

CHAPTER ONE  INTRODUCTION........................................................................................ 1

Mathematics Achievement in U.S. Public Schools................................................................. 3
Mathematics Instruction for Students with Disabilities ......................................................... 4
Mathematics Instruction to Meet Academic Expectations ..................................................... 5
Technology Integration for Mathematics ............................................................................. 8
Technology and Students with Disabilities ......................................................................... 10
Statement of the Problem ...................................................................................................... 11
Significance of the Study ....................................................................................................... 13
Definitions .............................................................................................................................. 14
Limitations .............................................................................................................................. 18

CHAPTER TWO  REVIEW OF RELATED LITERATURE.................................................. 20

Mobile Technology and Students with Disabilities ............................................................ 20
Comparing Teacher-Led and Mobile Technology Instruction ............................................. 33
Using Technology to Deliver Effective Instruction to Students with Disabilities ............... 48
Summary ................................................................................................................................. 65

CHAPTER THREE  METHODOLOGY................................................................................. 67

Overview ................................................................................................................................. 67
Research Questions ................................................................................................................ 69
Participants ............................................................................................................................. 71
Setting ..................................................................................................................................... 75
Instrumentation ...................................................................................................................... 75
Materials .................................................................................................................................. 78
Training .................................................................................................................................... 82
Design and Procedures .......................................................................................................... 83
Data Collection ....................................................................................................................... 88
Treatment of the Data ............................................................................................................. 89
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Demographic Information for Students</td>
<td>72</td>
</tr>
<tr>
<td>Table 2</td>
<td>Demographic Information for the Teacher</td>
<td>74</td>
</tr>
<tr>
<td>Table 3</td>
<td>Summary of Means and Standard Deviations for Teacher Fidelity</td>
<td>95</td>
</tr>
<tr>
<td>Table 4</td>
<td>Teacher Fidelity to Intervention Scores by Session</td>
<td>74</td>
</tr>
<tr>
<td>Table 5</td>
<td>Summary of Means and Standard Deviations for Assessments</td>
<td>97</td>
</tr>
<tr>
<td>Table 6</td>
<td>Tests of Between Subjects Effects for Student Math Achievement</td>
<td>98</td>
</tr>
<tr>
<td>Table 7</td>
<td>Tests of Within Subjects Effects for Student Math Achievement</td>
<td>99</td>
</tr>
<tr>
<td>Table 8</td>
<td>Summary of Means and Standard Deviations for Teacher Perceptions of Student Math Knowledge</td>
<td>101</td>
</tr>
<tr>
<td>Table 9</td>
<td>Summary of Means and Standard Deviations for Student Perceptions of Math Knowledge</td>
<td>102</td>
</tr>
<tr>
<td>Table 10</td>
<td>Independent Samples Test of Student Perceptions of Math Knowledge</td>
<td>102</td>
</tr>
<tr>
<td>Table 11</td>
<td>Summary of Means and Standard Deviations for Teacher Perceptions of Student Engagement</td>
<td>104</td>
</tr>
<tr>
<td>Table 12</td>
<td>Summary of Means and Standard Deviations for Student Perceptions of Engagement</td>
<td>105</td>
</tr>
<tr>
<td>Table 13</td>
<td>Independent Samples Test of Student Perceptions of Engagement</td>
<td>105</td>
</tr>
<tr>
<td>Table 14</td>
<td>Mean Observations of Student Behaviors During the MAI Condition By Session</td>
<td>106</td>
</tr>
<tr>
<td>Table 15</td>
<td>Mean Observations of Student Behaviors During the TMI Condition By Session</td>
<td>107</td>
</tr>
<tr>
<td>Table 16</td>
<td>Independent Samples Test of Observations of Student Behaviors</td>
<td>108</td>
</tr>
<tr>
<td>Table 17</td>
<td>Participants and Response Rate for Embedded Zeetings Questions</td>
<td>109</td>
</tr>
<tr>
<td>Table 18</td>
<td>Participants and Viewing Percentages for EDpuzzle</td>
<td>110</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1  Phases of the Study………………………………………………………………………………84
CHAPTER ONE
INTRODUCTION

Mathematics instruction is a critical component of education in the United States. Mathematics and related subjects (known collectively as Science, Technology, Engineering, and Mathematics, or STEM) foster critical thinking and reasoning skills that are needed to obtain employment in some of the fastest growing fields, including computer science and engineering (U.S. Department of Education, 2016). The ability to employ higher-level thinking is also needed to address national and global problems and advance knowledge across disciplines (Dossey, McCrone, & Halvorsen, 2016). Mathematics also focuses on the development of innovative and collaborative thinking and problem solving, skills that are in high demand by employers from all fields (Walters et al., 2014). Finally, rigorous, high-quality mathematics instruction prepares students for post-secondary education and allows students to compete for careers in a globalized society (U.S. Department of Education, 2016).

The movement to enhance mathematics instruction in the United States began over 65 years ago with the development of targeted research institutes, such as the University of Illinois School Mathematics Program, and continues to this day with the creation of the Common Core State Standards (Dossey et al., 2016). However, the groundwork for current mathematics instruction was laid in the 1980s with the release of the National Council for Teachers of Mathematics’ (NCTM) report *An Agenda for Action: Recommendations for School Mathematics of the 80s*, which detailed specific recommendations for strengthening mathematics curriculum and practice (Dossey et al., 2016). Eventually, this evolved into a set of rigorous standards that guided the implementation of math curriculum, professional development for teachers, and assessment procedures (Dossey et al., 2016).
Further reform was encouraged following a critical analysis of mathematics instruction in the United States that suggested current instructional components were not robust enough to support 21st century learning (Dossey et al., 2016). In 2009, the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for Best Practices (NGA Center) developed a set of content standards known as the Common Core State Standards (CCSS; Common Core State Standards Initiative, CCSSI, 2016). These standards attempted to address the critical skills and concepts needed to prepare students to compete in a global society and stress the importance of real-world problem solving (CCSSI, 2016). The CCSS represent significant changes to how mathematics instruction was previously delivered, namely due to: (a) an emphasis on depth of knowledge over learning a broad range of topics, (b) the provision of a sequential structure where previous knowledge serves as a foundation for new concepts, and (c) equity in the balance of the three components of rigorous instruction (i.e., conceptual understanding, procedural skills and fluency, application) (CCSSI, 2016). The CCSS also explicitly define the grade level expectations for mathematics instruction.

It is evident that mathematics instruction plays a critical role in preparing all students for postsecondary education and employment, however students with disabilities continue to struggle with math. Year after year students with disabilities score below proficiency in math on national and state assessments (NAEP, 2015). Often students with disabilities struggle to recall math facts and computation is a slow, laborious process (Ok & Bryant, 2016). When choosing a math strategy, students with disabilities tend to rely on elementary approaches that are not the most efficient methods for solving a problem (Ok & Bryant, 2016). All of these factors contribute to the poor outcomes experienced by students with disabilities and present a clear need for additional supports.
Mathematics Achievement in Public Schools in the United States

The Common Core State Standards (CCSS) provide educators with the skills and concepts students are expected to master throughout their school careers. The standards are grouped according to grade level (with the exception of the high school standards, which are grouped according to mathematical concepts), however school districts have the flexibility to dictate the sequence in which the standards are delivered (CCSSI, 2016). There are 11 domains in mathematics: (a) counting and cardinality (Kindergarten), (b) operations and algebraic thinking (grades K – 5), (c) number and operations in base 10 (grades K – 5), (d) number and operations – fractions (grades 3, 4, and 5), (e) measurement and data (grades K – 5), (f) geometry (grades K - 12), (f) ratios and proportional relationships (grades 6 and 7), (g) the number system (grades 6 – 12), (h) expressions and equations (grades 6 – 12), (i) functions (grades 8 – 12), and (j) statistics and probability (grades 6 – 12; CCSSI, 2016). Each domain contains a group of related standards that educators must “unwrap” in order to identify the critical learning components. The CCSS provide a useful roadmap for determining what skills students need to demonstrate in order to be proficient in math and meet rigorous college-and-career-ready expectations. However, the CCSS are not synonymous with mathematics curriculum. The specific mathematics curriculum utilized within each school is largely site or district based and can vary dramatically from one school to the next (Dossey et al., 2016).

Outcomes for Typical Students

Data from the National Assessment of Educational Progress (NAEP) indicate that approximately 40% of fourth grade students and 33% of eighth grade students are at or above proficiency in mathematics (NAEP, 2015). While this demonstrates a significant increase from the first year the NAEP was implemented in 1990 (only 13% of fourth grade students and 15%
of eighth grade students were at or above proficiency), the 2015 results show a slight decrease in achievement from the previous year. A comparison of U.S. students to students of the same age across 65 countries reveals more troubling statistics. According to the Program for International Student Assessment (PISA), only 9% of 15-year-old students in the United States demonstrated mastery in mathematics at a level 5 or above, with level 6 being the highest level of proficiency (Kelly et al., 2013). However, more than 25% of 15-year-old students in the United States scored below a level 2, which is considered the benchmark level for mathematics proficiency (Kelly et al., 2013).

**Outcomes for Students with Disabilities**

Students with disabilities continue to experience performance levels that are far behind their typical peers. In mathematics, students with disabilities earned an average of 1.6 credits in basic mathematics, 1.3 credits in middle level mathematics, and less than one credit in upper level mathematics (Newman et al., 2011). Across the United States only 16% of fourth grade students with disabilities scored at or above proficiency in mathematics on the NAEP assessment (NAEP, 2015). In eighth grade, the percentage of students with disabilities scoring at or above proficiency in mathematics drops dramatically to 8% (NAEP, 2015). Students with disabilities require targeted interventions to support competency in mathematics and improvement upon their current level of performance.

**Mathematics Instruction for Students with Disabilities**

Mathematics is one of the core content areas required for completing school and finding success in post-secondary settings. However, the breadth and complexity of mathematics present significant challenges for students with disabilities. Each strand of the CCSSM can serve as a roadblock to developing competency in mathematics and strengthening the foundational
knowledge that is needed to move forward. Specifically, students with disabilities have difficulty remembering basic math facts, applying systematic approaches to solving problems, performing mental math, and storing and retrieving information (National Council of Teachers of Mathematics, NCTM, 2007). Often students with disabilities demonstrate little to no growth in skill and content acquisition past the fourth grade (Freeman-Green, O'Brien, Wood, & Hitt, 2015).

Although there is no indication that either teacher-led or student-centered instruction is more effective for typical students, students with disabilities need direct and explicit instruction from the teacher (NMAP, 2008). The model for delivering mathematics content should include the following components: (a) scaffolded materials that emphasize key skills and concepts, (b) multiple occasions for students to respond and vocalize their thought process while solving problems, (c) immediate, applied feedback from the teacher, and (d) ongoing dialogue between the teacher and students (NMAP, 2008). In addition, students with disabilities should receive frequent review of the fundamental skills necessary to progress through the mathematics curriculum (NMAP, 2008).

Mathematics Instruction to Meet Academic Expectations

The National Mathematics Advisory Panel (NMAP; 2008) recommends linear, progressive mathematics instruction that emphasizes mastery of core concepts rather than rote repetition of facts. Although there has been an ongoing debate concerning the viability of teacher-led and student-centered instructional designs, NMAP determined that relying solely on either model is inappropriate for effective mathematics instruction (2008). Instead, educators should incorporate student collaboration as an integral component of mathematics instruction. An example of an evidence-based collaborative practice is peer assisted learning strategies
A key feature of PALS is the development of student dyads where each child is provided the opportunity to serve as a tutor and a tutee (Powell & Fuchs, 2015). In this way students are engaged with the content in a meaningful way in order to “teach” it to their partner.

Another key component of effective mathematics instruction is the use of continuous progress monitoring (Shapiro, Dennis, & Fu, 2015). Teachers should administer formative assessments for a variety of reasons, including: (a) determining the baseline functioning of the students, (b) observing the students’ progress towards skill mastery, and (c) planning thoughtful learning experiences that target student needs (Shapiro, Dennis, & Fu, 2015). When used appropriately the data from these assessments allow teachers to individualize instruction, thereby increasing student learning in mathematics (NMAP, 2008). Technology is recommended as a way for educators to access professional development on implementing progress monitoring and to deliver assessments to students (NMAP, 2008).

There are several evidence-based practices currently used to teach mathematics to students with disabilities. An emerging strategy commonly incorporated into school curricula is cognition or cognitive marking, where students are explicitly taught the procedures for thinking through, solving, and marking math problems using mnemonic devices or symbols (Krawec et al., 2013). Another strategy, the Concrete-Representational-Abstract (CRA) sequence, guides students through math concepts in stages using manipulative devices and models (concrete), diagrams and pictures (representational), and mathematical algorithms with numbers (abstract) (Watt & Therrien, 2016). Other educators believe in the concept of anchored instruction, where students with disabilities are taught how to solve a problem or develop a math skill and then the students apply the concepts/skills to a real-life project (Bottge et al., 2007).
In examining mathematics instruction from the broader lens of effective instructional models, teachers often use direct and explicit instruction. Explicit teaching includes teacher modeling, think alouds, multiple representations of the mathematical situation and possible solutions, opportunities for students to practice and apply the skills, and the provision of immediate feedback on student performance (Jayanthi, Gersten, Baker, & Center on Instruction, 2008). Another central component to mathematics instruction for students with disabilities is the use of ongoing progress monitoring through formative assessments (Jayanthi et al., 2008). By measuring student knowledge at regular intervals, teachers can develop appropriate lessons based on the students’ needs and movement towards mastery.

Academic supports commonly used at all grade levels for students with disabilities are manipulative devices (Satsangi & Bouck, 2015; Bouck & Flanagan, 2010; NCTM, 2007; Maccini & Gagnon, 2000). Manipulative devices are tangible items used to enhance mathematics instruction (Spear-Swerling, 2006). Specifically, these models serve as visual representations to assist students in making abstract mathematical concepts more concrete (Jayanthi et al., 2008). Finally, peer-assisted learning strategies are shown to increase the mathematics achievement of students with disabilities (PALS) (Jayanthi et al., 2008; Calhoon & Fuchs, 2003). PALS include pairing students based on academic ability level, with each student assuming the role of tutor and tutee (Calhoon & Fuchs, 2003). In this way students learn from each other, foster a collaborative relationship, and build confidence.

While all these pedagogical methods have some support in the literature, students with disabilities continue to struggle with mathematics concepts. One glaring issue with these practices is the lack of emphasis on self-pacing. Research shows that students with disabilities require additional time to absorb information and practice newly acquired skills (Vaughn,
Danielson, Zumeta, & Holdheide, 2015). Although sequencing and direct and explicit instruction are important, students with disabilities require the opportunity to revisit material multiple times and control the speed in which the content is delivered. Often in teacher-led instruction, the emphasis is on covering content quickly rather than individual exploration and understanding. This issue is compounded given the complex, abstract nature of mathematical skills. Additionally, students with disabilities often lack sufficient understanding of mathematics at the conceptual level (Little, 2009). This disrupts the sequential nature of mathematics learning and creates gaps in student knowledge.

The literature provides an abundance of evidence-based practices for delivering mathematics instruction to students with disabilities. When considering delivery methods that are based in a digital framework, it is important to adhere to these principles. Online learning, like the traditional brick-and-mortar classroom, should be designed with careful consideration of ability level and learning needs so that students with disabilities are able to access the curricula.

**Technology Integration for Mathematics**

There are a variety of ways technology is being integrated into the mathematics classroom in an attempt to diversify instruction and improve the achievement of students. While there is not much research to support its efficacy, blended or hybrid learning is a model that is gaining popularity, where students are exposed to teacher-led instruction and computer-based activities (U.S. Department of Education, 2010). Bottge et al. (2014) compared the effectiveness of enhanced anchored instruction (EAI) using teacher-led instruction and digital lessons and activities to business as usual (BAU) mathematics instruction using textbooks, interactive whiteboards, and manipulative devices for students with and without disabilities. The results indicate an increase in mathematics achievement for all students in the EAI condition.
Another way technology is used to deliver mathematics instruction is through the use of computer applications (apps). Zhang, Trussell, Gallegos, & Asam (2015) examined the effects of selected computer apps on the mathematics learning of typical students and students who struggled in math. The results indicate that both groups of students had significant gains in math performance after using the math apps.

Finally, math content teachers are using video modeling to increase the math skills of students with disabilities. Cihak & Bowlin (2009) examined the effects of using videos that depict math teachers writing, illustrating, and solving geometry problems on the acquisition and maintenance of geometry skills of students with learning disabilities. The results indicated a significant increase in math skills and maintenance of the skills after students viewed the videos.

The National Council of Teachers of Mathematics (NCTM, 2015) stressed the importance of incorporating technology in an authentic way and using digital tools to enhance students’ ability to engage in the content and develop math-related skills. Teachers need to identify the appropriate technological supports, provide explicit instruction on the use of the supports, and implement technology in a way that improves the learning outcomes of all students (NCTM, 2015).

**The Use Of Mobile Devices In The Classroom**

Mobile devices such as iPads, iPods, and Kindles are gaining popularity as instructional tools in the mathematics classroom (Smith & Basham, 2014). Through several state initiatives, grant opportunities, and federal funding, students have access to mobile devices more than ever before. The literature base for mobile technology is also growing. Several studies support the use of mobile devices to enhance math instruction and improve the academic achievement of students (Bryant et al., 2015; Musti-Rao & Plati, 2015; Zhang et al., 2015; Nordness, Haverkost,
While mobile learning is fast becoming the norm across educational settings, there is little research on the optimal circumstances for implementing digital lessons, or what components directly contribute to enhanced student performance and engagement. Also, there is little known about how students use technology and navigate online content.

**Technology and Students with Disabilities**

Technology can be used to increase accessibility and learning for students with disabilities, however care must be taken to ensure proper design and implementation of software and electronic devices. There are several components that should be considered when choosing technological tools, including (a) forgoing time constrictions and allowing students to self-pace, (b) chunking academic material into manageable, sequenced sections, (c) providing immediate, specific feedback for each student response, (d) providing explicit instructions for completing the activity, and (e) presenting content in a variety of formats, such as pictures, videos, and text (Boone & Higgins, 2007). Additionally, technology should not be the only vehicle used to deliver instruction. Students with disabilities require direct and explicit instruction from the teacher, with technology incorporated as a way to differentiate and individualize the content. If appropriately implemented in the classroom, well-designed programs can increase student learning, engagement, and productivity (Darling-Hammond, Zielezinski, & Goldman, 2014).

While a significant amount of funding has been applied to research projects investigating the use of technology for students with disabilities (National Center for Special Education Research, NCSER, 2015), there are still gaps in the literature. For instance, there is a dearth of research examining how students with disabilities use technology (e.g., student interaction with the program or device), as well as how technology is used as a tool for accessing background
knowledge, facilitating authentic learning over rote memorization, and providing review and practice (Allsop, Alvarez McHatton, & Farmer, 2010). In their meta-analysis of research investigating the effectiveness of computer-assisted instruction (CAI) for students with disabilities. Weng, Maeda, and Bouck (2014) found many studies applied an arbitrary method for selecting a particular device, software package, or set of integrated program features without an appropriate justification for using these tools. Even more worrisome is the lack of research that conforms to quality standards for rigorous, experimental research design, which calls in to question the validity of the proposed interventions (Okolo & Diedrich, 2014). Finally, there are few studies examining the delivery of direct instruction via a mobile computer application with the teacher as an instructional guide.

Given students with disabilities require multiple exposures to academic content in order to achieve mastery (Vaughn et al., 2015), digital tools could be an effective way to deliver content that is self-paced and appeals to the students’ specific learning needs. Educators can easily develop presentations that provide a detailed discussion of the targeted skills and concepts and incorporate several opportunities for practice and application. Additionally, the presentations can include formative assessments whereby each student is provided immediate feedback after a response is received. Mobile app technology supports student-led instruction and allows the teacher to take on a facilitative role.

**Statement of the Problem**

Students with disabilities require specialized instruction that addresses gaps in processing, organization, and strategy selection, and it is critical that educators adapt content delivery to meet these needs. Although direct and explicit instruction and the use of technology have been independently examined as methods of increasing academic achievement and
engagement, there is little empirical evidence to support the integration of direct instruction via mobile devices. Therefore, this study developed a pure traditional (teacher-led) mathematics curriculum based on the CCSS with explicit lesson plans and paper and pencil activities (traditional math instruction - TMI), and a second curriculum that incorporated a student-led mobile app based instructional sequence with several learning activities directly linked to the same standards (mobile app instruction - MAI) in order to determine the instructional model that results in the greatest increase in mathematics achievement and academic engagement. The specific research questions addressed by this study were:

1. Does the mathematics achievement of students with disabilities increase with the use of the mobile app instruction when compared to traditional math instruction?

2. Is there an increase in the academic engagement (i.e., when students review the material and actively complete the assigned task, exhibit appropriate physical responses such as typing or writing, ask for assistance in an acceptable manner, interact with the teacher or their peers about related topics, listen to the teacher’s directives) of students with disabilities with mobile app instruction when compared to traditional math instruction?

3. Do student perceptions of mathematics knowledge increase with the use of mobile app instruction when compared to traditional math instruction?

4. Do teacher perceptions of the mathematics knowledge of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

5. Do student perceptions of engagement increase with the use of mobile app instruction when compared to traditional math instruction?
6. Do teacher perceptions of the engagement of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

**Significance of the Study**

The rationale for delivering direct math instruction via a mobile app is directly connected to evidence-based practices that have been shown to increase the achievement of students with disabilities (Bryant et al., 2015; Musti-Rao & Plati, 2015; Zhang et al., 2015; Viel-Ruma, Houchins, Jolivette, Fredrick, & Gama, 2010; Miller, 2009). First, the instructional videos can be reviewed, paused, or advanced as needed at the student’s own pace, which targets individualization. The tailored pacing can lower student performance anxiety, thereby enhancing engagement and productivity. Next, technology can incorporate differentiation by integrating various presentation formats. Technology in the classroom can support college and career readiness by developing student proficiency in accessing, navigating, and applying computer-based tools and software. Finally, students with disabilities can be provided multiple exposures to content in order to increase the students’ ability to master math skills and concepts.

Mobile app instruction can also provide practitioners with an authentic use for technology, meaning the digital lessons can be designed to conform to evidence-based practices for students with disabilities and support student learning of the academic standards. Specifically, mobile app instruction can target differentiation, individualization, and engagement through self-paced lesson delivery and access to multiple means of representation. Opportunities for review and assessment can also be built into the lessons, thereby strengthening the students’ acquisition of math knowledge and monitoring their progress towards mastery.
Students from diverse backgrounds may also benefit from the strategy, as technology inherently appeals to individualized instruction. The presentations can be adapted to meet the students' cultural, linguistic, and academic needs through the use of native language text and audio, pictures, graphs, and videos. By providing cultural and academic relevance, teachers can greatly increase their students' potential for success.

Although current research suggests that combining technology with teacher-led instruction can improve the outcomes of students with disabilities (Bryant et al., 2015), there is little published research to support the integration of direct instruction purely on a mobile device. Thus, this study (a) developed lessons for both the traditional math instruction and the mobile app instruction to explicitly teach mathematics concepts, and (b) determined the relative effectiveness of each of the instructional models. The findings of this study contribute to the research base of effective classroom models related to (a) mathematics instruction for students with disabilities, (b) the use of technology to support the mathematics knowledge of students with disabilities, and (c) the use of technology to support the engagement of students with disabilities. This study compared the effectiveness of traditional teacher-led instruction and direct instruction delivered via a mobile device. This study expanded the literature by presenting data on what components of the digital lessons the students utilized, and how the students moved through the online learning platform.

Definition

Academic engagement. When the student is (a) reviewing the material, actively completing the task, and exhibiting appropriate physical responses such as typing or writing, (b) asking for assistance (where appropriate) in an acceptable manner, (c) interacting with the
teacher or their peers about related topics, and/or (d) listening to the teacher’s directives (Walker et al., 1990).

**Common Core State Standards (CCSS).** A set of rigorous academic standards in mathematics and English Language Arts. These standards are utilized by several states nationwide and teachers are expected to develop instructional plans based on these standards. Currently students with disabilities are expected to demonstrate proficiency in the standards with the appropriate accommodations and modifications (Common Core State Standards Initiative, 2016).

**Differentiated instruction.** The planning and delivery of classroom instruction that addresses the diverse learning needs and interests of students. Differentiated instruction utilizes various modes of delivery in order to engage learners and offers students multiple ways to demonstrate mastery of the material (U.S. Department of Education, The Teacher Excellence in Adult Literacy (TEAL) Center, 2016).

**Direct instruction, mobile app instruction (MAI).** This form of instruction is delivered during class time on a mobile device and driven by the student. Direct instruction, mobile app instruction (MAI) includes the following components: (a) warm-up activity related to the material presented in the previous and current lessons provided via learning videos and presentations, (b) new material is introduced via learning videos and presentations, (c) the skill/concept is modeled via learning videos and presentations, (d) guided practice is provided via step-by-step presentations, (e) independent practice (assessment) is provided via digital worksheets, and (f) review is provided as part of the closing activities. In this model the role of the teacher is to facilitate student use of the mobile app and answer questions.
Direct instruction, traditional math instruction (TMI). This form of instruction is delivered during class time and driven by the teacher. Direct instruction, traditional math instruction (TMI) includes the following components: (a) independent warm-up activity related to the material presented in the previous and current lessons, (b) teacher introduction of new material, (c) teacher model of the skill/concept, (d) teacher provision of step-by-step guided practice with the skill/concept, (e) students completion of an independent practice worksheet (assessment), and (f) teacher provision of a review as part of the closing activities.

EDpuzzle. A free, web-based application that allows the user to edit videos and embed questions. Students access this application via their individual, password protected Google account. All data from the videos are stored in the teacher’s personal, password protected EDpuzzle class (2017).

Google docs. A free, web-based application that allows the user to create various types of documents. The warm up and independent practice activities for this study were created using Google Docs. The application also allows the user to monitor responses and provides other descriptive data (2017).

Individualization. The process of planning and developing lessons that address an individual student’s educational needs (Heathers, 1977).

Kindle Fire. A Kindle Fire is a computer tablet created by Amazon with a 6”, multi-touch, high-definition display. The Kindle Fire can be equipped with various computer applications (apps) and includes the following accessibility features: (a) screen reader, (b) explore by touch, and (c) screen magnifier. Font sizes and color are adjustable, and a built-in Oxford dictionary is included (2017).
**Learning videos.** Presentations delivered in class through a mobile device (i.e., the Kindle Fire) that are directly related to the Common Core State Standards (CCSS) addressed in the mobile app math instruction. The videos are outsourced and serve as an opportunity for modeling of the skill or concept as well as student-controlled review and reteaching of the skills and concepts covered during class time.

**Mathematics achievement.** This is determined by comparing the pretest and posttest scores of a standardized math assessment, and analyzing the data from the warm up and independent practice activities completed during the intervention.

**Multimedia.** The presentation of material using both words and pictures, with the intention of promoting learning (Mayer, 2009).

**Scripted instruction.** Highly sequenced curricular materials that outline verbatim what the teacher will say during a lesson, as well as the student responses (McIntyre, Rightmyer, & Petrosko, 2008).

**Special education.** Specialized instructional practices designed to meet the needs of students with disabilities that does not incur an additional cost to the family. This includes instruction within the classroom, at the student’s home, or in a hospital, institution, or other setting (Special education defined, NAC § 388-115, 2007).

**Student with a disability.** A student with a disability is one who receives mathematics instruction in a special education (resource) setting and who has an active Individualized Education Program (IEP).

**Technology.** Electronic or digital products and systems considered as a group. When applied to education, these items are used to enhance the instructional practice of teachers, appeal to the unique needs of diverse students, and facilitate student proficiency.
**Wi-Fi.** A facility allowing electronic devices to connect to the internet or communicate wirelessly within an area.

**Zeetings.** A web-based presentation platform used to deliver instruction, assess students, and capture data on student progress (2016).

**Limitations**

The limitations to this study are:

1. The data for this study was collected in a special education resource math classroom for students with high-incidence disabilities. This limits the generalization of the results to other disability groups or types of classrooms.

2. This intervention was implemented over the course of two weeks in order to explore the design of the intervention and examine how students with disabilities use mobile technology in their learning. A longer intervention period might produce different results.

3. The sample size for this study was small (55 students). A larger number of students might produce different results.

4. The school used in the study was chosen from a convenience sample. The findings might not generalize to other schools.

5. Although the participating classrooms were randomly assigned to the treatment and control groups, the sample was chosen by convenience. This limits the amount of experimental control in the study.

6. The teacher fidelity in both instructional methods was low. A higher rate of teacher fidelity during implementation may produce different results.

7. The student attrition was high towards the end of the intervention because the study
was implemented at the end of the school year during the standardized testing period.

Implementation of the intervention at a different point in the calendar year may have led to different results.

8. Maintenance data were not collected because it was the end of the school year and students were taking final exams.

9. Currently there is little empirical support for delivering direct instruction solely on a mobile device with teacher guidance.
CHAPTER TWO
REVIEW OF RELATED LITERATURE

The use of digital devices in classrooms serving students with disabilities is rapidly rising, largely based on national and local mandates for increasing the access to the general education curriculum for this population of students (Poel, 2010). Specifically, students with disabilities require targeted support in mathematics, as recent National Assessment of Educational Progress (NAEP) data indicate students with disabilities are not reaching proficiency in math (2015). Mathematics involves complex cognitive processing and reasoning skills, and utilizes abstract concepts that pose a significant challenge for students who often display deficits in one or more of these areas (Bottge et al., 2014). Technology offers a promising alternative to traditional math instruction through differentiated, individualized lessons.

Mobile Technology and Students with Disabilities

Educators are integrating digital devices into a variety of classroom settings, including those serving students with disabilities. However, the instructional needs of students with learning disabilities and other high-incidence disabilities can differ greatly from those of nondisabled students, and therefore careful consideration must be made when designing online learning experiences (Hasselbring, Lott, & Zydney, n.d.). The existing literature on the use of technology with students with disabilities suggests a design framework that mirrors explicit instruction, which is comprised of these components: (a) advance organizer/accessing background knowledge, (b) modeling, (c) guided practice, (d) independent practice, and (e) review (Hasselbring, Lott, & Zydney, n.d; Hudson, Miller, & Butler, 2006). While evidence from the research has begun to suggest specific guidelines for using technology, specifically mobile technology (e.g., Kindles, iPads, and iPods), to enhance the learning of students with
disabilities, there are still significant gaps concerning the optimal features of online instruction that have the potential to increase student achievement.

Kennedy, Deshler, and Wills Lloyd (2015) used an experimental pretest-posttest design to investigate the effect of content acquisition podcasts (CAPs), a multimedia platform for delivering vocabulary instruction to adolescent students with LD, on the literacy skills of 278 students who attend an urban Midwestern high school. The participants consisted of 30 students with a learning disability in reading and 248 students who either did not have a disability or who were receiving special education services in an area other than reading. The authors used Mayer’s (2009) cognitive theory of multimedia learning (CTML) to shape their recommendations for developing appropriate vocabulary instruction, and the CAPs consisted of PowerPoint presentations that included audio and visual components lasting approximately 2 – 3 minutes.

The CAPs contained empirically based instructional practices used to teach vocabulary. The practices included promoting word consciousness, providing direct instruction, providing guided practice and scaffolded supports, promoting consciousness of related terms, using the keyword mnemonic strategy, and providing a rationale for learning the new vocabulary term. There were four conditions presented in this experiment during intervention: (a) the CAPs intervention using only explicit instruction (labeled EI), (b) the CAPs intervention using only a mnemonic keyword strategy (labeled KMS), (c) the CAPs intervention using both EI and KMS (labeled EI + KMS), and (d) instructional videos that contained appropriate audio content like the explicit instruction group (NM). The EI condition included research-based instructional practices for promoting literacy except the keyword mnemonic strategy. The KMS condition did not include the awareness of related terms, guided practice and supports, or word consciousness,
however it did include the keyword mnemonic. The EI + KMS condition included all empirically based instructional practices, and the NM condition had the same content as the EI condition but in a text only format (no images).

The research team used three instruments to measure vocabulary learning and student satisfaction. First, they used a 30-item multiple-choice assessment that measured the students’ ability to define significant terms in the World History content with a score range between 0 – 30. This instrument contained sentence stems utilizing vocabulary terms selected by the content teacher. The participants were required to select the definition that correctly fit the sentence stem. Another instrument utilized in the study was a 30-item open-ended assessment that measured the students’ ability to engage with the vocabulary at a deeper level. The participants were asked to “write what you know” about a term or concept. The scale range was from 0 to 60. Finally, the researchers used an eight-item survey that measured the social validity of the intervention. The instrument was a Likert-type survey with a ten-point scale ranging from strongly disagree (1) to strongly agree (10). The survey measured the ease of use and function of the intervention and the usefulness of the intervention in teaching new vocabulary.

Students were given a pretest and one week later completed all 10 CAPs in one class period. The students were given the open-ended assessment and the multiple-choice assessment (in that order) following completion of the CAPs, and the students resumed viewing the last five videos after completing the assessments. After 10 videos were viewed, the students again completed the assessment tools. The researcher returned three weeks after implementation to conduct maintenance probes.

The authors used a 4 x 2 split-plot, fixed-factor repeated measures ANOVA to analyze the between-subjects factors for the students who were classified as having LD according to each
group they were assigned to in the study (i.e., EI, KMS, EI + KMS, or NM) and a 4 x 3 split-plot, fixed-factor repeated measures ANOVA to analyze the dependent measures, which had three levels: pretest, posttest, and maintenance probe. The data were analyzed in the same manner for students without LD. This provided a comparison group and a way for the research team to analyze data from a larger sample. The responses from the student surveys were organized and analyzed using one-way ANOVAs.

There was not a significant difference between pretest scores of any of the four experimental groups of students with LD, however the EI + KMS group had significantly higher scores on the posttest than all other groups. The EI + KMS group also scored higher during maintenance than the other groups, and had significantly higher scores on the maintenance probes than the students without LD in the EI, KMS, and NM groups. Students without LD in the EI + KMS group had a significantly higher score on the posttest than students with LD in the EI and KMS groups. Students without LD in the EI and KMS groups had significantly higher scores on the maintenance probes than the students without LD in the NM group. Overall, the students without LD in the EI + KMS group had higher scores on the posttest. The results suggest that combining explicit instruction with the CAPs intervention using a mnemonic keyword strategy provides the most effective literacy instruction for students with and without LD.

Overall students were satisfied with the usability of the CAPs and believed the CAPs helped with the acquisition of vocabulary. They also reported that the material was engaging. The groups that utilized the keyword mnemonic found the strategy to be useful in learning vocabulary.

The results of this study support existing literature that suggests multimedia platforms using Mayer’s CTML quality indicators enhance student learning (2009). The authors recommend
combining empirically tested teacher-led instructional practices with technology to create rich, effective learning experiences for students with learning disabilities. Future research needs to explore other content areas and directly involve practitioners in the development and implementation of CAPs.

Nordness, Haverkost, and Volberding (2011) used a single subject, multiple baseline across subjects design to examine the effectiveness of a math flashcard application on the subtraction skills of three second grade students with learning and behavioral disabilities attending an urban elementary school in the midwestern United States. Two of the students (one male, one female) were identified as having a learning disability in the areas of reading and math, and one male student was identified as having a behavioral disorder and Attention-Deficit Hyperactivity Disorder (ADHD).

Math skills were measured using a district wide standardized assessment. The assessment included 100 problems targeting math fluency in addition, subtraction, multiplication, and division, however students in this study were only given the subtraction portion of the test. Students had five minutes to complete 100 randomly selected two-digit subtraction problems from 0 - 20.

The researchers used Math Magic (Anusen Inc., 2012), an application designed to teach students addition, subtraction, multiplication, and division facts. Math Magic has options for setting the difficulty level and number of problems presented in each set. There is also an option for creating a timed drill. If the students answer a problem correctly, a green check mark is presented and the response is recorded at the top of the screen. If the student answers incorrectly, a red “x” is presented and the response is recorded at the top of the screen. Students can retry the problem to get the correct answer, however their score does not change. For this study, the
students were required to complete 10 minutes of practice on two-digit subtraction problems (0–20) three times a week on an iPod Touch. The intervention took place in the students’ resource math class.

During baseline the participants completed their math homework and received support from the teaching staff. During intervention on Mondays, Wednesdays, and Fridays, students used the *Math Magic* app. Data from the application (i.e., percentage answered correctly out of number of problems attempted) was recorded by the teacher. Students were administered the math assessment on Friday. The baseline condition lasted for three weeks (three data points) and then the first student started the intervention. After three data points had been collected, the next student was introduced to the intervention. This procedure was continued for the final participant.

The research team used the improvement rate difference (IRD; the difference between the improvement rate in intervention and the improvement rate during baseline) and visual inspection to analyze the effectiveness of the *Math Magic* app. Results indicate an improvement on the standardized math assessment for all three students after the intervention was introduced. The IRD was calculated as .59, which indicates that the *Math Magic* app had a moderate effect on the math scores of participants.

Limitations of this study included: (a) different methods of practice were not compared, (b) the sample size was small and lacked sufficient diversity, (c) the amount of time in intervention was different for each participant and therefore could have affected the outcomes, (d) persistence of effect was not measured for an appropriate amount of time, and (e) only one skill was examined. However, the use of math applications for improving the math achievement of students with disabilities was found to be promising. The relative low cost of materials and the
minimal amount of time needed to train students provide a strong foundation for using technology in the classroom. Based on the results of the study, the authors recommended the use of mobile devices in the classroom to improve the academic achievement of students with disabilities. The researchers highlighted the cost effectiveness and minimal training as additional benefits of the devices.

Retter, Anderson, and Kieran (2013) used an experimental pretest posttest design to investigate the effect of using an iPad 2 with the Flashcards (Brainscape, 2013), BlueFire (BlueFire Productions, 2013), MiniMod Reading for Inference (E. Skills Learning LLC, 2013), and MiniMod Reading for Detail (E. Skills Learning LLC, 2013) applications on the reading comprehension, reading fluency, and vocabulary implementation of 13 students receiving special education services who attend a Midwestern high school. Seven of the students were identified as having Attention Deficit Hyperactivity Disorder or Attention Deficit Disorder, two students had a traumatic brain injury, two students had Bipolar Disorder, and one student had Autism. All participants struggled with reading and the students’ reading comprehension levels ranged from 3rd grade to 7th grade.

The reading applications addressed different literacy skills: the Flashcards app allowed students to type ten vocabulary words and the definitions into the program, and students would “flip” the cards by swiping their finger across the screen; the BlueFire app allowed students to record and read specific passages from a text and then listen to the recorded passages; the MiniMod Reading for Details and the MiniMod Reading for Inference apps allowed students to read passages, answer questions, and play games related to the passages. The iPads and applications were implemented as part of the Second Chance Reading – Reading Program that the students were enrolled in.
The entire project lasted 12 weeks and consisted of the following procedure: (a) Day one (Monday) - Students uploaded new vocabulary words and completed a vocabulary quiz, (b) Day two (Tuesday) – Students uploaded and completed a reading comprehension activity on the iPad, (c) Day three (Wednesday) – Students used the Flashcards app to create decks of vocabulary words, (d) Day four (Thursday) – Students used the Flashcards app and the MiniMod Reading for Details app (the MiniMod Reading for Inference app was substituted halfway through the intervention), and (e) Day five (Friday) – Students practiced using the BlueFire app with a reading selection from the Jametown Reading Assessment.

The students were given the Stanford Reading Diagnostic Test (SDRT) (Karlsen & Gardner, 2005) as a pre and posttest to determine the students’ reading comprehension and vocabulary skills. Additionally, student progress was monitored using weekly vocabulary quizzes and fluency probes from the Reading Fluency and Rate (Blachowicz, 2004) and the Vocabulary Drills (Fry, 2004) sections of the Jamestown Education Reading Assessments.

The researchers used a paired samples t-test to compare the students’ vocabulary scores before and after intervention. The researchers selected a one-tail p-value because they predicted that the students would make gains when using the iPad.

Results of the study indicated that the greatest gains were made in the scores for the Stanford Diagnostic Reading Test, with a statistically significant gain in vocabulary scores ($p < .05$). However, there was no statistically significant difference in scores for the reading comprehension portion of the assessment ($p = .101$). For the weekly vocabulary quizzes, gains and losses were calculated by subtracting the total words learned at the beginning of the intervention from the total words learned at the end of the intervention. Overall there was no statistically significant difference in scores on the weekly vocabulary quizzes ($p = .641$) or the
Jamestown Reading Fluency assessments \((p = .266)\). Informal teacher observations indicated a decrease in undesirable behaviors (i.e., off-task behavior) and an increase in student engagement.

The authors identified several limitations to this action research study, including logistical issues with the BlueFire app, an inability to determine which app or combination of apps had more of an influence on learning than the others, and the possibility that a loss of learning is related to an increase in the difficulty of the vocabulary words. The authors recommend using different apps in isolation that address specific components of reading.

Shin and Bryant (2017) used a single-subject design to investigate the effectiveness of a mathematics computer application on the fraction word problem solving of students with math related learning disabilities. The purpose of this study was to examine the overall effectiveness of a multi-faceted computer application (i.e., Fun Fraction) on the word problem solving of middle school students with math-related learning disabilities.

Initially, four middle school students with a learning disability in math met the criteria to participate in this study. Midway through the implementation of the intervention one student withdrew from the study, leaving three participants (two male students and one female student). The students were in grades 6 – 8, had math goals on their Individualized Education Plan (IEP), and scored at or below a 30% on a math-screening test created by the research team.

The study took place at a private school serving students with learning disabilities in a large city in the South-Central region of the United States. Students received the intervention in a conference room during sixth period. All students in the study had access to a laptop computer and Wi-Fi internet access.

A single subject, multiple baseline with multiple probes design was used to examine the effect of Fun Fraction on the math problem solving skills of middle school students with
learning disabilities in math. Intermittent probes were used to determine the students’ level of
math achievement during both phases (e.g., baseline, intervention) of the study. The dependent
variable was the percent correct on the problem-solving probes. A relationship between variables
was identified if student performance improved after instruction and students in baseline who
were not instructed maintained a stable level. Students were randomly assigned to order of
participation.

In addition to the math probes, the researchers used two student questionnaires to
measure the students’ opinion of the strategies presented in the application (cognitive strategy
questionnaire) and the students’ opinion of the self-regulation features (metacognitive
questionnaire). A social validity questionnaire was also administered to students regarding the
usability and design of the application.

The Fun Fraction computer application was the independent variable in this study, and it
included three components for teaching fractions: (a) cognitive and metacognitive strategies, (b)
virtual manipulatives, and (c) explicit instruction. Students were taught the Read, Restate,
Represent, and Answer strategies for solving fractions word problems over the course of seven
20-minute lessons. The lessons were developed using the explicit teaching model and included a
2-minute fractions warm-up, academic vocabulary, Modeling, Guided Practice 1, Guided
Practice 2, and video tutorials. Students were given a 20-minute training session prior to using
the application, and the lessons were administered to each student independently. After each of
the seven lessons were completed, the students reviewed the lessons for three days. The study
took place over 13 weeks. A fidelity checklist was used to monitor the students’ activity while
using the Fun Fractions application, and interobserver reliability was calculated.
Data analysis for this study included visual inspection of the data, calculating the percentage of non-overlapping data (PND), and comparison of student performance on the math probes. All three subjects demonstrated an increase in accuracy after the intervention was implemented, however only one of the students demonstrated a statistically significant PND (100%). Two of the three students reached mastery level on the fractions skills. When comparing student performance by problem type, students demonstrated the most improvement on Combination problems (e.g., a fraction of an item is on each table, how many items are on 3 tables?) and the least improvement on Partition problems (e.g., a person has a number of items and gives 1/3 of the items to a friend. How many items were given to the friend?).

On the cognitive survey, two students indicated that the Represent strategy was the most useful, while the remaining participant found it difficult to use. On the metacognitive survey, all students indicated that the self-instruct and self-check features were very useful. Two of the participants rated the usability of the application very high while one student indicated they would not use the application again. The two design features students rated the highest were the information and the interaction features.

The authors attributed a portion of the positive results to the combined use of explicit instruction and embedded cognitive and metacognitive strategies. Also, they highlighted the virtual manipulatives as an effective support for students learning fractions. Finally, the researchers noted that the types of problems students are presented can have an impact on their overall math performance (i.e., more conceptually difficult problems will produce lower levels of performance).

Limitations of this study included the small sample size (three participants), the authenticity of the study setting (students were removed from the classroom individually), and
the inability to pinpoint specific features that are effective in the application. Future empirical investigations should include a larger, more diverse sample of participants to increase generalizability, implementation of the intervention in an inclusive classroom setting as a supplement to teacher-led instruction, and analysis related to the multiple facets of the application in order to identify the features that most contribute to effective instruction.

Zhang, Trussell, Gallegos, and Asam (2015) used an experimental pretest-posttest design to investigate the effect of the mathematics applications Splash Math (StudyPad, 2012), Motion Math Zoom (Motion Math, 2012), and Long Multiplication (Esa Helttula, 2012) on the mathematics learning of 18 struggling students who attend an urban public elementary school in the southwestern United States. The participants consisted of 4 students who were identified as having a disability (autism, emotional and behavioral disorders, dyslexia, or learning disabilities), 6 students who were identified as “at risk”, 7 students identified as typical learners, and 1 student who was gifted.

The math apps presented concepts in multiplication and decimals that the students had previously learned, and were used as a supplement to direct instruction. There was a total of 4, 80 to 90 minute sessions. The students used Splash Math for about 40 minutes in the first session, and it included a total of 96 decimal problems divided into sets of 24 problems. The students were required to pass at least 20 questions in each set before moving on to the next set. Motion Math Zoom was used for about 30 minutes in the following session, and consisted of decimal problems arranged in consecutive levels of difficulty. The students were required to solve two sets of problems with 24 problems in each set. In the third session students returned to Splash Math to solve 65 decimal problems (the first set had 21 problems, the second set had 24
problems, and the third set had 20 problems), and in the final session students used *Long Multiplication* for about one hour to solve multi-digit multiplication problems.

The participants were given three mathematics assessments to measure their level of achievement on the math concepts introduced during class and in the math applications. Each assessment was administered as a pretest and a posttest and included problems that were like those presented in the apps. The first assessment had 20 questions and included place values and decimals, the second assessment had 19 questions and included comparing and ordering decimals, and the third assessment had 15 questions and included two digit by one digit multiplication. Additionally, the *Splash Math* app monitored student progress and supplied scores for student work. The researchers took field notes to monitor student engagement.

The researchers conducted several analyses including descriptive analysis (mean and standard deviation) and two tailed paired sample *t*-tests. The research team used the *t*-tests to compare the pre- and posttest scores for the participants, as well as to compare the differences between two groups of students (Group 1, identified as struggling students and Group 2, identified as typical students).

The results indicated a significant increase in learning from pretest to posttest for all three assessments and for both groups. Group 2 (typical students) outperformed Group 1 (struggling students) for all three assessments, however Group 1 made greater gains overall and the achievement gap between both groups decreased. During observations, the researchers noted that students appeared engaged in the material while using the math apps.

The results of this study support the use of math apps to increase the learning of students who are struggling in math. Several benefits of math apps were suggested, including self-pacing, prompt feedback, and chunking material into manageable steps. It was noted that the students
persisted in completing problems to achieve the criteria set by the teacher, and that they completed an average of 143 problems during one class session. The authors suggested these are much higher rates of perseverance and completion than would be observed if students used traditional paper and pencil worksheets. Recommendations for future research were to use a larger sample size and increase the length (in time) of the study.

Using mobile devices in the classroom for students with disabilities has the potential to increase academic achievement and engagement (Kennedy, Deshler, & Wills Lloyd, 2015; Nordness, Haverkost, & Volberding, 2011). A variety of math applications and programs provide opportunities for active learning, individualization, and self-paced lessons, all of which address the unique needs of students with disabilities (Zhang, Trussell, Gallegos, & Asam, 2015). However, a true comparison of traditional teacher-directed instruction and instruction delivered on a mobile device needs to be performed in order to determine the effectiveness of each. In this way an informed conclusion can be drawn regarding the utility of mobile instruction for students with disabilities.

Comparing Teacher-Led and Mobile Technology Instruction

The positive effects of explicit, teacher-led instruction is well documented in the literature for students with disabilities (Hudson, Miller, & Butler, 2006; Maccini & Gagnon, 2000; Miller, 2009). Student achievement has been shown to increase when content is presented in an explicit, systematic way by the teacher (Baker, Gersten, & Lee, 2002). This does not negate the possibilities presented by technology, instead it provides a foundation on which to make a comparison between the two methods. Several studies developed lessons using paper-and-pencil activities and digital devices and compared the student achievement and engagement in each condition. The results are promising and offer more support for the use of technology in the
classroom for students with disabilities. The following studies compare the effectiveness of teacher-led instruction and mobile technology instruction on the academic performance and engagement of students with disabilities.

Bryant et al. (2015) compared the effects of an application-based instructional model (AI) and a teacher-directed instructional model (TDI) on the reading achievement and engagement of students with learning disabilities. The purpose of the study was to: (a) compare the word identification, fluency and engagement of fourth grade students with learning disabilities (LD) in the AI model and in the TDI model, and (b) gather data on student perceptions of each model. The subjects for this study were four, fourth grade students with learning disabilities who scored below average on the site-based standardized reading assessment. All subjects had an Individualized Education Plan (IEP) with reading goals and were receiving specialized reading instruction. The study was implemented at an urban charter school in Central Texas during the students’ special education reading class.

There were two conditions for this study: (a) Application Instruction (AI), where students used the two iPad applications *Howie Finding Vowel* (PlaySmart-Kids, 2012) and *ABC Phonics Word Family Writing* (Hien Ton, 2011) for word reading and the timed reading application *K12 Timed Reading Practice* (K12 Inc., 2010) to determine the number of words read per minute (i.e., fluency), and (b) Teacher-Directed Instruction (TDI), where students were explicitly taught a word identification strategy (e.g., SPLIT) and engaged in fluency activities (e.g., Partner Reading).

The authors used a single subject alternating treatment design to examine the effects of AI and TDI on the word identification, fluency, and engagement of students with learning disabilities. Before the start of the baseline phase, the easyCBM Passage Reading Fluency (PRF;
University of Oregon, 2006) and a researcher-created pseudoword assessment were administered to students to determine their instructional reading level and their phonics skill level. During baseline, students were administered the easyCBM Word Reading Fluency (WRF; University of Oregon, 2006) and the PRF for seven consecutive days until a stable baseline could be established for each subject. To measure engagement, the researchers designed a student engagement form and conducted observations using momentary sampling at 30-second intervals.

After baseline, randomly assigned student pairs received the intervention for 30 minutes a day for 14 days over the course of a three-week period. The intervention was implemented in four phases: (a) Wave 1, consisting of 12 minutes of phonics instruction in either the TDI or the AI instructional models, (b) Wave 2, consisting of 1-minute WRF probes, (c) Wave 3, consisting of either Partner Reading, a TDI activity, or a fluency-based AI activity, and (d) Wave 4, consisting of 1-minute timed readings using the PRF. Maintenance probes for the WRF and the PRF were administered during Weeks 5 and 6.

Two methods of data analysis were used in this study: (a) visual analysis and (b) calculation of Nonoverlap of All Pairs (NAP). The visual analysis indicated a higher level of engagement in the AI condition, although engagement was high in both conditions. The NAP data confirmed the visual analysis for engagement. For visual analysis of reading achievement, the results were broken down by assessment (i.e., the WRF and the PRF). All students, except Student 2, scored higher in the TDI condition for the WRF and the PRF. The maintenance data for all students except Student 2 remained stable for both the WRF and the PRF (Student 2’s responses increased). When calculating the NAP, the TDI appeared more effective than the AI. During the student interviews, all subjects indicated they preferred the AI, although all students felt that the TDI helped them learn better.
While the results of the study indicate enhanced engagement in the AI condition, the authors noted that results should not be extended to all instructional apps. Additionally, the authors hypothesized that the increased reading achievement demonstrated in the TDI condition was based on the explicit instructional techniques inherent in teacher-led instruction. The authors recommended a collaborative project between software developers and teachers to design digital components that mirror direct, explicit teaching methods.

The authors noted four major limitations to the study: (a) potential carryover effects from one condition to the other, (b) the short time period of the study, (c) the skills taught in the AI condition did not match the skills taught in the TDI condition, and (d) maintenance procedures did not follow those recommended in the field. The authors recommend that future research address each of these limitations.

Bryant, Ok, Kang, Kim, Lang, Bryant, and Pfannestiel (2015) used an alternating treatments design to compare the effectiveness of Application-Based Instruction (AI), Teacher-Directed Instruction (TDI), and Combined Instruction (CI) on the mathematics learning (i.e., multiplication facts) of six students with learning disabilities in a central Texas charter school. The participants were fourth graders who were receiving pullout services for math instruction, and the study was conducted in the students’ special education classroom. Students were assigned to dyads based on their pretest scores.

For the AI condition, researchers used two iPad applications to deliver math instruction: Math Drills (Instant Interactive, 2012) and Math Evolve (InterAction Education, 2012). Math Drills follows the format of drill and practice, where students practice computing problems at their instructional level and monitor their progress. Math Evolve is set up in a game format, where students “battle” enemies by solving mathematics problems. Math Evolve allows students
to engage in activities via the video game (story mode) or through math drills (practice mode). For the TDI condition, teachers were provided five, 30-minute lessons consisting of preview (advance organizer), modeled practice, engage prior knowledge practice, and independent practice. The lessons were taught for five days over the course of a three-week period. For the CI condition, all the components of AI and TDI were incorporated into the lesson. In the CI condition, students were given the *Math Drills* application during the engage prior knowledge practice and the independent practice. Student dyads were randomly assigned to a condition, and each day the condition was alternated so that at the end of the 15-day intervention all pairs had participated in each condition.

Prior to beginning the study, students were given a multiplication assessment created by the research team. The assessment measured the students’ prerequisite skills (2s multiplication facts) needed to participate in the study, and all students achieved greater than 80% accuracy on the assessment. To measure the students’ learning of multiplication facts, the research team developed a 2-minute fact probe that contained 35 4’s facts and 35 8’s facts. Alternate forms of the assessment were given to each student in a dyad each day until all students had been given five probes. Additionally, researchers interviewed students to measure the social validity of the intervention.

The authors used descriptive statistics and visual analysis to examine the data. The results of the analysis were inconclusive. While most participants scored higher after TDI, the CI method produced better results based on the average scores across all six participants. Also, there was a large degree of overlap in the data paths for all participants in all conditions. Overall the students preferred the TDI method.
The results of this study support previous research suggesting there is little difference between AI, TDI, and CI methods. The authors recommended using sets of mathematical problems that are different and randomly assigned to each condition. Also, they recommended adding a concurrent baseline phase to reduce the possibility of multiple treatment interference. Future research needs to explore tailoring instructional methods to the learning needs of individual students (i.e., more structured supports for low functioning students, more dynamic components for high functioning students).

Flower (2014) used a single subject alternating treatments design to investigate the effect of an iPad on the time on task of three male students with emotional and behavioral disorders in a residential treatment center in a suburban area of central Texas. There were two conditions for this study, the worksheet or typical condition and the iPad condition, which were counterbalanced across the participants (i.e., two sessions per student, one typical practice, one iPad).

The iPad was used to provide instruction in reading and math. The reading skills addressed were phonics, fluency, and reading and listening comprehension using several commercially available reading mobile applications. The math skills addressed were calculation, fluency, and problem solving using several commercially available math mobile applications. All applications provided students with opportunities to respond, immediate feedback, and a virtual reward.

Time on task was measured when students were engaged in independent work under typical conditions and when the students engaged in independent work on the iPad. The specific behaviors related to on-task behavior were defined as eyes directed at the worksheet or the pencil moving on the paper (worksheet condition) or eyes directed at the iPad screen or the finger.
moving on the screen (iPad condition) without talking to other students. On-task behavior and off-task behavior were mutually exclusive. Behavior was observed during 10-second intervals.

The procedure for the worksheet condition was as follows: (a) students were given an independent paper-based task following modeling and guided practice, (b) students completed the task at their table using a pencil and crayons, and (c) teachers worked with other small groups of students while the participants completed the task. The procedure for the iPad condition were as follows: (a) students were monitored to ensure they possessed the required skills for using an iPad (i.e., scrolling, dragging letters, numbers, icons, selecting characters, and use of the keyboard), (b) participants were assigned an application by the researcher (at least one reading application and one math application per session), (c) students worked for at least 5 minutes on the assigned application before switching to a new one (change was prompted by the researcher), and (d) teachers worked with other small groups of students while the participants completed the task.

The researchers used observational analysis to determine the time on-task for each participant. Results of the study indicate an increase in time on-task for all students, with a maximum of 90% for some intervals during the iPad condition. The research team suggested that several components of the iPad apps (i.e., immediate feedback, feedback for incorrect responses, practice for mastery, and reinforcement through points) facilitated on-task behavior and had the potential to increase academic achievement.

Limitations included an inability to generalize (small sample with only males with externalizing behaviors in one educational setting) and a lack of data on learning outcomes for the participants. However, the use of iPad with academic apps was found to be promising for increasing the time on-task for students with disabilities.
Haydon et al. (2012) compared the effects of using traditional worksheets and practice problems delivered on an iPad on the mathematics achievement and engagement of students with emotional disturbance. The purpose of the study was to expand the research base on using technology to deliver math instruction to students with emotional disturbance. Specifically, the researchers examined the problem-solving accuracy and academic engagement of students using iPads and completing traditional math worksheets.

The experimental procedures were conducted in a high school level math class consisting of seven students, although data was only collected on three students who supplied consent and assent. The subjects were one female (17 years old) and two males (17 and 18 years old) identified as having emotional disturbance. The study took place in an alternative school for students with severe mental and behavioral needs located in an urban area in the Midwestern United States. The intervention was implemented during the students’ 40-minute math class.

Prior to beginning the study, the researchers consulted with the math teacher to identify the targeted skills, select the math materials for both conditions, and develop scripts for delivering instruction and establishing student expectations. The study consisted of 15 sessions over a five-week period, and although there were 40 minutes allotted for each session, the actual time varied between 26 and 40 minutes. There were two conditions for the study, the worksheet condition and the iPad condition. Each day the teacher followed the same routine for both conditions: (a) identified the targeted math skill, (b) accessed student background knowledge, (c) reviewed content-related vocabulary, (d) provided opportunities for guided and independent practice, and (e) answered questions. Students were then advised what condition (e.g., worksheet or iPad) would be used. Students were taught the same skills and used the same activities across conditions.
The researchers utilized a single subject alternating treatment design to compare the effects of the math worksheet and the iPad conditions on the math achievement and engagement of three students with emotional disturbance. The worksheet condition consisted of a review of the rules (e.g., behavioral expectations) and the teacher handing out the math worksheets. As the students worked, the teacher monitored student progress and answered questions. The teacher collected the worksheets when students were finished. In the iPad condition, students utilized mobile applications to complete math activities. The teacher reviewed the behavioral expectations and distributed the iPads to students, then assisted students in navigating to the appropriate activity. The teacher monitored student progress and answered questions. Behavior management systems (e.g., reinforcement) were the same across conditions. The number of correct responses per minute on the math worksheet and the iPad app were recorded. Additionally, the research team utilized momentary time sampling direct observation to record the active engagement of the students. The students were observed during 10-second intervals for the entire instructional period, and observations were recorded on an interval recording form. Finally, students and teachers were asked to complete a survey measuring the level of intervention acceptability. The survey utilized a 4-point Likert-type scale.

There were two types of data analysis in this study: (a) visual analysis and (b) percentage of non-overlapping data (PND). Visual analysis of the data indicated that the number of correct responses per minute was higher for the iPad condition than the worksheet condition for all three students. Additionally, all data points for the iPad condition exceeded the highest data point for the worksheet condition (PND). Regarding active engagement, all three students had higher levels of engagement during the iPad condition than the worksheet condition. The PND for one student was calculated at close to 100%, while the other two students experienced ceiling effects.
in the worksheet condition of over 33.3% of overlap with the iPad condition. The teacher indicated that she found the iPad intervention helpful and easy to implement, and she indicated that she would use it in the future. All the students indicated that the iPad was more effective and more engaging than the worksheets. Two students rated the iPad as very easy to use, and one student indicated that it was fairly easy to use.

The authors offered several reasons for the positive results of using the iPad: (a) students were provided the chance to redo any problems that were answered incorrectly, (b) students were given the results of each completed session (i.e., their performance on the tasks), and (c) immediate feedback was provided when students answered correctly, thereby increasing the probability that students would continue. The students in the worksheet condition were not given the opportunity to practice the problems multiple times, and students were not given any feedback or information on their performance. The authors also concluded that the iPad could increase the students’ ability to complete work independently. Limitations for this study included: (a) the novelty effect of using an iPad, (b) the content introduced in both conditions was not thoroughly evaluated to ensure equal levels of difficulty, (c) the initial math skill level of the students was not measured prior to beginning the study, and (d) the OTR (opportunities to respond) rate was not captured for either condition. The authors recommended future researchers use applications that provide various examples and nonexamples, embed links that review basic math skills throughout the program, and a computer application that balances content and design with individual learner needs.

Leh & Jitendra (2012) examined the effectiveness of computer-mediated instruction (CMI) and teacher-mediated instruction (TMI) on the word problem solving ability of third-grade students who struggle in math. Participants in this study were 25 third-grade students who
scored at or below the 50th percentile on a standardized math assessment. Three certified elementary school teachers delivered the CMI and TMI lessons. The study took place in an elementary school located in a suburban community in the Northeastern United States. Math instruction for the TMI and the CMI conditions was delivered during the students’ regular 50-minute math class.

Both groups received word problem solving instruction using similar curricula. The TMI group utilized the *Solving Math Word Problems: Teaching Students With Learning Disabilities Using Schema-Based Instruction* curriculum (Jitendra, 2007) and the CMI group used the *GO Solve Word Problems* software (Tom Snyder Productions, 2005). The programs were evaluated for similar sequencing, time spent with the content, and practice activities. Each condition consisted of 15 lessons over the course of 6 weeks, with whole class instruction two to three times per week for 50 minutes. The TMI and the CMI groups were implemented on alternating days.

The researchers used an experimental group design with a pretest and posttest to compare the effects of teacher-mediated instruction and computer mediated instruction on the math problem solving skills of student with math difficulties. For the CMI condition, students received 65 minutes of training on how to navigate the computer and the software. The teachers received eight hours of training with two 30-minute refresher sessions. Two teachers assisted with the lesson – one delivered the content and the other monitored students and answered questions. For whole group instruction, the teacher introduced students to the software program prior to releasing them to complete individual work. The software lessons were sequential and provided modeling, guided practice, and independent practice. The students were offered a text-to-speech
option for reading problems as needed. Additionally, students were provided feedback within the program based on their responses to the problems.

For the TMI condition, direct instruction was delivered by one teacher while a second teacher monitored students and answered questions during independent work. The teachers followed an explicit cycle of modeling, guided practice, and independent practice with multiple opportunities for student response and feedback. Students utilized problem solving schematics, checklists, and worksheets. Teachers read the problems to students as needed.

For both conditions, observation checklists were used to document teacher fidelity to the treatment (teacher fidelity and interrater agreement were both 100%). A district-wide standardized assessment (the mathematics subtest of the SAT-10) was used to determine the students’ level of mathematics functioning prior to the intervention. The pretest, posttest, and maintenance probe was a researcher-created word problem solving assessment. Student scores on the spring administration of the *Pennsylvania System of School Assessment* (PSSA) was also collected. Finally, student attitudes about solving word problems were identified using the *Instructional Material Motivation Survey*, and teachers’ perceptions of the CMI and TMI lessons were collected using a survey with scaled and open-ended items.

An ANOVA was conducted to determine if there was a statistically significant difference between the pretest and posttest for the CMI and TMI groups. The analyses indicated no statistical difference between the assessments, and the research team conducted an ANCOVA with the pretest as a covariate to again determine statistical significance. The ANCOVA indicated there was no significant main effect of the treatment group. Additionally, the data from the maintenance probe indicated no significant difference between groups.
Students in the TMI group reported more positive attitudes than the CMI group, although these results were not statistically significant. Students in the TMI group stated that they enjoyed doing and understanding the word problems but were frequently uninterested in the overall lesson. Students in the CMI group enjoyed using the technology but did not like the increased difficulty of the content. Overall, teachers preferred the TMI and two of the three teachers indicated they would use TMI over CMI. However, teachers noted that the CMI allowed them to work with students who required more intensive one-on-one attention.

Based on the results of the study, the researchers concluded that the quality of the instruction was more important than the mode of delivery. Specifically, traditional and digital methods should include components of effective instruction for students who are at risk for failure in mathematics. Also, the researchers discussed the importance of combining computer instruction with teacher-directed instruction. Limitations included the small sample size, the uneven numbers of male and female students in each group, the teachers’ occasional deviation from the scripted math lessons in the TMI group, and the uneven percentage of lessons taught by the “co-teachers” in each group. The researchers recommended that future studies address these limitations, in addition to providing adequate training for teachers and technology support during implementation.

Musti-Rao and Plati (2015) used an adapted alternating treatments design with initial baseline and final best treatment phase to examine and compare the effects of detect-practice-repair (DPR) and self-mediated iPad instruction on the multiplication facts fluency of 12 students receiving special education services in a suburban school district in the northeastern United States. The study took place in an integrated co-taught classroom.
The DPR condition included a PowerPoint presentation of 12 multiplication problems, where each slide described the steps to be implemented. The steps were delineated as follows: (a) the detect phase where students solved a series of multiplication problems presented at a fixed interval of 3-seconds, (b) the practice phase, where students marked problems they computed incorrectly and used the Cover Copy Compare (CCC) strategy to practice those problems, and (c) the repair phase where students completed a timed assessment of all the problems presented in the detect phase (Mad Minute Worksheet). Students then graded their work and graphed their progress. The iPad condition included the *Math Drills* application (Instant Interactive, 2012), where students were given a total of 20 multiplication problems for each phase of the intervention (review, practice, and test). Students were provided immediate feedback for incorrect responses and were required to correctly answer before advancing to the next problem.

The research team used three measures to evaluate the effectiveness of the instructional methods: (a) the digits correct per minute (DCM; calculated by multiplying the number of correct digits by 60 then dividing by the number of seconds taken to complete the sheet), (b) the response rate (calculated by dividing the number of math facts practiced during the CCC by the number of minutes provided for the phase), and (c) the practice time.

Each instructional method was implemented daily across eight consecutive school days, with a maintenance probe three days after intervention and a generalization probe one week after intervention. During baseline students were assessed but did not receive any explicit instruction in multiplication facts. During intervention in the DPR condition, students were given paper-based worksheets and teacher-led instruction in practicing multiplication facts. At the end of instruction, students were given a Mad Minute math probe. In the iPad condition, students were given a paper-based log and an iPad containing the math application. Participants then completed
the multiplication activities independently on the app, recording their start and end times in the log. After using the app, the students were given a paper-based Mad Minute math probe.

The authors used descriptive statistics and visual inspection to analyze the data. The results indicate an increase in multiplication fluency for both instructional methods, with the iPad producing larger gains from baseline to intervention. Also, the iPad intervention produced higher response rates than the DPR intervention and students could practice more multiplication facts in less time on the iPad than in the DPR condition.

The results of this study support the integration of applications and hand-held devices to deliver mathematics instruction (i.e., multiplication facts). The authors recommend replicating this study with students with disabilities and culturally and linguistically diverse populations. Also, the various components of each intervention should be examined independently to isolate the effectiveness of a specific element in improving engagement and achievement.

The data from several studies suggest mobile technology can be used as a viable alternative to traditional, paper-based instruction (Flower, 2014; Haydon et al., 2012; Means, Toyama, Murphy, & Baki, 2013; Musti-Rao & Plati, 2015). However in many cases technology is used for a stand-alone activity (e.g., warm up, guided practice, or independent practice) and is examined in isolation, not as an integrated component of explicit, teacher-directed instruction. Blended learning, an instructional model that combines teacher-led instruction with digital learning, is fast becoming a staple in classrooms nationwide (Smith & Basham, 2014). For students with disabilities, blended learning has the potential to offer the best of explicit teaching and online lessons.
Using Technology to Deliver Effective Instruction to Students with Disabilities

In addition to enhanced academic outcomes and engagement, digital learning offers students the opportunity to self-pace and have lessons tailored to their specific needs (Vaughn, Danielson, Zumeta, & Holdheide, 2015). Students can be provided multiple exposures to the content, and practice activities can be designed according to the students’ instructional level and Individualized Education Program (IEP) goals. This ability to personalize the learning environment has the potential to support students with disabilities by making the general education curriculum accessible via individualized instruction (Worthen, 2016). To develop effective online learning experiences for students, individualized lessons can be delivered in a blended learning model where students have access to direct instruction from the teacher supplemented with technology.

Blended Learning for Students with Disabilities

Several million children in K-12 classrooms in the U.S. are exposed to some form of digital learning, mostly at the secondary level and using a blended model (Smith & Basham, 2014). And yet there is little research providing a framework for developing this model with the unique needs of students with disabilities in mind. The following studies offer some guidance on the viability of blended learning for students with disabilities and how this model can be implemented in an inclusive or special education setting. The following studies investigate the concepts of self-paced, personalized learning and apply the concepts to developing digital learning experiences for students.

Bottge, Ma, Gassaway, Toland, Butler, and Cho (2014) used an experimental pretest-posttest cluster randomized trial to investigate the effects of using enhanced anchored instruction (EAI) and business as usual instruction (BAU) on the fraction and problem solving skills of 335
students with disabilities who attend 31 middle schools in a metropolitan area in the Southeast. Most student participants were receiving special education services under the categories of Mild Mental Disability (MMD), Other Health Impairment (OHI), or Specific Learning Disability (SLD), with a small number of students receiving services for Autism or Emotional and Behavioral Disorders (EBD). Instruction was delivered in the special education resource rooms of the middle schools, and each class was randomly assigned to either EAI (23 teachers, 33 resource rooms) or BAU (26 teachers, 31 resource rooms). Most teachers had comparable experience and education.

The EAI consisted of lessons linked to the Common Core State Standards For Math (i.e., Ratios and Proportional Relationships, Number System, Statistics and Probability, and Geometry) and included five units of computer-based activities, video-based problems, and project-based learning. Teachers were given lesson plans that incorporated explicit instruction and problem-solving activities. The lessons included several instructional models: (a) *Fractions at Work* (FAW), which consisted of computer-based lessons and manipulative devices for teaching mathematical concepts and increasing computation and required 20 instructional days to complete, (b) *Fraction of the Cost* (FOC), which consisted of interactive videos that presented real-life problem solving situations and required 17 instructional days to complete, (c) *Hovercraft Project* (HOV), which consisted of hands-on application of mathematical skills (i.e., designing and building a rollover cage for a hovercraft) and required 29 instructional days to complete, (d) *Kim’s Komet* (KK), which consisted of videos that assisted in developing an understanding of pre-algebraic concepts and required 19 instructional days, and (e) *Grand Pentathlon* (GP), which consisted of a hands-on project where students created their own pentathlon competition using the skills acquired in the previous lessons and required nine
instructional days to complete. All teachers were provided a two-day professional development workshop on how to implement the EAI (Bottge et al., 2014).

The BAU consisted of the typical mathematics instruction. The objectives of BAU aligned with those of EAI, and consisted of analyzing proportional relationships, solving real-life problems with whole numbers and fractions, graphing of ordered pairs, geometry, and basic pre-algebraic concepts. The instructional materials included textbooks, interactive white boards, and manipulative devices. Fidelity data was collected for EAI and BAU. The interobserver agreement for EAI was and BAU was 94%.

A total of four assessments were used to measure student computation and problem solving skills. The assessments were administered over three days immediately prior to and following the intervention. The first assessment, the fractions computation test, included 20 problems using addition and subtraction of fractions and mixed numbers and was worth 42 points. The second assessment, the problem-solving test part 1 and part 2, consisted of open-response items that measured the students’ ability to apply the skills learned in the EAI problem solving units. Part 1 consisted of 12 items addressing measurement and data, number and operations, and ratios and proportions, and was worth 20 points. Part 2 consisted of nine items addressing ratios and proportional relationships and geometry, and was worth 15 points. The third and fourth assessments were subtests of a norm-referenced, standardized achievement test (Iowa Tests of Basic Skills; ITBS), specifically the computation subtest and the problem solving and data interpretation subtest.

The authors used a three-level hierarchical linear model (regression) to measure the performance of the students on the math assessments. The level one model at the student level included control variables (i.e., gender, grade level, free-reduced lunch status, race-ethnicity, and
disability status) plus the pretest and posttest scores. The level two model at the teacher level included control variables (i.e., gender, teaching experience, and graduate degree) and treatment condition. Tests for statistical significance were conducted at the .05 alpha level.

The results suggested an increase in math scores for the EAI group over the BAU group. Specifically, students in the EAI group outperformed the students in the BAU group on the Fractions Computation Test (adding and subtracting fractions) and the ITBS Computation Test. Students in the EAI group also had statistically significant higher scores on Proportional Relationships and Geometry. The authors suggest the large gains are linked to the hands-on problem solving activities, appropriate cognitive supports, and pacing that allowed students to sufficiently interact with the material.

There were several limitations with this study, including the overall length of the study, the use of paper-based assessments to measure problem solving skills, and the lack of maintenance data to determine if students had retained the skills. The results of this study support the use of blended instruction for teaching complex math concepts to students with disabilities. The authors recommend developing instructional practices that provide relevance as well as conceptual and procedural knowledge to create enhanced learning experiences and improve student performance.

Ok and Bryant (2016) investigated the effect of using explicit, direct math instruction with practice on a mobile device (e.g., an iPad) on the mathematics achievement and strategy use of students with learning disabilities. The subjects were four fifth grade students (two males and two females) who met the following guidelines for participation in the study: (a) they were in the fourth or fifth grade, (b) they were identified as having a learning disability and had an Individualized Education Program (IEP) with goals in mathematics, and (c) they scored low on a
multiplication facts fluency assessment (factors of 4 and factors of 8). Only fifth grade students met all the criteria for participation.

The study took place in two elementary schools located in central Texas. Math instruction was delivered in classrooms near the students’ special education classrooms. It should be noted that the schools had vastly different demographics. For example, one school was a public elementary school with a majority of White students (74%), 12% Asian students, 10% Hispanic students, and 1% African American students. Approximately 4% of students were identified as limited English proficient, and one percent of the student population was identified as “economically disadvantaged”. The other school, a state charter school, had a majority of Hispanic students (64%), 19% White students, 15% African American students, and 1% Asian students. This school had double the population of limited English proficient students (8%) and 61% of students were identified as “economically disadvantaged”.

The researchers used a single subject, multiple probe across participants design to examine the effectiveness of explicit, direct instruction in fractions with iPad practice on the fractions fluency and strategy use of four students with learning disabilities. The independent variable, explicit instruction with iPad practice, was divided into three components: (a) explicit instruction in multiplication facts (i.e., factors of 4 and factors of 8) using a warm up activity, modeling, the concrete-representational-abstract (CRA) method, and guided practice, (b) independent practice using the iPad, and (c) daily progress monitoring. Students were also taught the doubling strategy to help them solve the multiplication problems. The lessons were delivered as tutoring sessions by the research team and were not part of the students’ regular math instruction.
Students received a total of 15 sequential lessons with two new facts in each lesson. The lessons were delivered using the following procedure: (a) three-minutes for a warm up, (b) eight minutes for modeling by the teacher, (c) seven minutes for guided practice, (d) five minutes for independent practice on the iPad, (e) two minutes for a daily math probe, and (f) three minutes for graphing data and providing feedback. The doubling strategy was integrated into the lessons. For the independent practice students used the Math Evolve iPad application (InterAction Education, 2012), a game-based math app designed to increase math fluency. The application monitored student progress, provided corrective feedback and multiple opportunities to solve problems, and was customizable.

A 2-minute multiplication pretest was administered daily to measure the students’ level of performance on the target multiplication facts. Students who scored in the frustration level (i.e., 0 - 19 digits correct per minute) were selected to participate. At the end of each lesson, students took a researcher-developed curriculum-based measure on the multiplication facts to monitor student progress during the treatment. Data on the students’ use of the doubling strategy was collected before, during, and after the intervention using a 10-problem multiplication worksheet and an observation form. A maintenance probe was administered two weeks after intervention. Additionally, student perceptions of the explicit instruction, iPad application, and overall lesson design were collected using Likert-style questionnaires.

The data from the study were analyzed using visual analysis and calculation of effect sizes (i.e., percentage of non-overlapping data, PND, and Tau U). Data from the visual analysis suggest that all four students experienced an increase in their multiplication fact fluency scores after intervention, and maintained the gains two weeks after the conclusion of the study. Similarly, data from the PND and Tau U suggested a significant increase in multiplication fact
fluency for all four students and maintenance of those skills. Three of the participants increased their use of the doubling strategy towards the middle of the intervention, however none of the students used the strategy after the intervention.

Overall the students rated the intervention positively, noting that they enjoyed the tutoring sessions and using the iPad for practice. There was only one negative comment from one student who did not like using worksheets. The students had differing perspectives on the doubling strategy – two students rated it very high, one student neither liked nor disliked the strategy, and one student strongly disliked it. Although all students enjoyed using the iPad and the *Math Evolve* app, all but one student indicated a preference for worksheets and flashcards during independent practice. The students indicated they preferred working with the investigator to working independently on the iPad.

The authors conclude that explicit instruction with integrated technology offers promising results for students with disabilities, specifically in math achievement and use of mathematical strategies. However, the instructional design for this study was multi-faceted, and it was not possible to pinpoint which aspect contributed to student gains. Future research should isolate specific components of digital instruction and compare them to a paper-based design. Also, the researchers recommended future investigations examine the effect of different content areas and computer applications. Finally, future research should involve implementation by the classroom teacher and include a comprehensive evaluation of the application that is integrated into instruction.

Pace and Mellard (2016) investigated the effects of using blended learning, an instructional model where students receive academic content online and from the teacher, on the ELA test scores of middle school students with disabilities. The purpose of the study was to
examine the following constructs: (a) the impact of blended learning on student academic achievement in reading, (b) the relationship between length of exposure to the intervention and student achievement, (c) differences in reading growth between students in special education and students in general education, (d) differences in reading growth based on gender, and (e) the correlation between reading efficacy and student performance in a blended learning setting.

The participants for this study included 495 middle school (sixth grade) students from three schools in one suburban/rural school district. Almost 11% of the total sample of students was identified as having a disability and an Individualized Education Program (IEP). The participants were split into two groups – two blended learning treatment groups (355 students) and one comparison group (140 students).

Three middle schools located in a suburban/rural school district in the Southeastern United States were chosen for this study. It should be noted that there were substantial differences in demographics between the schools. For example, one of the schools assigned to the treatment condition had a significantly higher population of white students and a smaller population of black students than the other school assigned to the treatment condition. Additionally, the school assigned to the comparison group had a much higher percentage of students receiving free or reduced lunch than the treatment schools.

Students in the blended learning schools received supplemental ELA instruction in a computer lab using a commercially developed program called Blended Language Arts (BELA). Students in the comparison school received 50 minutes of face-to-face ELA instruction from their ELA teacher. One blended learning group (BELA 1) received 70 minutes of computer-assisted instruction and 50 minutes of teacher-led instruction five days a week, and the other blended learning group (BELA 2) received 50 minutes of computer-assisted instruction and 50
minutes of teacher-led instruction two days a week. The intervention was implemented as a semester long course for BELA 1 and a sequence of 4- to 6-week courses for BELA 2. Students at the comparison school (Teaching English Language Arts – TELA) did not receive any instruction on the BELA program.

The researchers used a quasi-experimental group design with control and pre- and posttest to examine the effects of a blended learning environment on the ELA scores of middle school students with disabilities. The independent variable was a commercially produced computer software package (BELA) that offers supplemental ELA instruction. Specifically, students were taught how to read and analyze grade level text and literature, use academic vocabulary, create a written response to a prompt, develop speaking and listening skills, and learn how to use digital tools. Students were guided through interactive lessons that provided modeling, guided and independent practice, and assessment. Additionally, students interacted with their teachers and peers via email, chats, and posts.

Data on student achievement were collected using the Northwest Evaluation Association Measure of Academic Progress (NWEA MAP), an assessment that measured student reading skills. The assessment was administered three times during the school year (i.e., September, January, and May). Additionally, BELA staff members provided the research team with data on the percentage of activities completed by students and the students’ overall grade in the program. Finally, four questions from the Wigfield and Guthrie Motivation for Reading Questionnaire were used in a survey administered to the students.

To examine the rate of change in student scores over time and how gender, school, and special education status impacted those changes, a repeated measures analysis of covariance was used to evaluate the results of the NWEA MAP. The BELA program provided researchers with
data on the percentage of completed activities, student grades, and time spent on the math tasks. Additionally, a correlational analysis was performed to compare student reading efficacy with their test scores.

Overall the test scores for students at all three schools declined over the three-month period. Statistical significance was found for two three-way interactions: (a) Administration Time x Gender x Special Education status, and (b) Administration Time x Gender x School. Post hoc analyses were conducted on each interaction. For Administration Time x Gender x Special Education status, the data suggest that male and female general education students scored significantly lower on the May test than the January test. Male and female special education students had no significant change in score between the January and May test administrations.

For Administration Time x Gender x School, female students who were assigned to BELA 1 scored significantly lower on the May test than the January test, while female students at the other schools did not demonstrate a significant change in score. Male students at the BELA 1 and TELA schools scored significantly lower on the May test than the January test, however males at BELA 2 demonstrated no significant change in score. A two-way interaction was found for Administration Time x School, and post hoc analysis indicates that students at BELA 1 and TELA schools scored significantly lower in May than in January, while students at the BELA 2 school demonstrated no significant change. Positive correlations were found between the students’ reading efficacy, their test scores, and their grades in BELA.

The authors attribute the decline in test scores (and lack of change in others) to confounding variables not addressed in the study, one being student motivation and fatigue. The study took place during state testing, which could potentially influence students’ motivation to achieve on the math posttest. Another confounding factor presented by the researchers is the
possibility that the intervention was not implemented with fidelity. Observers noted that during implementation some students did not have access to headphones for audio support, and that some groups did not have adequate monitoring. Finally, there were discrepancies noted in lesson delivery across all three schools.

Recommendations for future studies include using a larger sample size of students with disabilities (for this study there were 44 students with disabilities across all three schools), providing more comprehensive support for a blended learning model, using the MAP as a formative assessment, providing teachers with professional development, ensuring an appropriate number of students are in the computer lab during implementation, and ensuring adequate supports and tools (i.e., headphones) are available for student use.

Carr (2012) compared the effectiveness of using an iPad and paper and pencil worksheets on the math achievement of fifth grade students. The purpose of the study was to investigate the effect of using the iPad with math applications on the math performance of the participating students.

Participants for this study included two fifth-grade math teachers with equivalent education and experience, and who taught at two different elementary schools in the same district. Both teachers instructed three 60-minute math classes five times per week. The student subjects consisted of two groups of fifth grade students, one group from each of the elementary schools chosen for participation. One group of students from one school was assigned to the treatment \((n = 56)\) and one group from the other school was assigned to the control \((n = 48)\). This study took place in a western Virginia school district located in an agricultural community. The intervention was implemented during the students’ regular math class and the math teachers delivered the lessons.
The researcher used a quasi-experimental group design with a pretest and posttest to examine the effectiveness of the iPad on the math achievement of the students. Prior to implementing the study, the teachers delivered math content that aligned with the district’s standards and served as foundational knowledge for the math skills students’ learned during the study. A site-based instructional coach trained the teachers on how to use the iPads, and the devices were distributed to the treatment group. Students were administered the Scott Foresman-Addison Wesley (SFAW) fifth-grade mathematics assessment as a pretest.

The study was implemented over the course of one academic quarter (approximately 40 school days). During the intervention, teachers developed their own lesson plans to deliver the math content. The researcher collected the lesson plans to compare them to the study protocol and monitor teacher activities during instruction. The participating teacher in the treatment group also completed the Lesson Plan Accuracy Rubric (LPAR), an instrument used to collect information about the instructional period, including iPad usage, outside events such as fire drills, and miscellaneous notes. The LPAR was completed daily and totaled at the end of each week to determine the teacher’s level of fidelity to the intervention.

In the treatment condition, the students used the iPad to engage in a variety of digital activities, including application-based math games, online presentations, video tutorials, and virtual manipulatives. The students in the comparison group participated in collaborative math games, completed paper-based worksheets and projects, and used concrete manipulatives. Both groups of students learned the same math skills and concepts. At the conclusion of the study, the students completed the SFAW as a posttest.

The researcher reported descriptive statistics for the data and used a one-way repeated measures ANOVA to conduct inferential statistics. The data indicated that the students in the
comparison group made significant gains over time from the pretest to the posttest. The treatment group also made gains from the pretest to the posttest, however it is not reported whether this change was significant over time. In the between-subjects comparison, the data indicate there was not a significant difference in test scores between the comparison and treatment groups. Data collected from the LPAR indicated that the teacher in the iPad condition implemented the lessons appropriately although no percentage of fidelity was calculated. The findings from the LPAR also indicated that the students utilized the iPads 85% of the time for a total of 32 out of the 40 days of the intervention.

The author concluded that there is no significant difference in the math achievement scores of the students in the iPad group and the comparison group, meaning neither intervention was more effective at increasing the students’ math scores. The author provided several possible reasons for this, including: (a) the short length of the study (one academic quarter), (b) limited professional development opportunities for teachers in using the iPads, (c) an invalid testing instrument (i.e., the SFAW), and (d) the students were limited to using the iPads for one class per day, and did not utilize the iPads for the entire length of the intervention. Limitations of the study included the variability in the prerequisite skill level of the students in the comparison and the iPad groups, the possible differences in teaching style of each of the participating teachers, the small sample size, and the location of the schools (i.e., agricultural community within the same school district). Recommendations for future research included addressing these limitations, as well as using a teacher and student perception survey to capture data on social validity.

**Self-Paced and Personalized Learning**

The mandates for high-quality instruction that guides students towards mastery of academic concepts apply to all educational settings, including those that serve students with
disabilities. However, instructional design for students with disabilities requires increased attention to the way in which these students receive and process information. In personalized, self-paced learning models, students are able to navigate content in multiple ways while still maintaining an appropriate level of rigor (Worthen, 2016). Empirical research in the area of personalized learning for students with disabilities in a K-12 setting is sparse, however there is some indication that technology can be used effectively to self-pace and personalize the learning environment. While in its infancy, research has begun to investigate the concepts of self-paced, personalized learning and apply the concepts to developing digital learning experiences for students.

Basham, Hall, Carter, and Stahl (2016) conducted a qualitative exploratory research study to develop an operationalized definition of personalized learning and determine the components of an effective personalized learning environment for students with disabilities.

The subjects for this study included students, teachers, and administrators located in an urban school district in the north-central United States. The district had 12 schools with approximately 6,500 students. Approximately 12% of the student population was identified as having a disability. Data were collected on 6,180 students in the district.

The setting for the study included targeted schools located in the urban school district. Classrooms in this district utilized a personalized learning format where students utilized technology in combination with teacher-led instruction to access academic content (i.e., blended learning). Each student had a personalized learning plan and students were grouped by age rather than grade level.

The authors utilized a qualitative exploratory design to examine personalized learning environments in an urban school district. During an 18-month period, the research team
conducted 50 observations of classrooms and every day school operations across several schools in this district. The observations ranged from 20 minutes to several hours in length. The researchers also interviewed staff, students, and parents regarding the implementation of the personalized learning format. The research team used the UDL Instructional Observation Instrument to gather data on the integration of UDL principles into personalized learning activities, and both long- and short-forms to conduct the observations. Researchers also obtained permission to access information on student demographics and academic growth.

The data from observations and interviews were analyzed using a multilevel coding process, where initial themes from open observations were gathered and used to develop an interview protocol. Student data were analyzed using a chi-squared test, and a generalized linear mixed model was used to identify factors related to student academic growth.

The results of the analysis indicated several characteristics that defined an effective personalized learning environment: (a) active, self-regulated learning where students set goals and planned future instructional activities, (b) UDL principles incorporated into the instructional sequence, (c) ongoing collaboration between teachers during and after school hours, (d) the promotion of a “can-do” attitude throughout the district, and (e) the use of technology to create individualized lessons, communicate with parents, and capture student academic and self-report data. Furthermore, qualitative data on student achievement suggest that personalized learning environments can foster academic growth for students with disabilities.

The authors recognize that personalized learning environments represent a departure from the “business as usual” model of instructional delivery, however they emphasized the vast potential of these models to facilitate academic achievement for all students through targeted, individualized instruction. The researchers encourage future empirical investigations into
personalized learning, specifically models that center on the development of positive school climate, targeted curriculum, and personal growth.

Balentyne and Varga (2016) investigated the effect of self-paced, blended learning on the mathematics achievement and math attitudes of high-achieving middle school students. The participants for this study were 26 high-achieving middle school students who were selected using the following criteria: (a) they were part of a pilot program on self-paced online learning, (b) they were part of an accelerated mathematics program in previous years, (c) a combination of standardized assessment scores and teacher recommendations, and (d) parent request.

The study took place in a small suburban middle school in the Midwestern United States. Students received math instruction in their regular math class using a commercial computer program called Accelerated Math (Renaissance Learning Inc., 2016). The program delivered personalized math instruction using example problems, videos, and digital and paper-based tasks. Students moved through the program by meeting specified objectives. If students did not meet the objectives they received small group instruction from the teacher.

A quantitative, quasi-experimental design was used to determine the effects of a self-paced computer math program on the math achievement and math perceptions of high-achieving middle school students. The study compared the students’ previous math scores on a standardized math assessment to their scores on the same assessment after treatment. To measure the students’ attitude towards math, the Attitudes Towards Mathematics Inventory (ATMI) was administered to students. The ATMI includes four categories: (a) self-confidence, (b) enjoyment, (c) motivation, and (d) value of mathematics. The ATMI was administered to students before and after they participated in the self-paced blended learning treatment. Student math achievement data was collected using the Northwest Evaluation Association Measures of Academic Progress.
Mathematics Test (NWEA MAP), a computerized assessment that adjusts the difficulty of the questions based on the students’ responses.

The research team conducted a paired-samples $t$-test on the students’ ATMI scores to compare the students’ attitudes towards math before and after treatment. They also calculated descriptive statistics for the student scores on the ATMI in each of the four categories. The data suggest that student attitudes improved after the self-paced blended math course was implemented. Additionally, the data indicate that although there was no significant difference in student self-confidence, enjoyment, or motivation, there was a statistically significant difference for student value of mathematics (students valued math more after treatment). Descriptive statistics and a paired-samples $t$-test were also conducted for student math achievement. The data suggest that students made less growth in math achievement after the self-paced blended course than when they took a traditional math course, although there was more variation in the math scores of students during the self-paced blended class.

The authors suggested that improved attitudes towards math, specifically in student value of mathematics, support multi-modal learning. They also posit that the high level of variation in the math scores of the students in the self-paced blended course indicate that self-paced learning is a viable option for some students. Limitations of this study include the small sample size and the possibility that different instructors and different curricula could influence the achievement and attitudes of the participants (i.e., internal validity). Additionally, differences in personal, social, and educational experiences between the previous year (from which the comparison data was obtained) and the year this study was conducted could influence the achievement and attitudes of the participants. Suggestions for future research include a larger sample from
various schools/districts, comparing several commercial blended learning programs, including a control group, and extending the length of the study to two or more years.

**Summary**

The literature provides a promising look at the use of technology for students with disabilities. Specifically, the use of mobile technology (e.g., Kindles, iPads, and iPods) with mobile apps has been shown to increase student achievement and engagement (Flower, 2014; Haydon et al., 2012; Means, Toyama, Murphy, & Baki, 2013; Musti-Rao & Plati, 2015; Nordness, Haverkost, & Volberding, 2011). However, these investigations do not present a complete picture of how students with disabilities use technology, or provide a definitive framework for developing online lessons. The mandates of the Every Student Succeeds Act (ESSA) and the Individuals with Disabilities Education Act (IDEA) require all students to be adequately prepared for post-secondary education and meaningful employment, most notably in the burgeoning fields of science, technology, engineering, and math (STEM; U.S. Department of Education, 2016). To do this, educators should integrate technology in an authentic way, meaning the lessons are thoughtfully designed to increase accessibility and overall student performance.

The purpose of this study was to investigate how students with disabilities interact with digital devices and navigate online lessons. Additionally, the specific components of mobile app instruction (e.g., content delivered on a mobile device using mobile apps) were examined to determine what features impact student learning and engagement. Digital math lessons were developed based on empirically-supported instructional design for students with disabilities. Two sections of a middle school resource math class were assigned to the treatment group (mobile app instruction – MAI) and two sections were assigned to the comparison group (traditional math
instruction – TMI). The same special education teacher was assigned to all four sections of the math class. Finally, survey data was collected regarding the student and teacher perceptions of student math knowledge and student engagement.
CHAPTER THREE

METHODOLOGY

The use of technology in the classroom for students with disabilities is well documented in the literature (Bryant et al., 2015; Darling-Hammond, Zielezinski, & Goldman, 2014; Boone & Higgins, 2007). Instructional models that integrate technology as part of the content delivery, namely as guided or independent practice, have demonstrated marked gains in engagement, productivity, academic achievement, and skill maintenance (Fletcher, Levin, Lipper, Leichty, & State Educational Technology Directors Association, SETDA, 2014). However, there is very little research examining the effectiveness of delivering direct instruction via mobile devices for students with disabilities. The purpose of this study was to compare the effectiveness of traditional math instruction to direct math instruction delivered via a mobile device on the mathematics achievement and engagement of students with disabilities. Student use of mobile technology was also examined.

This study compared the effectiveness of traditional, teacher-led instruction, characterized by an explicit, scripted mathematics lesson using paper and pencil activities (traditional math instruction; TMI), to an explicit mathematics lesson delivered via a mobile device (mobile app instruction; MAI). The participants were middle school students with high-incidence disabilities. Although both instructional models were designed to increase the mathematics achievement of students, this design explored any differences in the achievement and engagement of students between the two conditions. Specifically, the two models were compared on three measures: (a) the level of mastery relative to targeted math skills, (b) the level of student engagement, and (c) teacher and student perceptions of student math knowledge and engagement in both conditions.
Four sections of a resource math classroom for students with disabilities were identified and randomly assigned to either the TMI or the MAI groups. Two sections of the class were assigned to TMI, while the other two were assigned to MAI. The teacher was trained on implementing the intervention prior to the beginning of the study. The students in both conditions were taught one specific mathematics skill per day as designated by the teacher. The students were provided one new math lesson per day, for a total of 8 lessons (Wednesday and Thursday were designated “odd” and “even” block days, where students attended periods 1, 3, and 5 on Wednesday and periods 2, 4, and 6 on Thursday. Therefore, Wednesday’s math lesson was repeated on Thursday for the students in the other classes). Students completed one lesson during a 50-minute class period. The students were allowed to move through the lesson at their own pace. On the first day of the intervention, the students were given a math pretest on all the targeted mathematics skills covered during the course of the study. On the second day of the intervention, the targeted mathematics concept for that day was introduced. Students were assigned a self-guided lesson on the mobile device and the teacher circulated the classroom to monitor student progress, answer student questions, and provide feedback. On the final day of the intervention, the students were administered the same assessment as the one they completed on the first day of the intervention. In addition, student engagement was measured using an observational checklist, and student use of the mobile device was monitored through observations and data provided by the online learning platform.

During TMI, the teacher delivered direct, explicit math instruction. The math content delivered in the TMI group mirrored the math content delivered in the MAI group. The teacher was responsible for implementing the warm up and independent practice activities.
Data were collected using the pre- and posttests, the warm up activities, and the independent practice activities. The results were evaluated using a one-way MANOVA. Additionally, the data from the pretests and the posttests were analyzed using a 2 x 2 repeated-measures ANOVA to determine if there was any significant difference in the scores between groups over time. Teacher and student perception data were collected using surveys and analyzed using an independent samples t-test. Observations of student engagement and teacher fidelity to the intervention were collected using an observational checklist and a teacher fidelity checklist. The data from the student engagement checklist were analyzed using an independent samples t-test. Finally, data regarding student responses and participation were collected from the online learning platform and descriptive statistics were calculated.

**Research Questions**

This research study was designed to answer six research questions. They were:

1. Does the mathematics achievement of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

   It was predicted that the use of mobile app instruction would increase the mathematics achievement of students with disabilities when compared to the traditional scripted, explicit, teacher-led instruction using paper and pencil activities.

2. Is there an increase in the academic engagement (i.e., when students review the material and actively complete the assigned task, exhibit appropriate physical responses such as typing or writing, ask for assistance in an acceptable manner, interact with the teacher or their peers about related topics, and listen to the teacher’s directives) of students with disabilities with mobile app instruction when compared to traditional math instruction?
It was predicted that the use of mobile app instruction would increase the engagement of students with disabilities when compared to the traditional scripted, explicit, teacher-led instruction using paper and pencil activities.

3. Do student perceptions of mathematics knowledge increase with the use of the mobile app instruction when compared to traditional math instruction?

It was predicted that the use of mobile app instruction would increase student perceptions of mathematics knowledge when compared to the traditional scripted, explicit, teacher-led instruction using paper and pencil activities.

4. Do teacher perceptions of the mathematics knowledge of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

It was predicted that the use of mobile app instruction would increase the teachers’ perceptions of mathematics knowledge of students with disabilities when compared to the traditional scripted, explicit, teacher-led instruction using paper and pencil activities.

5. Do student perceptions of engagement increase with the use of mobile app instruction when compared to traditional math instruction?

It was predicted that the use of mobile app instruction would increase the student perceptions of engagement when compared to the traditional scripted, explicit, teacher-led instruction using paper and pencil activities.

6. Do teacher perceptions of the engagement of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

It was predicted that the teacher perceptions of student engagement would increase with the use of mobile app instruction when compared to traditional math instruction.
Participants

The participants in this study were 55 middle school students enrolled in a resource (special education) math class in an urban school district in the Southwestern United States. The participants ranged in age from 11 – 14 years old. Prior to participation in the study, parents signed an informed consent form (see Appendix A) and students signed a student assent form (see Appendix B).

Students with Disabilities

Students who participated in this study were identified by a multidisciplinary team as having a disability and received services in a special education resource math classroom. The classes consisted of students with learning disabilities, emotional and behavioral disorders, attention-deficit/hyperactivity disorder, and autism. Demographic information was collected for each student who participated in the study (see Table 1).
Table 1

Demographic Information for Students

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>TMI</th>
<th>MAI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12.2</td>
<td>12.8</td>
</tr>
<tr>
<td>Range</td>
<td>11-14</td>
<td>11-14</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Caucasian</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Latino</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Native American</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>28</td>
</tr>
</tbody>
</table>

Students completed a survey related to their perceptions of their mathematics knowledge (see Appendix C) and level of engagement during the intervention (see Appendix D). Additionally, students completed a pretest prior to the intervention and a posttest on the last day of the intervention (see Appendix E). These assessments measured the students’ knowledge of
the math skills and concepts before and after participation in the study. Each lesson included a
warm up activity and an independent practice activity related to the targeted math concepts. The
independent practice activity was used to gauge the students’ learning after each lesson. In order
to participate in the MAI condition, students were trained on the following skills: (a) turning on
the Kindle Fire, (b) accessing the internet, (c) logging on to their individual Google account, (d)
accessing the math lesson, (e) navigating the math lesson, including completing and submitting
activities, using hyperlinks, and accessing videos and embedded questions, (f) logging off of
their Google account, and (g) turning off the Kindle Fire. Students were also introduced to the
lesson presentation platform, Zeeings, and the video platform EDpuzzle.

The students were selected based on the following criteria: (a) they received math
instruction in a resource (special education) setting, and (b) they were receiving special
education services under an Individualized Education Program (IEP). The participants were
chosen using nonprobability, convenience sampling.

The primary investigator met with the students to explain the study, answer questions,
and explain the assent process. Students were provided with a student assent form and the
primary investigator read the form aloud and answered questions. Students were allowed to
discuss the study with their guardians prior to providing assent.

Teacher

One special education teacher participated in this study. The teacher was assigned to a
resource math classroom for students with disabilities and was licensed to teach special
education. Demographic information was collected for the teacher (see Table 2).
### Table 2

**Demographic Information for the Teacher**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Degree</th>
<th>Ethnicity</th>
<th>Years Teaching Students with Disabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>53</td>
<td>M.Ed</td>
<td>Caucasian</td>
<td>10</td>
</tr>
</tbody>
</table>

The teacher signed an informed consent form to participate in the study and taught all four sections (two TMI and two MAI) of the math class (see Appendix F). The teacher implemented either traditional instruction using paper and pencil activities or mobile app instruction. The teacher attended a training session prior to the implementation of the study. During this training, the teacher was given the opportunity to practice implementing both instructional models with feedback from the investigator.

The teacher completed surveys concerning their perceptions of student engagement (see Appendix G) and student knowledge of the math skills (see Appendix H). The teacher was responsible for delivering direct math instruction and implementing all activities (TMI), handing out the mobile devices and supporting students (MAI), and administering the pre- and posttests.

**Teacher Fidelity Observer**

The student investigator collected data on teacher fidelity using a teacher fidelity checklist (see Appendix I). The fidelity score was set at 100%, and if the teacher fell below the established criteria the teacher was given feedback on the specific gaps in instruction. The following is the formula used to calculate teacher fidelity: 

\[
\text{percent fidelity for each lesson} = \left( \frac{\text{number of steps implemented correctly}}{\text{total number of steps in the lesson}} \right) \times 100
\]
Setting

The setting for this study was four sections of a special education (resource) math classroom in a large urban Southwestern school district. All of the classrooms were located in a public middle school serving students in grades six through eight. The middle school included a variety of instructional settings, including special education (self-contained and resource) and general education (single teacher and co-taught classrooms). The community served by this school is diverse and includes a variety of cultures, languages, ethnicities, and economic backgrounds. The principal completed a facilities acknowledgment form prior to the beginning of the study (see Appendix J).

Classrooms

The classes used in this study were classrooms delivering direct, explicit math instruction to students with disabilities. The majority of instruction in these classes focused on academic supports in mathematics. Most of the students attended resource classrooms for their core content instruction (i.e., math and English language arts). Classrooms were selected for participation using convenience sampling, however specific sections of the math class were assigned to either the TMI or the MAI randomly. Each classroom was equipped with a wireless internet connection (Wi-Fi) which was password protected and accessible to the students, teachers, and research team. Students were seated at individual desks facing towards the whiteboard.

Instrumentation

There were several assessment measures used to collect data for this study: (a) a pre- and posttest measuring student performance on targeted math skills/concepts, (b) warm up activities, (c) independent practice activities (used to gauge student learning at the end of the lesson), (d) an observational checklist to measure the level of student engagement, (e) a survey on student
perceptions of their mathematical knowledge, (d) a survey on student perceptions of engagement, (e) a survey on teacher perceptions of student mathematical knowledge, (f) a survey on teacher perceptions of student engagement, and (g) a teacher fidelity checklist. Additionally, the presentation platform and video platform collected data on students’ responses to questions and participation in the activities.

**Pretest and Posttest**

In this study, a pretest and posttest was used to determine the mathematics achievement of participating students. The tests were AIMSweb (NCS Pearson, 2014) math probes for sixth grade, and the probes included computation problems directly related to the concepts taught during the study. The assessments were delivered in a paper and pencil format for both conditions. The assessments were scored to determine the number of problems answered correctly. The student investigator scored the assessments.

**Observational Checklist**

During the course of the study, an observational checklist was used to determine the students’ level of engagement in both conditions (see Appendix K). The checklist consisted of items related to specific student behaviors, including (a) reviewing the material, actively completing the task, and exhibiting appropriate physical responses such as typing or writing, (this includes the swiping motion necessary to advance slides in the MAI lesson), (b) asking for assistance (when appropriate) in an acceptable manner, (c) interacting with the teacher or their peers about related topics, and/or (d) listening to the teacher’s directives (Walker et al., 1990).

**Teacher Perception of Student Math Knowledge**

On the last day of the study the teacher completed a survey regarding her perception of student math knowledge. The questionnaire assessed the teacher’s beliefs of how well the
students understand the math skills and concepts taught during the intervention. The survey included a Likert scale ranging from 1 to 5, with 1 being strongly disagree and 5 being strongly agree.

**Student Perception of Math Knowledge**

On the last day of the study the students completed a survey regarding their perception of their own math knowledge. The questionnaire assessed the students’ beliefs of how well they understood the math skills and concepts taught during the intervention. The survey included a Likert scale ranging from 1 to 5, with 1 being strongly disagree and 5 being strongly agree.

**Teacher Perception of Student Engagement**

On the last day of the study the teacher completed a survey regarding her perception of student engagement. The questionnaire assessed the teachers’ beliefs of the level of student engagement during the intervention. The survey included a Likert scale ranging from 1 to 5, with 1 being strongly disagree and 5 being strongly agree.

**Student Perception of Engagement**

On the last day of the study the students completed a survey regarding their perception of their own engagement. The questionnaire assessed the students’ beliefs of their engagement during the intervention. The survey included a Likert scale ranging from 1 to 5, with 1 being strongly disagree and 5 being strongly agree.

**Teacher Fidelity Checklist**

During the course of the study the teacher was observed for fidelity to the scripted math lessons (TMI) and the protocol for the MAI. The student investigator utilized a teacher fidelity checklist to record the fidelity data.
Materials

Several materials were required for implementation of this study. For the TMI the following materials were used: (a) scripted math lessons, (b) paper and pencil warm up activity, (c) paper and pencil independent practice activity, and (d) PowerPoint presentation guided by the teacher and displayed on the SmartBoard. For the MAI the following materials were used: (a) Kindle Fire mobile devices, (b) individual student Google accounts, (c) Zeetings online presentation platform, (d) digital warm up (Google Docs), (e) digital independent practice (Google Docs), and (f) EDpuzzle video application. See Appendix L for an example of the warm up activity and Appendix M for an example of the independent practice activity. The activities were identical in both conditions.

Scripted Math Lessons - TMI

The teacher delivered the TMI via explicit, scripted math lessons (see Appendix N). The lessons included the elements of the explicit teaching cycle, including warm up, teacher modeling, guided practice, independent practice, and review. The student researcher developed all the math lessons for the TMI using the Common Core State Standards for math. The math teacher identified the specific content standards that correlated with the time period of the intervention. During week one, students covered CCSS.MATH.CONTENT.6.EE.B.6, use variable to represent numbers, write and evaluate expressions using variables and coefficients, write an inequality to represent a problem, and use substitution to determine if the inequality is true, and CCSS.MATH.CONTENT.6.EE.B.5, write and solve one-step inequalities. During week two, students covered CCSS.MATH.CONTENT.6.EE.B.8, write and solve multi-step inequalities using addition, subtraction, multiplication, and division, and write and solve
compound inequalities. Students in the TMI condition received teacher-led instruction with paper and pencil activities.

**Scripted Math Lessons - MAI**

The same explicit, scripted math lessons used in the TMI group were used in the MAI group. The lessons included the elements of the explicit teaching cycle, including warm up, teacher modeling, guided practice, independent practice, and review. The student researcher developed all the math lessons for the MAI using the Common Core State Standards for math. The math teacher identified the specific content standards that correlated with the time period of the intervention. During week one, students covered CCSS.MATH.CONTENT.6.EE.B.6, use variable to represent numbers, write and evaluate expressions using variables and coefficients, write an inequality to represent a problem, and use substitution to determine if the inequality is true, and CCSS.MATH.CONTENT.6.EE.B.5, write and solve one-step inequalities. During week two, students covered CCSS.MATH.CONTENT.6.EE.B.8, write and solve multi-step inequalities using addition, subtraction, multiplication, and division, and write and solve compound inequalities. Students in the MAI condition received all instruction via a mobile device.

Both conditions (TMI and MAI) ran simultaneously for two weeks. On the first day of instruction, the teacher introduced the math concept to be taught for the week. In the TMI model the teacher followed a specific routine for delivering the content: (a) students entered the classroom and completed the warm up activity (5 minutes), (b) the teacher facilitated whole group discussion of the warm-up activity and connected it to previous and new learning (5 minutes), (c) the teacher introduced the skill/concept, modeled instruction of the skill/concept, and provided guided practice with the skill/concept (30 minutes), (d) the students completed a
paper-and-pencil independent practice activity (5 minutes), and (d) the teacher answered questions and provided a review (5 minutes). The independent practice was counted as a measure of student learning for that day.

Students in the MAI model received all instruction via a mobile device. Each day the students were given a new math lesson. The lessons were loaded onto the Kindle each night by the student investigator. The instructional sequence for MAI was as follows: (a) digital warm-up activity related to the material presented in the current lesson to gauge background knowledge (i.e., Google Doc), (b) introduction to new material via a PowerPoint embedded in a presentation platform, (c) modeling of the skill/concept via outsourced learning videos, (d) guided practice via step-by-step presentations, (e) independent practice via a digital worksheet (i.e., Google Doc), and (f) review. Students were allowed to move through the lesson at their own pace. In this model the role of the teacher was to facilitate student use of the mobile app and answer student questions.

**Online Presentation Platform**

An online presentation platform (Zeetings) was selected to deliver the direct instruction in the MAI condition (see Appendix O). Zeetings was selected because it offered the following components: (a) advanced analytics, such as recording the number of participants, the participants’ individual responses to questions, percentage of questions answered, and percentage of questions correct, (b) students can take notes within the presentation and send them to their email account, post comments or questions (set to private), or chat with other students and the teacher (this was not enabled for this study), (c) the platform is easy to navigate, and (d) the platform is compatible with many devices and operating systems (i.e., Kindle Android or Apple iOS).
Additionally, students watched learning videos via a video editing and presentation application called EDpuzzle (see Appendix P). EDpuzzle is accessed through the students’ individual Google account, and students were able to watch selected videos and respond to embedded questions. The EDpuzzle application was used during the modeling portion of the MAI.

**Mobile App Instruction (MAI)**

The student investigator developed all 8 math lessons for the MAI. All math instruction (i.e., warm-up, introduction/modeling, guided practice, independent practice, and review) was delivered via the mobile device. Students in the MAI condition watched presentations and completed activities on the mobile device using the computer applications Zeetings, Google Docs, and EDpuzzle. Student responses to the questions in Zeetings, Google Docs, and EDpuzzle were automatically sent to the researcher’s individual, password-protected account. The teacher circulated throughout the class to answer questions and guide students as needed. Students received feedback from the presentation software based on their responses to questions, and the teacher also provided feedback when observing students on the devices.

**Mobile Devices**

The mobile device used for this study was a Kindle Fire 7" display Wi-Fi, 8 GB tablet. There were two students assigned to each tablet, and any identifying data such as email accounts were removed from the device prior to releasing it to the next student. Each student had an individual, password-protected Google account that they used to access the learning videos. Students were given two days of training on how to navigate the device and the Zeetings platform.
Training

The teacher and the students received training in order to familiarize them with the intervention materials and protocols. The special education teacher had one day of training prior to the beginning of the intervention. Students received two days of training on how to navigate the Kindle tablet and the Zeetings and EDpuzzle presentation platforms.

Teacher Training

The teacher attended a two-hour training on the implementation of the scripted math lessons and the mobile learning lessons. The teacher was provided the opportunity to practice the lessons and receive feedback.

Traditional math instruction (TMI). The teacher received training on the sequence of the scripted math lessons and the implementation of the paper and pencil activities. During this training, the teacher was able to review the instructional materials, ask questions, and participate in a simulation of the lesson. The teacher received feedback from the student investigator. At the end of the training, the teacher was provided with all the materials needed to implement the TMI lesson.

Mobile app instruction (MAI). The teacher received training on the sequence of the scripted math lessons and the implementation of the digital lessons. During this training, the teacher reviewed the instructional materials, asked questions, and participated in a simulation of the lesson. The teacher received feedback from the student investigator. At the end of the training, the teacher was provided with all the materials needed to implement the MAI lesson. A class set of the Kindle tablets was provided to the teacher for student use during the study.
**Student Training**

Students in the MAI condition received a two-day training on using the Kindle tablet and accessing the digital lessons. The students were taught the following skills: (a) turning on the Kindle Fire, (b) accessing the internet, (c) logging on to their individual Google account, (d) accessing the math lesson, (e) navigating the math lesson, including completing and submitting activities, using hyperlinks, and accessing videos and embedded questions, (f) logging off of their Google account, and (g) turning off the Kindle Fire. Students were also introduced to the lesson presentation platform, Zeetings, and the video platform EDpuzzle. Students were guided through the process with teacher prompts and a notecard was provided to remind students of the steps. Students in the TMI condition received a one-day training on the components of the explicit math lesson, including the sequence of the lessons and the expectations for completing the paper and pencil activities.

**Design and Procedures**

This study was conducted over a 2-week period and included two phases (see Figure 1). In the first phase, intervention groups were randomly assigned and participants attended training sessions. In the second phase, the pre- and posttests were administered, the intervention was implemented, the teacher and student surveys were administered, and data were collected.
Phases of the Study

**Phase One**
- Facilities Acknowledgement from the principal
- Consent obtained from the teacher
- Consent obtained from the parents
- Assent obtained from the student participants
- Teacher received training for both conditions of the intervention
- Students received training for both conditions of the intervention

**Phase Two**
- Students completed the math pretest
- Intervention implemented
- Students completed the posttest
- Students and teacher completed the student math knowledge and student engagement surveys

**Phase One**

During Phase One, support for the study was obtained from the school district officials, and upon approval the school site was recruited for participation. A middle school with a resource math class for students with disabilities was considered for inclusion in the study, and the school was contacted via email, phone calls, and in-person meetings. One resource math classroom was utilized in the study and consent forms were obtained from all participants.

**Consent.** Informed consent forms were distributed to teachers and parents of the student participants. A letter detailing the study and a consent form were sent home with the students. Once the parent consent forms were returned, student assent forms were collected from the student participants. For those students whose parents gave consent, a meeting was held with students in order to explain the study and answer questions prior to distributing the assent forms. Consent forms were collected from the teacher on their first day of training.

**Teacher participant.** The teacher was selected based on the following criteria: (a) possessed a valid special education teaching license in the state of Nevada, and (b) taught
Teacher training. Two of the four sections of the math class were randomly assigned to the TMI condition and two sections were randomly assigned to the MAI condition. The teacher attended one training to review the components of both conditions. During the training the teacher looked through the lesson materials, participated in a role-play lesson, and was scored by the student investigator. The teacher was provided feedback based on their performance of the lesson.

Student training. The students in the MAI condition received a two-day training on how to use the Kindle Fire mobile device, log on to their Google account, navigate the Zeetings and EDPuzzle applications, and complete and submit the activities. Students were provided the opportunity to become familiar with the device and complete two practice lessons. The practice lessons included an introductory presentation explaining a math concept, an activity related to the concept, and an independent practice activity. After completing the lessons, the students were permitted to ask questions and receive clarification from the student investigator.

Phase Two

During Phase Two, students completed the mathematics skills pretest and the intervention was implemented. At the conclusion of the intervention, students completed the same math skills posttest and the student perception surveys. The teacher also completed the teacher perception surveys.

Pretest. Students received a math skills pretest during the first week of intervention. The pretest included the math skills and concepts aligned with the Common Core State Standards for the sixth grade, spring semester. Students were asked to: (a) use variables to represent numbers,
(b) write and evaluate expressions using variables and coefficients, (c) write an inequality to represent a problem and use substitution to determine if the inequality is true, (d) write and solve one-step inequalities, (e) write and solve multi-step inequalities using addition, subtraction, multiplication and division, and (f) write and solve compound inequalities. The math pretests were scored by the student investigator and recorded. The data were entered into the SPSS data analysis program during the data analysis portion of the study and saved in an Excel spreadsheet.

Teacher and student perceptions surveys. Immediately following the implementation of the intervention, the teacher and students completed surveys regarding their perception of the students’ math knowledge and engagement. The surveys included a Likert rating scale from 1 (strongly disagree) to 5 (strongly agree). The data from the surveys were collected, scored, and entered into SPSS for data analysis.

Lesson implementation. In the TMI and MAI, a new math skill/concept was introduced each day over the course of two weeks (4 lessons per week). Each day of instruction in the TMI condition followed the same instructional sequence for math content delivery: (a) students entered the classroom and completed the warm up activity (5 minutes), (b) the teacher facilitated whole group discussion of the warm-up activity and connected it to previous and new learning (5 minutes), (c) the teacher introduced the skill/concept, modeled instruction of the skill/concept, and provided guided practice with the skill/concept (30 minutes), (d) the students completed a paper-and-pencil independent practice activity (5 minutes), and (d) the teacher answered questions and provided a review (5 minutes). The independent practice was counted as a measure of student learning for that day. The MAI group followed the same instructional sequence, however all instruction was student-led and presented on the Kindle Fire. The TMI group was presented with teacher-led instruction and paper and pencil activities.
Independent practice. The independent practice activities were included as a measure of student learning for each lesson. Specifically, students were asked to: (a) use variables to represent numbers, (b) write and evaluate expressions using variables and coefficients, (c) write an inequality to represent a problem and use substitution to determine if the inequality is true, (d) write and solve one-step inequalities, (e) write and solve multi-step inequalities using addition, subtraction, multiplication and division, and (f) write and solve compound inequalities. The students in the TMI completed these activities using paper and pencil, and the students in the MAI completed these on the Kindle (i.e., Google Doc). The student investigator collected the paper and pencil activities from the teacher and scored them. The student responses for the MAI were automatically scored and submitted to the student investigator’s password-protected account. The data was collected and entered into SPSS for data analysis; they were also saved in an Excel spreadsheet.

Posttest. After 2 weeks of instruction, students completed a posttest on the mathematics skills and concepts taught during the intervention. The posttest was the same assessment as the pretest and consisted of mathematical computation problems. Specifically, students were asked to: (a) use variables to represent numbers, (b) write and evaluate expressions using variables and coefficients, (c) write an inequality to represent a problem and use substitution to determine if the inequality is true, (d) write and solve one-step inequalities, (e) write and solve multi-step inequalities using addition, subtraction, multiplication and division, and (f) write and solve compound inequalities. The student investigator scored the posttest and the data were collected and entered into SPSS for data analysis. The data were also saved in an Excel spreadsheet.
Data Collection

Data were gathered during this study to answer the research questions. The student researcher developed data collection forms to capture information related to the pretest, posttest, warm up and independent practice activities, teacher and student perception surveys, student observations, and fidelity data. Additionally, data were collected on how students used the Kindle device and how they navigated the digital math lessons.

Pre- and Posttest Instruments

Traditional math instruction (TMI). The data from the pretest and posttest were collected and entered into the SPSS data analysis software.

Mobile app instruction (MAI). The data from the pretest and posttest were collected and entered into the SPSS data analysis software.

Teacher Perceptions of Math Knowledge

Teacher perceptions of student math knowledge were collected at the end of the intervention and entered into the SPSS data analysis software.

Student Perceptions of Math Knowledge

Student perceptions of math knowledge were collected at the end of the intervention and entered into the SPSS data analysis software.

Teacher Perceptions of Student Engagement

Teacher perceptions of student engagement were collected at the end the intervention and entered into the SPSS data analysis software.

Student Perceptions of Engagement

Student perceptions of engagement were collected at the end of the intervention and entered into the SPSS data analysis software.
**Student Engagement**

Data on student engagement were collected throughout the intervention and entered into the SPSS data analysis software.

**Teacher Fidelity Data**

Teacher fidelity data were collected throughout the intervention using the fidelity checklist. The formula that was used to calculate teacher fidelity was \[
\frac{\text{(number of steps implemented correctly)}}{\text{(total number of steps in the lesson)}} \times 100 = \text{percent fidelity for each lesson}\]. The percentage of fidelity agreement was conveyed to the teacher by the rater.

**Treatment of the Data**

Student scores on the pretest, posttest, warm up, and independent practice activities were used to answer the following research question:

Research Question 1: Does the mathematics achievement of students with disabilities increase with the use of the digital practice when compared to the traditional, teacher-led instruction using paper and pencil practice?

Analysis: In order to determine if there was a significant difference between the pretest and posttest math scores, a multivariate one-way analysis of the variance (MANOVA) was conducted using the SPSS data analysis software. An alpha level of .05 was set. Additionally, a 2 x 2 repeated-measures ANOVA was conducted to determine if there was a significant difference in the scores between groups over time.
Data from the observational checklists were used to answer the following research question:

Research Question 2: Does the engagement of students with disabilities increase with the use of the digital practice when compared to the traditional, teacher-led instruction using paper and pencil practice activities?

Analysis: In order to determine if there was a significant difference in the level of student engagement between the TMI and the MAI conditions, an independent samples t-test was conducted through the SPSS data analysis software. An alpha level of .05 was set.

Data from the teacher and student perception of math knowledge surveys was collected to answer the following research questions:

Research Question 3: Do student perceptions of mathematics knowledge increase with the use of the digital practice when compared to the traditional, teacher-led instruction using paper and pencil practice?

Analysis: In order to determine if there was a significant difference in the students’ level of perceived math knowledge between the TMI and the MAI conditions immediately following the posttest, a t-test was conducted through the SPSS data analysis software. An alpha level of .05 was set. The student perception survey was administered once after the intervention.

Research Question 4: Do teacher perceptions of the mathematics knowledge of students with disabilities increase with the use of the digital practice when compared to the traditional, teacher-led instruction using paper and pencil practice?

Analysis: There was only one teacher who participated in the intervention, and therefore statistical analysis does not apply. Descriptive statistics of the teacher’s perceived level of student math knowledge between the TMI and the MAI conditions were reported.
Data from the teacher and student perception of engagement surveys was collected to answer the following research questions:

Research Question 5: Do student perceptions of engagement increase with the use of the mobile app instruction (MAI) when compared to the traditional, teacher-led instruction using paper and pencil activities (TMI)?

Analysis: In order to determine if there was a significant difference in the students’ perceived level of engagement between the TMI and the MAI conditions, a t-test was conducted through the SPSS data analysis software. An alpha level of .05 was set.

Research Question 6: Do teacher perceptions of the engagement of students with disabilities increase with the use of the mobile app instruction (MAI) when compared to the traditional, teacher-led instruction using paper and pencil activities (TMI)?

Analysis: There was only one teacher who participated in the intervention, and therefore statistical analysis does not apply. Descriptive statistics of the teacher’s perceived level of student engagement between the TMI and the MAI conditions were reported.
CHAPTER FOUR

RESULTS

Students with disabilities, especially those who struggle in math, have a difficult time performing the complex cognitive processes associated with problem solving and other mathematical procedures (Gersten et al., 2008). Still, more than half of all students with disabilities receive content area instruction in the general education classroom and are responsible for meeting the same rigorous standards as their nondisabled peers (Weiss, Evmenova, Kennedy, & Duke, 2016). While many teachers provide some accommodations to support the learning of students with disabilities, traditional materials such as textbooks and paper-and-pencil drill activities are still widely utilized (Weiss et al., 2016). Technology has become a vast gateway into multi-modal learning where teachers develop authentic, individualized instruction for students with disabilities (Nepo, 2017). The use of technology in math, specifically mobile devices such as Kindles and iPads, has the potential to revolutionize curricula and thereby increase the academic achievement and engagement of students with disabilities (Nordness, Haerkost, & Volberding, 2011; Shin & Bryant, 2017; Zhang, Trussell, Gallegos, & Asam, 2015).

Despite the rising popularity of technology as a pedagogical tool, there is little empirical research examining how students with disabilities use these devices and what features facilitate learning and sustain attention in a K-12 setting. Legislation such as the Every Student Succeeds Act (ESSA) and the Individuals with Disabilities Education Act (IDEA) mandate the use of personalized instruction in order to provide students with disabilities a “meaningful” education that is matched to their specific needs (Nepo, 2017). Lessons delivered on a computer or mobile
device can provide differentiated instruction and increase students’ access to the general education math curriculum.

The purpose of this study was to determine how students with disabilities utilize digital tools to access academic content. This study also measured student achievement and engagement during mobile app instruction, and student and teacher perceptions of math achievement and engagement after instruction on the mobile device. Lesson materials for the mobile device and the comparison group were developed using relevant research on effective instructional practices for students with disabilities, and with feedback from the special education teacher. Fifty-two students and one special education teacher participated in the study (see Tables 1 and 2). The same teacher had four sections of middle school resource math. All student participants (a) had a current Individualized Education Program (IEP), (b) were eligible for special education services according to the state administrative policy, and (c) were receiving math instruction in a special education resource math class. Students were middle school students in sixth ($n = 14$), seventh ($n = 16$), and eighth grade ($n = 25$).

Classrooms were assigned to one of two groups: traditional math instruction (TMI) or mobile app instruction (MAI). Both groups received standards-based math instruction for a 50-minute period over the course of two weeks during their regular math class. Prior to implementation of the study, students completed a math pretest to determine their current level of knowledge of the math skills and concepts introduced in the study (e.g., algebraic expressions and inequalities).

Two sections of the math class were assigned to the TMI group ($n = 27$) and two sections of the math class were assigned to the MAI group ($n = 28$). The student investigator conducted fidelity observations of the teacher and observations of student engagement behaviors during the
intervention. At the end of the two-week period, the students completed a math posttest. Students and the teacher completed surveys that measured their perceptions regarding the students’ math achievement and engagement with the intervention materials.

**Teacher Fidelity to Interventions**

Teacher fidelity checklists were developed to measure teacher adherence to the scripted lessons during the TMI condition and her role as facilitator during the MAI condition. The student investigator performed observations in the math classes daily for the duration of the study. Fidelity was calculated using the following formula: 

\[
\frac{(\text{number of steps implemented correctly})}{(\text{total number of steps in the lesson})} \times 100 = \text{percent fidelity for each lesson}.
\]

Overall fidelity measures for each group were determined by calculating the fidelity averages for the teacher during TMI and MAI. The means and standard deviations for the teacher’s fidelity scores are presented in Table 3. The teacher’s average percent of fidelity for each session is presented in Table 4. During the TMI condition, the teacher demonstrated an overall percent fidelity score of 89%. During the MAI condition, the teacher demonstrated an overall percent fidelity of 93%. This means that the teacher had a slightly higher percent fidelity during MAI than during TMI.

It should be noted that during session 2 and session 4 of the TMI the teacher fidelity scores dropped to 78%. These classes were especially susceptible to students transitioning in and out because of state testing, and it was noted that the teacher often deviated from the scripted lesson. The student investigator met with the teacher after these sessions and provided feedback on the specific areas of the lesson that did not conform with the script. The student investigator emphasized the importance of maintaining fidelity to the intervention and answered the teacher’s questions.
Table 3

*Summary of Means and Standards Deviations for Teacher Fidelity to Intervention Scores*

<table>
<thead>
<tr>
<th>Instructional Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMI</td>
<td>89</td>
<td>7.8</td>
</tr>
<tr>
<td>MAI</td>
<td>93</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4

*Teacher Fidelity to Intervention Scores By Session*

<table>
<thead>
<tr>
<th>Session</th>
<th>TMI Percent of Fidelity</th>
<th>MAI Percent of Fidelity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>89%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>78%</td>
<td>86%</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>86%</td>
</tr>
<tr>
<td>4</td>
<td>78%</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td>6</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td>7</td>
<td>89%</td>
<td>100%</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Analysis of Student Math Knowledge

The students were assessed on their ability to accurately solve problems on targeted math skills and concepts. Specifically, students were assessed on the following objectives and related Common Core State Standards (CCSS) in math: (a) Use variables to represent numbers, CCSS.MATH.CONTENT.6.EE.B.6, (b) Write and evaluate expressions using variables and coefficients, CCSS.MATH.CONTENT.6.EE.B.6, (c) Write an inequality to represent a problem and use substitution to determine if the inequality is true, CCSS.MATH.CONTENT.6.EE.B.5, (d) write and solve one-step inequalities, CCSS.MATH.CONTENT.6.EE.B.8, (e) write and solve multi-step inequalities using addition and subtraction, CCSS.MATH.CONTENT.6.EE.B.8, (f) write and solve multi-step inequalities using multiplication and division, CCSS.MATH.CONTENT.6.EE.B.8, and (g) write and solve compound inequalities, CCSS.MATH.CONTENT.6.EE.B.8. The students were assigned warm up and independent practice activities during each lesson to measure their level of understanding before and after instruction.

Data from the pretest, posttest, warm up, and independent practice assessments were used to answer the following question:

1. Does the mathematics achievement of students with disabilities increase with the use of the mobile app instruction when compared to traditional math instruction?

It was predicted that mobile app instruction would result in a higher increase of the math achievement of students with disabilities when compared to traditional math instruction. See Table 5 for a presentation of the descriptive statistics for the assessments.
Table 5

Summary of Means and Standard Deviations for Assessments

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAI</td>
<td>29.2</td>
<td>17.2</td>
<td>28</td>
</tr>
<tr>
<td>TMI</td>
<td>29.0</td>
<td>19</td>
<td>27</td>
</tr>
<tr>
<td><strong>Warm Up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAI</td>
<td>44.3</td>
<td>18.9</td>
<td>28</td>
</tr>
<tr>
<td>TMI</td>
<td>41.4</td>
<td>8.2</td>
<td>27</td>
</tr>
<tr>
<td><strong>Independent Practice</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAI</td>
<td>50.2</td>
<td>16.9</td>
<td>28</td>
</tr>
<tr>
<td>TMI</td>
<td>41.7</td>
<td>9.3</td>
<td>27</td>
</tr>
<tr>
<td><strong>Posttest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAI</td>
<td>32.8</td>
<td>18.6</td>
<td>28</td>
</tr>
<tr>
<td>TMI</td>
<td>37.8</td>
<td>22.9</td>
<td>27</td>
</tr>
</tbody>
</table>

To address this hypothesis, the scores of individual pretest, posttest, warm up, and independent practice activities were combined to determine the group means and a one-way MANOVA was conducted to analyze any difference in academic achievement between groups on each of the identified assessments. The F test of between-subjects effects was not significant [F(4,50) = 1.67, p = .171] (see Table 6).
Table 6

*Tests of Between-Subject Effects for Student Math Achievement*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>.44</td>
<td>1</td>
<td>.44</td>
<td>.001</td>
<td>.971</td>
</tr>
<tr>
<td>Warm Up</td>
<td>113</td>
<td>1</td>
<td>113</td>
<td>.5</td>
<td>.472</td>
</tr>
<tr>
<td>Independent Practice</td>
<td>987.2</td>
<td>1</td>
<td>987.2</td>
<td>5.3</td>
<td>.026*</td>
</tr>
<tr>
<td>Posttest</td>
<td>342.7</td>
<td>1</td>
<td>342.7</td>
<td>.8</td>
<td>.377</td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>17336.1</td>
<td>53</td>
<td>327.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm Up</td>
<td>11403.4</td>
<td>53</td>
<td>215.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent Practice</td>
<td>9929.2</td>
<td>53</td>
<td>187.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>22928.1</td>
<td>53</td>
<td>432.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. p < .05.

The data indicate there was not a significant difference between the students’ pretest, posttest, and warm up scores related to instructional group (e.g., TMI or MAI). This means that one type of instructional group was not significantly better at improving student math achievement for these measures. However, it should be noted that there was a significant difference between groups for the independent practice. This means that the MAI group did
significantly better on the independent practice activity (M = 50.2, SD = 16.9) than the TMI group (M = 41.7, SD = 9.3), $p = .026$.

The mean scores from the pretest and the posttest were combined and a 2 x 2 repeated-measures ANOVA was conducted to determine if there was a significant difference in scores between groups over time (see Table 7). The F test of within subjects effects indicate there is no significant difference in the students’ pretest and posttest scores in the TMI group and the MAI group over time [$F(1, 53) = 3.67, p = .061$] (see Table 7). However, it should be noted that the scores approach significance.

Table 7

*Tests of Within-Subject Effects for Student Math Knowledge*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1066.603</td>
<td>1</td>
<td>1066.603</td>
<td>3.665</td>
<td>.061</td>
</tr>
<tr>
<td>Error (Time)</td>
<td>15426.251</td>
<td>53</td>
<td>291.061</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* $p < .05$.

**Analysis of Teacher and Student Perceptions of Student Math Knowledge**

The teacher and student participants completed a survey to determine their perceptions of student math knowledge of the targeted math skills and concepts. The survey contained seven items related to teacher and student perceptions of student learning of the targeted math skills during the TMI and MAI conditions. The teacher survey asked the teacher to rate their perception of student math knowledge during the two conditions of the intervention; the student
survey asked students to rate their own perception of their learning during both conditions. The teacher and students ranked each statement on a 5-point Likert scale, with 1 being strongly disagree and 5 being strongly agree. The minimum average score for each survey was 1 (indicating a high level of disagreement) and the maximum average score was 5 (indicating a high level of agreement). The teacher and students completed the surveys after the intervention. Since there was only one teacher in this study, the data from the teacher perception survey did not meet the threshold for statistical analysis and only descriptive statistics are reported. Data from the student perception of math knowledge surveys were analyzed using descriptive and inferential statistics.

Data from the teacher and the student surveys were analyzed to answer the following research questions:

7. Do student perceptions of mathematics knowledge increase with the use of mobile app instruction when compared to traditional math instruction?

8. Do teacher perceptions of the mathematics knowledge of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

It was predicted that the student perceptions of mathematics knowledge would increase after the mobile app instruction. It was also predicted that teacher perceptions of student math knowledge would increase after the mobile app instruction. To address this hypothesis, descriptive statistics were conducted for the teacher perception of student math knowledge survey (see Table 8). The mean score for teacher perception of math knowledge was higher in the TMI group (M = 4.0, SD = .58) than the MAI group (M = 3.6, SD = .53), indicating that the
teacher perceived student math knowledge to be slightly higher in the TMI group than the MAI group.

Table 8

*Summary of Means and Standard Deviations for Teacher Perceptions of Math Knowledge*

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMI</td>
<td>4.0</td>
<td>.58</td>
<td>19</td>
</tr>
<tr>
<td>MAI</td>
<td>3.6</td>
<td>.53</td>
<td>21</td>
</tr>
</tbody>
</table>

Descriptive statistics were also conducted for the student perception of math knowledge surveys (see Table 9). The means for the student surveys were slightly higher in the TMI group (M = 4.2, SD = .36) than the MAI group (M = 3.5, SD = .65), indicating that students perceived their math knowledge to be slightly higher in the TMI group than the MAI group. Survey data from the students in the TMI and MAI groups were combined and an independent samples t-test was conducted. The results of the t-test indicate a significant difference between student perception of math knowledge in the TMI and the MAI group \[ t (38) = -4.0, p < .001 \]. This indicates that the students perceived their math knowledge significantly higher in the TMI group than the MAI group (see Table 10).
Table 9

Summary of Means and Standard Deviations for Student Perceptions of Math Knowledge

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMI</td>
<td>4.2</td>
<td>.36</td>
<td>19</td>
</tr>
<tr>
<td>MAI</td>
<td>3.5</td>
<td>.65</td>
<td>21</td>
</tr>
</tbody>
</table>

Table 10

Independent Samples Test of Student Perception of Math Knowledge

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Math Survey</td>
<td>-.6787</td>
<td>.1693</td>
<td>-4.008</td>
<td>38</td>
<td>.000*</td>
</tr>
</tbody>
</table>

Note. p < .05.

Analysis of Teacher and Student Perceptions of Student Engagement

The teacher and student participants completed a survey to determine their perceptions of student engagement during the TMI and the MAI instruction. The teacher and student surveys contained six items related to teacher and student perceptions of engagement. The teacher survey asked the teacher to rate their perception of student engagement during the two conditions of the intervention; the student survey asked students to rate their own perception of their engagement during both conditions. The teacher and students ranked each statement on a 5-point Likert scale, with 1 being strongly disagree and 5 being strongly agree. The minimum average score for each
survey was 1 (indicating a high level of disagreement) and the maximum average score was 5 (indicating a high level of agreement). The teacher and students completed the surveys after the intervention. Since there was only one teacher in this study, the data from the teacher perception survey did not meet the threshold for statistical analysis and only descriptive statistics were reported. Data from the student perception of engagement surveys were analyzed using descriptive and inferential statistics. Data from the teacher and the student surveys were analyzed to answer the following research questions:

5. Do student perceptions of engagement increase with the use of mobile app instruction when compared to traditional math instruction?

6. Do teacher perceptions of the engagement of students with disabilities increase with the use of mobile app instruction when compared to traditional math instruction?

It was predicted that the student perceptions of engagement would increase after the mobile app instruction. It was also predicted that teacher perceptions of student engagement would increase after the mobile app instruction. To address this hypothesis, descriptive statistics were conducted for the teacher perception of student engagement survey (see Table 11). The mean score for teacher perception of student engagement was higher in the TMI group (M = 4.2, SD = .41) than the MAI group (M = 3.8, SD = .41), indicating that the teacher perceived student engagement to be slightly higher in the TMI group than the MAI group.
Table 11

Summary of Means and Standard Deviations for Teacher Perceptions of Student Engagement

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMI</td>
<td>4.2</td>
<td>.41</td>
<td>19</td>
</tr>
<tr>
<td>MAI</td>
<td>3.8</td>
<td>.41</td>
<td>21</td>
</tr>
</tbody>
</table>

Descriptive statistics were conducted for the student perceptions of engagement survey (see Table 12). The mean student engagement scores were higher in the TMI group (M = 4.3, SD = .32) than in the MAI group (M = 3.7, SD = .75). This data indicates that the students in the TMI group perceived their engagement to be higher than the students in the MAI group.

The mean scores from the student perception of engagement survey were combined and an independent samples $t$-test was conducted. The results of the $t$-test indicate a significant difference between student perception of engagement in the TMI and the MAI group [$t (38) = -3.5$, $p = .001$]. This indicates that there was a significant difference between the students’ perception of their engagement between the groups (see Table 13). Students in the TMI group reported higher perceptions of engagement as compared to the MAI group.
Table 12

Summary of Means and Standard Deviations for Student Perceptions of Student Engagement

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMI</td>
<td>4.3</td>
<td>.32</td>
<td>19</td>
</tr>
<tr>
<td>MAI</td>
<td>3.7</td>
<td>.75</td>
<td>21</td>
</tr>
</tbody>
</table>

Table 13

Independent Samples of Student Perceptions of Student Engagement

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Engagement</td>
<td>-.6386</td>
<td>.1847</td>
<td>-3.457</td>
<td>38</td>
<td>.001*</td>
</tr>
</tbody>
</table>

Note. p < .05.

Observations of Student Engagement

Finally, the student investigator conducted observations of students during the TMI and the MAI conditions to answer the following research question:

2. Is there an increase in the academic engagement (i.e., when students review the material and actively complete the assigned task, exhibit appropriate physical responses such as typing or writing, ask for assistance in an acceptable manner, interact with the teacher or their peers about related topics, listen to the teacher’s directives) of students with disabilities with mobile app instruction when compared to traditional math instruction?
An observation checklist was developed and completed during each session. Descriptive statistics were conducted and are presented in Table 14 for MAI and Table 15 for TMI.

Table 14

Mean Observations of Student Behavior During the MAI Condition by Session

<table>
<thead>
<tr>
<th>Session</th>
<th>Mean of Behaviors Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.60</td>
</tr>
<tr>
<td>2</td>
<td>.40</td>
</tr>
<tr>
<td>3</td>
<td>.60</td>
</tr>
<tr>
<td>4</td>
<td>.60</td>
</tr>
<tr>
<td>5</td>
<td>.80</td>
</tr>
<tr>
<td>6</td>
<td>.80</td>
</tr>
<tr>
<td>7</td>
<td>.40</td>
</tr>
<tr>
<td>8</td>
<td>.80</td>
</tr>
</tbody>
</table>
The means of each participant were combined and an independent samples $t$-test was conducted to compare the means of the groups during each session (see Table 16). The results revealed a statistically significant difference in engagement between the TMI group ($M = .8$, $SD = .1$) and the MAI group ($M = .6$, $SD = .2$); $t (14) = -2.5$, $p = .026$. Students in the TMI condition exhibited behaviors associated with engagement (e.g., students review the material and actively complete the assigned task, exhibit appropriate physical responses such as typing or swiping, ask for assistance in an acceptable manner, interact with the teacher about related topics, and listen to the teacher’s directives) at a significantly higher rate than the MAI group. This means that the TMI group appeared to be more engaged in the lesson than the MAI group.
Table 16

*Independent Samples Test of Observations of Student Behaviors*

<table>
<thead>
<tr>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations of Student Behaviors</td>
<td>-.1750</td>
<td>.0701</td>
<td>-2.497</td>
<td>14</td>
</tr>
</tbody>
</table>

Note. p < .05.

**Student Use of the Mobile Device During the Mobile App Lessons**

Data were collected on how students used the mobile devices during the MAI condition. The presentation platform used for the online math lessons collected data on the total number of participants for each lesson and the percentage of responses recorded for each embedded question (see Table 17). The mean student response rate for all students in the MAI condition was 90.6% (SD = 10.7). This data indicates that most students accessed the online lesson each session and completed the embedded questions at the end of the lesson.
Table 17

*Participants and Response Rate for Embedded Zeetings Questions*

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Number of Participants ( (n = 28) )</th>
<th>Number of Questions</th>
<th>Participant Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>6</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>3</td>
<td>79%</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>3</td>
<td>82%</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>3</td>
<td>89%</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>4</td>
<td>75%</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
<td>4</td>
<td>100%</td>
</tr>
</tbody>
</table>

Students were also presented with learning videos through the online platform. Data were collected regarding student views and responses to embedded questions in the videos (see Table 18). Overall, students watched an average of 31.8% of a video and answered approximately 1.2 questions per video. This data indicates that, although most students accessed the videos \( (M = 26.4) \), they did not watch the videos through to the end or answer most of the questions.
Table 18

Participants and Viewing Percentages for EDpuzzle Videos and Questions

<table>
<thead>
<tr>
<th>Video</th>
<th>Number of Students Who Accessed Videos ((n = 28))</th>
<th>Number of Questions Answered (Out of Total Number of Questions)</th>
<th>Percentage of Video Watched</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>1.2 / 3</td>
<td>36.9%</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>0.9 / 2</td>
<td>38.2%</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>1.4 / 4</td>
<td>27.9%</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>1.2 / 4</td>
<td>23.7%</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>1.6 / 4</td>
<td>25.7%</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>0.6 / 1</td>
<td>24.5%</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
<td>0.85 / 2</td>
<td>29.0%</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
<td>1.2 / 3</td>
<td>28.5%</td>
</tr>
<tr>
<td>9</td>
<td>26</td>
<td>1.0 / 2</td>
<td>29.1%</td>
</tr>
<tr>
<td>10</td>
<td>28</td>
<td>1.8 / 3</td>
<td>36.1%</td>
</tr>
<tr>
<td>11</td>
<td>23</td>
<td>1.6 / 2</td>
<td>50.4%</td>
</tr>
</tbody>
</table>

Another important finding from observational data is that many students utilized the calculator application on the Kindle device. During instruction, it was observed that students would navigate out of the lesson to access the calculator and compute problems on the warm up and independent practice activities. The student investigator also noticed the calculator application open on many of the Kindles when they were collected after the lesson. Although the
students were introduced to the calculator application during the student training sessions, it was not emphasized as a tool during the intervention. This indicates that students will independently utilize digital tools to support their progress in an online environment.
CHAPTER FIVE

DISCUSSION

To access the general education math curricula, students with disabilities require personalized, self-paced, explicit instruction that offers a variety of activities and delivery methods (Worthen, 2016). While teacher-led instruction is the usual method of lesson delivery, technology is gaining momentum as an accepted and widely used supplement to traditional math instruction (Bottge et al., 2014). Technology allows students to move through lessons at their own pace, and provides opportunities for individualization, differentiation, and review. Mobile devices such as Kindles are portable, inexpensive, and can be equipped with various educational computer applications to further support the intensive needs of students with disabilities. Digital learning provides students the opportunity to utilize technology as a tool for academic growth rather than an instrument for passing time between activities.

The literature on technology in the classroom provides support for integrating digital tools with content area instruction (e.g., Kennedy, Deshler, & Lloyd, 2015; Ok & Bryant, 2016; Ok & Kim, 2017; Shin & Bryant, 2017), however there is little research on how students with disabilities use the technology, how they navigate through the digital lessons, or how teachers can use technology to deliver new content. Most empirical investigations focus on achievement and engagement, which are important, but not the only factors to consider when designing online instruction.

The purpose of this study was to determine if the math achievement and engagement of students with disabilities increased with the use of Mobile App Instruction (MAI). Additionally, student use of the mobile device (i.e., the Kindle) and how they navigate the digital lessons
during MAI was examined. It was predicted that student math achievement and engagement would increase with the use of MAI as compared to traditional math instruction (TMI).

Teacher and student perceptions of math knowledge and engagement were measured after implementation of the intervention. It was predicted that teacher and student perception of math knowledge and engagement would increase following the intervention. The perceptions of the teacher and the students on math knowledge and engagement were measured using surveys with a Likert rating scale ranging from 1 (strongly disagree) to 5 (strongly agree). The data from the surveys were collected and analyzed to determine if there was a significant difference in math knowledge and engagement between the TMI group and the MAI group.

A total of 55 students with disabilities who received math instruction in a resource math classroom in a middle school participated in this study. One teacher was assigned to four sections of the same math class. Prior to beginning the intervention, students were administered a mathematics pretest to measure their current level of achievement on the math skills and concepts that were targeted for instruction during the study. Each section of the resource math class was randomly assigned to either the TMI or the MAI condition. Students in each condition received a total of eight math lessons over the course of two weeks. After the study, the students completed a posttest to measure their level of mathematics knowledge following intervention, and both the teacher and students completed surveys measuring their perception of math knowledge and engagement.

**Student Mathematics Knowledge**

Prior to implementing both conditions of the study, students were administered a mathematics pretest. The pretest measured the students’ ability to solve problems related to the following objectives: (a) use variables to represent numbers, (b) write and evaluate expressions
using variables and coefficients, (c) write an inequality to represent a problem and use substitution to determine if the inequality is true, (d) write and solve one-step inequalities, (e) write and solve multi-step inequalities using addition and subtraction, (f) write and solve multi-step inequalities using multiplication and division, (g) write and solve compound inequalities, and (h) identify the components of a coordinate plane and ordered pair. After receiving two weeks of instruction, students were administered a mathematics posttest measuring the same skills and concepts introduced in the TMI and MAI conditions.

The mean scores from the pretest to the posttest increased for the MAI group (3.6 points) and the TMI group (8.8 points), however the data indicated that there was no significant difference between group scores on each of these assessments. Additionally, the data indicated that there was no significant difference in groups across time, although the difference did approach significance ($p = .061$). While both interventions were effective at increasing the math knowledge of participating students, there was no statistically significant difference between either of the interventions. One possible reason for the lack of statistical significance is the length of the intervention. Since little is known about how students with disabilities engage with mobile technology during content area instruction (Hasselbring, Lott, & Zydney, n.d), this study was designed to (a) formatively evaluate the instructional design of mobile application instruction, and (b) determine how students engaged with this type of technology-based instruction. A major focus was how students engaged with the technology and their thoughts about content deliver on the mobile device. Additional time in intervention may have had an impact on student math outcomes.

Related to this, data suggest that students were more actively engaged with TMI than MAI. Data from the EDpuzzle application indicated that students watched an average of 31.8%
of a video (approximately 1.2 minutes of actual viewing time out of a total average of 3.9 minutes in length) and answered 1.2 questions, which suggests students were not fully engaged in the content. Research in online lesson design for students with disabilities suggest “chunking” material into manageable learning units and utilizing relevant examples that pique students’ interest (Boone & Higgins, 2007; Keeler et al., 2007). While the videos related directly to the content delivered in the math lesson and were utilized to model the math concepts, the material was not vetted for student interest or appropriate playing time. Additionally, classroom observations revealed some students spent the majority of the class period completing the warm up activity and were unable to finish the entire lesson. Future investigations should adhere to recommended guidelines for presenting content online to students with disabilities. Researchers should also consider examining timed lessons that prompt students to move forward.

Although students in both conditions were able to request assistance from the teacher to read problems and text, students in the MAI condition did not have access to audio support during the online lesson. The lessons were not narrated and therefore students had to take the time to read the content or ask the teacher. The only portions of the lesson that provided audio support were the videos. This can present a barrier to learning and increase the cognitive load for students. During the MAI condition it was observed that several students asked the teacher to read content, and others became visibly frustrated and did not remain engaged with the lesson.

Additionally, this study was implemented just prior to the end of the school year. Although there are no data to directly link the time of the year to student performance, the teacher indicated via informal communication that the students had “checked out”, and that is was difficult to “get them to do anything”. Related to this, students were in the process of
completing the year-end district mandated standardized assessments and demonstrated signs of fatigue.

The results of this study support earlier research that suggests there is not a significant difference in student academic performance using teacher-directed or mobile app/computer assisted instruction (Bryant et al., 2015; Leh & Jitendra, 2012; Pace & Mellard, 2016). However, the data indicate that the students made greater academic gains in the TMI group and students in the TMI group perceived their math knowledge and engagement to be higher. These findings lend support to research that suggests traditional, teacher-led instruction works better for students with disabilities (Bryant et al., 2015; Stultz, 2013; Wilson, Majsterek, & Simmons, 1996). This does not negate the validity of using technology to deliver instruction to students with disabilities, rather it intensifies the need for further research in the following areas: (a) the specific features that support student learning in a digital environment, and (b) the conditions under which the digital lesson should be implemented.

**Teacher and Student Perceptions of Math Knowledge**

After the study, the teacher and students completed a survey regarding their perceptions of student math knowledge for the TMI and the MAI. The survey asked teachers and students to rank their perceptions of student knowledge of specific math skills and concepts.

**Teacher Perceptions of Math Knowledge**

The teacher rated student math knowledge higher for the TMI group (4.0) than the MAI group (3.6), indicating that the teacher felt the students’ math knowledge was slightly higher for the TMI group than the MAI group. For both conditions, the teacher indicated that the students could use variables to represent numbers and write expressions to mastery (M = 5). However, for both conditions the teacher indicated that the students did not learn how to solve an inequality.
(M = 3). While these findings are in line with student perceptions of math knowledge, they should be interpreted with caution since the teacher was evaluating her own performance.

**Student Perceptions of Math Knowledge**

The students rated their knowledge of the math skills and concepts higher in the TMI group (M = 4.2) than in the MAI group (M = 3.5), indicating they felt they learned the math skills and concepts better in the TMI group than in the MAI group. The results from the data analyses of the math knowledge surveys indicated a significant difference between the groups ($p < .001$), meaning there was a significant difference between the students’ perceptions of math knowledge in the TMI and the MAI conditions. However, data from the pretest, posttest, and math activities do not support the students’ views that they made greater math gains in the TMI over the MAI. Additionally, the findings suggest that there was no significant difference in scores over time, although the data did approach significance ($p = .062$).

The students’ views of math knowledge indicate a preference for the TMI over the MAI. This supports research that favors traditional face-to-face instruction over digital delivery (Stultz, 2013). Students with disabilities require direct instruction from the teacher, particularly for new content (Jayanthi et al., 2008; NMAP, 2008). Although the teacher was present during the MAI sessions, the teacher was told to only answer student questions, not directly teach the content. This could have negatively influenced students’ perceptions of the MAI condition, particularly if students were struggling to grasp the concepts. Also, while the students were familiar with using the computer to support teacher-directed instruction on occasion, they did not use technology daily and were not exposed to mobile app instruction as a means of delivering new content. Moving from a supportive teacher-led model to a self-paced, independent digital model can increase performance anxiety and negatively impact student learning. Future research should
explore methods for introducing students to MAI and the conditions under which it may best be integrated into content area instruction.

**Teacher and Student Perceptions of Student Engagement**

To determine if there was a difference between teacher and student perceptions of engagement in the TMI and the MAI conditions, the teacher and students completed a survey rating their perception of student engagement in each group. The surveys were administered after the study.

**Teacher Perceptions of Student Engagement**

The mean scores for the teacher perception of student engagement survey were slightly higher for the TMI group (M = 4.2) than the MAI group (M = 3.8). This indicates that the teacher felt the TMI group was more engaged in the content than the MAI group. In the TMI condition, the teacher rated student attentiveness to teacher directives the highest (e.g., the students looked at the teacher and responded immediately to the teacher’s directives (M = 5), and rated all other items as a 4). In the MAI condition, the teacher felt that the students were not attending to the digital lesson (e.g., the students’ eyes were not on the Kindle during instruction, M = 3), but rated all other items as a 4. This indicates that the teacher felt that the students were more attentive and willing to follow directives during the TMI than during the MAI. It is possible that the teacher felt more engaged during TMI and therefore rated the responsiveness of the students higher. Conversely, during MAI the teacher could more readily notice off-task behaviors and thus perceived a lower rate of attentiveness from the students. This finding also relates to data from the presentation platform that suggests students did not watch the entirety of the learning videos or answer all of the questions. While these findings are in line with student
perceptions and observational engagement data, they should be interpreted with caution since the teacher was evaluating her own performance.

**Student Perceptions of Engagement**

The mean scores for student perceptions of engagement were higher for the TMI group (M = 4.3) than the MAI group (M = 3.7). This indicates that the students perceived their engagement to be somewhat higher in the TMI than in the MAI. Data analyses revealed a significant difference between the student perception of engagement in the TMI and the MAI (p = .001). This indicates that there was a significant difference in how students perceived their engagement in the TMI and the MAI, with students feeling more engaged in the TMI condition. While much of the research literature suggests students are more engaged in a digital environment (Bryant et al., 2015), the data from this study indicate students with disabilities are more engaged during teacher-led instruction and perceive themselves to be more engaged with the content. These findings are supported by the data indicating students did not view the entirety of the learning videos or answer all the questions in the MAI group. Overall this suggests that critical design components were missing from the MAI lessons, specifically those related to student engagement.

**Observations of Student Engagement**

The mean for observed student engagement behaviors was higher in the TMI group (M = .8) than in the MAI group (M = .6). This indicates that the students demonstrated more behaviors associated with being engaged during the TMI than the MAI. Data analysis indicated there was a significant difference between groups (p = .026). The findings suggest the students had higher levels of engagement in the TMI than in the MAI. The observational data supports the students’ perceived increased engagement during the TMI.
Student Use of Mobile Technology

Data from the online learning platform Zeetings indicated that most of the students accessed the online lessons (M = 25.4) and responded to the embedded questions (response rate averaged 90.6%). However, the participant response rate dropped to 79% during lesson 1 (Introduction to Expressions) and 75% during lesson 7 (Compound Inequalities). This corresponds with observations of student engagement in the MAI condition, which were low for both sessions (.60 for session 1 and .40 for session 7). Although previous research indicates students are more engaged while using technology (Bryant et al., 2015; Poel, 2010), students in the MAI were overall less engaged than students in the TMI group and therefore did not fully participate in the online activities.

However, the data collected from the learning videos indicated that, while most students accessed the videos (M = 26.4), they only watched an average of 31.8% of each video and answered an average of 1.2 of the embedded questions. This data supports the students’ perceived increase in engagement during TMI and observational data indicating students were more engaged during the TMI.

This data also provides valuable information concerning how students navigate a lesson delivered on a mobile device. Anecdotal notes indicate that students did not have difficulty turning on the device, accessing the lesson, or moving through the content. However, it was noted that students would reach a certain threshold where they would begin “manic swiping”, meaning they moved their finger in a frantic swiping motion, to get through the lesson. The mobile app lessons were constructed in the following sequence: (a) objectives, (b) warm up, (c) introduction to new content, (d) modeling (i.e., videos), (e) guided practice, (f) review, (g) independent practice, and (h) stand-alone validity questions. The videos were presented towards
the middle of the lesson, and it is possible that students were experiencing fatigue. Also, it was noted anecdotally that the Wi-Fi service was interrupted during some lessons, which could impact the students’ ability to access the videos. Future investigations should consider including the videos and embedded questions as “ice breakers” to pique student interest and gauge background knowledge.

Finally, observational data indicate that most students utilized the calculator application on the Kindle even though use of the tool was not emphasized during implementation. Many students were observed toggling between the lesson and the calculator application to solve the math problems in the warm up and independent practice. This indicates that students are willing to access digital tools independently to complete the assigned complete tasks, even if the tools are not emphasized as part of the intervention. This finding relates to research conducted by Crawford, Higgins, Huscroft-D'Angelo, & Hall (2016). The investigators examined student use of digital tools and found a significant relationship between student math performance (i.e., students with disabilities and students who struggled in math) and the use of supports such as an embedded calculator (Crawford, Higgins, & Freeman, 2012; Crawford et al., 2016). Specifically, the data from the study suggests that students who perform lower on mathematics tasks are more likely to utilize tools that support their learning and differentiate instruction (Crawford et al., 2016).

Conclusions

Several conclusions can be drawn from this study. It should be noted that these conclusions are based on data collected through quantitative analyses and anecdotal notes, and should be considered with the study limitations in mind.
1. Although the posttest scores for both the TMI and the MAI conditions increased from the pretest scores, there was no significant difference between groups for increasing the math knowledge of students with disabilities. This means that one method of instruction was not statistically more effective at increasing the math knowledge of students than the other.

2. The teacher fidelity was higher for the MAI condition that the TMI condition as measured by a teacher fidelity checklist. Overall, the teacher implemented both instructional methods with a relatively high level of fidelity.

3. The data from teacher perception of student math knowledge survey indicate the teacher perceived student math knowledge to be higher in the TMI group than the MAI group.

4. The data from the student perception of math knowledge survey indicate the students in the TMI condition perceived a greater increase in their math knowledge than the students in the MAI condition. This means that students in the TMI group felt that they learned more math concepts than the students in the MAI group. The data indicate a statistical significance between the TMI group and the MAI group on student perception of math knowledge.

5. The data from the teacher perception of student engagement survey indicate the teacher perceived student engagement to be higher in the TMI group than the MAI group.

6. The data from the student perception of engagement survey indicate the students in the TMI condition perceived a higher rate of engagement than the students in the MAI condition. This means that the students in the TMI group felt more engaged in the lesson than the students in the MAI group. The data indicate a significant difference between the
students perceived engagement in the TMI group and the students perceived engagement in the MAI group.

7. The data from observations of student engagement indicate that the students in the TMI group were more engaged than the students in the MAI group. The data analysis indicates a significant difference in student engagement in the TMI group and the MAI group.

8. The data from the online learning platform indicate that the students easily access the lesson and complete the embedded questions and activities. However, data from the learning videos suggest students do not watch the entire video and do not answer the questions embedded in the videos.

**Recommendations for Future Research**

Technology is fast becoming an integral part of educational practice for students with disabilities. However, these students require carefully designed lessons that address their unique learning needs. Suggested areas for further study:

1. This study should be replicated using other educational settings, such as inclusive general education classrooms and self-contained classrooms, and with students identified in other disability categories to increase the generalizability of the results.

2. This study should be expanded to a period longer than two weeks. A longer period of implementation could produce different results.

3. This study should be replicated using a larger sample size to determine if a larger sample size produces different results.

4. Schools should be randomly assigned from a larger population (i.e., district wide) to increase generalizability and provide a true experimental design.
5. Teachers and students should be randomly chosen for participation to increase generalizability of the results and provide a true experimental design.

6. Future research should focus on the design of online lessons pertaining to the achievement and engagement of students with disabilities. Specifically, researchers should examine the optimal length of lessons and videos, and the amount of content delivered in one lesson.

7. Future research should explore the optimal timing for introduction of mobile application technology (i.e., following introduction of content by the teacher, prior to introduction of content by the teacher).

8. Future research should consider implementation at the beginning of the school year to acclimate students to lesson delivery in a digital format.

9. Future research should explore the impact of certain components of mobile application learning on the academic achievement of students with disabilities, as some components may be more effective at teaching math skills than others.

10. Future research should include explicit training for teachers and students concerning the integration of technology in classroom instruction, specifically learning environments serving students with disabilities.

Summary

The digital age is rapidly expanding into the classroom and broadening the options for delivering academic content to students with disabilities. In recognition of this growth in technology, legislation such as the Every Student Succeeds Act of 2015 (ESSA) and the update to the National Education Technology Plan (NETP) provide guidelines for greater accessibility and integration of technology for students with disabilities (U.S. Department of Education,
Indeed, researchers have explored the effect of online learning on the academic performance and engagement of students with disabilities. These studies indicate a potential for increased learning and engagement, as well as opportunities for self-paced instruction and differentiation of materials (Haydon et al., 2012; Ok & Kim, 2017). However, there remains a gap in knowledge concerning how students with disabilities use digital devices and the optimal elements for designing online learning experiences.

This study extends the research in that it provides a preliminary investigation of how students with disabilities use technology and the components that can help students with disabilities access general education curriculum. As technology expands into all learning environments, it is imperative that teachers utilize digital practices that conform to the individualized needs of all students. This study utilized the components of direct instruction (i.e., objectives, modeling, guided practice, independent practice, and review) and differentiation through pictures, graphics, videos, and text to deliver math lessons to students with disabilities. The findings of no significant difference in test scores from pretest to posttest between the TMI group and the MAI group support prior research comparing digital delivery to teacher-led instruction (Bryant et al., 2015; Carr, 2012). However, valuable information was obtained about the design and delivery of online instruction.

The present study establishes the groundwork for further research into how students with disabilities interact with digital content, and how teachers can design lessons that allow students access to a Free and Appropriate Public Education (FAPE) in a globalized, 21st century classroom. With the increased availability of powerful technological tools, app-based and online instruction promises to transform the learning of students with disabilities. However, careful consideration must be taken when considering the components of digital lessons and how
students interact with the digital devices. The concept of equity holds true for the implementation of technology in the classroom, in that what works for nondisabled students may not apply to students with special needs. As the literature base grows for digital learning, teachers are afforded the opportunity to integrate research-based practices into blended and fully online learning environments, thereby assuring accessibility to academic content for all students.
APPENDIX A: PARENT CONSENT FORM
Purpose of the Study
Your child is invited to participate in a research study. The purpose of this study is to compare the use of mobile technology, such as tablets, to deliver math instruction with instruction delivered by the math teacher on your child’s performance in mathematics.

Participants
Your child is being asked to participate in the study because they are enrolled in a resource mathematics class, they receive special education services under the Individuals with Disabilities Education Act (IDEA), and they have an Individualized Education Program (IEP). Your child will take a mathematics pretest, and a cut off score of 60% will be used to determine if your child is at risk for math difficulties.

Procedures
After taking the math pretest, your child will receive math instruction from their math teacher during the regular school day in their math class. If you allow your child to volunteer to participate in this study, the student investigator will collect data on your child’s performance on a math pretest and posttest, and your child will answer survey questions on the math instruction and their engagement in the lessons. If you do not allow your child to participate, the student investigator will not collect data on your child’s math scores, and your child will not answer any survey questions.

Benefits of Participation
There may not be direct benefits to your child as a participant in this study, although we expect that participants will increase their knowledge of math content.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks. The risk involved in this study is the breach of student information that identifies them as a
participant in the study. However this risk is minimal as your child’s information will be secured in a locked file and their name will not be used on any documents related to the study.

**Cost /Compensation**
There will not be a financial cost to you to participate in this study. The study will take approximately one month of your child’s time, although all of this time will be part of the normal instructional sequence on the school site. Your child will not be compensated for their time.

**Contact Information**
If you or your child have any questions or concerns about the study, you may contact Dr. Joseph Morgan at 702-895-3329. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794, or via email at IRB@unlv.edu.

**Voluntary Participation**
Your child’s participation in this study is voluntary. Your child may refuse to participate in this study or in any part of this study. Your child may withdraw or you may withdraw your child at any time without prejudice to your relations with the university. You or your child is encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link your child to this study. A unique code will be assigned to all materials used in this study and your child’s name will not be used on any of the study materials. All records will be stored in a locked facility at UNLV for 3 years after completion of the study. After the storage time the information gathered will be shredded and electronic storage devices erased.

**Participant Consent:**
I have read the above information and agree to allow my child to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

<table>
<thead>
<tr>
<th>Signature of Parent</th>
<th>Child’s Name (Please print)</th>
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<tbody>
<tr>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Parent Name (Please Print)</th>
<th>Date</th>
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</table>

#1020692-2, Expiration: 05-03-2018
Purpose of the Study
Your child is invited to participate in a research study. The purpose of this study is to see if using mobile technology, such as tablets, to deliver classroom instruction increases your child’s performance in mathematics.

Participants
Your child is being asked to participate in the study because they are enrolled in a resource mathematics class, they receive special education services under the Individuals with Disabilities Education Act (IDEA), and they have an Individualized Education Program (IEP). Your child will take a mathematics pretest as part of this research study to determine their current level of mathematics proficiency.

Procedures
After taking the math pretest, your child will receive math instruction on a mobile device (such as a Kindle) and complete math activities on the mobile device during the regular school day in their math class. If you allow your child to volunteer to participate in this study, the student investigator will collect data on your child’s performance on a math pretest and posttest, and your child will answer survey questions on the math instruction and their engagement in the lessons. If you do not allow your child to participate, the student investigator will not collect data on your child’s math scores, and your child will not answer any survey questions.

Benefits of Participation
There may not be direct benefits to your child as a participant in this study, although we expect that participants will increase their knowledge of math content. However, we hope to learn about the use of technology in the classroom and whether it improves your child’s performance in mathematics.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks. The risk involved in this study is the breach of student information that identifies them as a
participant in the study. However this risk is minimal as your child’s information will be secured in a locked file and their name will not be used on any documents related to the study.

**Cost /Compensation**
There will not be a financial cost to you to participate in this study. The study will take approximately one month of your child’s time, although all of this time will be part of the normal instructional sequence on the school site. Your child will not be compensated for their time.

**Contact Information**
If you or your child have any questions or concerns about the study, you may contact Dr. Joseph Morgan at 702-895-3329. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794, or via email at IRB@unlv.edu.

**Voluntary Participation**
Your child’s participation in this study is voluntary. Your child may refuse to participate in this study or in any part of this study. Your child may withdraw or you may withdraw your child at any time without prejudice to your relations with the university. You or your child is encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link your child to this study. A unique code will be assigned to all materials used in this study and your child’s name will not be used on any of the study materials. All records will be stored in a locked facility at UNLV for 3 years after completion of the study. After the storage time the information gathered will be shredded and electronic storage devices erased.

**Participant Consent:**
I have read the above information and agree to allow my child to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

Signature of Parent          Child’s Name (Please print)
Parent Name (Please Print)   Date

#1020692-2, Expiration: 05-03-2018
APPENDIX B: STUDENT ASSENT FORM
1. My name is Dominique Tetzlaff, and I am working with Dr. Joseph Morgan at UNLV.

2. We are asking you to take part in a research study because we are trying to learn more about how we can use technology, such as tablets, to improve your math performance.

3. You will take a math pretest to see your current performance in math. For the next two weeks you will be receiving math instruction from your teacher. If you agree to be in this study, I will collect data on your math performance and you will answer questions about the math lessons and your engagement in the math lessons. If you do not agree to be in this study, I will not collect data on your math performance and you will not answer questions about the math lessons and your engagement in the math lessons.

4. The risks involved in this study are very small. There is a slight chance that you may be identified as a participant in this study, however this risk will be minimized by giving each of you a secret ID on all materials and by storing all your information in a locked file at UNLV. There also may be a chance that your math learning does not improve, however this risk will be minimized by using lessons that are developed using research.

5. The direct benefit you may receive is a better understanding of math concepts and an increase in your performance on mathematics tests.

6. Please talk this over with your parents before you decide whether to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say “yes” you can still decide not to do this.

7. If you don’t want to be in this study, you don’t have to participate. Remember, being in this study is up to you and no one will be upset if you don’t want to participate or even if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you didn’t think of now, you can call Dr. Morgan at 702-895-3329 or ask me next time. [If applicable: You may call me at any time to ask questions.] If I have not answered your questions or you do not feel comfortable talking to me about your question, you or your parent can call the UNLV Office of Research Integrity – Human Subjects at 702-895-2794 or toll free at 877-895-2794.

9. Signing your name at the bottom means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

Print your name _____________________________ Date _____________________________

Sign your name _____________________________

#1020692-2, Expiration: 05-03-2018
ASSENT TO PARTICIPATE IN RESEARCH

Using Mobile Technology to Increase the Mathematics Achievement and Engagement of Students with Disabilities

1. My name is Dominique Tetzlaff, and I am working with Dr. Joseph Morgan at UNLV.

2. We are asking you to take part in a research study because we are trying to learn more about how we can use technology, such as tablets and learning videos, to improve your performance in math.

3. You will take a math pretest to see your current performance in math. For the next two weeks you will be receiving math instruction on a tablet, such as a Kindle, and your teacher will be there to help you if needed. If you agree to be in this study, I will collect data on your math performance and you will answer questions about the math lessons and your engagement in the math lessons. If you do not agree to be in this study, I will not collect data on your math performance and you will not answer questions about the math lessons and your engagement in the math lessons.

4. The risks involved in this study are very small. There is a slight chance that you may be identified as a participant in this study, however this risk will be minimized by giving each of you a secret ID on all materials and by storing all your information in a locked file at UNLV. There also may be a chance that your math learning does not improve, however this risk will be minimized by using lessons that are developed using research.

5. The direct benefit you may receive is a better understanding of math concepts and an increase in your performance on mathematics tests.

6. Please talk this over with your parents before you decide whether to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.

7. If you don’t want to be in this study, you don’t have to participate. Remember, being in this study is up to you and no one will be upset if you don’t want to participate or even if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you didn’t think of now, you can call Dr. Morgan at 702-895-3329 or ask me next time. [If applicable: You may call me at any time to ask questions.] If I have not answered your questions or you do not feel comfortable talking to me about your question, you or your parent can call the UNLV Office of Research Integrity – Human Subjects at 702-895-2794 or toll free at 877-895-2794.

9. Signing your name at the bottom means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

Print your name __________________________ Date __________________________

Sign your name __________________________

#1020692-2, Expiration: 05-03-2018
APPENDIX C: STUDENT PERCEPTIONS OF MATH KNOWLEDGE SURVEY
**Student Perception of Math Knowledge (TMI)**

Read through each of the following statements regarding your math knowledge, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I feel that I am able to solve the math problems without help from the teacher.</td>
<td></td>
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<tr>
<td>2.) I know how to write an inequality.</td>
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<tr>
<td>3.) I know how to solve an inequality.</td>
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<tr>
<td>4.) I know how to use variables to represent numbers and write expressions.</td>
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<tr>
<td>5.) I know how to apply the math skills to real life problems.</td>
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<tr>
<td>6.) I feel that I will still be able to solve these math problems later on in the school year.</td>
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<tr>
<td>7.) Overall, I feel I learned the math concepts that were taught to me by the teacher.</td>
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</table>
Student Perception of Math Knowledge - MAI

Read through each of the following statements regarding your math knowledge, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I feel that I am able to solve the math problems without help from the teacher.</td>
<td></td>
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<tr>
<td>2.) I know how to write an inequality.</td>
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<tr>
<td>3.) I know how to solve an inequality.</td>
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<td></td>
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<tr>
<td>4.) I know how to use variables to represent numbers and write expressions.</td>
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<td></td>
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<tr>
<td>5.) I know how to apply the math skills to real life problems.</td>
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<td></td>
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<tr>
<td>6.) I feel that I will still be able to solve these math problems later on in the school year.</td>
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<tr>
<td>7.) Overall, I feel I learned the math skills and concepts that were taught to me on the Kindle.</td>
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</tbody>
</table>
**Student Perception of Engagement (TMI)**

Read through each of the following statements regarding your level of engagement, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I enjoyed using the worksheets to complete the math lessons.</td>
<td></td>
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<tr>
<td>2.) I feel I learned the math skills better with my teacher.</td>
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<tr>
<td>3.) I felt that I could complete all the activities independently.</td>
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<tr>
<td>4.) The lessons taught by my teacher were easy to understand.</td>
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<tr>
<td>5.) I was able to complete all the activities in one class period.</td>
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<tr>
<td>6.) Overall, I feel I was engaged in the lesson that was taught by my teacher.</td>
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</tbody>
</table>
Student Perception of Engagement (MAI)

Read through each of the following statements regarding your level of engagement, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I enjoyed using the Kindle to complete the math lessons.</td>
<td></td>
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</tr>
<tr>
<td>2.) I feel I learned the math skills better using the Kindle.</td>
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</tr>
<tr>
<td>3.) I felt that I could complete all the activities on the Kindle independently.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.) The lessons were easy to understand on the Kindle.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.) I was able to complete an entire lesson on the Kindle in one class period.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.) Overall, I feel I was engaged in the lesson on the Kindle.</td>
<td></td>
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</tr>
</tbody>
</table>
APPENDIX E: PRETEST AND POSTTEST ASSESSMENT
1. Solve for the value of $p$.

$$3 \times p = 15$$

2. Solve for the value of $p$.

3. Da

Day

<table>
<thead>
<tr>
<th>Minutes for Nancy to Reach School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
</tr>
<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
</tbody>
</table>

On which day did Nancy reach school in the shortest amount of time?

3. Write $<$, $>$, or $=$ in each blank.

$$11 \quad 20 \quad 11$$

$$12 \quad 22 \quad 13$$

4. Write the correct letter in the blank.

What is an appropriate measurement of the distance between two stadiums?

A 8 kilometers

B 8 centimeters

C 8 meters

5. The shaded area is what fraction of rectangle $ABCD$?

6. Complete the sequence.

$$0.345, 0.455, 0.565, \quad$$

7. Use the graph to answer the question.

On which day was the number of strawberry donuts made at the factory greater than the number of chocolate donuts?

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**AIMSweb® Math Concepts and Applications**

**Progress Monitor Grade 6, Probe 4, Page 1**

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8. Write the correct letter in the blank.

\[ \triangle ABC \]

What is the measure of \( \angle ABC \)?

A. 45°
B. 60°
C. 90°

9. 924,249,229,994

Which digit is in the hundred-thousands place?

Which digit is in the ten-billions place?

10. Solve for the value of \( m \).

\[ 4 \times m + 16 = 40 \]

11. Write <, >, or = in the blank.

\[ 2.6 \underline{\phantom{0}} \frac{15}{9} \]

12. There are 7 flavors of ice cream available at an ice cream shop. This shop also has 2 different kinds of cones (waffle and plain). How many different combinations of 1 cone and 1 flavor of ice cream can you have?

13. Write the answer in the blank.

\[ 1 \text{ km} = 1000 \text{ m} \]

\[ 36 \text{ km} = \underline{\phantom{0}} \text{ m} \]

14. Sandy can run 1 lap around the track in 9 minutes and Jimmy can run the same lap in 3 minutes. If they both start at the same time, how long will it take for them to both return to the starting point at the same time?

_______ minutes
15. Write the correct letter in the blank.
   Which expression means the product of $l$ and 59?
   
   A $l$ \hspace{1cm} B $59 \times l$ \hspace{1cm} C $\frac{59}{l}$

16. 4,952,259,529.9052
   Which digit is in the millions place?

17. Write the answer in each blank.
   Note: 16 oz = 1 lb
   $98 \text{ oz} = \underline{\hspace{1cm}} \text{ lb} \underline{\hspace{1cm}} \text{ oz}$

18. Joanne spent $23.15 on groceries and $13.95 on clothes. Estimate to the nearest dollar the total amount spent by Joanne.
   $\underline{\hspace{1cm}}$

19. Write the correct letter in the blank.
   $E$ is the center of the circle.
   
   Which line segment shows the diameter of the circle?
   
   A $\overline{BD}$ \hspace{1cm} B $\overline{CD}$ \hspace{1cm} C $\overline{AB}$

20. Write the numbers from least to greatest.
   \[
   \frac{11}{13}, \frac{9}{12}, \frac{31}{12}, 3, \frac{12}{15}
   \]
   $\underline{\hspace{1cm}} < \underline{\hspace{1cm}} < \underline{\hspace{1cm}} < \underline{\hspace{1cm}} < \underline{\hspace{1cm}}$

21. Estimate the sum to the nearest tens place.
   \[158 + 132 + 162 + 132 = \underline{\hspace{1cm}}\]

22. Write the greatest common factor of the numbers below.
   18, 90
   $\underline{\hspace{1cm}}$
<table>
<thead>
<tr>
<th>Student:</th>
<th>Teacher:</th>
<th>Date:</th>
</tr>
</thead>
</table>

23. Write the correct letter in the blank.
Which expression means the sum of seven times y and ten times n?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$10 \times y + 7 \times n$</td>
</tr>
<tr>
<td>B</td>
<td>$7 \times y - 10 \times n$</td>
</tr>
<tr>
<td>C</td>
<td>$7 \times y + 10 \times n$</td>
</tr>
</tbody>
</table>

24. Of all the visitors to an amusement park on Monday, 5% were kids younger than 5 years old. In lowest terms, write the fraction of visitors to the amusement park who were younger than 5 years old.

25. Write $\frac{37}{7}$ as a mixed number.

26. Write the correct letter in the blank.
What is an appropriate measurement of the area of a playing field?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>800 square millimeters</td>
</tr>
<tr>
<td>B</td>
<td>800 square centimeters</td>
</tr>
<tr>
<td>C</td>
<td>800 square meters</td>
</tr>
</tbody>
</table>

27. Simplify the expression.

$$(7 + 3) \times (7 - 3)$$

28. Round to the nearest thousandths place:

8.31361245

29. A four-day charity fundraiser received 38 donations on the first day, 28 donations on the second day, 33 donations on the third day, and 45 donations on the final day. What was the mean number of donations per day?

Mean = _________
TITLE OF STUDY: Using Mobile Technology to Increase the Mathematics Achievement and Engagement of Students with Disabilities

INVESTIGATOR(S): Dr. Joseph Morgan and Dominique Tetzlaff, M.Ed

For questions or concerns about the study, you may contact Dr. Joseph Morgan at 702-895-3329.

For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted, contact the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794 or via email at IRB@unlv.edu.

Purpose of the Study
You are invited to participate in a research study. The purpose of this study is to see if using mobile technology, such as tablets, to deliver classroom instruction increases your students’ performance in mathematics when compared to traditional mathematics instruction.

Participants
You are being asked to participate in the study because you fit this criteria: 1.) You are a licensed special education teacher, 2.) You deliver mathematics instruction in a resource classroom, and 3.) Your class consists of students identified as having a disability.

Procedures
If you volunteer to participate in this study, you will be asked to do the following: Complete two surveys on your perception of student math achievement and student engagement.

Benefits of Participation
There may not be direct benefits to you as a participant in this study, although we expect that students will increase their knowledge of math content and their level of engagement with the math content. However, we hope to learn about the use of technology in the classroom and whether it improves your students’ performance in mathematics.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks. The risk involved in this study is the breach of your information that identifies you as a participant in the study. However this risk is minimal as your information will be secured in a locked file and your name will not be used on any documents related to the study.
**Cost /Compensation**
There will not be financial cost to you to participate in this study. The study will take approximately one month of your time, although all this time will be part of the normal instructional sequence on the school site. You will not be compensated for your time.

**Confidentiality**
All information gathered in this study will be kept as confidential as possible. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for 3 years after completion of the study. After the storage time the information gathered will be shredded and electronic storage devices erased.

**Voluntary Participation**
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with UNLV. If you choose to withdraw from the study you will not be asked to complete the research surveys. You are encouraged to ask questions about this study at the beginning or any time during the research study.

**Participant Consent:**
I have read the above information and agree to participate in this study. I have been able to ask questions about the research study. I am at least 18 years of age. A copy of this form has been given to me.

_________________________________________  _________________________
Signature of Participant                      Date

_________________________________________
Participant Name (Please Print)

#1020692-2, Expiration: 05-03-2018
APPENDIX G: TEACHER PERCEPTIONS OF STUDENT ENGAGEMENT SURVEY
Read through each of the following statements regarding your students’ level of engagement, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) My students exhibited appropriate physical responses such as writing on their worksheet. Students completed the appropriate worksheet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.) My students only interacted with their peers or myself when engaged in a teacher-led discussion related to the topic, or when asking questions related to the lesson/content.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.) My students’ eyes were on me during instruction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.) My students asked for assistance by raising their hand.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.) My students listened to my directives (e.g., looked at me and responded immediately to my directives).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.) Overall, I feel my students were engaged in the lesson.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teacher Perception of Student Engagement (MAI)

Read through each of the following statements regarding your students’ level of engagement, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) My students exhibited appropriate physical responses such as typing, scrolling, swiping, or clicking on the Kindle; students had the appropriate activity showing on the Kindle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.) My students only interacted with their peers or myself when asking questions related to the lesson/content.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.) My students’ eyes were on the Kindle during instruction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.) My students asked for assistance by raising their hand.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.) My students listened to my directives (e.g., looked at me and responded immediately to my directives).</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6.) Overall, I feel my students were engaged in the lesson.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teacher Perception of Student Math Knowledge Survey (TMI)

Read through each of the following statements regarding the math knowledge of your students, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I feel that my students understand how to solve an inequality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.) I feel that my students are able to use variables to represent numbers and write expressions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.) I feel that my students are able to apply the math skills to real-world and mathematical problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.) I feel that my students are able to write an inequality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.) Overall, I feel that my students can solve the targeted math skills and concepts independently.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.) I feel that my students will maintain the information over time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.) Overall, I feel my students learned the targeted math skills and concepts that I taught to them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teacher Perception of Student Math Knowledge Survey (MAI)

Read through each of the following statements regarding the math knowledge of your students, ranking them from a 1 (strongly disagree) to a 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>1 (Strongly Disagree)</th>
<th>2 (Disagree)</th>
<th>3 (Neutral)</th>
<th>4 (Agree)</th>
<th>5 (Strongly Agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) I feel that my students understand how to solve an inequality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.) I feel that my students are able to use variables to represent numbers and write expressions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.) I feel that my students are able to apply the math skills to real-world and mathematical problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.) I feel that my students are able to write an inequality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.) Overall, I feel that my students can solve the targeted math skills and concepts independently.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.) I feel that my students will maintain the information over time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.) Overall, I feel my students learned the targeted math skills and concepts that were taught to them on the Kindle.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I: TEACHER FIDELITY CHECKLIST
Teacher Fidelity Checklist – Traditional Math Instruction (TMI)

Teacher ID: ___________________

Class ID: ___________________

Date and time: ________________________________

Rater name: __________________________________

<table>
<thead>
<tr>
<th>Teacher Behavior</th>
<th>Observed?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Teacher read the warm-up activity to students.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.) Teacher reviewed the warm-up activity, objectives, and made connection to current lesson.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.) Teacher introduced math skill/concept and modeled how to apply the skill/concept.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.) Teacher provided guided practice via a worksheet.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.) Teacher provided independent practice via a worksheet.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6.) Teacher provided a 5 minute warning for students to complete the activity.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7.) Teacher provided a closing with a review of the math skill/concept.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>8.) Teacher provided feedback based on student responses throughout the lesson.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9.) Teacher completed activities within the allotted class time.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
**Teacher Fidelity Checklist – Mobile App Instruction (MAI)**

Teacher ID: ____________________

Class ID: _______________________

Date and time: _____________________________

Rater name: _____________________________

<table>
<thead>
<tr>
<th>Teacher Behavior</th>
<th>Observed?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Teacher instructed students to turn on the Kindle.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.) Teacher walked students through the process for logging on to the Kindle and accessing the learning module.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.) Teacher circulated the classroom as students worked on the Kindles.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.) Teacher answered questions related to the content and provided feedback based on student responses.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.) Teacher provided a 5 minute warning for students to complete the activity.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6.) Teacher instructed students to shut down the Kindles.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7.) Teacher completed activities within the allotted class time.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
John C. Fremont
Professional Development Middle School
Ann T. Schiller, Principal
Melissa M. Roehm, Assistant Principal
Brian Brill, Dean of Students

Office of Research Integrity – Human Subjects
University of Nevada, Las Vegas
4505 S. Maryland Parkway, Box 451047
Las Vegas, NV 89154-1047

Subject: Letter of Acknowledgement of a Research Project at a CCSD Facility

Dear ORI – Human Subjects:

This letter will acknowledge that I have reviewed a request by Dr. Joseph Morgan and Dominique Tetzlaff, M.Ed to conduct a research project entitled, Using Mobile Technology to Increase the Math Achievement and Engagement of Students with Disabilities at John C. Fremont Professional Development Middle School.

When the research project has received approval from the UNLV Institutional Review Board and the Department of Research of the Clark County School District, and upon presentation of the approval letter to me by the approved researcher, as site administrator for John C. Fremont Professional Development Middle School, I agree to allow access for the approved research project.

If we have any concerns or need additional information, the project researcher will be contacted or we will contact the UNLV Office of Research Integrity – Human Subjects at 702-895-2794.

Sincerely,

[Signature]
Authorized Facility Representative Signature

[Date]

Ann Schiller, Principal
Print Representative Name and Title

1100 E. St. Louis Ave. Las Vegas, Nevada 89104
Phone (702) 799-5558 ~ FAX (702) 799-5566
APPENDIX K: OBSERVATIONAL CHECKLIST
Observational Checklist (TMI)

Teacher name: ___________________________________________

Date and time: ___________________________________________

Length of time observed: __________________________________

<table>
<thead>
<tr>
<th>Student Behavior</th>
<th>Observed?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Students exhibit appropriate physical responses such as writing on their worksheet and completing the appropriate worksheet.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.) Students only interact with their teacher or their peers when engaged in a teacher-led discussion related to the topic.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.) Students eyes are on the teacher during instruction.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.) Students ask for assistance by raising their hand.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.) Students are listening to the teacher’s directives (e.g., looking at the teacher and responding immediately to the given directives).</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Observational Checklist (MAI)

Teacher name: ____________________________________________

Date and time: ____________________________________________

Length of time observed: ___________________________________

<table>
<thead>
<tr>
<th>Student Behavior</th>
<th>Observed?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Students exhibit appropriate physical responses such as typing, scrolling, swiping, or clicking on the Kindle; students have the appropriate activity showing on the Kindle.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.) Students only interact with their teacher or their peers when asking questions related to the lesson/content.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.) Students eyes are on the Kindle during instruction.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.) Students ask for assistance by raising their hand.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.) Students are listening to the teacher’s directives (e.g., looking at the teacher and responding immediately to the given directives).</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Warm Up

Read the directions in each section and answer the questions. Do not forget to write your name!

* Required

Name *

Your answer

Section A

Read each question and choose the correct answer.

What is the name of the horizontal axis on a coordinate plane? *

- The z-axis
- The x-axis
- The y-axis

What is the name of the intersection of the x-axis and the y-axis on a coordinate plane? *

0 points
What is the ordered pair for the point on the coordinate plane above? *

- (-2, 3)
- (3, 3)
- (3, -2)

What quadrant is the point located in? *

- Quadrant I
- Quadrant II
- Quadrant III
- Quadrant IV
What is the name of the second number in a coordinate pair? *

- The x-coordinate
- The y-coordinate ✓
- The z-coordinate

Feedback
Correct! The second number in an ordered pair is the y-coordinate. The second number represents the number on the y-axis.

What is the name of the intersection of the x-axis and the y-axis on a coordinate plane? *

- The middle coordinate
- The midway point ✗
- The origin

Correct answer
- The origin

Feedback
The intersection between the x-axis and the y-axis on a coordinate plane is called the origin.
APPENDIX N: SCRIPTED LESSON PLAN EXAMPLE
<table>
<thead>
<tr>
<th><strong>Lesson Components</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identification of the Class</strong></td>
<td>Population of Students: Resource Math</td>
</tr>
<tr>
<td></td>
<td>Grade: 6</td>
</tr>
<tr>
<td></td>
<td>Number of Students: 15</td>
</tr>
<tr>
<td><strong>Common Core State Standards</strong></td>
<td>CCSS.MATH.CONTENT.6.EE.B.5: Understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true? Use substitution to determine whether a given number in a specified set makes an equation or inequality true.</td>
</tr>
<tr>
<td><strong>Rationale for Instruction</strong></td>
<td>Topic: Inequalities</td>
</tr>
<tr>
<td></td>
<td><strong>Rationale:</strong> Aside from the importance of this skill to later math and science content, students will also learn that identifying the value of numbers and how numbers relate to each other is an essential life skill. Knowing how to identify larger and smaller amounts and the relationship between numbers is important for making purchases and comparing prices, identifying the price or value of a single item in a group, how to identify the value of an item in a group given the value of the other items, and where a number is positioned on a number line. This skill builds on things they should already know, such as adding, subtracting, and using a number line. Furthermore, the students should know positive and negative numbers, how to add and subtract positive and negative numbers, and the signs used to illustrate an inequality (i.e., &lt;, &gt;,). This concept will serve as the basis for the algebraic concepts that come after, such as using variables to represent numbers and write expressions when solving a real-world or mathematical problems, understanding that a variable can represent an unknown number or any number in a specified set, recognizing that inequalities of the form $x &gt; c$ or $x &lt; c$ have infinitely many solutions, and representing solutions of such inequalities on number line diagrams.</td>
</tr>
<tr>
<td>Daily Objectives</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>1. Students will be able to identify numbers that are greater than or less than a given number with 90% accuracy</td>
<td></td>
</tr>
<tr>
<td>2. Given a set of numbers, students will be able to identify a specific value that makes an equation or inequality true with 90% accuracy</td>
<td></td>
</tr>
<tr>
<td>3. Students will be able to use substitution to determine whether a given number in a specified set makes an equation or inequality true with 90% accuracy</td>
<td></td>
</tr>
</tbody>
</table>
### Evaluation/Monitoring

1. During independent practice students will be given a number on a paper or digital worksheet, and they must identify numbers that are greater than or less than the given number.
2. During independent practice students will be given a set of equations and inequalities on a paper or digital worksheet, and they must identify the value that makes the equation or inequality true.
3. During independent practice students will be given a set of equations and inequalities on a paper or digital worksheet, and they must use substitution to determine whether a given number in a specified set makes an equation or inequality true.

### Instructional Sequence

#### Teacher Does

1. **Advance Organizer/Warm Up (10 minutes)**
   
   "Today we are going to learn about inequalities and how to determine if an inequality is true. But before we begin, please complete this warm up activity. This will introduce you to the math concepts we are going to learn today.

   OK, let's review a couple important things you'll need to know in order to understand inequalities and how to solve them. Please take out your whiteboards."

   "Ok, I am writing the number 2 on my whiteboard." *Teacher has small whiteboard projected via the ELMO.* "Who can give me a number that is less than the number 2?"

   "Great! All of those numbers are less than 2. Now I am going to draw a number line." *Teacher draws number line on whiteboard* "When I use a number line, which direction do I need to go to find the numbers less than 2?"

#### Students Do

1. **Advance Organizer/Warm Up (10 minutes)**

   *Students complete Warm Up*

   *Students take out their whiteboards.*

   *Students write one number on their whiteboards and hold them up*

   *Students respond: You go to the left*
“Excellent! You guys are doing a great job remembering. And what symbol do we use to show **less than**?” *Teacher expands her arms with fingertips coming to a point in front of her to remind students*

“Perfect! It looks kind of like a bird’s beak. Now this is tricky – what does the symbol for **greater than** look like?” *Teacher expands her arms out in front of her, arms spread apart in a “v” shape to remind students*

“Well done, it looks kind of like a big hungry mouth!”

“Now I want you to draw a number line just like mine on your whiteboard.”

*Teacher quickly checks the boards for accuracy.*

“Good work guys! Now think about this – are the numbers you gave me the only numbers **less than 2**?” *Teacher points to the number 2 on the number line, then moves her finger to the left to help students identify the numbers less than 2*

“Nice work! All the numbers to the left, including 1 and 0, are **less than 2**. And what do we call the numbers that are **less than 0**?” *Teacher points to the 0, then moves her finger to the left to help students identify numbers less than 0. She taps her finger on the negative sign*

<table>
<thead>
<tr>
<th>Students draw the &lt; symbol and hold up their whiteboards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students draw the &gt; symbol and hold up their whiteboards</td>
</tr>
<tr>
<td>Students draw a number line on their white boards</td>
</tr>
<tr>
<td>Students answer, “No, all numbers to the left are smaller”</td>
</tr>
<tr>
<td>Students answer, “Negative”</td>
</tr>
</tbody>
</table>
“Wow, you are really impressing me with your memory! But wait are you ready for my next super hard question?! What do we call the numbers that are greater than 0?” Teacher points to the 0, then moves her finger to the right to help students identify numbers greater than 0.

“Bravo, give yourself a round of applause!”

“The last thing I would like to cover is substitution. What does the word substitute mean?”

Teacher calls on student

“I like your thinking, and you are on the right track! When we substitute, we put something in to take the place of something that is missing. So like Student said when I am out another teacher will substitute or take my place when I am missing. We can do that with inequalities too. We can use substitution to make an inequality true.”

2. Demonstration (15 minutes)

“Now that we have reviewed those important skills, we are going to learn about inequalities. Knowing about inequalities is important for the math classes you’ll have to take for the rest of your school careers, but it is also a really important skill to have in your daily lives. I’m going to give you an example of why it is important that really happened to me. When I was 10 years old my family and I...
went to Knott's Berry Farm. I was so excited because I wanted to ride all the rollercoasters – they are my favorite! When we got to Knott's I ran over to the first rollercoaster, Silver Bullet. There was a sign posted out front that read, “You must be more than 54” tall to ride the rollercoaster”. I wasn't sure what that meant – I had just went to the doctor for a check up and he said that I was 52”, and that is close to 54” so I figured I was ok to ride. I waited in line for one hour and 45 minutes, and finally I was the next one to ride! As the gates opened the operator stopped me and held up a measuring stick. Then he told me I could not get on the rollercoaster because I was not tall enough! I was so mad! I told him I was close to 54”, and he said “It doesn’t matter if you are close to 54”, you have to be greater than 54” to get on the ride.” Bummer!! I was in such a bad mood – but then we got ice cream so I was happy, sort of!

Teacher writes the inequality on the whiteboard: Height > 54”

“So you see, it is important to know what an inequality is and what it means. An inequality tells us the relative size of something, meaning we don’t know exactly how big. So in our example at Knott’s Berry Farm, did the sign say you must be 55”, 56”, 57”, 58”, 59” (etc. etc.) tall to ride the rollercoaster?

“Right! All we know is that you have to be bigger or greater than 54”. And I didn't understand that so I waited for a long time for nothing. But from that day on I made sure I knew what the sign said!”

Teacher points to the inequality she wrote on the
“This is an example of an inequality. It is read like this “Height is greater than 54”’. I want everyone to repeat it after me – ready?

Teacher reads the inequality

“Now, remember when we talked about substituting? Well let’s think of a number we can substitute for the word height that would make our inequality true.”

Teacher points to the word height in the inequality.

“So, what number can I put in here to take the place of the word height? What numbers are greater than 54?”

Teacher calls on several students

“Ok, let’s use the number 59. I am going to erase the word height and write in the number 59. Who can read our new inequality with the substitution?”

Teacher calls on a student

“Very good! We have just used substitution to make the inequality true. Now let’s say I substitute the number 52 for the word height. Is my inequality still true?”

“Excellent! The number 52 is not greater than 54. Let’s do one more example with a little twist. Let’s see if you can solve it!

Teacher places a copy of the text on the ELMO with a picture of her head on a football player’s body and reads to the students:

Mrs. Tetzlaff is considering trying out for her favorite football team – the New York Giants! Hey –

Students respond, “Height is greater than 54”

Various students respond, “55, 56, 59, 63, etc.”

Student responds, “59 is greater than 54”

Students respond, “No!”
why is that funny?! Anyway, I want to be a tackle because I think I can really take down the big guys – check out my muscles!

*Teacher flexes*

“Geez I really don’t know what is so funny! Well, I read the requirements to be a tackle on the football team, and it said, “All players must be greater than 6’ tall, less than 35 years old, and must be greater than or equal to 295 pounds. Hey, that sounds just like me!”

*Teacher poses*

“Ok, ok, maybe not. Anyway, who can come up here and underline my inequalities?”

*Teacher picks a student*

Alright, nice job! Now, who can help Mrs. Tetzlaff, the future New York Giants tackle, to write out the inequalities on the whiteboard?”

*Teacher picks three different students*

“Ok – it seems my nefarious trick has worked!! No more laughing at my football dream!”

*Teacher laughs*

“So the first two answers are correct. However, the inequality for weight is not. The inequality for weight stated, “greater than or equal to 295 pounds”, meaning that I have to be greater than or equal to 295 pounds in order to join the team as a tackle. The symbol for greater than or equal to is this”

*Students laugh throughout the example*

*Students raise hands*

One student writes

*Height > 6’*

Another writes

*Age < 35 years old*

Another writes

*Weight > 295 pounds*
Teacher writes the symbol on the whiteboard:
\[ \geq \]
“So my inequality would be..”

Teacher writes inequality on the whiteboard:
Weight $\geq 295$ pounds

“I guess I need to eat a few more bags of Takis! So now who thinks they can write the symbol for **less than or equal to**?”

Teacher calls on student

“Whoa!! You guys are so smart – nice job! Now, give me some numbers we can use as substitutions for the words age and height.”

Teacher calls on various students

3. Guided Practice (15 minutes)

“So let’s put our new knowledge to the test. I am going to read a problem, and you are going to walk me through solving it. Ready? Let’s go!”

Teacher reads problem:

“Cameron and Liz heard about the new movie coming out this weekend and they are so excited! It has their favorite singers in it – Rihanna and Jennifer Lopez. On Saturday night their mom drops them off at the movie theatre. As they walk up to the window they read about each of the movies. The sign under the movie they want to see reads, “You must be 13 years old or older to see this movie. My first question is what is the inequality?”

Teacher chooses a student

Students raise hands

One student writes
\[ \leq \]

Students respond with various answers

3. Guided Practice (15 minutes)

Students respond, “Yes!”

Student responds, “You must be 13 years old or
“That’s right! I am going to underline that. Now who can help me write out the first part of the inequality? Go ahead and write it on your whiteboard.”
*Teacher calls on a student*

“Nice job! Now who knows the symbol for the inequality?”
*Teacher calls on a student*

“Perfecto! Now, who can tell me the last part of the inequality?”
*Teacher calls on a student*

“Yes! You guys are awesome, thank you! The inequality would look like this.”
*Teacher writes the inequality on her whiteboard*

\[ \text{Age} \geq 13 \]

“Now super math aces, who can read the inequality for me?”
*Teacher calls on a student*

“Nice job! It reads: Age must be greater than or equal to 13. Please repeat it after me”
*Teacher restates the inequality*

4. Independent Practice (5 minutes)

“Now I would like you guys to try this on your own. I am going to pass out a worksheet. On this...”

older to see this movie”

4. Independent Practice (5 minutes)

Students work on the worksheet.
worksheet, you are going to read the problems, underline the inequalities, and then write the inequalities underneath the problem using the correct symbol. Please work quietly and independently. I want to know what you know, not what your neighbor knows. If you need help, please raise your hand, and I’ll come help you. When you finish, bring it to me so I can look it over.”

5. Closure/Review (5 minutes)

“Great job, everybody! If you didn’t finish the worksheet, don’t worry. There will be some time to finish it tomorrow. Pass it forward, and I’ll have it for you tomorrow.”

“So today we learned about inequalities and what they mean. We used an example from when I went to Knott’s Berry Farm and could not ride the rollercoaster. Can anyone tell me why else this might be a useful skill to know in our lives away from school?” Teacher calls on student with hand raised.

“What a great example, and good luck to your brother! Anyone else?” Teacher calls on student with hand raised.

“Awesome! Tomorrow, we’re going to continue with this skill, but we’re going to try doing it using problems with a little more information.”

5. Closure/Review (5 minutes)

Students who didn’t finish pass their papers forward for teacher to collect.

Student responds, “Well my brother wants to go to UNLV, and his grade average has to be like 3.0 or greater to get in.”

Student responds, “To go on our sixth grade field trip we have to have less than 10 absences.”
Coordinate Plane

Warm Up

Ordered Pairs

Demonstration

Quadrants

Take this opportunity to take a one minute brain break! Click on...
APPENDIX P: EDPUZZLE SCREENSHOTS
Plot the ordered pair (6, -8) in the coordinate plane.

What is the name of the horizontal axis?

- The y-axis
- The x-axis

Submit  Skip
100/100

Correct! The ordered pair for the origin or the intersection of the x-axis and the y-axis is (0,0)

(1,1)

Remember, the ordered pair for the origin or the intersection of the x-axis and the y-axis is (0,0)

What is the name of the horizontal axis?

0/100

The y-axis

Remember, the horizontal (left to right) axis is called the x-axis

The x-axis

Correct! The horizontal (left to right) axis is called the x-axis

Continue
Timeline of the Study

Phase One - April 2017

- Facilities Acknowledgement from the principal
- Consent obtained from the teacher
- Consent obtained from the parents
- Assent obtained from the student participants
- Teacher received training for both conditions of the intervention
- Students received training for both conditions of the intervention

Phase Two - May 2017

- Students completed the math pretest
- Intervention implemented
- Students completed the posttest
- Students and teacher completed the student math knowledge and student engagement surveys
References


instruction in written expression: The effects on English speakers and English language

Walker, H., Severson, H., Todis, B., Block-Pedego, A., Williams, G., Haring, N., and
validation, replication, and normative data. *Remedial and Special Education* 2, 32–45

Look At Student Centered Math Teaching: A Study of Highly Regarded High School
Teachers and Their Students*. Retrieved from
https://www.nmefoundation.org/getattachment/Resources/Student-Centered-
Learning/An-Up-Close-Look-at-Student-Centered-Math-Teaching/An-UpClose-Look-at-
Student-Centered-Math-Teaching-(1).pdf?ext=.pdf

Watt, S. W., & Therrien, W. J. (2016). Examining a preteaching framework to improve
fraction computation outcomes among struggling learners. *Preventing School Failure*, 60,
311-319.

podcasts (caps) for vocabulary: The intersection of content, pedagogy, and
technology. *Journal of Special Education Technology*, 31, 228-235.

computer-assisted instruction for students with disabilities: A Synthesis. *Remedial &


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EDUCATION AND PROFESSIONAL CREDENTIALS

Degrees
Ph.D. University of Nevada, Las Vegas Special Education
M.Ed. 2009 University of Nevada, Las Vegas Special Education
B.A. 1997 William Paterson University Psychology

Licenses
Highly Qualified Special Education English (Grades 6-8)
State of Nevada Teacher License Special Education Generalist (Grades K-12)

PROFESSIONAL EXPERIENCE

2015 – 2016 Editorial Assistant, Intervention in School and Clinic
University of Nevada, Las Vegas

2015 – Present Research Fellow, Project CULTURED Scholar
University of Nevada, Las Vegas

2014 – Present Doctoral Graduate Assistant – Teaching
University of Nevada, Las Vegas

2008 – 2014 Special Education Teacher, 6-8, Cortney Junior High School
Clark County School District, Las Vegas, Nevada

2007 – 2008 Lead Teacher, Early Childhood (8 – 12 months)
Kiddie Academy Preschool, Henderson, NV

2000 – 2006 Police Officer
Henderson Police Department, Henderson, Nevada
### TEACHING

**Spring 2014**
- EDSP 466 Group Teaching Methods for Students with Disabilities
- ESP 724 Math Methods for Students with Mild Disabilities
- ESP 733 Management and Modification of Students with Special Needs (Guest Lecturer)

**Fall 2014**
- EDSP 423 Collaboration and Consultation in Special Education
- EDSP 453 Behavior Management Techniques for Students with Disabilities (Guest Lecturer)
- EDSP 466 Group Teaching Methods for Students with Disabilities
- ESP 730 Parent Involvement in Special and General Education (Online)

**Spring 2015**
- EDSP 466 Group Teaching Methods for Students with Disabilities
- ESP 708 Advanced Strategies for Students with Disabilities

**Summer 2015**
- EDSP 491 Student Teaching in Special Education (Field Supervisor)
- EDSP 492 Student Teaching Seminar

**Fall 2015**
- ESP 708 Advanced Strategies for Students with Disabilities
- TESL 752 TESL Methods and Materials (Co-taught with faculty)

**Spring 2016**
- ESP 701 Introduction to Special Education and Legal Issues (Online)
- ESP 701 Introduction to Special Education and Legal Issues (Course Development)

**Summer 2016**
- EDSP 491 Student Teaching in Special Education (Field Supervisor)
- EDSP 492 Student Teaching Seminar

**Fall 2016**
- TESL 471 Language Acquisition, Development, and Learning

**Spring 2017**
- TESL 471 Language Acquisition, Development, and Learning

**Summer 2017**
- ESP 724 Math Methods for Students with Mild Disabilities (Online)
SPECIALIZED TRAINING
February 9 – 11, 2016 The IRIS Center Faculty Seminar, Las Vegas, Nevada

RESEARCH

PUBLICATIONS

Love, M. L., & Tetzlaff, D. M. (2016). 5 ways to apply UDL in science to support students with LD.


PRESENTATIONS


202


DATA COLLECTION

Data collection for an IES funded grant project: Numbershire Efficacy Study, Spring 2017


SERVICE

Treasurer, Council for Learning Disabilities Nevada Chapter, 2016 – Present

Member, Doctoral Recruitment Committee, 2015 – 2016

Member, Student Technology Advisory Board, 2015 – 2016

Article reviewer for Intervention in School and Clinic, 2016

Department Representative, Graduate and Professional Student Association, 2014 – 2016

Member, UNLV Foundation Teaching Award Review Committee, 2014 – 2016

Member, Council for Learning Disabilities Local Arrangements Committee, Fall 2015
Secretary, Student Council for Exceptional Children – University of Nevada, Las Vegas Chapter, 2014 – 2015

Article reviewer for LD Forum, 2015

Member, Search Committee for International Recruitment and Admissions Specialist for the University of Nevada, Las Vegas, Fall 2014

Member, Cortney Junior High School Advisory Committee, 2013 – 2014

Member, Cortney Junior High School Disciplinary Committee, 2010 – 2011

**HONORS AND AWARDS**

Certificate of Distinction, Master’s Portfolio, University of Nevada, Las Vegas, 2009

**PROFESSIONAL MEMBERSHIPS**

Council for Learning Disabilities, 2015 – Present

National Society for Leadership and Success, 2015 – Present

National Association of Special Education Teachers, 2011 – Present

Council for Exceptional Children, 2011 – Present

Council for Children with Behavioral Disorders, 2011 – Present

Phi Kappa Phi Collegiate Honor Society, 2009 – Present

National Education Association, 2008 – Present

Nevada State Education Association, 2008 – Present