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Instructional Math Technology in Secondary Special Education: Teacher-Reported Practices and Perceptions

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INSTRUCTIONAL MATH TECHNOLOGY IN SECONDARY SPECIAL EDUCATION:

TEACHER-REPORTED PRACTICES AND PERCEPTIONS

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ABSTRACT

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Students with disabilities often have difficulty meeting established math proficiency levels. Without these skills, students may face increased challenges in transitioning to adulthood, including fewer post-secondary educational opportunities, limited career options, and decreased long-term income. Addressing low math skills is important to improving options for students with disabilities. Research indicates that technology-based interventions have the potential to improve academic outcomes.

The purpose of this study was to examine the math instructional technology used in secondary math classrooms with students with disabilities. The study also examined teacher-perceived barriers and desired supports related to the integration of technology. A three-round Delphi method was used to collect survey data from participants. Participants were 36 secondary general and special education teachers who were identified as experts by their school principals and currently teaching secondary math to students with disabilities in co-teach and/or resource settings. Expertise criteria included a standard teaching license, experience using instructional software with students, and a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings.

The results indicated that participants most frequently used *ALEKS*, *Kahoot*, *ST Math*, or no instructional software in math instruction for students with disabilities. Software selection was based on software availability, software features, or no specific selection methods. Participants identified lack of time, cost, and lack of technology as barriers to implementation. The most frequently identified desired supports were training and support, additional technology, and no supports, and participants perceived technology as increasing engagement, improving math outcomes, or having an unknown impact on math performance.

These findings have implications for administrators, practitioners, researchers, and teacher preparation program developers. Instructional software continues to be underutilized in secondary math classrooms with students with disabilities, and the instructional software programs that are utilized do not have a strong evidence base. Administrators and practitioners should use a rigorous decision-making process to select and implement evidence-based instructional software to improve the math outcomes of students with disabilities.

Administrators should also provide ongoing training to teachers to support technology integration. For researchers, additional focus is needed on replication studies to strengthen the evidence base of instructional software programs. Finally, teacher preparation programs should include coverage of basic technology concepts, educational technology, software evaluation methods, budgeting, and time management.

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Dedicated to my parents,

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CHAPTER ONE

INTRODUCTION

Math skills are crucial for a wide variety of essential life functions. Difficulty using critical math thinking skills can limit the ability to solve real-life problems involving math concepts (Snyder & Snyder, 2008). From cooking to handling personal finances, math skills are essential to the successful management of daily life tasks. Math proficiency also impacts college- and career-readiness and increases the number and type of post-secondary opportunities (NMAP, 2008).

Academically, students are expected to display achievement on high-stakes math assessments that may impact long-term educational opportunities (NCTM, 2008). Students with math deficits also may have difficulty meeting the proficiency requirements for a standard high school diploma. The lack of a diploma limits the post-secondary options available for furthering education (e.g., college, trade school), and students may be ill-prepared for the available options (NMAP, 2008). Nationally, math achievement does not meet the levels necessary for college success (Lee, 2012). Many students entering college require remedial coursework, and these students are less likely to earn a degree (Wirt et al., 2004).

In the workplace, the level of requisite math skills has continued to rise over time (NCTM, 2014). The increasing importance of technology in many industries requires a more complex understanding of math concepts and the ability to understand and apply these concepts to job-related tasks (Hoyles, Wolf, Molyneux-Hodgson, & Kent, 2002). The number and type of career opportunities may be limited for students lacking the necessary math skills to earn a high school diploma (Hartwig & Sitlington, 2008).

Without math proficiency, students may have difficulty obtaining and maintaining employment, as well as qualifying for positions other than entry-level positions with lower salaries (NMAP, 2008). Students who have not taken high-level math courses in high school tend to have lower average incomes (Joensen & Nielsen, 2009; Kena et al., 2015). Unemployment rates are also generally higher for individuals with lower levels of education (Kena et al., 2015). The lack of financial resources may lead to significant challenges in adequately providing for family needs (NMAP, 2008).

In light of the relationship between mathematics proficiency and post-secondary success, it is important for schools to focus on the provision of high quality math instruction for students. However, students in the U. S. continue to struggle with achieving proficiency in math (USDOE, 2013). Based on international averages, students in the U. S. lag behind their counterparts in many countries (NCES, 2012). Measures of performance also indicate a lack of meaningful growth in the area of math (Kena et al., 2015; NCES, 2012).

In an effort to improve math skills and establish expectations, various organizations have worked to establish rigorous math standards (Klein, 2003). These provide guidance for the content of math courses at each grade level, as well as recommendations for the preparation of math teachers. The standards have continued to evolve based on stakeholder reports, an expanding evidence base, and the prevailing concerns of the field (Klein, 2003).

Standards-based curricula typically include an increased focus on student-generated ideas and solutions and the ability to develop multiple approaches to analyze unknown situations (Jitendra, 2013). Students with disabilities struggle to meet established proficiency levels and succeed in the environment of standards-based mathematics instruction (USDOE, 2013).

Difficulties with long-term memory, procedural accuracy, problem solving, and information processing inhibit the success of these students in standards-based classrooms (Geary, 2004).

Researchers have identified components of effective instruction that support students with disabilities in the acquisition of math skills, including explicit teaching, multiple practice opportunities (Fuchs, Fuchs, Schumacher, & Seethaler, 2013; Mastropieri, Scruggs, Hauth, & Allen-Bronaugh, 2012), multiple examples, instruction in metacognitive strategies (Mastropieri et al., 2012), proactive instructional design, conceptual explanations, cumulative review, and use of motivators (Fuchs et al., 2013). The Concrete-Representational-Abstract (CRA) methodology also has a strong evidentiary base supporting its use with students with disabilities (Flores, Hinton, & Schweck, 2014; Mancl, Miller, & Kennedy, 2012; Miller & Kaffar, 2011; Strickland & Maccini, 2012).

Evidence suggests that technology-based interventions incorporating many of these elements can be used to improve academic outcomes and remediate the math deficits of students with disabilities (Strickland & Maccini, 2010). The benefits of technology include individualized content, increased engagement, and multiple opportunities for practice (NCTM, 2011). Professional organizations, including the Council for the Accreditation of Educator Preparation (CAEP), recommend that teacher preparation programs include instruction in the effective integration of technology (CAEP, 2015). As a result, many teachers complete technology-related courses as part of both preparatory training and ongoing professional development (Gray, Thomas, & Lewis, 2010; Kleiner, Thomas, & Lewis, 2007).

Despite the promising evidence supporting technology-based interventions and the recommended inclusion of technology-related courses in teacher education, technology has been relatively underutilized in remediating math deficits (Gray et al., 2010). Additional information

is needed to determine the factors supporting and inhibiting the use of technology. If the barriers to technology integration are identified, corresponding solutions can be developed and implemented, and the benefits of technology can be more fully realized.

Mathematics Achievement in the United States

In 2013, only 9% of eighth-grade students in the U. S. demonstrated advanced math skills on the National Assessment of Educational Progress (NAEP), and 26% of eighth-grade students scored below the basic proficiency level (USDOE, 2013). In comparison with other countries, the average math literacy score in the U. S. was below the international average determined by the Organization for Economic Co-Operation and Development (OECD) (Kelly et al., 2013). Identified weaknesses included reasoning, interpretation, and the application of math concepts to real-world situations (OECD, 2012).

Perhaps more concerning is the lack of growth and improvement in math skills over time. Between 2007 and 2013, the average math score of eighth-grade students remained relatively unchanged in the U. S. (Kena et al., 2015; NCES, 2012). Results were similar for fourth- and eighth-grade students between 2011 and 2013 and twelfth-grade students between 2009 and 2013 (USDOE, 2013). In fact, the average score for 17-year-old students in 2012 was not measurably different from their scores in 1973 (Kena et al., 2015). Between 2008 and 2012, only the 13-year age group demonstrated a measurable increase in math scores (NCES, 2014). In 2015, NAEP scores again decreased in both fourth grade and eighth grade (USDOE, 2015).

For students with disabilities, the deficit in math skills is concerning. High-stakes assessment scores indicate that students with disabilities often have difficulty achieving mastery of standards (USDOE, 2013). In 2013, only 18% of fourth-grade students with disabilities

demonstrated mathematical proficiency (USDOE, 2013). In the same year, only 8% of eighth-grade students with disabilities were considered proficient (USDOE, 2013).

In 2015, the scores of fourth-grade students with disabilities remained unchanged and eighth-grade scores decreased (USDOE, 2015). In the same year, 45% of fourth-grade students and 68% of eighth-grade students with disabilities scored below the basic level on the math portion of the NAEP assessment (USDOE, 2015). Only 16% of fourth-grade students with disabilities and 8% of eighth-grade students with disabilities scored at or above a proficient level (USDOE, 2015). Students with disabilities often struggle with the diverse problem-solving skills required on standardized assessments due to underlying deficit areas, including long-term memory, procedural accuracy, and information processing (Geary, 2004).

Mathematics Standards and Expectations in the United States

To address the concerns of limited mathematics proficiency, there has been a focus on mathematics learning and grade-level expectations for much of American public school history (Klein, 2003). In 1916, the Mathematical Association of America appointed a committee to investigate reform in mathematics instruction (National Committee on Mathematical Requirements, 1922). The resulting publication, the *Reorganization of Mathematics for Secondary Education*, was a comprehensive report on mathematics instruction and teacher preparation (National Committee on Mathematical Requirements, 1922). The report outlined the goals of math instruction and included detailed descriptions of specific grade-level content, college entrance requirements, instruction in geometry and functions, and teacher training requirements (National Committee on Mathematical Requirements, 1922).

In subsequent years, various movements designed to improve math instruction gained momentum (Klein, 2003). The Activity Movement of the 1930s advocated for the end of

subject-specific instruction and the integration of mathematics into holistic instruction (Klein, 2003). In the 1950s, dissatisfaction led to the new math reform movement (Kilpatrick, 2014). New math encouraged instruction in logical explanations for mathematical algorithms (Klein, 2003). The new math movement was largely viewed as unsuccessful due to poor test results, leading to a new emphasis on accountability (Kilpatrick, 2014). Growing public concern regarding the quality of education led to the publication of two influential reports in the 1980s, *An Agenda for Action* and *A Nation at Risk* (Kilpatrick, 2014).

The National Council of Teachers of Mathematics (1980) published *An Agenda for Action* emphasizing the importance of problem-solving and technology in mathematics instruction. The report served as a foundation for the development of mathematical standards to guide instruction (Klein, 2003). *A Nation at Risk* (National Commission on Excellence in Education, 1983) focused attention on the lack of achievement in the nation and emphasized the importance of assessment and teacher preparation. Both reports provided the impetus for standards-based reform in mathematics instruction (Klein, 2003).

National Council for Teachers of Mathematics Standards

In 1989, the NCTM published the *Curriculum and Evaluation Standards for School Mathematics* to establish criteria for curricula, instruction, and evaluation at each grade level (Frye, 1989). Two additional publications, *Professional Standards for Teaching Mathematics* and *Assessment Standards for Teaching Mathematics* were subsequently released to further guide teaching, evaluation, and assessment practices (NCTM, 2015). The standards were designed to describe the components of high-quality math instruction and establish a common foundation for all students (NCTM, 2015). The updated standards, published in 2000 and

entitled *Principles and Standards for School Mathematics*, included both content and process standards to be integrated in all grade levels at varying degrees (NCTM, 2000).

The content standards include five key skill areas that students should learn: (a) numbers and operations, (b) algebra, (c) geometry, (d) measurement, and (e) data analysis and probability (NCTM, 2000). The five process standards describe how students should learn and apply content, specifically through (a) problem solving, (b) reasoning and proof, (c) communication, (d) connections, and (e) representations (NCTM, 2000). The *Principles and Standards for School Mathematics* also identified key principles of mathematics education: equity, curriculum, teaching, learning, assessment, and technology (Powell, Fuchs, & Fuchs, 2013).

Common Core State Standards

Recently, state leaders collaborated with various stakeholders to develop the Common Core State Standards, a set of learning goals targeting college- and career-readiness (Common Core State Standards Initiative, 2015a). Released in 2010, the Common Core State Standards for Mathematics (CCSS-M) focus on the same broad categories of essential skills as the previously published NCTM standards (Powell et al., 2013). However, the CCSS-M also include several shifts from previously established standards (Common Core State Standards Initiative, 2015b).

The CCSS-M focus on requiring more thorough coverage of fewer topic areas and linking topics across grade levels (Common Core State Standards Initiative, 2015b). The standards also differ in grade-level and reasoning expectations (Dingman, Teuscher, Newton, & Kasmer, 2013). In addition, the CCSS-M focus on increased rigor through simultaneous instruction in conceptual understanding, procedural skills and fluency, and application (Common Core State Standards Initiative, 2015b). The overarching goal of the CCSS-M is to build

competence in the application of higher-order thinking skills (Common Core State Standards Initiative, 2015a).

Impact of Standards-Based Instruction on Students with Disabilities

Standards-based instruction is designed to ensure that students receive instruction in the skills necessary for college and career success (Common Core State Standards Initiative, 2015a). Students with disabilities need access to standards-based instruction to be prepared for future success (The Regents of the University of Minnesota, 2013). However, significant challenges exist when implementing standards-based instruction for students with disabilities (Powell et al., 2013).

Standards-based instruction focuses on teaching broad concepts, followed by the application of conceptual understanding to unknown mathematical situations (Jitendra, 2013). The corresponding high-stakes assessments are designed to measure student achievement relative to mastery of the standards (Powell et al., 2013). In an effort to cover all of the concepts included on the standards-aligned assessments, teachers may allocate less instructional time to each topic (Russell, 2012). However, students with disabilities often lack the foundational skills necessary for conceptual understanding (Powell et al., 2013).

An increased pace of instruction may not provide the level of scaffolding necessary for students with disabilities to achieve mastery of the increasingly rigorous standards (Russell, 2012). Critics also question the ability of standards-based curricula to meet the diverse needs of students with disabilities (Powell et al., 2013). All students may not benefit from instruction based on the same standards-based curricula (Tienken, 2011). For students with disabilities, identification of missing foundational skills and responsive instruction may be more beneficial and lead to eventual mastery of standards (Powell et al., 2013).

Use of Technology to Teach Mathematics

Given the importance of math achievement and the continued challenges faced by students with disabilities in meeting standards, additional supports are needed. Technology has been identified as one potentially effective support in remediating math deficits and increasing higher-order math skills (NCTM, n.d.). The NCTM emphasizes the essential role of technology in developing "mathematical sense making, reasoning, problem solving, and communication" (NCTM, 2011, para. 1). Technology-based interventions have been shown to positively affect the math performance of students (NCTM, 2014). The ongoing use of technology often results in an increase in engagement (Haydon et al., 2012; NCTM, 2011) and initiative (Sandholtz, Ringstaff, & Dwyer, 1994).

Technology Integration in the General Education Curricula

Technology has been used to target deficits in declarative knowledge, procedural knowledge, conceptual knowledge, and problem-solving (Barrow, Markman, & Rouse, 2009; Gesbocker, 2011; Roschelle et al., 2010). Improved outcomes have resulted from multiple applications of technology (Kiger, Herro, & Prunty, 2012; Musti-Rao & Plati, 2015). The use of computer-based instruction has resulted in positive outcomes in various skill areas, including basic math facts (Gesbocker, 2011), rate and proportionality (Roschelle et al., 2010), and algebra and prealgebra (Barrow et al., 2009). Practice integrating apps on both iPads (Musti-Rao & Plati, 2015) and iPods (Kiger et al., 2012) has resulted in an increase in math fluency skills.

Instruction involving virtual manipulatives has improved student math outcomes. Virtual manipulatives have been used to effectively target specific concepts, including fractions (Reimer & Moyer, 2005) and geometry (Steen, Brooks, & Lyon, 2006). Social validity measures indicate that students reacted positively to the use of virtual manipulatives during instruction (Reimer &

Moyer, 2005). Web-based tutoring has been used to improve math problem-solving skills (Maloy, Edwards, & Anderson, 2010).

Technology Integration for Students with Disabilities Related to Math

Research supports the use of technology as a promising practice to teach math skills to students with disabilities (Strickland & Maccini, 2010). Positive effects on the fluency outcomes of students with disabilities have resulted from computer-assisted instruction (Bottge et al., 2014; Seo & Bryant, 2012), computer-based games (Ke & Abras, 2013), computer-based interventions (Burns, Kanive, & DeGrande, 2012), and iPad-based interventions (Haydon et al., 2012).

Other effective technology-based interventions, including synchronous peer tutoring (Tsuei, 2014), video modeling (Burton, Anderson, Prater, & Dyches, 2013), and the use of virtual manipulatives (Bouck, Satsangi, Doughty, & Courtney, 2014). These have been used to improve computation fluency, conceptual knowledge, and math application skills. Both teachers and students have indicated a preference for technology-based interventions (Bouck et al., 2014; Haydon et al., 2012). The Council for Exceptional Children (CEC) also recognizes the role of technology in improving the educational outcomes of students with disabilities (CEC, 2014).

Teacher Preparation Related to the Integration of Technology

The Council for the Accreditation of Educator Preparation (CAEP) has emphasized the importance of including instruction in technology integration in teacher preparation programs (CAEP, 2015). Most teacher preparation programs include a technology course or incorporate technology instruction within other courses (Kleiner et al., 2007; Niess, 2012). Courses focusing on the benefits of using instructional technology can decrease technology-related anxiety and improve skill level, feelings of self-efficacy, and perception of technology as an effective learning tool (Lambert & Gong, 2010).

However, technology courses often focus on traditional uses of technology (e.g., word processing, scanning material, storing information) with little exposure to newer-generation technologies (McGrail, Tinker Sachs, Many, Myrick, & Sackor, 2011). Institutions of higher education may encounter barriers to providing effective instruction in real-world technology integration (Kleiner et al., 2007). Consequently, graduates may feel underprepared to implement technology in classroom instruction (Ruggiero & Mong, 2013).

Most teachers also participate in post-hire professional development sessions focusing on technology integration (Gray et al., 2010). The literature suggests that professional development can improve teacher skills, knowledge, and ability to integrate instructional technology (Kopcha, 2012; O'Hara, Pritchard, Huang, & Pella, 2013; Walker et al., 2012). However, not all professional development sessions are successful in effecting change in technology integration (Skoretz & Childress, 2013).

The NCTM recommends that teacher education programs and professional development opportunities focus on providing instruction in current technologies and their application in the classroom (NCTM, 2011). Specifically, teachers should be provided with instruction in effectively integrating technology during math lesson plan development and instruction (Nelson, Christopher, & Mims, 2009). Teacher education programs should include courses on both technology and math content, as well as experiences that allow the application of knowledge and skills in a practicum environment (Niess, 2012).

The Technological Pedagogical Content Knowledge (TPACK) framework was designed to identify the areas of knowledge necessary to effectively integrate technology into instruction (Koehler, Mishra, & Cain, 2013). Specifically, teachers need expertise in the areas of technology, pedagogy, and content, as well as the ability to integrate this knowledge into

instruction cohesively (Stoilescu, 2015). Effective integration of technology, pedagogy, and content also requires an understanding of how each area of knowledge interacts with and influences other areas (i.e., technological content knowledge, pedagogical content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge) (Koehler et al., 2013).

Statement of the Problem

Despite research supporting technology-based interventions and the recommendations of the NCTM and teacher preparation organizations, the use of instructional technology in the classroom is not widespread. Only 33% of public school teachers indicated using simulation and visualization programs sometimes or often, and only 50% used tutorials and practice programs sometimes or often (Gray et al., 2010). Special education teachers reported similar usage rates; 32% sometimes or often used simulation and visualization programs, and 57% sometimes or often used tutorials and practice programs (Gray et al., 2010). Additional research is needed to examine the usage of instructional technology in secondary math classrooms. The purpose of this study is to examine the integration of instructional technology in secondary math classrooms with students with disabilities.

Research Question One. How are teachers incorporating instructional technologies into secondary classrooms to support math instruction for students with disabilities?

Research Question Two. What barriers do teachers identify relative to the integration of instructional technology in secondary math classrooms with students with disabilities?

Research Question Three. What supports do teachers report needing in order to effectively incorporate instructional technologies into secondary classrooms to support math instruction for students with disabilities?

Significance of the Study

Math proficiency increases the number and type of postsecondary options available to students (NCTM, 2008). However, students with disabilities typically have the lowest math proficiency scores (NCES, 1997). Addressing the low math skills of students with disabilities is important to improving long-term outcomes for these students. Research indicates that technology has the potential to improve academic outcomes (Burns et al., 2012; Ke, 2008; Maloy et al., 2010; NCTM, 2014; Roschelle et al., 2010; Seo & Bryant, 2012).

The findings of this study will contribute to the research base related to: (a) the use of instructional technology in secondary math classrooms with students with disabilities, (b) teacher perceptions of the use of instructional technology to improve math outcomes of students with disabilities, and (c) teacher perceptions of the benefits and barriers to the effective use of instructional technology in secondary classrooms with students with disabilities. The findings will provide a foundation for the development of solutions to implementation obstacles and, hopefully, allow the benefits of technology to be more fully realized in secondary math classrooms.

Definition of Terms

Application. The use of math skills to solve problems (Common Core State Standards Initiative, 2015b).

Axial coding. The grouping of open codes according to common points of intersection (Marshall & Rossman, 2011).

Clustering. The grouping of ideas in relation to broad topics (Marshall & Rossman, 2011).

Computational fluency. The ability to use multiple approaches to solve math problems efficiently and accurately (Russell, 2000).

Computer-assisted instruction. The use of software to provide supplemental instruction and practice opportunities (Hudson & Miller, 2006).

Conceptual understanding. Comprehension of the underlying reasoning of math knowledge and skills (Hudson & Miller, 2006).

Delphi method. A method of information collection involving the completion of multiple survey instruments until responses are stable (Kloser, 2014).

Instructional software. Computer programs that deliver content, provide opportunities to practice content, and/or assess content knowledge (Ogle et al., 2002).

Open coding. The sorting of qualitative data into conceptual categories (Marshall & Rossman, 2011).

Procedural knowledge. An understanding of the steps necessary to solve mathematical problems (Canobi, 2009).

Professional development. Activities designed to further develop the knowledge and skills of post-hire teachers (NCATE, 2014).

Survey design. Quantitative research procedures involving the administration of a survey instrument (Creswell, 2012).

Teacher preparation programs. Planned series of activities designed to prepare graduates for the teaching profession (NCATE, 2014).

Technology integration. The use of technology-based resources and practices in school and classroom activities (Ogle et al., 2002).

Thematic analysis. Identifying key ideas within a dataset (Guest, MacQueen, & Namey, 2012).

Limitations of the Study

The limitations of this study are:

1. Participants were limited to secondary math teachers of students with disabilities. Generalization of the results to other grade levels, subject areas, or student groups is limited.

2. The sample of participants was not random. Participants were secondary math teachers of students with disabilities identified by school principals who elected to complete the survey. Generalization of the results to the broader population of secondary math teachers of students with disabilities is limited.

3. The study relied on self-report data. Answers may have been influenced by participant perception of socially desirable responses and participant time constraints.

4. Delphi surveys are exploratory in nature, designed to build consensus around a specific topic. Inferences made from this data are limited.

5. Demographic information was not collected in the second and third rounds of the survey.

6. The study took place over a twelve-week period. Answers may have been influenced by current trends in the field of education.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Despite the importance of math skills to personal and professional outcomes, students in the United States continue to demonstrate proficiency below the international average (Kelly et al., 2013), and students with disabilities often have increased difficulty achieving proficiency due to characteristics of their disabilities (Geary, 2004). Higher-level thinking skills including reasoning, interpretation, and application are areas of particular weakness (OECD, 2012). Even with an ongoing focus on educational reform, there continues to be an overall lack of improvement in student math outcomes over time (Kena et al., 2015; NCES, 2012; USDOE, 2013). Without proficiency in these skills, students often lack access to more lucrative post-secondary opportunities available to their math-proficient peers (Hartwig & Sitlington, 2008).

In an effort to increase math proficiency outcomes, reform has focused on evaluating math instruction, identifying effective practices, and developing standards and expectations for the field (Kilpatrick, 2014). Research suggests that technology can be used to improve the math outcomes of students with disabilities in multiple skill areas (Strickland & Maccini, 2010). Professional teaching organizations also recognize the importance of including courses in technology-based instructional strategies in teacher preparation programs (CAEP, 2015). The following review will discuss the literature related to technology integration in secondary classrooms and teacher preparation programs.

Technology Integration in the General Education Curricula

Multiple applications of technology have been used to target math skills in general education settings. Researchers have explored the effects of virtual tutoring (Maloy et al., 2010) and virtual manipulatives (Reimer & Moyer, 2005; Steen et al., 2006) on math performance.

Instructional approaches incorporating mobile device applications (Kiger et al., 2012; Musti-Rao & Plati, 2015) and computer-assisted instruction (Barrow et al., 2009; Gesbocker, 2011; Roschelle et al., 2010) have also been evaluated.

Maloy et al. (2010) evaluated the effect of online tutoring on the problem-solving and test-taking skills of fourth-grade math students. The focus was on overall growth, as well as the relationship between growth and the use of special hint features programmed into the tutoring system. The researchers also used qualitative measures to explore how teachers integrated the intervention into instruction. A total of 125 students and their teachers from five fourth-grade classrooms participated in the study. The classes ranged in size from 20 to 37 students and were located in three rural Massachusetts public school districts. The intervention was conducted in a computer lab in each participating school during math or computer instruction time.

A pretest posttest design with no control group was used, and the assessments were created using math problems from previously-administered standardized tests in Massachusetts. Participants were trained in 4MALITY, a web-based tutoring system, completed a pretest, and then used 4MALITY once per week over a period of 10 weeks to practice third- to fifth-grade math content. The system displayed on-screen math problems and incorporated virtual coaches that provided problem-solving hints in the areas of language, computation, strategy, and pictorial representation, as well as a scoreboard as a motivational tool.

Participants earned points for correct answers, as well as points for corrected answers. For corrected answers, more points were awarded if hints were accessed prior to selecting a response. In two of the three schools, the intervention was part of a multi-activity, small-group rotation that also included computer math games, math board games, and creative writing of math problems. After completing six modules, a posttest was administered.

Descriptive statistics (i.e., median, mean, standard deviation, minimum, maximum, first quartile, third quartile) were calculated, and a two-tailed matched-pair *t*-test was used determine statistical significance. An analysis of variance (ANOVA) was also used to determine if classroom growth averages were significantly different. To evaluate the use of hints, a regression model was used to correlate the number of hints used to growth performance. Researchers also conducted classroom observations to collect qualitative data.

Results from the data indicated that 70% of students had higher scores following the intervention, with a mean gain of 25.51% for all students. For 36 students, the gain was 40% or higher from pretest to posttest. The gains were statistically significant (t = -12.58, $p < .01$), and the classroom averages were not significantly different. The regression model indicated that the number of hints used did not predict the posttest score ($p < .45$). Qualitatively, researchers observed students in two of the three schools using the hints, carefully considering answer choices, and actively engaging in writing their own math problems.

Maloy et al. (2010) concluded that, although the score increase could not be wholly attributed to 4MALITY, a combination of online and in-person math activities can be an effective alternative to whole-group instruction. The length of time of each activity type can be flexibly adjusted to meet the needs of the classroom. In addition, the researchers observed students engaging in increased problem-solving activities as opposed to clicking quickly on answers without thoughtful consideration. The researchers suggested that future research focus on applying the integrated approach (i.e., web-based tutoring, math games, and creative math writing) over a longer period of time.

Steen et al. (2006) also used mixed methods design to examine the effect of virtual manipulatives on geometry skills. Specifically, the researchers compared the use of virtual

manipulatives to the use of textbook-based practice exercises and investigated teacher perceptions of student attitudes and behaviors. Thirty-one first-grade students and two teachers participated in the study. The students included 21 Caucasian students, three African American students, three Asian students, two Hispanic students, one Native American student, and one Middle Eastern student. Both teachers had similar academic backgrounds and teaching experience. The study took place in an urban elementary school in the U. S. Forty-three percent of students who attended this school qualified for free and reduced lunch. In terms of home technology, 77.4% of families had computers in the home, and 64.5% also had internet access.

A pretest-posttest design with control group was used, with both students and teachers randomly assigned to either treatment or control group. The study lasted 13 instructional days and targeted the same geometry skills. Both groups received instruction based on the textbook. The treatment group then used web-based virtual manipulatives to practice skills. The control group used worksheets and tangible manipulatives.

First- and second-grade assessments provided by the textbook publisher were used as both pretests and posttests. The second-grade assessment was included to eliminate the potential for a ceiling effect on the first-grade assessment. The teacher for the treatment group recorded perceptions and observations related to on-task behavior, effectiveness, and practice time. The researchers calculated descriptive statistics and used *t*-tests to perform comparisons. A two by two mixed model ANOVA was also used to evaluate changes in performance from pretest to posttest.

On both pretests, the treatment group began at a significantly lower level (first-grade: M = 71.6%; second-grade: M = 62.8%) than the control group (first-grade: M = 89.5%; second-grade: M = 72%). The treatment group outscored the control group on both posttests and made

significant improvement from pretest to posttest ($p < 0.05$). The posttest means were 93% for the treatment group, and 86% for the control group.

The results of the ANOVA indicated a significant main effect for within factor and a significant interaction between pretest to posttest and group membership with a large effect size (F (1, 29) = 7.17, p = 0.012, partial $\eta 2$ = 0.2). Follow-up tests were then conducted on the simple main effects, and no significant difference was found between groups on the pretest or posttest. However, a significant difference was found from pretest to posttest for the treatment group ($p \leq 0$) and the control group (p = .004).

Based on the *t*-test results for the first-grade test, mean changes were 7.81 for the treatment group and 2.13 for the control group. A significant difference ($p \leq 0$) was found between the groups with a large effect size (ES = 1.47). The *t*-test results for the second-grade test indicated mean changes of 7.25 for the treatment group and 3.33 for the control group, a significant difference between the groups (p = .012) with a large effect size (ES = 0.94). The teacher of the treatment group also observed increased instructional time, increased repetition of practice, increased time on task, increased motivation, and increased work levels.

Steen et al. (2006) concluded that, although both interventions may have resulted in increased performance, the virtual manipulative condition resulted in significantly greater overall improvement. The researchers noted that the treatment group was able to decrease the initial gap in performance and surpass the control group, indicating that the use of virtual manipulatives may be more effective than the use of traditional textbook-based practice activities. Students were also able to generalize virtual manipulative practice to the paper and pencil posttest assessments.

The researchers also noted that the use of virtual manipulatives allowed for instant feedback, opportunities for self-regulation, and increased instructional time. Virtual objects can also be manipulated in more ways than physical manipulatives, providing opportunities for increased conceptual understanding and addressing challenges that may be caused by motor skill deficits. The researchers suggested that future studies use a larger sample size, collect longitudinal data, and focus on individual student attitudes and behaviors. The collection of additional data is also recommended, including quantitative practice data, student survey data, and data related to effective feedback.

Reimer and Moyer (2005) also investigated the use of virtual manipulatives. The researchers focused on student understanding of fraction concepts and student attitudes toward virtual manipulatives. The participants were 19 third-grade students (10 Caucasian, three Middle Eastern, three Asian, two Hispanic, and one African American). Participants included students with learning disabilities, English language learners, and gifted and talented students. A suburban school with a diverse population was used as the study site. Initial instructional sessions took place in a classroom setting, and practice sessions were held in an on-site computer lab.

A pretest-posttest design with no control group was used to collect data. During the first half of the two-week intervention, students were introduced to the use of web-based virtual manipulatives for addition and subtraction problems. During the second week, students were taught a unit on fractions and used various virtual manipulative sets from the National Library of Virtual Manipulatives website for one hour per day to solve fraction-related problems on a teacher-made worksheet. A teacher-made assessment for conceptual knowledge and a teacher-made assessment for procedural knowledge were used as pretests and posttests. To measure

social validity, daily student interviews were conducted, and a Likert-type scale student survey was administered.

Paired *t*-tests were used to compare pretest and posttest measures on both procedural and conceptual knowledge. The relationship between student scores on both posttests was evaluated by calculating Pearson's correlation. For the qualitative measures, a narrative analysis procedure was followed to identify overarching themes.

Participants scored significantly higher on the conceptual knowledge posttest ($M = 11.0$) than on the pretest (M = 9.58), $t(l8) = 2.05$, $p < .05$. Analysis of the student survey data showed that students believed that the immediate feedback provided by the virtual manipulatives helped them learn more and made math more enjoyable. Students also felt that virtual manipulatives were easy to use. Overall, student responses were 59% positive, 23% neutral, and 18% negative.

No students responded negatively to questions related to ease of use and enjoyability. Negative responses indicated that some students did not perceive virtual manipulatives to be learning tools. Qualitative analysis of the student interviews identified four themes: (a) students felt virtual manipulatives helped them learn, (b) students liked the immediate feedback, (c) students felt virtual manipulatives were easier and faster than paper-and-pencil methods, and (d) students enjoyed using the virtual manipulatives.

Based on the results of the study, Reimer and Moyer (2005) concluded that virtual manipulatives can positively affect students' conceptual knowledge. The researchers emphasized that the benefits of virtual manipulatives include the dynamic nature of the images, the visual support provided by the medium (e.g., symbols, written words, objects), and the ability to provide immediate feedback and individualize pacing based on students' needs. Initially, participants had difficulty explaining concepts, but the use of virtual manipulatives increased

students' ability to explain and represent math concepts. The researchers also emphasized the participants' positive attitude towards the intervention and the potential impact on student engagement. Reimer and Moyer (2005) suggest that future research focus on exploring the use of multiple representations and dynamic formats to simulate math concepts.

Musti-Rao and Plati (2015) compared the effects of two interventions, detect-practice-repair (DPR) and self-mediated iPad instruction on multiplication fluency. Participants were 12 third-grade students without disabilities. One student was Asian, and the remainder were Caucasian. The study took place in a co-taught classroom in a suburban school in the northeastern U. S. The school population was 83% Caucasian, 11% Asian, 4% Hispanic, and 1% African-American, with no English language learners or students receiving free or reduced lunches. The classroom had one general education teacher, one special education teacher, and one teaching assistant.

The researchers used an adapted alternating treatments design which included a baseline phase, a three-week treatment phase, and a final best treatment phase (i.e., treatment using the intervention that resulted in the most positive outcome during the initial treatment phase). During the study, the special education teacher provided pull-out services to students with disabilities while general education students participated in the intervention. Prior to the study, the concept of multiplication was introduced to students without explicit instruction or practice. One daily 10-minute session was conducted for each condition with all students participating in both conditions each day.

In the iPad condition, participants utilized the *Math Drills* application to review, practice, and test multiplication fact fluency. Initially, each multiplication fact was presented individually on the screen with an animated number line as a visual support. The students would then solve

the multiplication fact without the number line and be automatically advanced to the test mode when the correct answer was entered. During the test mode, the students again solved the multiplication fact, but a score was recorded for each answer.

In the DPR condition, students completed the detect phase by answering multiplication facts on a probe sheet. During the practice phase, students watched a PowerPoint presentation that presented each multiplication fact individually one slide at a time. Participants then selected five facts from their probe sheet for the repair phase and practiced them for five minutes using the cover-copy-compare strategy and completed a one-minute assessment probe.

In both conditions, participants then completed a timed assessment probe and graphed their performance. The researcher-developed assessment probes included 36 relevant multiplication facts and were also used as baseline measures. Additional researcher-developed screening probes were used as timed pretest and posttest measures. Maintenance and generalization probes were also administered following the treatment phase, with generalization probes including the inverse of the multiplication facts practiced during the treatment phase. Researchers collected data on digits correct per minute (DCM), response rate (RR), and practice time. Visual analysis was used to evaluate student performance. In addition, students, parents, and teaching staff completed surveys to assess social validity. Interscorer agreement was calculated for baseline and intervention, and procedural integrity was assessed with a researcher-developed checklist.

Results indicated that both interventions were effective, but student performance increased more under the iPad condition. During initial sessions, overlap existed in both DCM and RR data. Both conditions resulted in an increasing trend; however, the slope was steeper in the iPad condition, indicating more rapid improvement for students in this condition. Only one

student demonstrated comparable DCM in both conditions. Participants provided twice as many responses in the iPad condition. Mean practice time was 40.1 minutes for the iPad condition and 39.6 minutes for the DPR condition. Some students spent less time practicing in the iPad condition, but this comparison may have been skewed by the fixed five minutes of practice time required in the DPR condition. Participants were also continued to demonstrate learned skills during both maintenance and generalization phases.

Interscorer agreement for baseline and intervention was over 99%, and procedural integrity measures were 100% for both conditions. Social validity measures indicated that students, teachers, and parents preferred the iPad condition. The teacher and assistant considered the iPad condition easy to implement, motivating for students, and useful for increasing independent work time. Students described the iPad condition as more effective in increasing learning and easier due to the ability to type answers.

Musti-Rao and Plati (2015) concluded that the use of applications on mobile devices can increase math fact fluency in a whole group setting. Although both conditions were effective in increasing math skills, the iPad condition resulted in larger gains, and students were able to work with a lower level of adult support. Based on social validity measures, the researchers noted that the use of mobile applications may increase motivation and decrease fatigue. The ease of implementation may also increase the likelihood that teachers would implement and sustain the intervention with minimal training needs.

The researchers also concluded that mobile applications allow for immediate feedback which helps to address the issue of students practicing inaccurate responses. Students are also increasingly familiar with technology, so their technology knowledge can be used to supplement instruction. The researchers recommend that future research focus on evaluating the effect of

each intervention separately, controlling for practice time, and investigating the effect of mobile applications on on-task behavior. Future research should also explore the use of mobile applications with different populations and with more complex math skills.

Kiger et al. (2012) also used mobile devices in their investigation of the effect of iPod Touch applications on math performance. The researchers examined the effect of the intervention in relation to multiple covariates. Four third-grade classes from a midwestern elementary school participated in the study, including four teachers and 87 students. The school population was 88% white, 54% male, 29% economically disadvantaged, 16% special education, and 2% English language learners.

A regression-adjusted covariate comparison group design was used to explore the effect of the nine-week intervention on multiplication skills. Based on a pre-intervention survey, the four classes were comparable in terms of student demographics and teacher experience. Two of the classes used the *Everyday Math* curriculum implemented by the school. This approach involved whole-group, small-group, and individualized instruction followed by daily practice using tools such as flash cards and fact triangles. The intervention group received the same *Everyday Math* instruction; however, daily practice involved the use of applications on an iPod Touch. Participants spent 10 minutes using a maximum of two apps per session.

A 50-question researcher-developed pretest and a 100-question researcher-developed posttest were used as measurement tools. Data analysis included the calculation of measures of central tendency and Cohen's *d* for effect size comparison. An ordinary least squares multivariate regression analysis was also used to control for covariates, and a standardized beta was calculated to evaluate the magnitude of the intervention's influence. Dependent variables

included both overall performance on the posttest and performance on the most difficult posttest items.

On the posttest, the intervention group ($M = 54.5$) outperformed the comparison group ($M = 46.3$) and had a statistically significant medium-sized performance advantage ($b = .217$). The intervention explained 68.1% of the variance. Math-related effort and attitude were also influential predictors. On the most difficult test items, the intervention group ($M = 11.6$) also outperformed the comparison group ($M = 8.2$), but the intervention was less powerful ($b = .201$) in predicting performance. The intervention explained 42.9% of the variance, but both student demographics ($b = .213$) and teacher degree ($b = .210$) were also influential predictors.

Kiger et al. (2012) concluded that the higher performance of the intervention group supports the use of mobile applications as a cost-effective method to improve math performance. However, the researchers noted that the success of mobile technology requires institutional commitment, teacher training and support, and an ongoing accountability plan. The researchers recommend that future studies focus on longitudinal results, logistical challenges, application with diverse student groups and in diverse settings, and expansion beyond a single device.

Barrow et al. (2009) used a quasi-experimental pretest-posttest design to compare the effects of a computer-based intervention to traditional instruction on math skills. Participants were 57 teachers and 3,541 middle and high school students from 142 classes. In total, 15 high schools and two middle schools with demographics representative of their districts participated in the study. The study was conducted in three large, urban school districts from different regions of the U.S. The school districts selected had a high percentage of minority students and difficulties with student achievement and teacher recruitment.

Participants were randomly assigned at the classroom level to either the computer-aided instruction condition or the control condition. Both groups had comparable demographics, class size, and abilities. In the computer-aided condition, participants used *I Can Learn*, a computer-based math intervention that included a pretest, a review of prerequisite knowledge, new concept instruction, periodic cumulative review, and comprehensive tests. Students completed pre-algebra and algebra lessons at their own pace, with no advancement to subsequent lessons until mastery was achieved.

In the control condition, students were taught using traditional methods that did not include instructional software. An outside company developed a 30-item assessment that was used to measure baseline and postintervention performance. Benchmark exams and state-administered standardized tests were also used as performance measures. Results indicated that the three assessments were highly correlated. Demographic data were also collected from the schools.

The researchers calculated descriptive statistics and used empirical models to compare test scores. Results indicated that students in the computer-assisted instruction condition significantly outperformed the students in the control condition on all measures. The researchers also examined the effect of the intervention in relation to attendance, class size, and ability range. Although the intervention did have a positive effect on students in large classes and classes with a diverse range of abilities, the effect was not statistically significant. However, the intervention did have a larger effect for students in classes that were both larger and had students with a wider range of student abilities. The intervention was also more effective for students with historically poor attendance.

Barrow et al. (2009) concluded that the evidence supported the use of computer-assisted instruction to increase individualization of instruction. The researchers also suggested that computer-assisted instruction may provide benefits similar to class size reduction, but at a slightly lower cost and with greater ease of implementation. Finally, the researchers recommended that future research focus on further evaluation of computer-assisted instruction and policies to support implementation.

In another investigation incorporating computer-assisted instruction, Roschelle et al. (2010) conducted three studies over a period of two years to examine the impact of instructional units with a technology component on advanced middle school math skills. Participants were seventh- and eighth-grade teachers with diverse backgrounds, knowledge levels, and attitudes. Seventh-grade studies focused on rate and proportionality, and the eighth-grade study targeted linear function. In Year One of the study, 95 seventh-grade teachers completed the study, and 67 of those teachers also completed Year Two.

The eighth-grade teachers were added in Year Two, and a total of 56 eighth-grade teachers completed the study. Based on initial surveys, the students in the selected classes had diverse demographic characteristics and math abilities. The study sites included schools in seven Texas regions with a wide range of poverty levels, school sizes, and student ethnicities. The teacher characteristics were comparable to the means of their region and the state overall.

Two randomized controlled experiments with one embedded quasi-experiment were conducted, and randomization was done at the school level to avoid cross-contamination within schools. The eighth-grade experiment was also done at a different school to avoid carryover effects from the seventh-grade experiments. For each experiment, a control group was provided with business-as-usual instruction, and the treatment group was instructed in the same concepts

using an integrated SimCalc unit that included professional development, curriculum, and the representational software *Math Worlds*.

Initial participant workshops covered both the intervention and general content knowledge. In order to minimize the possibility that professional development alone might account for intervention effects, the control group also received professional development focusing on content knowledge only. Following the professional development, teachers implemented the provided concept units over a two- to three-week period.

The units included lesson plans and guidance for small-group work, whole-class discussion, and independent seat work, as well as the use of the Math Worlds software. Students used the software to apply math concepts to real-world scenarios as either soccer team managers or game designers. Researcher-developed assessments were used as pretest and posttest measures, and question types included multiple choice, short answer, and representation construction. Data were also collected from teacher logs, surveys, and interviews.

Descriptive statistics were calculated, and hierarchical linear modeling was used to evaluate the effects of the intervention. Both intervention and control groups began with similar pretest scores, but the intervention group demonstrated consistently higher gains over the course of the intervention. Results indicated a statistically significant main effect for both the two seventh-grade experiments and the eighth-grade experiment (ES = .63, .50, and .56, respectively). Multiple models were also used to examine the effect of gender, ethnicity, prior achievement level, and free or reduced lunch as covariates. Results for covariates were nonsignificant for the two primary experiments; however, in the quasi-experiment, ethnicity, region, and free or reduced lunch were negative predictors of posttest scores. Teacher feedback measures did not indicate that either control or treatment condition was preferred.

Roschelle et al. (2010) concluded that the integration of technology, curriculum, and professional development can be used with diverse students and teachers in diverse settings to improve the advanced math skills of middle school students. The inclusion of representational software also allows students to practice basic skills and apply more advanced concepts simultaneously. Based on the findings, the researchers also indicated that the intervention can be successfully implemented by teachers of diverse experience and attitudes. The researchers recommended that future studies apply the intervention with variations in sample, setting, assessment, software, and mathematical concepts. Longitudinal studies to evaluate gains over time were also suggested.

Gesbocker (2011) also investigated computer-assisted instruction when conducting a three-pronged study that examined the relationship between basic math fact knowledge and standardized test scores, as well as the effect of computer-assisted instruction on math fact knowledge with a focus on gender differences. For the test correlation study, 998 sixth-, seventh-, and eighth-grade students participated in the study.

A total of 59 students from two seventh-grade classes and their two teachers participated in the computer-assisted instruction portion of the study. These participants all scored below 240 on the Illinois Standards Achievement Test (ISAT), and the two classes were 30.5% Hispanic, 33.9% African American, 26.1% Caucasian, 5.1% multiracial, and 3.4% Asian, with 14% English language learners, 44.1% free and reduced lunch, and 23.7% students with Individualized Education Programs (IEPs). The study took place in a suburban middle school with an approximate total enrollment of 1,000 students.

For the test relationship question, a correlational study compared scores on the ISAT to scores on a two-minute multiplication and division drill created by an outside company. To

evaluate computer-assisted instruction, a quasi-experimental switching replications design was used over a period of 16 weeks. The 30-minute intervention sessions took place three times per week, and the two-minute multiplication and division drill was used as both a pretest and a posttest at the end of the two phases of intervention.

For the first eight weeks of the study, one class was instructed in basic multiplication and division facts using traditional instructional components such as flash cards, paper-and-pencil practice, and oral practice. During this time, the other class used *FASST Math*, a computer-based intervention focusing on basic multiplication and division skills.

FASST Math included a placement assessment, adaptive instruction based on assessment results, independent practice games, rewards, and 44 levels of timed assessment. Students were unable to advance to a new level until mastery was achieved on the current level. At the end of the first eight-week period, a posttest was given to both groups. The classes then switched conditions for the remaining eight weeks of the study, and a final posttest was administered at 16 weeks.

Correlational analysis and visual analysis of scatterplots was used to evaluate the test relationships. A moderately high correlation was found between the two-minute drills and the ISAT (r =.45, $p < .001$). For the computer-assisted instruction question, descriptive statistics were calculated and repeated-measures analysis was used to assess group differences. The researchers constructed two linear contrasts to evaluate both group differences and gender differences.

Although the average pretest score was comparable for both groups, participants in the first computer-assisted instruction condition demonstrated significantly larger growth rates than their counterparts in the traditional instruction condition, $F(1, 44.58) = 9.66$, $p < .01$), with a

large effect size. Participants in the second computer-assisted instruction condition also outperformed the students in the traditional instruction condition, $F(1, 57) = 6.42$, $p = .01$, with a moderate-to-large effect size. Males did not show significantly greater growth than females on posttest measures.

Gesbocker (2011) concluded that the test correlation results emphasize the impact of basic math fact knowledge on overall math performance. The researcher also noted that technology-based interventions can be more effective than traditional methods in helping both male and female students master basic math facts. In addition, Gesbocker (2011) concluded that computer-assisted instruction provides multiple benefits, including multimedia features, learner control, immediate feedback, and increased individualization capabilities. The researcher recommended that future research focus on teacher and administration perceptions, student motivation, subgroup comparisons, additional software applications, and evaluating longitudinal results.

The use of technology in general education settings can increase student motivation and engagement (Maloy et al., 2010; Musti-Rao & Plati, 2015; Reimer & Moyer, 2005) when learning math skills. Other benefits of technology-based interventions include immediate feedback (Gesbocker, 2011; Reimer & Moyer, 2005; Steen et al., 2006), dynamic features (Gesbocker, 2011; Reimer & Moyer, 2005), increased individualization (Barrow et al., 2009; Gesbocker, 2011; Reimer & Moyer, 2005; Steen et al., 2006), and ease of implementation (Barrow et al., 2009, Musti-Rao & Plati, 2015; Roschelle et al., 2010). Additionally, educational technology can be effectively combined with curriculum to improve math performance (Maloy et al., 2010; Roschelle et al., 2010). However, planning, training, and commitment are essential to support successful implementation (Kiger et al., 2012).

Technology Integration for Students with Disabilities Related to Math

Educational technology has also been used to address the math deficits of students with disabilities. Interventions incorporating virtual manipulatives (Bouck et al., 2014), iPad applications (Haydon et al., 2012), and computer-assisted instruction (Burns et al., 2012; Seo & Bryant, 2012) have been explored. Researchers have also investigated game-based learning (Ke & Abras, 2013), synchronous peer tutoring (Tsuei, 2014), and video-based interventions (Burton et al., 2013; Bottge et al., 2014).

Bouck et al. (2014) compared the effect of concrete and virtual manipulatives on the subtraction skills of students with Autism Spectrum Disorder (ASD). Three males with ASD ranging in age from six to 10 met the criteria for participation (i.e., subtraction deficit and the fine motor skills necessary to work with virtual and concrete manipulatives). The participants did not attend a school setting, but did receive full-time interventions focusing on communication, social skills, and/or behavioral skills at a clinic specializing in providing support for students with ASD. The intervention took place at the clinic site, with an office used for the concrete manipulative condition, and a computer room used for the virtual manipulative condition. No control group was used.

The single-subject alternating treatments design included pre-training, baseline, intervention, maintenance, and generalization phases. In the pretraining phase, students were given instruction on the use of concrete and virtual manipulatives to solve addition problems. During three of the six baseline sessions, students had access to concrete manipulatives, and during the other three sessions, students had access to a computer with virtual manipulatives. No instruction or training on the use of manipulatives for subtraction problems was provided.

During the 10 sessions in the intervention phase, participants completed five subtraction problems in either the concrete manipulative or the virtual manipulative condition with no more than two consecutive sessions in either condition. In the concrete condition, students had access to concrete base-ten blocks to solve problems. In the virtual condition, students accessed the free National Library of Virtual Manipulatives website. The interventionist typed the problem on the right side of the computer screen, and the student accessed virtual manipulatives on the left side of the screen to solve the problem. In all sessions, the interventionist provided prompting (e.g., verbal, modeling) until the correct response was achieved.

Three maintenance sessions using the virtual condition and no prompting and six sessions of generalization with no prompting were measured. Half of the generalization sessions involved use of concrete manipulatives to purchase items in a token economy. During the other half of the generalization sessions, participants accessed virtual manipulatives to solve problems on a worksheet in different settings throughout the clinic. In all phases of the intervention, researchers used event recording to collect data on accuracy and independence.

Visual analysis was used to evaluate the data. Accuracy was defined as the percentage of correctly completed subtraction problems without prompting, and independence was defined as the percentage of steps from a task analysis completed without prompting. A treatment fidelity checklist was used across 32.3% of the sessions, and interobserver agreement was measured during 30% of all phases. Social validity measures included both student and teacher interviews. Between baseline and intervention, no overlap of data was observed for any participants.

In both conditions, all students increased in accuracy and independence over the course of the intervention and demonstrated learned skills during maintenance and generalization

phases. Independence increased more during the virtual condition. Overall, generalization scores were lower in the virtual condition than in the concrete condition. Treatment fidelity was 100% for all students, and interobserver agreement was 100% for accuracy and averaged 93% for independence across all participants. Social validity measures indicated that both students and interventionists preferred the virtual condition.

Bouck et al. (2014) concluded that both forms of manipulatives assisted students in accurately and independently solving subtraction problems and generalizing these skills to real-world scenarios. However, the researchers emphasized that virtual manipulatives supported students in developing independence at a quicker rate than concrete manipulatives. The decreased performance during generalization was attributed to the need for students to set up problems independently, a task which was previously completed by the interventionists.

The researchers identified the benefits of virtual manipulatives as cost effectiveness, built-in opportunities for motivation (e.g., animation), and ease of use for both teachers and students. The use of virtual manipulatives also required less prompting and allowed for more opportunities for self-correction. The researchers suggested future research in school-based settings, with different disability populations, and with different measures for the accuracy variable.

Haydon et al. (2012) compared the effects of two treatment conditions (iPad and worksheet) on math fluency and engagement. The study was conducted with seven participants and was designed to compare math problem-solving accuracy and rates of engagement in both conditions. However, permission and assent was received from only three tenth- and eleventh-grade students. These three tenth- and eleventh-graders were identified as having emotional disturbance and had math deficits. The study was conducted in an urban alternative school

setting in the midwestern U.S. The campus served the needs of approximately 65 second- to twelfth-grade students with significant mental health and behavioral needs. The intervention took place in a classroom during the 40 minutes allocated for math instruction.

Over a period of five weeks, an alternating treatments design with no control group was used to investigate the effects of a traditional worksheet condition and an iPad condition on the money, fraction, numerical pattern, and order of operations skills of participants. In the fifteen 26- to 40-minute sessions, the teacher conducted group instruction in the targeted skills, including introducing the topic, reviewing prior knowledge, explaining definitions, and working through problems. During this time, the students were given opportunities to respond, engage in guided practice, and ask questions. The students then began independent seatwork in either the worksheet condition or the iPad condition. Teachers monitored progress and answered questions, and both conditions included tasks at similar difficulty levels.

In the worksheet condition, the teacher provided a worksheet for students to complete based on the targeted skills. When students finished the worksheet, the session was ended. In the iPad condition, students typically worked for the entire 40-minute session. Three iPad applications (iTooch MATH Grade 5-LITE v.2.1, Coin Math v.3.0, and enVisionMATH: Understanding Fractions v.1.1) were used to teach the targeted skills. When students finished with the applications, they could access the application Motion Math for the remainder of the session. Data were collected on the dependent variables (correct responses per minute and active engagement). For active engagement, momentary time sampling was used during all math sessions, and data were recorded on an interval recording form.

Mean values were calculated for the dependent variable, and visual analyses were conducted for level, trend, and immediacy of effect. The percent of non-overlapping data were

also calculated, and interscorer agreement was measured for 40% of the sessions. A checklist detailing all procedural steps was used to measure intervention adherence. In addition, a social validity survey with a Likert-type scale was competed by both the teacher and the students.

Results of the analyses indicated that participants solved more math problems correctly in less time in the iPad condition. The mean participant scores for problems correct per minute in the worksheet condition ranged from .65 to 1.23 with an overall mean of .66. In the iPad condition, the mean participant scores were 2.55 to 3.93 with an overall mean of 3.24. In the area of engagement, the students in the iPad condition demonstrated increased engagement. The mean participant scores were 69.3 to 88.7 with an overall mean of 81.4 in the worksheet condition and 98.0 to 100 with an overall mean of 98.9 in the iPad condition.

The percent of non-overlapping data could not be calculated accurately; however, all iPad measurements over the course of the study exceeded the highest data point recorded in the worksheet condition. The average interscorer agreement was 100% for problems correct per minute and 94.6% for active engagement. Intervention adherence measures were 100% for all sessions in both conditions, and social validity measures indicated that both teacher and students preferred the iPad condition.

Based on the higher scores in the iPad condition, Haydon et al. (2012) concluded that the use of the iPad allowed students to complete more problems accurately with higher levels of engagement than the traditional worksheet method. The researchers suggested that the positive results may be an indication of the technology's ability to provide increased immediate feedback on both correct and incorrect responses, as well as immediate scores at the end of each math session. Immediate feedback may provide positive reinforcement for correct responses and prevent inaccurate practice for incorrect responses. In the worksheet condition, teachers are not

able to provide the level of immediate feedback that is possible when students are engaged in one-to-one technology.

During observations, the researchers noted that students also demonstrated increased persistence and concentration, as well as decreased levels of frustration. For students with emotional disturbance, the use of iPad applications may improve the effectiveness of independent work time. The researchers recommended that future research include pretest assessments, verify equivalent difficulty level of problem sets, and use varied math content and applications. In addition, the researchers suggested that future research focus on optimizing the level of technology integration.

Burns et al. (2012) investigated the effect of a computer-based math fluency intervention on the math skills of students identified as at risk for math difficulties. Specifically, the researchers compared the growth rates of students at risk for math difficulties to both the control group and to students with severe math deficits. The researchers also evaluated the percentage of students remaining at risk for math difficulties after completing the intervention.

Participants in the intervention group included 145 third-grade students and 86 fourth-grade students. The control group was comprised of 150 third-grade students and 90 fourth-grade students. All participants scored below the 25th percentile on the pretest. The study was conducted at 104 elementary schools in 26 states. Student-specific demographic information was not available; however, the schools' average enrollment was 534.8 students (65.8% eligible for free and reduced lunch; 52.58% Caucasian, 19.92% African American, 1.58% Asian American, 23.31% Hispanic, and 2.42% Native American). The computer-based math intervention, *Math Facts in a Flash*, was used to independently practice math facts at least three times per week over the course of eight to 15 weeks. The control group also accessed the

intervention software program; however, participation occurred less than once per week over a time period of less than eight weeks. Each session was completed on a computer within five to 15 minutes and included 40 math problems in the four basic math operations at the student's pre-determined level. The problems appeared on the screen, the student selected the correct answer, and the overall results were displayed on the screen at the end of the session. After mastering each level, students would move on to the next level with periodic reviews of previous levels.

A pretest-posttest design was used with the *StarMath* computer-adapted achievement test (Renaissance Learning, 2002) used for both measures. The scores were converted to normal curve equivalents (NCEs), and the pretest NCEs were subtracted from the posttest NCEs to determine the NCE growth score. An analysis of covariance (ANCOVA) was conducted using the NCE growth score as the dependent variable and the pretest NCE as the covariate. To account for the two grade levels, an alpha level of .025 was used. Cohen's *d* was also calculated, and a $\chi 2$ nonparametric test was conducted.

Significant effects were found for the growth-pretest ANCOVA for both third-grade students, $F(2, 278) = 4.24$, $p < .025$, and fourth-grade students, $F(2, 158) = 4.61$, $p < .025$. The intervention group had significantly larger score increases than the control group. Effect sizes ranged from small for third grade ($d = .34$) to moderate for fourth grade ($d = .44$). The comparison of at-risk and students with more pronounced deficits did not result in significant effects for students in third, $F(1, 276) = 0.24$, $p = .63$, or fourth grade, $F(1, 156) = 1.29$, $p = .2$, indicating that both groups grew at similar rates. Finally, the percentage of participants who scored above the 25th percentile (above the at-risk range) after the intervention was greater in the intervention group than the control group with a significant effect in both third grade, $\chi 2(n = 103, df = 1) = 8.56$, $p < .025$, and fourth grade, $\chi 2(n = 60, df = 1) = 9.86$, $p < .025$.

Burns et al. (2012) concluded that the computer-based intervention was effective in remediating the math deficits of students at risk for math difficulties and noted the benefit of increased practice opportunities. The authors recommended that future research focus on determining whether fluency-based or conceptually-based math interventions should be used with this population. Additionally, the authors suggested that replications of the study include a multi-tiered intervention model, measures of instruction quality, measures of teacher supervision needs, periodic progress monitoring, and direct observation of student interaction with the intervention software.

Seo and Bryant (2012) also examined the effect of a computer-based intervention, *Math Explorer*, on the word problem-solving skills of students with math difficulties. The intervention focused on teaching participants to apply cognitive and metacognitive strategies to one-step and two-step addition and subtraction word problems. Accuracy on computer-based tasks, generalization to paper-based tests, and skill maintenance were the targeted outcomes of the study.

Four students with teacher-identified math difficulties participated in the study. The teachers based identification on the response-to-intervention model and student performance on the state standardized test. Participants were all in the second or third grade and included one white female student, two male Hispanic students, and one African American male student. All students were eligible to receive free and reduced lunch. The intervention took place in a public elementary school in a mid-sized city in Texas with an enrollment of 850 students. The school-level demographic information indicated a student population of 12.82% African American, 0.35% Asian, 82.94% Hispanic, and 3.76% White. For the intervention, students were moved to a hallway tutoring area or to a conference room if a quieter space was needed.

A multiple probe across subjects design with no control group was implemented over a period of 18 weeks. Researchers designed both computer-based and pencil/paper-based tests for screening, baseline, intervention, and follow-up assessments. The test problems were selected from the *Math Explorer* database and included 18 problems (nine from each of the two difficulty levels available in the software), and students were given 10 minutes to complete the assessment. All problems were one- and two-step addition and subtraction word problems that required students to change, combine, or compare values. All participants scored 30% or less on the assessment during the screening phase.

After screening, baseline data were taken once per week on test performance until a stable baseline was reached. At that point, computer training was conducted to acclimate the first student to the technology, and the first student began the intervention. The second participant began the intervention when the first student had reached 70% accuracy on four consecutive tests, and this same criterion was used to begin the intervention with the two remaining participants.

The computer-based intervention provided instruction in a four-step cognitive strategy (i.e., reading, finding, drawing, and computing) for solving math word problems. Within each four-step cognitive strategy, students were taught to use a three-step metacognitive strategy (i.e., do activity, ask activity, and check activity). The software program included clear instructional goals, explicit modeling, guided and independent practice, prerequisite math skill review, vocabulary skill review, visual representations, feedback (related to instruction, ability, and effort), and a text-to-speech function.

Participants completed up to five intervention sessions per week. Within each session, participants spent 20 to 30 minutes using the software, followed by a ten-minute computer- or

paper-based assessment. After the intervention, follow-up was conducted once per week over a three- to six-week period to evaluate maintenance of skills. Prior to each follow-up session, the cognitive and metacognitive strategies were reviewed with the participants. The dependent variable was the number of problems solved correctly on the tests, and researchers evaluated the data by visually inspecting scores. Between each phase, stability, level change, and trend direction were analyzed.

The data indicated an immediate increase in level and an accelerating trend for all participants. In addition, all participants exceeded the criterion level on both the computer- and paper-based tests, with slightly higher scores on computer-based tests. On maintenance measures, three of the four participants maintained their accuracy gains. Analysis of scores by problem type indicated that all participants scored higher on problems involving changing or combining values than on problems involving comparing values. Mean interrater reliability was 99% for both fidelity of students' use of software and for student engagement

Seo and Bryant (2012) concluded that computer-based instruction in cognitive and metacognitive strategies can be effective in improving the addition and subtraction word problem-solving performance of students with math difficulties on both computer- and paper-based tests. The researchers hypothesized that students benefitted from increased opportunities to practice. The researchers also theorized that the slightly lower scores on paper-based tests may have been related to the writing component of paper-based tests (e.g., increased time needed to write problems, errors in number alignment).

Further research was recommended to evaluate the intervention with more complex math skills, in other educational settings, with a larger population, with other disability categories, and with older students. In addition, the researchers recommended future investigation into the

development of technology-based interventions incorporating instructional design features, advanced technologies, learning strategies, and increased student-engagement features. Finally, the researchers suggested that future research designs control for concurrent teacher instruction to isolate the effect of the *Math Explorer* intervention.

Ke and Abras (2013) explored the effects of game-based learning on the math skills of middle school students. Nine socioeconomically disadvantaged students, including eight minorities, participated in the study. Six of the students had special education needs, and three students were English language learners. The study took place in one Native American pueblo school and one low-performing school with a high percentage of Hispanic students. Both schools were located in the southwestern U. S., and intervention sessions took place in school computer labs during a computer class period.

The researchers conducted a descriptive case study with no control group over the course of three weeks. Participants completed 15 one-hour sessions and were randomly assigned to one of three web-based pre-algebra games during each session. The math concepts in the games did not overlap with the math concepts currently being taught in the students' math classes. During the sessions, adult mentors provided feedback, prompting, and explanations on the games as needed. Data collection included observations, artifact analysis, progress reports, and knowledge tests.

Observations were conducted using a researcher-developed protocol which included the documentation of participant comments during the sessions. Artifact analysis involved the review of available game-based data, and progress reports were collected weekly from the participants' math teachers. The progress reports included current math grades as well as a teacher-completed Likert-type scale evaluation and descriptive comments related to each

student's math performance. Finally, knowledge tests were developed using concept-related items from state assessments. The knowledge tests were administered as both a pretest and a posttest measure and administered to 64 students at the participating schools. Member checks were conducted throughout the data collection process.

Qualitative data were consolidated and coded to identify common themes with each game as an individual case study. The same process was then used to analyze the data using each individual student as a case study. All cases were then reviewed together to identify patterns of interest. Quantitative analysis was also used to evaluate school performance and knowledge test results, and Cronbach's alpha was calculated to evaluate the reliability of the knowledge tests.

Cronbach's alpha for all knowledge tests was greater than 0.70. Mean posttest scores were higher than mean pretest scores for all three games. However, based on the results of three paired *t*-tests, pretest and posttest scores were significantly different for only one of the three games (t (8) = -5.54, p = 0.01). Thematic analysis revealed that additional support is needed to assist students with text comprehension; however, participants viewed additional mentoring during game play as intrusive. Student reflection was also more successfully demonstrated through game play demonstration than through question and answer interaction.

Thematic analysis also identified four features that supported increased student learning and engagement: relevance and engagement, embedded learning in game-play mechanics, game-based collaboration and competition, and immersive learning. The effective gaming experience provided relevance and engagement through a well-developed game world, reward and feedback structures, adaptable challenge levels, visual cues, and a sense of user control within the game world. Embedded learning required players to actively apply math concepts to navigate a game. Collaboration and competition were demonstrated by increased interaction related to teaching

peers how to navigate a game and comparing scores with peers. Finally, immersive learning involved increasing player engagement in concept-specific tasks more than engagement in game-related play.

Ke and Abras (2013) concluded that web-based games can be used to increase student learning and engagement when specific design features are included. Adaptive components are necessary to allow players to be challenged at their skill level. Visual cues are also important to increase understanding and support comprehension and retention difficulties. Learning games should also allow users to control aspects of the experience to increase confidence and decrease frustration.

In addition, the researchers suggested that effective learning games should demand active application of targeted skills, but also provide a balance of content and play. Support should be provided to players, but in the form of collaborative peer mentoring instead of adult instruction. The researchers recommend that future studies use an experimental design, examine program-embedded supports, and include more comprehensive assessment measures.

Tsuei (2014) used a single-case study to investigate the effect of the *G-Math Peer Tutoring System* on the math skills of students with learning disabilities. Four fourth-grade students who received additional support in math participated in the study. All four students were identified as having a learning disability, and one of the students was also diagnosed with a mild intellectual disability. The intervention was conducted in a resource classroom in an elementary school in Taipei.

The study included one weekly 40-minute session using the *G-Math Peer Tutoring System* for an entire school year. Following 10 minutes of teacher-directed instruction, the participants accessed *G-Math* on classroom computers for 30 minutes. For comparison purposes,

32 students in a general education class accessed *G-Math* once a month during the intervention period. The *G-Math* system presented math problems on a white screen surrounded by representational manipulatives (e.g., objects, symbols), communication tools, and motivational items. The four students worked in pairs at side-by-side computers viewing the same math problem and screen activity simultaneously.

For each problem, one student was the tutor and one student was the tutee. The system assigned problems related to the teacher-selected unit (i.e., fractions, whole integer computation, geometry). Tutors manipulated objects on the screen and solved the assigned problem as tutees watched and asked questions. After each problem, the system displayed the correct answer and awarded participants points based on accuracy. The participants then continued to alternate roles of tutor and tutee for each problem until the end of the 40-minute session. Throughout the intervention, the teacher observed the participants, provided corrective feedback, and rotated partners biweekly.

A curriculum-based measurement tool was used to collect baseline and intervention data. Three baseline probes were administered each semester prior to intervention. Weekly probes were then administered during the intervention phase. The 10 items on each probe were randomly selected from the web-based item bank and included conceptual, computational, and application-based problems. Scores were calculated by adding the number of correct digits.

The researchers calculated mean, standard deviation, and z score, and used non-parametric tests to compare mean score differences. Rosenthal's r was calculated to determine effect size. A linear growth function was calculated using least-squares regression, and Pearson correlation analysis and Mann-Whitney U-tests were also conducted. Both the average number of object manipulations and the average problem solution time were also calculated.

All participants improved overall math skills, with three participants improving significantly (*r* = -0.37, -0.53, -0.33) and one participant improving slightly (*r* = -0.13). The results of the Mann-Whitney *U*-tests indicated that three subjects improved significantly on conceptual problems (*r* = -0.37, -0.40, -0.68). None of the participants improved significantly on computational problems, and all subjects improved on application problems. Three of the subjects equaled or exceeded the normative growth rate of same-grade peers during the first semester. All subjects exceeded the normative growth rate during the second semester and had positive overall growth rates comparable to the growth rates of the comparison group.

Participants took longer on average to solve computational and application problems during the second semester than during the first semester and took twice as long as their general education peers or longer to solve these problem types. On average, participants took longer to solve computational problems than conceptual problems during both semesters. For conceptual problems, participants decreased solution time in the second semester and improved overall performance. Object manipulation increased during the second semester, and significant correlation was found between object manipulation and student scores on computational problems during the first semester ($r = .97$, $p < .05$). In the second semester, significant correlation was found for student scores on computational and conceptual problems ($r = .98$, $p < .05$; $r = 97$, $p < .05$; $r = .99$, $p < .01$).

Tsuei (2014) concluded that the *G-Math Peer Tutoring Syste*m can be effective in improving the math skills of students with learning disabilities in the areas of conceptual and application problem types. The researcher emphasized that the benefits of the intervention included the provision of virtual manipulatives and the ability to watch the problem-solving process of another student. Students who manipulated more objects had greater increases on

CBM probes. However, the researcher noted that the online intervention did not improve computational fluency, possibly due to the need to manipulate more objects in the online condition than in a traditional worksheet condition.

Based on teacher observations, the researcher concluded that the students enjoyed the intervention and demonstrated increased motivation. The researcher suggested that future studies focus on technology-supported peer tutoring with additional scaffolding and input tools, the use of virtual tutors to improve accuracy, and increased sample size. The researchers also recommended the collection of additional qualitative data to explore student interaction with the intervention.

Bottge et al. (2014) examined the effects of explicit and anchored instruction on fraction computation and problem-solving skills. A total of 335 students with disabilities and their 49 special education teachers participated in the study. All students were in sixth, seventh, or eighth grade and received math instruction in a resource setting. Approximately one-third of the students had intellectual disabilities, and the remainder had specific learning disabilities, other health impairments, autism or emotional behavioral disorders. The setting was 31 middle schools in an urban area in the southeastern U. S., and all sessions were conducted in one of 64 resource rooms on these campuses.

The researchers used a pretest-posttest cluster design to compare the two conditions of enhanced anchored instruction (EAI) and business as usual (BAU). Group assignment was randomized at the school level, and the study took place over 90 instructional days with sessions lasting from 45 to 90 minutes. The EAI group included 159 students in 15 schools, and the BAU group included 176 students in 16 schools. The groups were comparable in terms of total instructional days, teacher demographics (i.e., gender, ethnicity, educational level, and teaching

experience), and student demographics (i.e., gender, ethnicity, disability area, and free and reduced lunch). Average class sizes were also statistically similar, $t(49.41) = 1.87$, $p = .07$.

Both groups completed five units of math instruction targeting objectives in the areas of rations and proportional relationships, the number system, statistics and probability, and geometry. In the BAU condition, teachers used the existing curriculum, including textbooks, interactive whiteboards, manipulatives, and the Calendar Math program. The EAI condition integrated computer-based lessons, video-based problems, and hands-on projects. EAI teachers were provided with lesson plans, materials, and professional development on the EAI components. The researchers used two standardized assessments (subtests from the Iowa Test of Basic Skills (ITBS)) and two researcher-developed tests as pretest and posttest measures. Over 300 classroom observations were also conducted with the use of a data template.

Data analysis included a hierarchical linear model with three levels (i.e., student, teacher, school). Performance on each outcome measure was evaluated controlling for five variables (i.e., gender, grade level, free and reduced lunch, race-ethnicity, disability status) at the student level and three variables (i.e., gender, teaching experience, graduate degree) at the teacher level. Hedge's *g* was calculated to determine effect size. The researchers also calculated interobserver agreement on both EAI and BAU sessions and interrater agreement on the assessment measures.

After adjusting for pretest scores, student characteristics, and teacher characteristics, participants in the EAI condition outscored the BAU students on three of the four measures. On the researcher-developed Fractions Computation Test, EAI students showed greater increases (pretest: $M = 2.34$; posttest: $M = 17.36$) than BAU students (pretest: $M = 3.04$; posttest: $M = 4.74$) on all 10 subscales. Treatment effects of the EAI condition were approximately one standard deviation more than the effects of the BAU condition on the addition subscales and

almost one standard deviation more on the subtraction scales. On the ITBS computation subtest, students in the EAI condition also showed greater increases (pretest: M = 11.47; posttest: M = 13.62) than BAU students (pretest: M = 10.27; posttest: M = 10.73). Students in the EAI condition gained at least half of a standard deviation more than students in the BAU condition.

The researcher-developed problem-solving subtest had similar results for the EAI condition (pretest: M = 6.16; posttest: M = 9.52) and the BAU condition (pretest: M = 5.32; posttest: M = 7.40). The only test with no statistically significant difference in outcomes was the ITBS problem-solving and data interpretation test. Classroom observations indicated that teachers in the EAI condition taught the provided lesson plans in 95% of observations. Interobserver agreement was 94% for both EAI and BAU sessions. Interrater agreement for the outcome measures ranged from 97% to 100%.

Bottge et al. (2014) concluded that the integration of explicit instruction, hands-on problem solving and engaging learning activities can encourage a greater understanding than typical instructional methods. The researchers suggested that the students may be better able to understand the reasons for learning math concepts with a blended curriculum. The researchers also noted that the instructional pacing varied across conditions. In the BAU condition, teachers often moved on to new concepts more quickly than teachers in the EAI condition. The researchers suggested that the additional problem-solving time in the EAI condition may have helped students to better grasp concepts. The researchers recommended that future studies focus on the application of EAI in inclusive settings.

Burton et al. (2013) also incorporated the use of video into math intervention. The researchers examined the effects of video self-modeling (VSM) using an iPad on the math calculation skills of students with autism and/or intellectual disability. The researchers used

iPads to implement the intervention and focused on money-related skills. In addition, the application of learned skills to novel problems was explored in a post-intervention phase.

Four male students from 13 to 15 years old with IQ scores ranging from 61 to 85 participated in the intervention. Three students were identified as having autism, and one student was identified as having an intellectual disability. All students were receiving some instruction in a self-contained special education classroom during the day. Three of the students received math instruction in the self-contained environment, and the student with the highest IQ score received math instruction in a resource setting. All students had goals related to the money-related skill targeted in the study.

The study was conducted in a suburban junior high school in the western U. S. with a total enrollment of approximately 1200 students. Intervention took place in a partitioned section of a self-contained classroom. The classroom included five male students, five female students, one teacher, two classroom paraeducators, and one student-specific paraeducator. All students in the classroom had disabilities (i.e., autism, intellectual disability, other health impairment, emotional disturbance, and multiple disabilities), all students were familiar with the use of an iPad, particularly as a reinforcer.

A multiple-baseline-across-participants design, including baseline, intervention, and post-intervention phases was used to evaluate the effect of VSM on the ability of participants to estimate and count change. Two classroom paraeducators were trained to assist in the study, and four to eight daily intervention sessions lasting 20- to 30-minutes were individually conducted with each student during both baseline and intervention. During baseline, students were presented with five story problems and instructed to read the problems and follow the directions on the worksheet provided. No additional instruction or feedback was provided to the students.

The worksheet included five one-sentence math word problems and seven steps to follow when solving the problems. For all phases of the study, a visual model of the seven steps was available to the participants.

Following the baseline phase, five videos were developed for each student. The students were given a script, a worksheet with five story problems, and a cash drawer with simulated paper and coin denominations. Students were given prompting to accurately solve the problems, and the prompting was subsequently edited out, resulting in five videos of each student accurately solving math story problems by estimating how much money to use to pay for an item, estimating the change and counting out change. The intervention was implemented with the first student when stable level and trend were observed in the baseline data. When the first student met the criterion (80% accuracy over three consecutive sessions), the intervention was implemented for the second student. This criterion was also used to determine the beginning of intervention for the remaining two students.

During the intervention, students were again provided with a worksheet with the five one-sentence math word problems solved in the videos and the seven steps to follow when solving the problems. Math instruction involved each student watching their video as many times as desired prior to completing the corresponding math problem on the worksheet with no teacher assistance. The teacher provided positive reinforcement for appropriate behavior only and used a scoring form to document response accuracy, the number of steps each participant accurately completed for each problem, and how many times the participant watched the video for each problem.

During the six-stage post-intervention phase, the same procedures and four of the same math problems were used, but the number of video models provided was faded over time, and

one novel problem was introduced. In the sixth stage, the participants were given the same five problems used during intervention without access to the videos. Following Phase 6, three weekly follow-up probes were given with no VSM using the intervention math problems.

The dependent variable for the study was the percentage of steps accurately completed, and a visual analysis of graphed data was used to evaluate changes in level, trend, and variability. Average performance scores were also calculated and compared across phases. Two observers independently scored 33% of the videotaped sessions to measure interobserver agreement, and one independent observer evaluated 33% of sessions using a task analysis checklist to measure treatment fidelity.

Mean performance percentages during baseline ranged from 0% to 24% for the four participants. When the intervention was introduced, an immediate change in level was observed. Over the course of the intervention phase, mean performance percentages were from 98% to 100%. In Phase Six of the post-intervention phase, percentages were 85.8% to 100%, and follow-up probe percentages were from 79.6% to 100%. For the novel problems in the first five phases of post-intervention, performance percentages ranged from 59.8% to 82.8% with a mean percentage of 70%.

Both interobserver agreement and treatment fidelity were 100%. To measure social validity, a four-question open-ended survey was completed by students and paraeducators. Paraeducators reacted positively to the intervention, but identified time and scheduling as challenges. All students reacted positively to the VSM intervention, with three of the four students specifically mentioning iPad usage positively. In addition, classroom observations indicated that students were enthusiastic and excited to participate in the intervention and demonstrated increased on-task behavior.

Burton et al. (2013) concluded that the study supported a functional relationship between VSM and math skill acquisition, as well as the use of a handheld device to deliver instruction to adolescent students with autism and/or intellectual disabilities. The researchers hypothesized that the variability in the post-intervention and follow-up phases may have been attributed to the spring break interruption of the study and/or specific student characteristics.

The researchers also suggested that technology may be used to increase student independence, task engagement, and math skills. In addition, teacher supervision needs may be decreased, allowing more students to receive individualized attention. The researchers suggested that future research be conducted to replicate the study and recommended increasing the variability of problems presented, adding additional social validity measures, and adjusting the dependent variable (e.g., different math skills, different content areas, different settings, on-task behavior).

Educational technology has been successfully used to address the math deficits of students with disabilities. Identified benefits include increased independence (Bouck et al., 2014; Burton et al., 2013), increased motivation (Bottge et al., 2014; Bouck et al., 2014; Burton et al., 2012; Haydon et al., 2012; Tsuei, 2014), and increased opportunities to practice (Bottge et al., 2014; Burns et al., 2012; Haydon et al., 2012; Seo & Bryant, 2012). Students also benefit from visual cues (Ke & Abras, 2013) and develop increased independence when technology is integrated into math instruction (Bouck et al., 2014; Burton et al., 2013). Despite promising results, increased efforts are needed to increase technology integration in the classroom (Ruggiero & Mong, 2013; Skoretz & Childress, 2013).

Teacher Preparation Related to the Integration of Technology

Based on research supporting the impact of technology on student academic outcomes, stakeholders recommend the inclusion of technology integration coursework in pre-service education programs (CAEP, 2015; NCTM, 2011), and post-hire professional development sessions (NCTM, 2011). Researchers have investigated the technology-related components of teacher preparation programs from a faculty point of view (Kleiner et al., 2007; McGrail et al., 2011) and from the perspective of pre-service teachers (Lambert & Gong, 2010; Ruggiero & Mong, 2013). Other studies have focused on the impact of various forms of professional development on technology integration in schools (Kopcha 2012; O'Hara et al., 2013; Skoretz & Childress, 2013; Walker et al., 2012). The TPACK framework has also been explored as a tool to evaluate the integration of technology into mathematics instruction (Stoilescu, 2015).

Technology Integration in Teacher Preparation Programs

Kleiner et al. (2007) examined the extent of educational technology instruction in initial teacher licensure programs. The researchers focused on the inclusion of technology-related topics, practices, uses, application opportunities, barriers, and perceived program outcomes. Participants were representatives from all Title IV degree-granting four-year postsecondary institutions in the U. S. Data were collected online or via mailed responses.

Researchers used a survey design and had a 95% response rate. The survey was developed with contribution from experts in the field and included questions designed to identify technology-related characteristics of teacher preparation programs. Based on descriptive analysis of the data, technology integration was included in programs at all responding institutions. More topics were taught at public institutions than at private institutions, and faculty

at public institutions were offered more educational technology courses than their private-institution counterparts.

Educational technology was included in methods courses (93%), field experiences (79%), content courses (71%), and technology-specific courses of three-to-four credits (51%) or one-to-two credits (34%). Although respondents were asked to indicate the topics covered (e.g., interactive math programs, virtual field trips, student assessment), they were not asked to assess the depth and quality of coverage. Overall, few differences were identified based on institutional control (i.e., public or private), size, or program types (i.e., elementary or secondary education). Respondents identified lack of faculty time, training, and interest as the primary barriers to the inclusion of educational technology instruction in coursework and field experiences. Similar barriers were also identified in field experiences. A lack of interest or skill on the part of teacher candidates was not identified as a barrier. Most institutions perceived program graduates as having the necessary skills and experience to integrate technology in the classroom.

Kleiner et al. (2007) concluded that the minimal variation in responses across institutions indicated a common approach to the inclusion of educational technology in education courses, although the extent of coverage was not clear. The researchers also suggested that although respondents indicated a clear focus on technology, barriers exist that hinder the efforts to integrate educational technology in program coursework. Kleiner et al. (2007) recommended that future research explore the topic further using statistical analyses to investigate the relationship between institutional control, institutional size, and program types.

McGrail et al. (2011) also investigated technology integration in pre-service education programs from the perspective of program representatives. The researchers focused on the technologies used in secondary reading instruction courses by exploring what technologies were

used, how they were used, and why they were used. Participants were faculty, program directors, and other program contacts from state-certified secondary teacher preparation programs.

The study took place in selected institutes of higher education in a large southern state in the U. S. A stratified random sample of 24 institutions with state-certified secondary teacher preparation programs resulted in 12 participating campuses, including two research universities, two regional institutions, two private colleges/universities, nine state universities, and 10 public universities.

The researchers used a two-phase qualitative design. In the first phase, participants provided program-related documents (e.g., syllabi), and these were examined to identify common themes. The second phase served as member checking and included both a survey and an interview to clarify the information collected in the first phase. Total data collected included 46 artifacts, seven survey responses, and seven one-hour interview responses. All data were analyzed using qualitative methods, including open coding, axial coding, and recursive revisions.

Results indicated that teacher education coursework included traditional technology, information/communication technology tools, and multimedia applications. Traditional technology was used to increase teacher and student productivity, including recording, storage, and delivery of data. Information/communication tools (e.g., email, course management software) were used to share documents and ideas, and multimedia applications were used for presentation-related tasks.

Students were encouraged to investigate reading instruction software and more current technology applications, but typically only older technologies were used in teacher preparation

courses. Respondents indicated a lack of access to programs as a barrier to sharing additional technologies with pre-service teachers in methods courses.

McGrail et al. (2011) concluded that teacher preparation programs vary in terms of focus on technology, but often do not provide opportunities for pre-service teachers to engage directly with newer technologies and reading software systems. The researchers also noted that these opportunities should be integrated into curricula throughout teacher preparation programs. McGrail et al. (2011) recommended that future studies include observation data related to instructional practices and investigate student perspectives of pre-service methods courses.

Ruggiero & Mong (2013) explored the perceptions of preservice education students regarding technology integration in teacher education programs. Specifically, the researchers investigated perceptions of technology use, technology practices, and technology experiences. Purposive sampling was used to identify participants in accredited education programs in the U.S. A total of 656 students from colleges or universities participated in the study. Participants had taken or were currently taking a technology integration course.

The average age of participants was 21, and participants were 70% female and 90% full-time students. Approximately 50% of participants were majoring in elementary education. Five universities from rural, suburban, and urban areas were selected to participate. These universities all served culturally, linguistically, and economically diverse populations. Data were collected online or in person at local restaurants or libraries.

A qualitative design incorporating both surveys and interviews was used in the study. Participants completed an online survey that included both closed- and open-ended questions related to technology use, philosophy, preferences, beliefs, and growth opportunities. In addition to the survey, 10% of participants were randomly selected to complete a 30-minute follow-up

interview consisting of 12 open-ended questions regarding technology experiences and understandings. Interviews were conducted in person when possible or online when in-person contact was not feasible. Follow-up emails were sent to online interview participants when clarification was necessary.

The researchers used thematic analysis and axial coding to identify themes and trends in both survey and interview data. Data were then condensed and organized, and statements for each theme were developed. Peer debriefing, triangulation, member checking, progress subjectivity checks, and dependability audits were used to ensure reliable interpretation of the data. All measures indicated that the data had been reliably represented.

Analysis revealed three recurrent themes: (a) technology as a tool, (b) technology as a process, and (c) technology use to design curriculum. Participants recognized technology as a tool for teaching, learning, and communication of ideas and information. However, most participants did not see technology use effectively modeled or get to use technology in technology integration courses. The primary method of instruction was lecture, and 648 of the participants indicated that PowerPoint was the primary application of technology experienced by students. The next most common uses of technology were group work and problem solving; however, far fewer participants reported experiencing these applications of technology in their courses.

Participants also recognized the importance of technology as a process to improve learning. However, technology integration courses offered few opportunities to apply technology in a manner relevant to future classroom teaching. Participants indicated that 70% of course time was spent listening to lectures, and little time was provided for pre-service teachers to analyze how to best use technology in their future classrooms.

Finally, technology use in curriculum design was identified as a major theme. Although course projects involving evaluation of technology and creation of curriculum were included in coursework, participants did not recognize these as effective opportunities to evaluate and integrate technology. Participants were also asked to use technology resources to complete assignments; however, the technologies required often did not include the most current applications available.

Ruggiero and Mong (2013) concluded that pre-service teachers do value the integration of technology in instruction. However, institutes of higher education do not have standards for technology integration courses, and this results in varied experiences for students. The researchers noted that basic technology courses in teacher preparation programs often lack modeling, which can result in pre-service teachers feeling unprepared to incorporate technology into classroom instruction.

The researchers also suggested that technology integration be demonstrated through modeling, used in application assignments, and added to all methods courses. The researchers recommended that school districts and schools of education work collaboratively in designing pre-service curriculum that includes technology integration. In addition, Ruggiero and Mong (2013) suggested that future research investigate the effect of previous technology experiences on technology integration and include other measures (e.g., observations) to collect additional data.

Lambert and Gong (2010) also explored pre-service education programs. The researchers examined the effect of an educational technology course redesign on technology-related attitudes, self-efficacy beliefs, and computer skills. The researchers investigated overall changes as well as demographic characteristics affecting individual perceptions and abilities. A total of

50 male and 50 female pre-service teachers were randomly selected from 11 sections of an educational technology course at a midwestern university in the U.S. Most participants were first-generation college students that varied in age, computer experience, and years of college.

The researchers used a survey design with pre- and post-intervention measures. An educational technology course was revised to include more advanced requirements related to 21st century skills. A demographic questionnaire was completed prior to instruction. Three other measures were also administered both prior to instruction and at the completion of the course.

Five factors of the *Teachers' Attitude Toward Computers* survey were used to measure pre-service teachers' attitudes toward computers as useful learning tools in the classroom. The International Society for Technology in Education (ISTE) General Preparation Profile for Prospective Teachers Survey was used to assess self-efficacy beliefs related to technology integration. Finally, a 50-queston computer skills test was used to determine knowledge related to technology integration in the classroom.

At the beginning of the semester, independent sample *t*-tests were used to identify differences in attitudes, self-efficacy beliefs, and computer skills in relation to the characteristics of gender, technology background, and years of college. At the end of the semester, independent sample *t*-tests were again used to identify differences in terms of gender and years of college. Paired sample *t*-tests were also used at the end of the semester to determine if significant changes in outcome measures occurred after intervention.

Pre-assessments indicated no significant difference in attitudes or self-efficacy beliefs in relation to gender or years of college. Non-freshman students did have significantly higher computer skills (M = 60.61) than freshman (M = 54.11). A technology background that included

technology use and exposure to technology modeling was positively correlated to technology-related attitudes and self-efficacy beliefs.

Post-assessments indicated that there continued to be no significant differences related to gender following the intervention. However, non-freshman did demonstrate significantly higher beliefs in the value of technology in the classroom (M = 4.20) than freshman (M = 3.86). Overall, post-intervention measures indicated significantly lower levels of anxiety, increased self-efficacy beliefs, increased belief in the value of classroom technology, and improved computer skills.

Lambert and Gong (2010) concluded that the redesigned course improved student attitudes, beliefs, and skills despite the increased difficulty level. The researchers also noted that teachers benefit from technology modeling and the communication of a clear rationale for using classroom technology. Technology modeling throughout primary, secondary, and post-secondary education was recommended, as well as the development of college-level curricular materials that incorporate technology. Lambert and Gong (2010) also suggested that future research investigate longitudinal outcomes, use experimental designs, and explore how to effectively incorporate technology in pre-service teacher education programs.

Professional Development Focused on Technology Integration

Kopcha (2012) explored teacher perceptions and practices related to technology integration and evaluated changes in perceptions and practices over time when professional development was implemented. A total of 18 teachers participated in the study which took place in an urban southwestern elementary school with an enrollment of approximately 600 students. The school had recently completed a campus-wide technology upgrade and was in an upper middle-class neighborhood.

A single case study design was implemented over a period of two years. During the first year, a mentor conducted professional development sessions focusing on the effective integration of technology. The following year, the mentor facilitated the transition to teacher-led communities of practice focusing on technology integration. Data collection included teacher surveys and protocols for teacher interviews and observations.

For the survey and observation data, descriptive statistics were calculated. A Cohen's kappa statistic was also calculated for observation data to estimate reviewer agreement, and a Spearman rank-order correlation was calculated to compare survey item rankings across years. Inductive analysis was used to code and analyze interview data. Finally, triangulation was used to compare data from all sources and identify common elements.

On the survey, the barrier of access had the highest mean rating ($M = 3.35$) during the first year and the second highest rating during the second year ($M = 3.21$). The barrier of vision had the second highest rating for the first year ($M = 3.26$) and the highest rating for the second year ($M = 3.24$). The barriers of vision, beliefs, and access were also relatively high for both years. The lowest rated barriers were time and professional development. The Spearman's rank-order correlation indicated a relatively high correlation between responses across years.

In interviews, most teachers believed that technology improved student outcomes and wanted to use technology in instruction. Most teachers also reported working collaboratively with peers to integrate technology, but identified time as the greatest barrier to technology integration. For observation data, the Cohen's kappa statistic was 0.65 indicating strong agreement between reviewers' observation scores. Teachers were observed using technology that contributed to the learning process ($M = 3.57$), students were generally on-task and engaged ($M = 3.55$), and teachers appeared to use technology competently ($M = 3.75$).

Kopcha (2012) concluded that situated professional development and mentoring can affect teacher perceptions and beliefs related to technology integration. The researcher also noted that the perception of time as a barrier may be due to the lack of familiarity with the different types of planning, teaching, and classroom management that are necessary when technology is implemented.

In addition, Kopcha (2012) suggested that mentoring appeared to provide better outcomes than the more cost-effective communities of practice. The researcher recommended that future research investigate the role that mentoring, communities of practice, and teacher beliefs play in creating a supportive environment for technology integration. The researcher also suggested further research include a control group and explore the relationship between teacher-identified barriers and technology use over time.

O'Hara et al. (2013) also investigated the effect of professional development on technology integration in the classroom. The researchers examined the impact of an intervention on both teacher and student outcomes and explored the effect of specific professional development components. Participants were 16 fourth- and fifth-grade teachers. The study took place at an elementary school in California with a high population of English language learners.

The researchers used a mixed-methods design with both pre- and post-assessment measures. A total of 56 hours of professional development were provided to participants during the year. The sessions included equal time for explicit instruction in technology integration, hands-on experimentation, and collaboration with peers. The explicit instruction portion included modeling of current technologies, and the experimentation and collaboration portions included time for teachers to design and share lessons.

Multiple pre- and post-assessment measures were used to evaluate the impact of the intervention. Quantitative assessments were comprised of a Knowledge/Use Scale, a Teacher Technology Proficiency Assessment, and a Student Technology Proficiency Assessment. Qualitative measures included teacher reflections, classroom observations, and teacher interviews.

The researchers calculated descriptive statistics and used paired *t*-tests to evaluate changes over time. Coding procedures were used to organize and identify themes in qualitative data. Identified themes from all sources were then combined, and selective coding was used to evaluate the merged data. Analysis of the data indicated that technology proficiency scores improved for both teachers and students. Teachers also reported increased knowledge and use of technology after the intervention. Results of paired *t*-tests indicated that significant growth occurred on all measures.

Based on classroom observations, teachers integrated technology into 89% of classroom lessons after intervention. Three specific components of the professional development were identified as the most impactful elements: (a) the sessions incorporated the specific curricula used by participants, (b) the participants were given opportunities to reflect, and (c) the participants were given opportunities to develop and share relevant class lessons.

O'Hara et al. (2013) concluded that responsive professional development can be used to effectively improve teacher knowledge and integration of technology into teaching and learning. The researchers noted that effective professional development should include modeling and active learning opportunities and be sustainable, situated in practice, focused on student learning, and integrated into the school context. O'Hara et al. (2013) also emphasized the importance of including time for practice and collaboration and recommended that future research focus on

implementing similar professional development models in pre-service teacher education programs.

Skoretz and Childress (2013) investigated the effect of school-based professional development on self-efficacy measures and technology-integration practices. Specifically, the researchers examined changes after intervention, differences between experimental and control groups, and the relationship between self-efficacy and technology integration. Participants were teachers from four elementary schools and four middle schools in a southeastern U. S. state. The experimental group included 37 teachers, and the comparison group included 28 teachers.

A quasi-experimental design was used, and both qualitative and quantitative data were collected. Five days of formal training, including rationale, modeling, and hands-on activities, was provided to participants. Following the formal training, the intervention continued in the form of a school-based learning community. During this phase of intervention, participants applied technology in classroom lessons and received feedback from other participants and an online mentor. In-person monthly support was also provided during this phase. The comparison group did not receive any similar supports.

Qualitative measures included journal entries and survey responses. Daily journal entries were begun prior to intervention as a pretest measure and continued throughout the study. Final journal entries were used as a posttest measure. Quantitative instruments were also used. The *Grappling's Technology and Learning Spectrum* framework was used to evaluate technology integration, and the *Computer Technology Integration Survey* was used to collect self-efficacy and demographic data.

Journal entries were evaluated to determine the change in level of technology integration from pretest to posttest. To analyze the change in level, a paired samples *t*-test was used to

evaluate pre- and post-intervention journal entries, and a one-way ANOVA was used to evaluate technology-integration differences in relation to teaching experience, grade level, and number of subject areas taught. Quantitative data analysis included a *t*-test for independent samples to evaluate group differences. A two-way ANOVA was also used to examine self-efficacy differences in relation to teaching experience, grade level, and number of subject areas taught. A Pearson Product Moment Correlation was also used to evaluate the relationship between the experimental group's self-efficacy and technology integration levels.

Posttest levels of technology integration (M = 10.81) were higher than pretest levels (M = 9.97), and the number of people using technology in more advanced ways increased by 14.83%. However, the paired-samples *t*-test indicated that the change from pretest to posttest was not statistically significant. The one-way ANOVA also indicated no statistically significant difference in pretest and posttest technology integration levels in relation to teaching experience, grade level, and number of subject areas taught.

The differences in posttest self-efficacy levels of the experimental (M = 89.7) and control (M = 82.35) groups were found to be statistically significant with a moderate effect size. The posttest self-efficacy levels of the experimental group were found to be statistically significant in terms of teaching experience, grade level, and number of subject areas taught. Posttest self-efficacy measures for the experimental group were higher for middle school teachers and teachers of single subjects, but were lower for teachers with increased experience. Posttest measures for the control group were also lower for teachers with increased experience, but were higher for elementary school teachers and teachers of multiple subjects.

The interaction effect between participation in professional development and years of teaching experience was statistically significant with a large effect size, and the main effect was

also statistically significant. The interaction effects between professional development and both grade level and number of subjects taught were also statistically significant with moderate effect sizes. The main effect for grade level was statistically significant, but the main effect for number of subjects taught did not reach statistical significance. The relationship between technology integration and self-efficacy levels was not found to be statistically significant even when evaluated in terms of teaching experience, grade level, and number of subject areas taught.

Skoretz and Childress (2013) concluded that the higher levels of self-efficacy reported by the intervention group support the need for professional development related to technology integration. In relation to the technology integration results, the researchers hypothesized that the measurement tool was not specific enough to adequately measure changes in practices. Skoretz and Childress (2013) also emphasized the importance of including time to collaborate and implement learned material when conducting professional development.

Differentiated professional development sessions based on participant grade level and application of the professional development model to teacher preparation programs were also recommended. Skoretz and Childress (2013) suggested that future research use more precise measurement tools as well as class observations and evaluate the effect of technology-related professional development on high-school level participants.

Walker et al. (2012) compared the effect of two professional development models on student outcomes and teachers' knowledge, skills, and levels of technology integration. The researchers attempted to identify which variables significantly predicted student outcomes. Participants were 36 seventh-, eighth-, and ninth-grade math and science teachers. The study took place in 15 junior high schools in a large suburban school district in the western U. S.

Professional development sessions were held in the school computer labs, and all additional activities occurred in the teachers' classrooms.

The researchers used a quasi-experimental design to compare intervention outcomes. Participants received professional development in either technology only or technology plus problem-based learning (PBL). Both groups attended three in-person workshops over a period of three months. After each workshop, participants applied workshop concepts in their classrooms. Both professional development models included training on designing online activities using a web-based tool, *Instructional Architect*. The technology-only group received additional training to increase technology knowledge, skills, strategies, and methods. The technology-plus-PBL group received additional training on designing PBL activities for students using technology.

Data collection methods included pre- and post-intervention teacher surveys and student questionnaires, as well as a PBL alignment rubric and an online measure of web usage. Data were analyzed descriptively, and three generalized estimating equation models were used to evaluate gains in behavior, knowledge, and attitudes. Two-way factorial ANOVAs with repeated measures and *t*-tests were also used to analyze the data.

Analyses of participant characteristics indicated that both groups were similar. On posttest measures, both groups showed large gains in knowledge, skills, and technology integration. However, the technology-plus-PBL group had higher means on the posttest survey and larger effect sizes for all variables related to their professional development sessions. On student measures, behaviors, knowledge, and attitudes showed gains in the technology-plus-PBL condition. In the technology-only condition, only student attitudes increased from pretest to posttest.

Walker et al. (2012) concluded that although both professional development activities had positive effects, the larger gains of the technology-plus-PBL group demonstrate that technology-related professional development activities should focus on integrating technology and one specific teaching practice (e.g., PBL). The researchers suggested that future research investigate the integration of technology and other pedagogies, consider long-term interventions, and use multi-level modeling to analyze data.

Stoilescu (2015) used the TPACK framework to investigate the process of technology integration in the classroom. Participants were three secondary math teachers with at least a Bachelor's degree in math and a background in educational technology. All participants also had more than 10 years of experience teaching secondary math. The study was conducted in a public high school in Canada that served a large population of immigrant families.

A multiple case study design was used to collect data on each teacher's practices. A total of 20 classroom observations lasting a minimum of 75 minutes each were compiled. The researcher also examined class artifacts and interviewed each teacher twice. The resulting data were thematically analyzed to identify attitudes and skill levels, and a cross-case analysis was then used to compare results across participants.

Results indicated that the three experienced teachers used technology to increase accessibility, provide experimentation opportunities, evaluate performance, improve instruction, and improve concept communication. The participants used a considerable amount of time to adapt instruction and engage in collaboration related to the integration of technology. All participants were essentially self-taught in the technologies used due to a deficit in technology-related training.

Stoilescu (2015) concluded that expert teachers have a positive approach toward technology integration. Although teacher characteristics such as ethnic background, pacing, personality type, and teaching style varied, the ability of participants to integrate technology successfully indicated to the researcher that technology integration can be successfully achieved across a range of diverse teachers. Stoilescu (2015) also noted that the TPACK framework provides a consistent method of evaluating overall technology integration in math classrooms, although the framework may not meet the needs of more complex scenarios. The researchers recommended that future research investigate technology integration with teachers of varying experience levels in more diverse settings.

Technology-related training has been used to improve knowledge, skills, and practices of both pre-service and post-licensure teachers. Faculty and staff perceptions indicate that teacher preparation programs include an emphasis on technology; however, barriers hinder the effective integration of technology instruction into coursework (Kleiner et al., 2007; McGrail et al., 2011). Students, on the other hand, perceive technology integration in teacher preparation programs to be insufficient to prepare them for the classroom (Ruggiero & Mong, 2013). Effective training, however, can increase technology-related knowledge and skills of both pre-service teachers (Lambert & Gong, 2010) and teachers currently in the field (Kopcha 2012; O'Hara et al., 2013; Skoretz & Childress, 2013; Walker et al., 2012). In addition, the TPACK framework can be used to evaluate technology-related practices (Stoilescu, 2015).

Summary

Various technology-based math interventions have resulted in improved outcomes for students in both general and special education environments. For students in general education, the benefits of technology-based interventions include increased student motivation and

engagement (Maloy et al., 2010; Musti-Rao & Plati, 2015; Reimer & Moyer, 2005), immediate feedback opportunities (Gesbocker, 2011; Reimer & Moyer, 2005; Steen et al., 2006), and graphic displays (Gesbocker, 2011; Reimer & Moyer, 2005). For general education teachers, technology-based interventions provide increased opportunities for individualization (Barrow et al., 2009; Gesbocker, 2011; Reimer & Moyer, 2005; Steen et al., 2006), ease of implementation (Barrow et al., 2009, Musti-Rao & Plati, 2015; Roschelle et al., 2010), and curriculum integration opportunities (Maloy et al., 2010; Roschelle et al., 2010).

Students with disabilities also benefit from technology-based interventions, demonstrating increased independence (Bouck et al., 2014; Burton et al., 2013), increased motivation (Bottge et al., 2014; Bouck et al., 2014; Burton et al., 2012; Haydon et al., 2012; Tsuei, 2014), and increased independence (Bouck et al., 2014; Burton et al., 2013). Advantages include increased opportunities to practice (Bottge et al., 2014; Burns et al., 2012; Haydon et al., 2012; Seo & Bryant, 2012) and visual cues (Ke & Abras, 2013).

Effective supports are essential to successful implementation of technology-based interventions (Kiger et al., 2012); however, there is a disparity in the perceptions of faculty and students regarding technology instruction in teacher preparation programs. Institutional faculty and staff from education programs view pre-service coursework as adequately focused on technology (Kleiner et al., 2007; McGrail et al., 2011). However, pre-service education students believe they are unprepared to implement technology in the field (Ruggiero & Mong, 2013). Implementing technology instruction for both pre-service teachers (Lambert & Gong, 2010) and post-hire teachers can improve technology-related outcomes (Kopcha 2012; O’Hara et al., 2013; Skoretz & Childress, 2013; Walker et al., 2012). Limited research has been done to explore

technology instruction in special education teacher preparations programs with specific content areas (e.g., math).

Based on the literature supporting technology-based math interventions, more information is needed to explore technology integration in practice. The present study will expand the literature by investigating teacher beliefs, selection methods, and actual usage of educational technology in secondary math classrooms. In addition, the teacher-perceived barriers to implementation and required supports will be explored.

CHAPTER THREE

METHODS

Overview

Mathematical competence is critical to personal and professional success. Mathematical concepts are embedded in a multitude of personal and professional tasks (NMAP, 2008). Unfortunately, many students enrolled in public schools in the United States lack the foundational understanding necessary to achieve proficiency in math skills (USDOE, 2013). Without proficiency in math skills, students may face increased challenges in transitioning to adulthood, including fewer post-secondary educational opportunities (NMAP, 2008), limited career options (Hartwig & Sitlington, 2008), and decreased long-term income (Joensen & Nielsen, 2009; Kena et al., 2015).

Given the relationship of mathematical competence to personal and professional success, effective math instruction is critical. However, despite the introduction and evolution of standards-based instruction, students with disabilities in the United States have struggled to demonstrate competency (USDOE, 2013). Various forms of technology have been used to improve the outcomes of students with disabilities (Strickland & Maccini, 2010), and professional organizations advocate for the integration of technology into mathematics instruction (CAEP, 2013; NCTM, 2011). However, the promise of technology has not been thoroughly realized (Gray, Thomas, & Lewis, 2010). This shortcoming may be related in part to the inability of teachers to effectively integrate technology in the classroom (Ruggiero & Mong, 2013). The present study examined the integration of technology in secondary math classrooms with students with disabilities to develop an understanding of teacher-reported practices and perceptions.

Research Questions

This exploratory study implemented a three-round Delphi survey design to collect information related to the use of instructional technology in secondary math classrooms with students with disabilities. The study addressed the following questions:

Research Question One. How are teachers incorporating instructional technologies into secondary classrooms to support math instruction for students with disabilities?

Research Question Two. What barriers do teachers identify relative to the integration of instructional technology in secondary math classrooms with students with disabilities?

Research Question Three. What supports do teachers report needing in order to effectively incorporate instructional technologies into secondary classrooms to support math instruction for students with disabilities?

Participants

The Delphi process is an iterative survey process designed to elicit feedback from stakeholders with expertise in the targeted field (Cohen, Manion, & Morrison, 2011; Kloser, 2014; Skulmoski, Hartman, & Krahn, 2007). For the purposes of this study, middle school principals who provided access to their facilities were sent an initial contact email (see Appendix A for facility authorization letters and Appendix B for initial contact email to principals) and asked to identify and provide email addresses for individuals on their campuses who met the expertise criteria. Experts were defined as general and special education teachers who met the following criteria for expertise: (a) held a standard teaching license, (b) had a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings, (c) currently taught secondary math to students with disabilities in co-teach and/or resource settings, and (d) had used instructional software with students.

The principals referred a total of 36 experts, ranging from zero to 12 individuals per school. Electronic survey research typically has a 20% to 35% return rate (Cook, Heath, & Thompson, 2000; Sax, Gilmartin, & Bryant, 2003; Shih & Fan, 2009). Therefore, a minimum target of seven to 12 respondents was set in order to begin the first round of data analysis. The target return rate for the second and third rounds was also 20% to 35%. The responses of participants who did not currently report teaching students with disabilities in either a resource and/or co-teaching setting were recorded, but excluded from the data set. Informed consent was obtained from participants, and only participants who signed consent forms (see Appendix C) were included in the study. Participants completed a demographic questionnaire (see Appendix D), and the results are presented in Table 1.

Table 1

Participant Demographic Information

Characteristics	Number of Participants
Age	
<25 years	0
26-35 years	3
36-45 years	6
46-55 years	7
>56 years	2
Gender	
Male	6
Female	12
Ethnic background	
American Indian or Alaskan Native	0
Asian	0
Black or African American	2
Hispanic or Latino	0
Native Hawaiian or Other Pacific Islander	0
White	16
Multiethnic	0
Primary teaching placement that includes students with disabilities	
Co-teach	10
Resource	2
Co-teach and resource	2
SLD	1
Instructional aide	1
General education	2
Years teaching middle school mathematics	
<5 years	6
6-10 years	4
11-15 years	3
16-20 years	3
>20 years	2
Grade level of assigned students with disabilities[a]	
Sixth grade	2
Seventh grade	3
Eighth grade	5
Sixth, seventh, and eighth grades	6
Seventh and eighth grades	1
Education level	
Undergraduate degree	3
Graduate degree	15
Doctoral degree	0

[a] One respondent did not provide a valid grade level (i.e. ‘general education’).

Setting

The study was conducted in a large, urban school district in the southwestern United States that serves a minority-majority population. A director of special education authorized the Study in the school district and dissemination of materials to middle school principals within the district (see Appendix E). Ten middle school principals in the selected school district provided access for the study. The middle schools served students in grades six through eight.

The referred participants were sent an email (see Appendix F) with a link to the informed consent form (see Appendix C), the demographic questionnaire (see Appendix D), and the first round of the web-based survey (see Appendix G). Hyperlinks to subsequent iterations of the survey were also distributed to participants via email (see Appendices H and I). The surveys were developed using *Qualtrics*, an electronic survey software that supports distribution and analysis of online surveys (Qualtrics LLC, 2016).

Instrumentation and Materials

Developed in the 1950s (Linstone & Turoff, 2011), the Delphi method facilitates the collection of information through a three-phase iterative process of survey completion (Manizade & Mason, 2011). The initial round of the survey solicits ideas from selected experts in the field, and the second round of the survey serves to refine the information collected (Kloser, 2014). During later rounds, participants are provided with descriptive statistics related to the group results, and data collection continues until a consensus is reached (Ludwig, 1997) or responses are stable (Linstone & Turoff, 2011).

The Delphi method allows for the collection of input from a large panel of individuals that may be difficult to physically convene due to distance and time constraints (Manizade & Mason, 2011). The Delphi method's efficient use of time also allows for the participation of

individuals who might not be able to participate in other data collection methods (Turoff, 1970). This study included the recommended three rounds of survey distribution and collection (Hallowell & Gambatese, 2010).

Limited research has been done to determine why technology is underutilized in addressing math deficits. An exploratory study of this nature provides researchers, teacher educators, and other educational professionals with a better understanding of the factors affecting teachers' use of technology in math instruction. For this study, the iterative Delphi method was the most appropriate design to gather information and build consensus. This method also facilitated the efficient gathering of information. The participants were teachers located at multiple campuses across the identified school district. Gathering the teachers in one location would have been logistically difficult due to distance and scheduling issues.

An in-person discussion would also require the allocation of a substantial amount of time to reach consensus or stability of responses. An electronic survey requires a significantly lower investment of time, thereby increasing the number of teachers likely to participate in the study. Participants also have the flexibility of completing the survey at a personally convenient time.

Round One

The first round contained an informed consent form (see Appendix C), a demographic questionnaire (see Appendix D), and a survey consisting of five open-ended questions related to the use of instructional software in secondary math classrooms with students with disabilities (see Appendix G). Prior to implementation, the first-round survey instrument was reviewed for clarity by one doctoral student with expertise in instructional technology design, and one faculty member in special education with expertise in mathematics and students with disabilities. The

survey was revised based on the feedback received. The following prompts were included in the first round:

1. List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.
2. List at least three methods you use to select instructional software for integration in your classroom.
3. List three barriers you have encountered relative to the effective use of instructional software.
4. What supports do you need in order to effectively integrate instructional software during math instruction?
5. How do you think the use of instructional software impacts the math performance of your students?

The first round of the survey remained open for two weeks. Upon completion of the first round, the responses were thematically analyzed using open and axial coding procedures. Initially, responses were open coded to identify each individually unique statement made relative to the Delphi questions (Marshall & Rossman, 2011). Once this initial coding was completed, clusters and subclusters of responses with shared meaning were developed within each category (Marshall & Rossman, 2011). The number of participants who provided unique statements contributing to each subcluster was calculated to determine the subclusters with the three highest frequencies for each question during the Delphi Round One. After the coding process, the second survey instrument was developed using these results.

Round Two

In Round Two, the participants were asked if they completed the first round of the survey. If participants indicated that they did participate in Round One, they proceeded to the second round of the survey. If participants indicated that they did not participate in Round One, they were exited from the survey, and no data were collected.

The second round of the survey (see Appendix J) included the original five questions; however, the response subclusters with the three highest frequencies for each question from the initial survey were rewritten as Likert-type scale perception statements that served as the response choices. These statements were presented to participants in Round Two. For example, when *Assessment and LEarning in Knowledge Spaces (ALEKS)* was identified as a commonly used software to support students with disabilities in math instruction during Round One, the Round Two statement read, "I use *ALEKS* during math instruction for students with disabilities." After each statement, the frequency of participants who provided unique first-round responses contributing to the statement was provided in parentheses. Each participant was asked to rate their level of agreement with each perception statement based on a five-item Likert-type response scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree). A five-point response scale minimizes participant misresponse and can result in improved data quality (Weijters, Cabooter, & Schillewaert, 2010).

Round Three

Round Three was the final iteration of the survey and focused on refining areas of participant agreement. Participants were first asked if they completed the first and second rounds of the survey. If participants indicated that they did participate in the previous rounds,

they proceeded to the third round of the survey. If participants indicated that they did not participate in the previous rounds, they were exited from the survey, and no data were collected.

The survey instrument for the third round (see Appendix K) was identical to the second survey instrument with the exception of the statistics included. The third round of the survey included descriptive statistics (i.e., mean and standard deviation) in lieu of frequency. The second-round statistics for each response were provided in parentheses at the end of each response choice. Participants were asked to review the survey and the accompanying statistics and respond again using the same Likert-type scale.

Design and Procedures

The study was conducted over a twelve-week period. Permission to conduct research was obtained from the school district (see Appendix E), and principals of participating middle school campuses were asked to identify general education and special education teachers on their campuses who met the expertise criteria (see Appendix B). Initial participant materials included an informational email (see Appendix F) and a hyperlink to the informed consent form (see Appendix C), the demographic questionnaire, (see Appendix D), and first round of the web-based survey (see Appendix G).

The first round of the survey was distributed to the 36 identified participants, and a reminder email (see Appendix L) was sent after one week. The survey was closed after two weeks, and analysis proceeded because the minimum return rate of 20% to 35% of total respondents had been reached for the first round. The responses were then collected and coded using open and axial coding procedures.

The results of first-round coding were used to develop the second iteration of the survey (see Appendix J). When the second survey had been developed, a hyperlink to the survey was

distributed to participants via email (see Appendix H). A reminder email (see Appendix M) was sent after one week. The survey was closed after two weeks because the target return rate for the second round (i.e., 20% to 35%) had been met. Descriptive statistics were calculated on the second-round data and used to design the final survey (see Appendix K).

An email (see Appendix I) with a hyperlink to the final survey was then sent to all participants, and a reminder email (see Appendix N) was sent after one week. The survey was closed after two weeks because the target return rate for the third round (i.e., 20% to 35%) had been met. Descriptive statistics for the third round were then calculated to determine if responses had changed based on the descriptive statistics provided.

Interscorer Reliability

Interscorer reliability was calculated for all rounds of the survey. A graduate research assistant with knowledge of qualitative and quantitative data analysis procedures was trained in open and axial coding procedures. All first-round responses were then reviewed by the graduate research assistant to verify appropriate placement in aggregated category clusters. Perception statements were also reviewed to confirm accurate representation of the response clusters. In the second and third rounds, the graduate research assistant verified statistical calculations. Interscorer agreement was calculated using the following formula:

[(agreements)/(agreements+disagreements) x 100 = percent of interscorer agreement].

Interscorer agreement for all rounds was 100%.

Data Analysis

Both qualitative and quantitative data were collected and analyzed. Specific analysis procedures for each question are described below.

Research Question One. How are teachers incorporating instructional technologies into secondary classrooms to support math instruction for students with disabilities?

For Round One responses, open coding was used to identify unique statements related to the types of instructional software commonly used in secondary mathematics classrooms, followed by axial coding to cluster the data (Marshall & Rossman, 2011). Responses to the first round of the survey were reviewed and organized to identify overarching themes and patterns. Each response was then assigned to the previously-identified theme that best matched the response.

When all responses had been assigned to a theme, individual theme categories were reviewed to identify response clusters (e.g., recurring ideas, similar concepts) within each category. A similar process was used to identify subclusters within each main cluster. The resulting subclusters were used to develop closed-end statements for the second round of the survey. The frequency of participants who provided unique responses included within each subcluster was also calculated and included with each response choice. Both the second and third rounds included Likert-type scale response choices. The results of the second and third rounds were quantitatively analyzed and descriptive statistics calculated (i.e., mean and standard deviation).

Research Question Two. What barriers do teachers identify relative to the integration of instructional technology in secondary math classrooms with students with disabilities?

For Round One responses, open coding was used to identify unique statements related to barriers to effective technology integration, followed by axial coding to cluster the data (Marshall & Rossman, 2011). Responses to the first round of the survey were reviewed and

organized to identify overarching themes and patterns. Each response was then assigned to the previously-identified theme that best matched the response.

When all responses had been assigned to a theme, individual theme categories were reviewed to identify response clusters (e.g., recurring ideas, similar concepts) within each category. A similar process was used to identify subclusters within each main cluster. The resulting subclusters were used to develop closed-end statements for the second round of the survey. Response frequency was also calculated and included with each response choice. Both the second and third rounds included Likert-type scale response choices. The results of the second and third rounds were quantitatively analyzed and descriptive statistics calculated (i.e., mean and standard deviation).

Research Question Three. What supports do teachers report needing in order to effectively incorporate instructional technologies into secondary classrooms to support math instruction for students with disabilities?

For Round One responses, open coding was used to identify unique statements related to teacher-reported supports needed for technology integration, followed by axial coding to cluster the data (Marshall & Rossman, 2011). Responses to the first round of the survey were reviewed and organized to identify overarching themes and patterns. Each response was then assigned to the previously-identified theme that best matched the response.

When all responses had been assigned to a theme, individual theme categories were reviewed to identify response clusters (e.g., recurring ideas, similar concepts) within each category. A similar process was used to identify subclusters within each main cluster. The resulting subclusters were used to develop closed-end statements for the second round of the survey. Response frequency was also calculated and included with each response choice. Both

the second and third rounds included Likert-type scale response choices. The results of the second and third rounds were quantitatively analyzed and descriptive statistics calculated (i.e., mean and standard deviation).

Response tables were also developed to report the data. Individual response tables were created for the highest-frequency response subclusters from Round One and included:

1. The category of the response subcluster.
2. The response subcluster.
3. The number of participants providing unique responses that contributed to the aggregated response subcluster in the first round of the survey.
4. The percentage of participants providing unique responses that contributed to the aggregated response subcluster in the first round of the survey.
5. The rank of the response subcluster based on frequency data from the first round of the survey.
6. The mean score of the response subcluster in the second round of the survey.
7. The rank of the response subcluster based on the mean score from the second round of the survey.
8. The mean score of the response subcluster in the third round of the survey.
9. The rank of the response subcluster based on the mean score from the third round of the survey.

CHAPTER FOUR

RESULTS OF THE STUDY

Overview

The development of math proficiency has a significant impact on long-term personal and professional success (NMAP, 2008). Deficits in math skills can have a negative impact on college-readiness and the likelihood of earning a post-secondary degree (Wirt et al., 2004). Career opportunities are also limited (Hartwig & Sitlington, 2008), and the level of math skill needed in many jobs has continued to rise (NCTM, 2014). Math proficiency has also been directly linked to average income (Joensen & Nielsen, 2009; Kena et al., 2015).

Despite recognition of the importance of math skills, math achievement in the U. S. continues to fall below international averages (Kelly et al., 2013) and has not improved significantly over time (USDOE, 2015). Math achievement rates for students with disabilities are also low (USDOE, 2013). For these students, math proficiency can be particularly difficult to attain due to deficit areas related to their disability (Geary, 2004).

The literature suggests that technology-based interventions based on the components of effective instruction can be used to support the math skills of students with disabilities (Strickland & Maccini, 2010). In addition to improved math skills, technology-based interventions can also provide the benefits of increased opportunities to practice (Bottge et al., 2014; Burns et al., 2012; Haydon et al., 2012; Seo & Bryant, 2012) and visual supports (Ke & Abras, 2013). Research indicates that technology allows students to demonstrate increased independence (Bouck et al., 2014; Burton et al., 2013) and increased motivation (Bottge et al., 2014; Bouck et al., 2014; Burton et al., 2012; Haydon et al., 2012; Tsuei, 2014).

However, research on the use of math instructional software has focused on investigating the effects of individual programs with relatively few replication studies. Research has also explored overall technology usage among broad teacher populations. There is limited research on the use of instructional software by teachers that specifically work with students with disabilities. Further research is warranted because these teachers work with a population of students that struggles to master math skills and concepts (USDOE, 2013).

The purpose of this exploratory study was to examine how math instructional technology is being used in secondary math classrooms with students with disabilities as measured by a multi-round iterative survey. The study also focused on identifying teacher-perceived barriers and desired supports related to the integration of technology. Participants were 36 general and special education teachers from 10 middle schools who were identified as experts by the school principals. A three-round Delphi method was used to collect survey data over the course of a twelve-week period. For the first round, data from open-ended responses were qualitatively coded and then reported as frequencies and percentages. Descriptive statistics were calculated for second- and third-round responses to Likert-type scales.

Analysis of Round One

A total of 18 individuals (50% of the identified experts) responded to the first round of the survey. The return rate for electronic survey research is typically 20% to 35% (Cook et al., 2000; Sax et al., 2003; Shih & Fan, 2009) with an anticipated decline in responses over the course of the Delphi process (Bardecki, 1984). Of the initial 18 individuals, four of the respondents indicated that they did not meet the inclusion criteria: three individuals were not currently teaching math to students with disabilities in co-teach and/or resource settings (i.e., self-contained classroom or non-co-teach general education classroom), and one individual did

not hold a standard teaching license (i.e., instructional aide). The responses of the remaining 14 individuals (38.89%) were included in data analysis.

Respondents could include more than one response for each question on the survey. Initially, open coding was used to create a comprehensive list of unique responses to each question. Responses were then organized into categories based on similarity of theme. Within each category, statements were grouped into clusters and subclusters of shared meaning. After data reduction was completed, the number of participants who provided unique statements included within each aggregated subcluster was calculated. The subclusters with the three highest frequencies were selected for inclusion in the second round of the survey.

Types of Instructional Software

The first question on the survey asked participants to list the instructional software types that they commonly use in math instruction for students with disabilities. Although the question referred specifically to software, some responses included references to hardware (i.e., computer, SmartBoard, document camera, overhead projector, graphing calculator) or non-instructional software (i.e., *Google Calendar*). These items were not included in the response calculations. When a respondent included only references to hardware or non-instructional software, the response was placed in the 'none' category of instructional software because the participant did not indicate any instructional software usage.

The response subclusters with the three highest frequencies were *ALEKS* (n = 7), none (n = 4), *Kahoot* (n = 3), and *Spatial-Temporal (ST) Math* (n = 3). The following response subclusters were identified at lower frequencies: *Classkick*, *Connect*, *Glencoe, Encore, Google Classroom*, *Khan Academy*, *Moby Math*, *Coolmath*, *FASTT Math*, *Quizlet*, *Ascend Math*, *Sumdog*, *Quizzizz*, 'videos', and 'websites'. The response '*Kutut*' was also referenced by one

respondent; however, *Kutut* was not an identifiable instructional software. Although it may be a misspelling of *Kahoot*, this could not be confirmed due to the anonymous nature of the survey; therefore, the response was not included in the *Kahoot* subcluster.

Table 2

Round One Types of Instructional Software

Subcluster (Frequency)	Percentage of Participants	Perception Statement
ALEKS (n = 7)	38.89%	I use *ALEKS* during math instruction for students with disabilities.
None (n = 4)	22.22%	I do not use instructional software during math instruction for students with disabilities.
Kahoot (n = 3)	16.67%	I use *Kahoot* during math instruction for students with disabilities.
ST Math (n = 3)	16.67%	I use *ST Math* during math instruction for students with disabilities.
Classkick (n = 2)	11.11%	N/A
Connect (n = 2)	11.11%	N/A
Glencoe (n = 2)	11.11%	N/A
Encore (n = 1)	5.56%	N/A
Google Classroom (n = 1)	5.56%	N/A
Khan Academy (n = 1)	5.56%	N/A
Moby Math (n = 1)	5.56%	N/A
Coolmath (n = 1)	5.56%	N/A
FASST Math (n = 1)	5.56%	N/A
Quizlet (n = 1)	5.56%	N/A
Ascend Math (n = 1)	5.56%	N/A
Sumdog (n = 1)	5.56%	N/A
Quizzizz (n = 1)	5.56%	N/A
Videos (n = 1)	5.56%	N/A
Websites (n = 1)	5.56%	N/A
Kutut (n = 1)	5.56%	N/A

Note. In the first round, participants were asked to list multiple responses for each question. After coding, the number of participants (*n*) with unique responses in each subcluster was determined.

Selection Methods

The second survey question asked respondents to identify the methods they use to select instructional software for integration in the classroom. The response subclusters with the three highest frequencies were features of the software (n = 6), availability (n = 5), and none (n = 4). The unique statements that referred to features of the software are listed in Table 3 and included 'formative assessment capabilities', 'adaptive abilities', 'ability to customize content', 'reports', 'correlation' and 'iPad accessible'. The unique statements grouped under availability included 'district-mandated', 'assigned', and 'district-purchased'. The following response subclusters were identified at lower frequencies: ease of implementation, appeal to students, impact on student performance, and word-of-mouth recommendation.

Table 3

Round One Selection Methods

Subcluster (Frequency)	Percentage of Participants	Unique Responses	Perception Statement
Features of the software (*n* = 6)	33.33%	Formative assessment capabilities iPad accessible Grade levels available Adaptive capabilities Reports available Level of correlation with what I'm teaching Data reports Ability to customize content Reports Web access Comprehension, differentiation and rigor	I select instructional software based on the content and capabilities of the software (e.g., formative assessment, reports, differentiation).
Availability (*n* = 5)	27.78%	Availability District-mandated District-purchased Assigned Purchased by the school	I select instructional software based on what has been purchased or recommended by my school or district.
None (*n* = 4)	22.22%	None N/A I don't currently use any software	I do not use any specific methods to select instructional software.
Ease of implementation (*n* = 3)	16.67%	Ease of use Ease of implementation Ease of integration	N/A
Appeal to students (*n* = 3)	16.67%	What seems to…appeal to students Possible engagement Student-friendly user interface	N/A
Impact on student performance (*n* = 2)	11.11%	What seems to work Benefits to students If it seems to work and fit our goals	N/A
Word-of-mouth recommendation (*n* = 2)	11.11%	Colleagues share Word of mouth PDE[a] classes	N/A

Note. In the first round, participants were asked to list multiple responses for each question. After coding, the number of participants (*n*) with unique responses in each subcluster was determined.
[a]Professional Development Education

Barriers to Implementation

On the third question, participants were asked to identify barriers relative to the effective use of instructional software. The response subclusters with the highest frequencies were lack of time ($n = 9$), lack of technology ($n = 5$), and cost ($n = 4$). The following response subclusters were identified at lower frequencies: teacher knowledge, software quality, student characteristics, none, and training.

Table 4

Round One Barriers to Implementation

Subcluster (Frequency)	Percentage of Participants	Unique Responses	Perception Statement
Lack of time (n = 9)	50%	Signing up students No time to use it Consistency of use Not enough time to effectively integrate technology Training time Lack of my time to review lessons Time for students to use it	Lack of time for training, integration, and student use is a barrier to the effective use of instructional software.
Lack of technology (n = 5)	27.78%	Many students in one-to-one schools still do not have iPads Not enough students with iPads Hardware is outdated and slow with software Availability I don't have enough for all of my kids	Lack of technology is a barrier to the effective use of instructional software.
Cost (n = 4)	22.22%	Cost Many people advertise, but then they are not free (I can't afford to pay for licenses for a whole class) example: Scholastic News---they have a math version that is very fun and current for real world math	Cost is a barrier to the effective use of instructional software.
Teacher knowledge (n = 3)	16.67%	Lack of training in how to use it Too many options My lack of computer use Knowledge of what is available	N/A
Software quality (n = 2)	11.11%	Data reports are not relevant enough or customizable for my classroom The content is not differentiated	N/A
Student characteristics (n = 2)	11.11%	Student comprehension Student engagement Students playing games Students who don't work on anything outside the classroom Students who don't work to their educational potential Languages (ESL[a]) Previous backgrounds Transiency	N/A
None (n = 2)	11.11%	None I don't currently use any software	N/A
Training (n = 1)	5.56%	Training	N/A

Note. In the first round, participants were asked to list multiple responses for each question. After coding, the number of participants (n) with unique responses in each subcluster was determined.
[a]English as a Second Language

Desired Supports

The fourth question on the survey required respondents to identify the supports needed to effectively integrate instructional software during math instruction. The three response subclusters with the highest frequency were training and support (n = 3), additional technology (n = 3), and none (n = 3). One participant identified 'resources' with no further specification. Once the three most frequent subclusters were determined, the 'resources' response was reconsidered within the framework of the identified subclusters. The intent of the 'resources' response may have included either training and support or additional technology or both. However, this could not be determined based on the anonymous nature of the survey, so the response was counted as a response for both training and support and additional technology, and the frequencies were adjusted accordingly (i.e., training and support: n = 4; additional technology: n = 4). The following response subclusters were identified at lower frequencies: software features, time for students to use technology, teacher knowledge, and administrative approval.

Table 5

Round One Desired Supports

Subcluster (Frequency)	Percentage of Participants	Unique Responses	Perception Statement
Training and support (*n* = 4)	22.22%	On-campus tech people to keep everything working correctly On-going training on how to implement and use it effectively A well thought and useful instructor manual describing how to set up accounts, differentiate content, and share data with students	Training and support are needed to integrate instructional software during math instruction
Additional technology (*n* = 4)	22.22%	iPad class set Projector Additional iPads Updated devices, operating servers and wi-fi	Additional technology is needed to integrate instructional software during math instruction.
None (*n* = 3)	16.67%	Because we are a one to one school it is much easier to integrate instructional software I don't have any needs at this time None I don’t currently use any software	No supports are needed to integrate instructional software during math instruction.
Software features (*n* = 2)	11.11%	Teacher component mirrors student component The option to slow down pacing	N/A
Time for students to use technology (*n* = 2)	11.11%	Consistent scheduling for students. The students also need time to use them	N/A
Teacher knowledge (*n* = 2)	11.11%	More time for me to use the programs I need the options for educational software I would like to know what programs are available and approved to use I also need to know if they are effective and what they cost (and whether the school will pay for them)	N/A
Administrative approval (*n* = 1)	5.56%	Approval from admin	N/A

Note. In the first round, participants were asked to list multiple responses for each question. After coding, the number of participants (*n*) with unique responses in each subcluster was determined.

Student Impact

On the final survey question, participants were asked how they thought the use of instructional software impacted the math performance of their students. The response subclusters with the highest frequencies were: improved learning outcomes (n = 8), increased engagement (n = 5), and unknown (n = 3). The following response subclusters were identified at lower frequencies: immediate feedback, differentiated experience, opportunities for progress monitoring, and ease of use.

Table 6

Round One Student Impact

Subcluster (Frequency)	Percentage of Participants	Unique Responses	Perception Statement
Improved learning outcomes (n = 8)	44.44%	Helps students visualize graphs Enhances their learning Increase, slowly but evident It positively effects the students' math performance *ALEKS* has a significant impact on students when they work on the program with fidelity Makes some concepts easy to grasp It varies from student to student. Mostly successful... It does impact math performance IF the students take it seriously. I've had students just click away and use it as playtime.	The use of instructional software improves the math performance of my students.
Increased engagement (n = 5)	27.78%	Many students are more focused when they have their own device and assignment on that device for them I have always felt that it is the world they are living in and is very powerful when used to encourage and interest the middle school mind I think it engages them more Students enjoy working on the computers More engagement/on task More interesting It keeps the students involved in math	The use of instructional software increases student engagement.
Unknown (n = 3)	16.67%	None I don't see my students (especially Co-teach) using instructional software The students don't have time to use it during class I don't currently use any software	I don't know how the use of instructional software impacts the math performance of my students.
Immediate feedback (n = 2)	11.11%	They get instantaneous results Provides immediate feedback	N/A
Differentiated experience (n = 1)	5.56%	Students are able to have a differentiated experience that is meaningful to them	N/A
Opportunities for progress monitoring (n = 1)	5.56%	Progress monitoring	N/A
Ease of use (n = 1)	5.56%	Without the painstaking process of graphing on paper Can manipulate equations and graphs with ease	N/A

Note. In the first round, participants were asked to list multiple responses for each question. After coding, the number of participants (n) with unique responses in each subcluster was determined.

Analysis of Round Two

The perception statements included in the second round of the survey were related to the most frequent responses for each question as indicated in the first round of the survey. After each statement, the number (*n*) of first-round participants who provided unique responses included in the perception statement was provided. Respondents were asked to rate their agreement with the perception statements. The target return rate was the recommended 20% to 35% for electronic survey research (Cook et al., 2000; Sax et al., 2003; Shih & Fan, 2009), although a decline in return rate was anticipated (Bardecki, 1984).

The second round of the survey was sent to all originally-identified experts. A total of 17 individuals (47.22% of the identified experts) responded to the second round of the survey; however, data were only collected from the 15 individuals who indicated that they had responded to the first round of the survey. This was 41.67% of the original expert pool and 83.33% of the individuals who responded to the first round of the survey. The results of Round Two are presented in Table 7.

Types of Instructional Software

The first question addressed the types of instructional software used in secondary math classrooms with students with disabilities. In the first round, the subclusters with the highest number of unique statements included *ALEKS* (n = 7), none (n = 4), *Kahoot* (n = 3), and *ST Math* (n = 3). In the second round, respondents indicated the highest rate of agreement (M = 3.07, SD = 1.53), with the statement ‘I use *Kahoot* during math instruction for students with disabilities.’ The *ALEKS*-related perception statement (‘I use *ALEKS* during math instruction for students with disabilities’) received the second-highest rate of agreement (M = 3.06, SD = 1.34), followed by ‘I do not use instructional software during math instruction for students with

disabilities' (*M* = 2.33, *SD* = 1.30). The *ST Math*-related perception statement, 'I use *ST Math* during math instruction for students with disabilities' had the lowest rate of agreement (*M* = 2.07, *SD* = 1.18).

Selection Methods

For the second question, respondents were asked to rate their level of agreement with methods used to select instructional software for integration in the classroom. In the first round, respondents indicated features of the software (n = 6), availability (n = 5), and none (n = 4) as the most frequent factors in software selection. In the second round of the survey, the availability-related perception statement ('I select instructional software based on what has been purchased or recommended by my school or district') received the highest rate of agreement (*M* = 4.27, *SD* = 0.57). The features-related perception statement ['I select instructional software based on the content and capabilities of the software (e.g., 'formative assessment, reports, differentiation)'] had the second highest rate of agreement (*M* = 4.13, *SD* = 0.62), and the lowest rate of agreement (*M* = 2.27, *SD* = 0.77) was with the statement: 'I do not use any specific methods to select instructional software.'

Barriers to Implementation

Participants were also asked to rate their level of agreement with the most frequently identified barriers to the effective use of instructional software in the classroom. In the first round, the most frequent responses were lack of time (n = 9), lack of technology (n = 5), and cost (n = 4). In the second round, the time-related perception statement ('Lack of time for training, integration, and student use is a barrier to the effective use of instructional software') had the highest rate of agreement (*M* = 3.87, *SD* = 0.96). Cost ('Cost is a barrier to the effective use of instructional software') had the second-highest rate of agreement (*M* = 3.33, *SD* = 1.01).

The technology-related statement, ‘Lack of technology is a barrier to the effective use of instructional software’, had the lowest level of agreement (M = 3.07, SD = 0.93).

Desired Supports

In the first round, respondents identified training and support (n = 4), additional technology (n = 4), and none (n = 3) as supports needed to effectively integrate instructional software during math instruction. In the second round, respondents indicated the highest rate of agreement (M = 4.20, SD = 0.65) with the training-related statement (‘Training and support are needed to integrate instructional software during math instruction’). Technology (‘Additional technology is needed to integrate instructional software during math instruction’) had the second-highest rate of agreement (M = 3.27, SD = 1.00). No supports (‘No supports are needed to integrate instructional software during math instruction’) received the lowest level of agreement (M = 2.27, SD = 0.85).

Student Impact

Finally, respondents were asked to rate their level of agreement with statements identifying the impact of instructional software on math performance. In the first round, improved learning outcomes (n = 8), increased engagement (n = 5), and unknown (n = 3) were the subclusters with the highest frequencies. The mean level of agreement for the responses to this question aligned with their frequency order in the first round.

The highest level of agreement (M = 4.13, SD = 0.62) was with the performance-related statement (‘The use of instructional software improves the math performance of my students’). The engagement-related statement (‘The use of instructional software increases student engagement’) had the second-highest level of agreement (M = 4.07, SD = 0.68). The lowest

level of agreement (M = 2.20, SD = 0.91) was with the unknown impact statement ('I don't know how the use of instructional software impacts the math performance of my students').

Table 7

Round Two Descriptive Statistics

	Round Two	
Topic	*Mean*	*SD*
Types of Instructional Software		
Kahoot	3.07	1.53
ALEKS	3.06	1.34
None	2.33	1.30
ST Math	2.07	1.18
Selection Methods		
Availability	4.27	0.57
Features of the software	4.13	0.62
None	2.27	0.77
Barriers to Implementation		
Lack of time	3.87	0.96
Cost	3.33	1.01
Lack of technology	3.07	0.93
Desired Supports		
Training and support	4.20	0.65
Additional technology	3.27	1.00
None	2.27	0.85
Student Impact		
Improved learning outcomes	4.13	0.62
Increased engagement	4.07	0.68
Unknown	2.20	0.91

Analysis of Round Three

In the final round of the survey, the second-round perception statements were repeated; however, the frequency statistic was replaced with the mean and standard deviation of each response from the second round of the survey. A total of 14 respondents (38.89% of the identified experts) completed the survey; however, data were only recorded for the 11 participants who indicated that they had responded to the first two rounds of the survey. This was 30.56% of the original expert pool and 61.11% of the individuals who responded to the first round of the survey. A decline in responses over the course of a Delphi survey is expected (Bardecki, 1984), and the third-round response rate did exceed the typical electronic survey return rate of 20% to 35% (Cook et al., 2000; Sax et al., 2003; Shih & Fan, 2009). The results of Round Three are presented in Table 8. For comparison purposes, response tables (see Figures 1 through 16) are provided for each subcluster.

Table 8

Round Three Descriptive Statistics

Topic	Round Three	
	Mean	*SD*
Types of Instructional Software		
ALEKS	2.91	1.24
Kahoot	2.89	1.20
ST Math	2.33	1.15
None	2.00	1.05
Selection Methods		
Availability	3.91	0.67
Features of the software	3.64	0.77
None	2.27	0.86
Barriers to Implementation		
Lack of time	4.00	1.04
Cost	3.45	0.50
Lack of technology	3.27	0.86
Desired Supports		
Training and support	4.00	0.74
Additional technology	3.64	0.64
None	1.91	0.79
Student Impact		
Increased engagement	3.91	0.67
Increased learning outcomes	3.82	0.57
Unknown	2.27	0.75

Types of Instructional Software

Mean responses for three of the four instructional software statements decreased in the third round (see Figures 1 through 4). The mean response for the use of *ALEKS* dropped from 3.06 to 2.91 (*SD* = 1.24); however, this response supplanted *Kahoot* as the highest instructional

software mean. The mean response for the *Kahoot* statement decreased from 3.07 to 2.89 (*SD* = 1.20). The mean response for *ST Math* increased from 2.07 to 2.33 (*SD* = 1.15). The lowest mean in the third round was for the statement indicating no instructional software use during math instruction; this mean decreased from 2.33 to 2.00 (*SD* = 1.05).

TYPES OF INSTRUCTIONAL SOFTWARE

Number of participants providing unique responses in the Round 1 survey	7
Percentage of participants providing unique responses in the Round 1 survey	38.89%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	3.06
Rank based on mean score from the Round 2 survey	2
Mean score from the Round 3 survey	2.91
Rank based on mean score from the Round 3 survey	1

Figure 1. ALEKS

TYPES OF INSTRUCTIONAL SOFTWARE

Number of participants providing unique responses in the Round 1 survey	4
Percentage of participants providing unique responses in the Round 1 survey	22.22%
Rank based on frequency from the Round 1 survey	2
Mean score from the Round 2 survey	2.33
Rank based on mean score from the Round 2 survey	3
Mean score from the Round 3 survey	2.00
Rank based on mean score from the Round 3 survey	4

Figure 2. None

TYPES OF INSTRUCTIONAL SOFTWARE

Number of participants providing unique responses in the Round 1 survey	3
Percentage of participants providing unique responses in the Round 1 survey	16.67%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	3.07
Rank based on mean score from the Round 2 survey	1
Mean score from the Round 3 survey	2.89
Rank based on mean score from the Round 3 survey	2

Figure 3. Kahoot

TYPES OF INSTRUCTIONAL SOFTWARE

Number of participants providing unique responses in the Round 1 survey	3
Percentage of participants providing unique responses in the Round 1 survey	16.67%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	2.07
Rank based on mean score from the Round 2 survey	4
Mean score from the Round 3 survey	2.33
Rank based on mean score from the Round 3 survey	3

Figure 4. ST Math

Selection Methods

In the third round, two of the three means for selection methods decreased (see Figures 5 through 7). Availability continued to have the highest mean with a decrease from 4.27 to 3.91 (*SD* = 0.67). Software selection based on features and content decreased from 4.13 to 3.64 (*SD* = 0.77). The mean for no specific methods of software selection remained the same (*M* = 2.27) with an increase in standard deviation from 0.77 to 0.86.

SELECTION METHODS

Number of participants providing unique responses in the Round 1 survey	6
Percentage of participants providing unique responses in the Round 1 survey	33.33%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	4.13
Rank based on mean score from the Round 2 survey	2
Mean score from the Round 3 survey	3.64
Rank based on mean score from the Round 3 survey	2

Figure 5. Features of the software

SELECTION METHODS

Number of participants providing unique responses in the Round 1 survey	5
Percentage of participants providing unique responses in the Round 1 survey	27.78%
Rank based on frequency from the Round 1 survey	2
Mean score from the Round 2 survey	4.27
Rank based on mean score from the Round 2 survey	1
Mean score from the Round 3 survey	3.91
Rank based on mean score from the Round 3 survey	1

Figure 6. Availability

SELECTION METHODS

Number of participants providing unique responses in the Round 1 survey	4
Percentage of participants providing unique responses in the Round 1 survey	22.22%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	2.27
Rank based on mean score from the Round 2 survey	3
Mean score from the Round 3 survey	2.27
Rank based on mean score from the Round 3 survey	3

Figure 7. None

Barriers to Implementation

All means for implementation barriers increased from the second to the third round of the survey (see Figures 8 through 10). However, when listed in mean order, the results remained in the same order as the second round. The mean for lack of time increased from 3.87 to 4.00 (*SD* = 1.04), and the mean for cost increased from 3.33 to 3.45 (*SD* = 0.50). The mean for lack of technology increased from 3.07 to 3.27 (*SD* = 0.86).

BARRIERS TO IMPLEMENTATION

Number of participants providing unique responses in the Round 1 survey	9
Percentage of participants providing unique responses in the Round 1 survey	50%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	3.87
Rank based on mean score from the Round 2 survey	1
Mean score from the Round 3 survey	4.00
Rank based on mean score from the Round 3 survey	1

Figure 8. Lack of time

BARRIERS TO IMPLEMENTATION

Number of participants providing unique responses in the Round 1 survey	5
Percentage of participants providing unique responses in the Round 1 survey	27.78%
Rank based on frequency from the Round 1 survey	2
Mean score from the Round 2 survey	3.07
Rank based on mean score from the Round 2 survey	3
Mean score from the Round 3 survey	3.27
Rank based on mean score from the Round 3 survey	3

Figure 9. Lack of technology

BARRIERS TO IMPLEMENTATION

Number of participants providing unique responses in the Round 1 survey	4
Percentage of participants providing unique responses in the Round 1 survey	22.22%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	3.33
Rank based on mean score from the Round 2 survey	2
Mean score from the Round 3 survey	3.45
Rank based on mean score from the Round 3 survey	2

Figure 10. Cost

Desired Supports

The mean order for desired supports also remained the same from the second to the third round (see Figures 11 through 13). Despite a decrease in mean from 4.20 to 4.00 (*SD* = 0.74), training and support remained the desired support with the highest overall mean. The second highest mean was additional technology with an increase from 3.27 to 3.64 (*SD* = 0.64). The mean for no support decreased from 2.27 to 1.91 (*SD* = 0.79).

DESIRED SUPPORTS

Number of participants providing unique responses in the Round 1 survey	4
Percentage of participants providing unique responses in the Round 1 survey	22.22%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	4.20
Rank based on mean score from the Round 2 survey	1
Mean score from the Round 3 survey	4.00
Rank based on mean score from the Round 3 survey	1

Figure 11. Training and support

DESIRED SUPPORTS

Number of participants providing unique responses in the Round 1 survey	4
Percentage of participants providing unique responses in the Round 1 survey	22.22%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	3.27
Rank based on mean score from the Round 2 survey	2
Mean score from the Round 3 survey	3.64
Rank based on mean score from the Round 3 survey	2

Figure 12. Additional technology

DESIRED SUPPORTS

Number of participants providing unique responses in the Round 1 survey	3
Percentage of participants providing unique responses in the Round 1 survey	16.67%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	2.27
Rank based on mean score from the Round 2 survey	3
Mean score from the Round 3 survey	1.91
Rank based on mean score from the Round 3 survey	3

Figure 13. No support

Student Impact

The mean order of responses for student impact differed from the second to the third round (see Figures 14 through 16). The mean for increased engagement decreased from 4.07 to 3.91 (SD = 0.67); however, this result was higher than the mean for improved learning outcomes (M = 3.82, SD = 0.57) which also decreased. Unknown impact continued to have the lowest mean despite an increase from 2.20 to 2.27 (SD = 0.75).

STUDENT IMPACT

Number of participants providing unique responses in the Round 1 survey	8
Percentage of participants providing unique responses in the Round 1 survey	44.44%
Rank based on frequency from the Round 1 survey	1
Mean score from the Round 2 survey	4.13
Rank based on mean score from the Round 2 survey	1
Mean score from the Round 3 survey	3.82
Rank based on mean score from the Round 3 survey	2

Figure 14. Improved learning outcomes

STUDENT IMPACT

Number of participants providing unique responses in the Round 1 survey	5
Percentage of participants providing unique responses in the Round 1 survey	27.78%
Rank based on frequency from the Round 1 survey	2
Mean score from the Round 2 survey	4.07
Rank based on mean score from the Round 2 survey	2
Mean score from the Round 3 survey	3.91
Rank based on mean score from the Round 3 survey	1

Figure 15. Increased engagement

STUDENT IMPACT

Number of participants providing unique responses in the Round 1 survey	3
Percentage of participants providing unique responses in the Round 1 survey	16.67%
Rank based on frequency from the Round 1 survey	3
Mean score from the Round 2 survey	2.20
Rank based on mean score from the Round 2 survey	3
Mean score from the Round 3 survey	2.27
Rank based on mean score from the Round 3 survey	3

Figure 16. Unknown

Summary

The current study examined the perceptions of secondary math teachers regarding the use of instructional technology with students with disabilities. A three-round Delphi survey technique was used to achieve this objective. The initial round of the survey was sent to 36 expert panelists and included a demographic questionnaire and five open-ended questions related to technology use. The data from the first round were coded to identify common themes. The data were then organized into subclusters, and corresponding perception statements were developed. The frequency of participants who provided unique response statements included in each subcluster was also calculated.

In the second round, participants were provided with the perception statements and frequencies and asked to rate their level of agreement with each statement. Data analysis indicated that the mean order of all second-round responses, except for student impact, varied from the first-round frequency order. In the third round, participants were again provided with the perception statements and asked to rate their level of agreement. During this round, first-round frequencies were replaced with the mean and standard deviation results from the second round. The average mean scores and standard deviations of third-round responses indicated varying levels of agreement; however, the mean order of responses remained the same for all questions except those related to the types of instructional software and student impact.

CHAPTER FIVE

DISCUSSION

Overview

The ability to critically understand mathematical concepts affects both the number and quality of personal and professional postsecondary opportunities (NMAP, 2008). However, overall math proficiency rates in the U. S., particularly for students with disabilities, continue to be a concern (USDOE, 2013). Previous studies have identified the use of technology as a potentially effective intervention for improving the math outcomes of this population of students (Strickland & Maccini, 2010).

For students with disabilities to benefit from technology integration in their mathematics instruction, it is important that teachers are adequately trained on using technology for instructional purposes and have ready access to educational technology. To achieve this, research supports the implementation of technology-focused training for both pre-service education students (Lambert & Gong, 2010) and post-hire teachers (Kopcha, 2012; O'Hara et al., 2013; Skoretz & Childress, 2013; Walker et al., 2012). However, pre-service teachers report feeling underprepared to implement technology in the classroom (Ruggiero & Mong, 2013), and technology as an intervention has been relatively underutilized with students with disabilities (Gray et al., 2010).

Given the underutilization of technology with this population, limited research has been conducted to explore teachers' use of technology in the provision of special education. The current study used a three-round Delphi survey method to investigate teacher-reported usage, selection methods, perceived barriers, desired supports, and beliefs related to the use of educational technology in secondary math classrooms with students with disabilities. School

principals were recruited to participate in this study and identified 36 general and special education math teachers who met the following expertise criteria: (a) hold a standard teaching license, (b) have a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings, (c) currently teach secondary math to students with disabilities in co-teach and/or resource settings, and (d) have used instructional software with students.

A total of 18 teachers from 10 schools completed the first round of the survey which consisted of open-ended questions related to instructional software usage, selection methods, perceived barriers, desired supports, and beliefs. After analysis of first-round data, perception statements were developed to reflect the most frequent responses. Both the second and third rounds of the survey included these perception statements and descriptive statistics, and participants were asked to rate their level of agreement with each statement. In the second round, data from 15 participants were analyzed. In the third round, data from 11 participants were analyzed.

Types of Instructional Software

The first question in the survey focused on identifying instructional software used in secondary math classrooms with students with disabilities. Instructional software refers to computer programs that deliver content, provide opportunities to practice content, and/or assess content knowledge (Ogle et al., 2002). Types of instructional software include drill and practice, tutorial, simulation, game, and problem-solving programs (Roblyer & Doering, 2010) used in the delivery of instruction.

In the first round of the survey, many respondents misidentified technology hardware (i.e., computer, SmartBoard, document camera, overhead projector, graphing calculator) as instructional software. This indicated a fundamental lack of understanding of basic technology

concepts (i.e., the difference between hardware and software). Non-instructional software (i.e., Google Calendar) was also included in first-round responses, demonstrating a lack of understanding of the multiple functions of software (e.g., instructional, time management).

Ruggiero and Mong (2013) found that preservice teachers often feel unprepared to implement technology in the classroom, and the current results indicate that basic technology courses, in addition to educational technology courses, may be necessary to address this deficit. Even well-designed educational technology courses that include coverage of research-based instructional software options may be ineffective and be overwhelming for teachers if they lack a fundamental understanding of basic technology.

First-round responses also included a wide variety of software with low frequencies (i.e., identified by only one or two participants). The wide variety of low-frequency responses from participants in the same school district may indicate that teachers are selecting instructional software without following a rigorous decision-making process. Boone and Higgins (2007) developed a tool for evaluating educational software for students with disabilities. The development process included a review of the literature, expert panel input, content validation by teachers, and one-on-one field testing with teachers and parents. In addition, reproduction and use of the tool with copyright was not limited by the developers.

Despite the existence of a well-designed and accessible tool, the results of the current study indicate that teachers of students with disabilities are not employing rigorous techniques when selecting instructional software. The results also indicate the need for more effective communication regarding the selection of research-based instructional software in both teacher preparation programs and post-hire professional development sessions.

In the first round, many participants also indicated that they used no instructional software in secondary math instruction. The frequency of the 'none' response dropped in the second and third rounds of the survey; however, participants may have changed their answer due to perceived expectations that they should be using technology based on first-round feedback. The high frequency of the 'none' response indicates that the conclusions of Gray et al. (2010) related to the underutilization of technology continue to be true seven years later. Despite the increased availability of software and advancements in technology, some practitioners are not using instructional software with their students with disabilities. Given the research base supporting the use of technology to improve the math outcomes of students with disabilities (Strickland & Maccini, 2010), additional training and implementation support may be needed to encourage the use of instructional software in secondary math classrooms.

The highest-frequency responses for instructional software were *ALEKS*, *Kahoot*, and *ST Math*. *ALEKS* is a web-based learning system that provides adaptive assessment and instruction in concepts identified as areas of need for each student based on the assessment results (McGraw-Hill Education, 2017). *Kahoot* is a web-based tool that allows users to create multiple-choice assessments that can be played as classroom games (*Kahoot*, 2017). *ST Math* is also game-based and includes both assessment and instruction capabilities. Multiple-choice pretests and posttests are administered, and mathematical concepts are presented using graphic animations (MIND Research Institute, 2017).

ALEKS, *Kahoot*, and *ST Math* provide alternative methods for math instruction and assessment. Practitioners can use these software programs as instructional techniques to provide components of effective instruction that support students with disabilities in the acquisition of math skills, including multiple practice opportunities (Fuchs et al., 2013; Mastropieri et al.,,

2012), multiple examples, instruction in metacognitive strategies (Mastropieri et al., 2012), conceptual explanations, cumulative review, and use of motivators (Fuchs et al., 2013).

Although *ALEKS*, *Kahoot*, and *ST Math* were the highest-frequency responses, these interventions do not have a strong evidence base. None of the interventions are listed in the What Works Clearinghouse (Institute of Education Sciences, n.d.). In a review of peer-reviewed math education literature, no studies of *Kahoot* were found. Two studies of *ST Math* were found; however, the studies focused on elementary students and had mixed results (Rutherford et al., 2014; Schenke, Rutherford, & Farkas, 2014). A larger body of research focusing on *ALEKS* was found. Although many studies focused on university-level students (e.g., Spradlin & Ackerman, 2010; Stillson & Nag, 2009), there were three studies that described the implementation of ALEKS with middle school students (Craig et al., 2013; Fanusi, 2015; Huang, Craig, Xie, Graesser, & Hu, 2016). These studies had mixed results, and none of the studies focused on students with disabilities.

The absence of instructional software with a strong evidence base in the responses has implications for practitioners, researchers, and school-based administrators. Practitioners need to use a systematic method for selecting instructional software that has an evidentiary base. For researchers, additional replication studies are needed to evaluate and strengthen the evidence base for instructional software applications. Finally, administrators may need to analyze the current methods of selecting instructional software for classroom use.

Selection Methods

The second question in the survey asked participants to indicate how instructional software was selected for use in the classroom. One of the highest-frequency responses was availability, and first-round responses in this category (e.g., 'mandated', 'assigned') indicated

that software selection was controlled at an administrative level. The instructional software types indicated in the first question of the survey lacked a strong evidence base; therefore, training at an administrative level that includes a framework for selecting instructional software supported by the literature, such as the checklist developed by Boone and Higgins (2007), may be beneficial.

The other high-frequency responses were none and features of the software. The none response provides further evidence that some teachers do not feel prepared to implement instructional software in the classroom, as indicated by Ruggiero and Mong (2013). However, the 'none' response had a lower mean score in the second and third rounds. Further research is needed to explore why the 'none' response decreased when respondents were presented with a quantitative statement.

The 'features of the software' response indicated that, in many cases, participants themselves individually evaluated specific characteristics of instructional software to determine selection. However, additional information is needed to determine the criteria used for evaluation and identify the specific features that teachers find most important. In addition, additional research is needed to determine how respondents identified these features as critical to achieving their desired outcomes.

Although higher-education professionals believe that technology is emphasized in teacher preparation programs (Kleiner et al., 2007; McGrail et al., 2011), preservice coursework and professional development sessions may need to be expanded to include specific frameworks for software selection for those teachers whose administrators do not mandate or assign specific instructional software. Even for those teachers whose administrators do make instructional software decisions, this training may be necessary to empower teachers to validate an

administrator's decision-making process. Teacher preparation programs typically focus on older technologies (McGrail et al., 2011), and additional research is needed to continue to develop and evaluate effective frameworks that help practitioners effectively select from the wide range of changing technologies.

Barriers to Implementation

The third question on the survey focused on identifying the teacher-perceived barriers to implementation. Despite research indicating that teachers report feeling underprepared to implement technology (Ruggiero & Mong, 2013), teacher knowledge was not one of the barriers most frequently identified. Instead, participants most frequently identified lack of technology, cost, and lack of time as significant barriers. In a previous survey of general education teachers, access to technology and lack of time were also identified as barriers (Kopcha, 2012).

A lack of technology could be overcome by purchasing needed items (e.g., computers, iPads, network devices). Therefore, the perceived lack of technology and cost barriers may indicate the need to assess the funding mechanisms in place for teachers of students with disabilities. Additional federal funding is allocated to states to meet the needs of students with disabilities (USDOE, 2016). Therefore, the perception that funding is insufficient to purchase needed technology and instructional software may indicate the need to establish more effective programming and purchasing infrastructures that ensure funding is applied to the purchase of evidence-based instructional software that meets the needs of students with disabilities.

Teachers may benefit from preservice coursework and professional development focused on effective budgeting practices. Given the myriad responsibilities required of teachers, additional focus on effective time management skills may also be needed to address the

perceived barrier of time. In addition, practitioners may benefit from administrative release time that allows them to focus on developing an effective plan to integrate instructional software.

Desired Supports

On the fourth question of the survey, participants were asked to identify supports needed to effectively implement instructional software. Although cost and lack of time were previously identified as barriers, additional funding and time were not frequently identified as desired supports to address these barriers. However, additional technology was frequently identified as a desired support, and this correlated with the perception of lack of technology as a barrier. This further supports the need to evaluate programming and purchase infrastructures and include effective budgeting practices in teacher preparation programs.

Although participants did not identify teacher knowledge as a high-frequency barrier to implementation, they did identify additional training as a desired support to improve the implementation of instructional software. The identification of training as a desired support may indicate an area on which both school districts and teacher preparation programs should focus. Both preservice coursework (Kopcha 2012; O'Hara et al., 2013; Skoretz & Childress, 2013; Walker et al., 2012) and professional development (Lambert & Gong, 2010) have resulted in positive outcomes related to technology implementation. The high frequency of the 'none' response may reflect the underutilization of technology reported by Ruggiero and Mong (2013). However, additional research is needed to determine why the mean of the 'none' response decreased in the second and third rounds of the survey.

Student Impact

The final question of the survey focused on the perceived impact of instructional software on the math performance of students. The highest-frequency responses across all three rounds of

the survey were increased engagement, improved learning outcomes, and unknown. Increased engagement and improved learning outcomes are supported by the literature (Strickland & Maccini, 2010). This supports previous conclusions indicating that teachers have positive perceptions of technology and want to implement technology in the classroom (Kopcha, 2012; Ruggiero and Mong, 2013).

However, the high frequency of participants indicating that they did not know the impact of instructional software on math performance indicates that there are still many teachers who do not understand the value of technology in the classroom. This has implications for both teacher preparation programs and professional development sessions. Designers of preservice and post-hire instruction may need to increase participants' exposure to research that indicates increased performance of students with disabilities using technology (e.g., Bouck et al., 2014; Burton et al., 2013; Haydon et al., 2012; Seo & Bryant, 2012) to increase the overall understanding of instructional software and its impact on math performance.

Conclusions

Based on the results of this study, several conclusions may be drawn. These conclusions should be considered within the limitations of the study.

1. Secondary math teachers reported that instructional software is not being used consistently across classrooms with students with disabilities.
2. Secondary math teachers reported using instructional software applications that do not have a strong evidence base for effectiveness.
3. Secondary math teachers reported that the instructional software used is often determined at an administrative level.

4. Secondary math teachers reported using software selection methods that did not include consideration of data to support effectiveness.
5. Secondary math teachers reported that lack of time, cost, and lack of technology are barriers to the implementation of instructional software in classrooms with students with disabilities.
6. Secondary math teachers reported that additional technology and training are needed to support the implementation of instructional software with students with disabilities.
7. Consensus across secondary math teachers is not evident on the impact of technology and instructional software. While some secondary math teachers were not clear on the impact instructional software and technology have on the math outcomes of students with disabilities, others believed that technology increased student engagement in math instruction as well as student math outcomes.

Recommendations for Further Study

The use of instructional software has the potential to improve the math outcomes of students with disabilities (Strickland & Maccini, 2010), and national organizations advocate for the use of instructional software with this population (CAEP, 2015; NCTM, 2011). The purpose of the current study was to examine teacher perceptions related to the use of math instructional software with students with disabilities. Based on the findings of the current study, additional research in the following areas is suggested.

1. A replication of the current study should be done with a larger sample size of secondary math teachers of students with disabilities.

2. A replication of the current study should be done with additional qualitative data collected (i.e., observations, interviews) to further clarify and triangulate participant responses.
3. Demographic data should be analyzed in relation to survey responses to determine factors that may contribute to teacher-reported practices and perceptions.
4. Further research should be conducted to develop and evaluate frameworks for effective software selection for both teachers and administrative decision-makers.
5. Further research should be conducted to design and evaluate pre-service training and post-hire professional development that include a focus on basic technology in addition to educational technology.
6. Further research should be conducted to design and evaluate pre-service training and post-hire professional development that include a focus on budgeting and time management.
7. Further research should be conducted to design and evaluate pre-service training and post-hire professional development that include a focus on the evaluation of instructional software research, as well as research-to-practice application of results.
8. Further research should be conducted to develop and evaluate professional development focused on seamlessly integrating instructional technology into classroom instruction.
9. Additional replication research is needed to address the thin research base that exists for individual software applications and their impact on the math outcomes of targeted populations.

Summary

Research supports the use of instructional software to improve the math outcomes of secondary students with disabilities (Strickland & Maccini, 2010). However, limited research has been conducted to investigate the use of math instructional software with this population. This study used a Delphi survey method to examine teacher-reported practices and perceptions related to the implementation of instructional technology in the classroom.

The results of this study indicated that secondary math teachers were not consistently using instructional software with students with disabilities. In addition, when software applications were being used, they typically lacked strong research support. Often, instructional software decisions were made at an administrative level, and teachers who did select software independently did not use the existing research base as a factor in the selection process.

Teachers reported encountering barriers related to lack of time, cost, and lack of technology and believed that additional training and technology would help them effectively integrate instructional software in the classroom. The perception of the impact of instructional software on math performance varied. Some teachers believed that students benefitted from increased engagement and improved learning outcomes; however, other teachers did not perceive an impact on student performance.

These findings have implications for administrators, teachers, researchers, and teacher preparation program developers. Both administrators and teachers should ensure that instructional software used in the classroom has demonstrated results with students with disabilities. Researchers should continue to develop frameworks for software selection and implementation. Researchers should also replicate technology-related studies to provide a stronger evidence base for practitioners to review. The findings of the study also indicate areas

of emphasis for professional development and teacher preparation programs, including technology integration, research review, budgeting, and time management.

APPENDIX A

FACILITY AUTHORIZATION LETTERS

William H. "Bob" Bailey
Middle School

2500 N. Hollywood Blvd. Las Vegas NV, 89156 Phone (702) 799-4811/ Fax (702) 799-4807

Gregory L. Cole, Principal
Yvette M. Tippetts, Assistant Principal
Eric L. Videau, Assistant Principal

Sarah J. Cyprus, Dean of Students
Elizabeth S. Hammel, Dean of Students
Derrick Williams, Dean of Students

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Dr. William H. Bailey Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Dr. William H. Bailey 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Signature of Principal or Division/Department Director — Date: 11.18.16

Greg Cole, Principal
Print Name and Title

http://www.iambaileynation.com/

Canarelli Middle School

Lisa Rizzuto O'Keefe, Assistant Principal
David Osterhuber, Assistant Principal

Monica Lang, Principal

Stacy Schaumburg, Dean of Students
Lonyae Bigby, Dean of Students

December 16, 2016

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Canarelli Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Canarelli 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Signature of Principal or Division/Department Director

12/16/16
Date

Monica Lang, Principal
Print Name and Title

7808 S. Torrey Pines Drive, Las Vegas, NV 89139
Phone: 702-799-1340 Fax: 702-799-5715

CCSD Clark County School District

FAISS MIDDLE SCHOOL

9525 W. Maule Avenue – Las Vegas, Nevada – 89148
Office (702) 799-6850 – Fax (702) 799-6852 – www.faissmiddleschool.net

Home of the Flyers

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Faiss Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Faiss 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Roger West
Signature of Principal or Division/Department Director

12/16/16
Date

Roger West - Principal
Print Name and Title

Dream... Believe... Soar to Achieve!

CHARLES A. HUGHES MIDDLE SCHOOL

Home of the Hawks

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Mesquite, NV 89027

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Maurice Perkins, Principal
Stephen Walters, Assistant Principal
Michael Kazek, Dean of Students

Kenneth Retzl,
Coordinator III
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Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Charles A. Hughes Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Charles A. Hughes 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

______________________________ 11-21-16
Signature of Principal or Division/Department Director Date

Maurice Perkins, Principal
Print Name and Title

CCSD
CLARK COUNTY
SCHOOL DISTRICT
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Principal, Roxanne James •• Assistant Principal, Rhonda Calvo •• Dean of Students, JoAnn Strand

Kenneth Retzl,
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Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Jerome Mack Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Jerome Mack 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Signature of Principal or Division/Department Director

12·16·16
Date

Roxanne James, Principal
Print Name and Title

NEVADA LEARNING ACADEMY AT CCSD

Andrea M Connolly
PRINCIPAL

David A. Miller
ASSISTANT PRINCIPAL

Lin B. Soriano
ASSISTANT PRINCIPAL

3050
E. FLAMINGO RD
LAS VEGAS, NV
89121

702.855.8435
PHONE

702.855.8438
FAX

WWW.NVLA.ME

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Nevada Learning Academy.

When the research project has received approval from the University of Nevada, Las Vegas 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 Nevada Learning Academy, 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Andrea Connolly 1/5/17

Signature of Principal or Division/Department Director Date

Andrea Connolly, Principal

Print Name and Title

CCSD CLARK COUNTY SCHOOL DISTRICT

every STUDENT every CLASSROOM

Clark County School District

Dell H. Robison Middle School

825 Marion Drive Las Vegas, NV 89110

ZOOM SCHOOLS

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Robison Middle School.

When the research project has received approval from the University of Nevada, Las Vegas 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 Robison 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

11/21/16

Signature of Principal or Division/Department Director Date

Immer Liza Ravalo, Principal
Print Name and Title

Respect, Motivation, Scholarship

Office: (702) 799-7300
Immer Liza Ravalo, Principal

Fax (702) 799-7302
Jacqueline Lee-Sit, Assistant Principal
Valencia Meyer, Dean of Students

Anthony Saville Middle School

Sean Davis, Principal
Ann Cella, Assistant Principal
Jennifer Morley, Assistant Principal
John Carlton, Dean of Students
Lin Soriano, Dean of Students

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Anthony Saville Middle School

When the research project has received approval from the University of Nevada, Las Vegas 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 Anthony Saville 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Sean Davis
Signature of Principal or Division/Department Director

11/28/16
Date

Sean Davis, Principal
Print Name and Title

LOIS & JERRY TARKANIAN MIDDLE SCHOOL

5800 W. Pyle Ave. Las Vegas, NV 89141 702.799.6801

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Tarkanian MS.

When the research project has received approval from the University of Nevada, Las Vegas 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 Tarkanian MS 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

Erin [signature] 11-17-16

Signature of Principal or Division/Department Director Date

Erin Johnson, Principal

Print Name and Title

Empowering All Students to Achieve Success

Thurman White Academy of the Performing Arts

Andrea Katona, Principal
Theresa Taylor, Assistant Principal
April Barr, Dean of Students
Jennifer Boeddeker, Dean of Students
Josh Wikler, Dean of Students

1661 Galleria Drive, Henderson Nevada 89014
Phone: (702) 799-0777 Fax: (702) 799-7690
Website: www.thurmanwhitems.com
Facebook: http://on.fb.me/ThurmanWhite

November 18, 2016

Kenneth Retzl,
Coordinator III
Research Department
Assessment, Accountability, Research, and School Improvement Division
Clark County School District
4212 Eucalyptus Avenue
Las Vegas, NV 89121-5207

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

Dear Kenneth:

This letter will acknowledge that I have reviewed a request by Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator) to conduct a research project entitled, entitled 'Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education' at Thurman White Academy

When the research project has received approval from the University of Nevada, Las Vegas 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 Thurman White Academy 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 Department of Research at (702) 799-1041 Ext 5837.

Sincerely,

AKatona 11-17-16

Signature of Principal or Division/Department Director Date

Andrea Katona, principal

Print Name and Title

Every Student, Every Classroom, Without Exceptions, Without Excuses!

APPENDIX B

INITIAL CONTACT EMAIL

To: Middle School Principals

From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your assistance with this study!

The purpose of this study is to examine the integration of instructional technology in secondary math classrooms with students with disabilities. You are being asked to identify participants who meet the following criteria:

General education teacher or special education teacher with a standard teaching license and a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings. In addition, participants must be currently teaching secondary math to students with disabilities in co-teach and/or resource settings and have used instructional software with students

Participants will be asked to complete a demographic questionnaire and three rounds of a survey. Each round of the survey will have five questions, and the study will take a total of approximately 30 minutes to complete.

After identifying all teachers on your campus who meet the criteria above, please send the names and email addresses to Joice Higa at higaj@unlv.nevada.edu.

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

APPENDIX C

INFORMED CONSENT FORM

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

EXEMPT RESEARCH STUDY

INFORMATION SHEET

Department of Educational and Clinical Studies

TITLE OF STUDY: The Use of Instructional Technology to Support the Math Achievement of Secondary Students with Disabilities: Teacher-Reported Practices and Perceptions

INVESTIGATOR(S) AND CONTACT PHONE NUMBER: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator); Phone 702-895-3329

The purpose of this study is to examine the integration of instructional technology in secondary math classrooms with students with disabilities. You are being asked to participate in the study because you meet the following criteria: general education teacher or special education teacher currently working with students with disabilities in secondary math resource and/or co-teach settings.

If you volunteer to participate in this study, you will be asked to do the following: complete a demographic questionnaire and three rounds of a survey. Each round of the survey will contain five questions.

This study includes only minimal risks. The study will take 30 minutes of your time. You will not be compensated for your time.

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.**

Your participation in this study is voluntary. You may withdraw at any time. 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 am at least 18 years of age. A copy of this form has been given to me.

1 of 1

APPENDIX D

DEMOGRAPHIC QUESTIONNAIRE

UNLV COLLEGE OF EDUCATION | Department of Educational & Clinical Studies

Demographic Questionnaire

Please complete the following demograhic information.

Age

- ◯ <25 years
- ◯ 26-35 years
- ◯ 36-45 years
- ◯ 46-55 years
- ◯ >56 years

Gender

- ◯ Male
- ◯ Female

Ethnic Background

- ◯ American Indian or Alaskan Native
- ◯ Asian
- ◯ Black or African American
- ◯ Hispanic or Latino
- ◯ Native Hawaiian or Other Pacific
- ◯ Islander
- ◯ White
- ◯ Multiethnic (please indicate) ______________

- Other (please indicate) ________

Primary teaching placement that includes students with disabilities

- Co-teach
- Resource
- Other (please indicate) ________

Grade level of assigned students with disabilities

- 6
- 7
- 8
- Mixed grade levels (please indicate) ________

Years teaching middle school mathematics

- <5 years
- 6-10 years
- 11-15 years
- 16-20 years
- >20 years

Education level

- Undergraduate degree
- Graduate degree
- Doctoral degree

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APPENDIX E

DISTRICT LETTER OF SUPPORT

STUDENT SERVICES DIVISION

4170 MCLEOD DRIVE • LAS VEGAS, NV 89121 • (702) 799-5471 • FAX (702) 799-5043

CCSD

CLARK COUNTY
SCHOOL DISTRICT

09/01/16

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

Subject: Letter of Authorization to Conduct Research at Clark County School District.

Dear Office of Research Integrity – Human Subjects:

This letter will serve as authorization for the University of Nevada, Las Vegas ("UNLV") researchers, Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator), to conduct the research project entitled "Secondary Math Instructional Software: Teacher-reported Practices and Perceptions in Special Education" at Clark County School District (the "Facility").

The Facility acknowledges that it has reviewed the protocol presented by the researcher, as well as the associated risks to the Facility. The Facility accepts the protocol and the associated risks to the Facility, and authorizes the research project to proceed upon approval from both UNLV and the Facility Research office. The research project may be implemented at the Facility upon approval from the UNLV Institutional Review Board.

If we have any concerns or require additional information, we will contact the researcher and/or the UNLV Office of Research Integrity – Human Subjects.

Sincerely,

Julia Chavez

Julia Chavez
Director II, Student Services Division

9/1/16
Date

Main Office: 5100 WEST SAHARA AVENUE • LAS VEGAS, NEVADA 89146 • TELEPHONE (702) 799-5000

APPENDIX F

PARTICIPANT EMAIL ROUND ONE

To: Survey Participants
From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your willingness to assist with this study!
The purpose of this study is to examine the integration of instructional technology in secondary math classrooms with students with disabilities. You are being asked to participate because you meet the following criteria:

> *General education teacher or special education teacher with a standard teaching license and a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings. In addition, participants must be currently teaching secondary math to students with disabilities in co-teach and/or resource settings and have used instructional software with students*

You will be asked to complete a demographic questionnaire and three rounds of a survey. Each round of the survey will have five questions, and the study will take a total of approximately 30 minutes to complete.

To begin, please access the consent form, demographic questionnaire, and Round One of the survey by clicking on the link below:

https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_2hNy9zm8SQYG1Jr

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

APPENDIX G

SURVEY ROUND ONE

UNLV COLLEGE OF EDUCATION | Department of Educational & Clinical Studies

Round One

Survey Round One:
Thank you for your willingness to complete the survey! Completion should take no more than 15 minutes.

List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.

List at least three methods you use to select instructional software for integration in your classroom.

List at least three barriers you have encountered relative to the effective use of instructional software.

What supports do you need in order to effectively integrate instructional software during math instruction?

How do you think the use of instructional software impacts the math performance of your students?

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APPENDIX H

PARTICIPANT EMAIL ROUND TWO

To: Survey Participants

From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your participation in the first round of the study!

The second round has five questions and should take no longer than 10 minutes to complete. Please click on the link below to access the second round of the survey:

https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_7WIzJjHnqtGl6Fn

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

APPENDIX I

PARTICIPANT EMAIL ROUND THREE

To: Survey Participants

From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your participation in the second round of the study!

The final round has five questions and should take no longer than 10 minutes to complete. Please click on the link below to access the final round of the survey:

https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_1B1r1tgE2asEkux

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

APPENDIX J

SURVEY ROUND TWO

UNLV
COLLEGE OF EDUCATION
Department of Educational & Clinical Studies

Round Two

Did you complete Round One of the survey?

- ○ Yes
- ○ No

Please indicate to what extent you agree with the responses to the following questions. The number of times each response was given by participants on the first round of the survey is indicated in parentheses after each statement.

List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I use ALEKS during math instruction for students with disabilities. (7)	○	○	○	○	○

How many days per week and how many minutes per day do you use ALEKS with students with disabilities (e.g., 3 days a week, 10 minutes each day)?

List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I do not use instructional software during math instruction for students with disabilities. (4)	○	○	○	○	○

List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I use Kahoot during math instruction for students with disabilities. (3)	○	○	○	○	○

How many days per week and how many minutes per day do you use Kahoot with students with disabilities (e.g., 3 days a week, 10 minutes each day)?

List at least five types of instructional software that you commonly use in math instruction for students with disabilities. Next to each type, list an estimated number of days per week that you integrate that software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I use ST Math during math instruction for students with disabilities. (3)	○	○	○	○	○

How many days per week and how many minutes per day do you use ST Math with students with disabilities (e.g., 3 days a week, 10 minutes each day)?

List at least three methods you use to select instructional software for integration in your classroom.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I select instructional software based on the content and capabilities of the software (e.g., formative assessment, reports, differentiation). (6)	○	○	○	○	○
I select instructional software based on what has been purchased or recommended by my school or district. (5)	○	○	○	○	○
I do not use any specific methods to select instructional software. (4)	○	○	○	○	○

List at least three barriers you have encountered relative to the effective use of instructional software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Lack of time for training, integration, and student use is a barrier to the effective use of instructional software. (9)	○	○	○	○	○
Lack of technology is a barrier to the effective use of instructional software. (5)	○	○	○	○	○
Cost is a barrier to the effective use of instructional software. (4)	○	○	○	○	○

What supports do you need in order to effectively integrate instructional software during math instruction?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Additional technology is needed to integrate instructional software during math instruction. (4)	○	○	○	○	○
Training and support are needed to integrate instructional software during math instruction. (4)	○	○	○	○	○
No supports are needed to integrate instructional software during math instruction. (3)	○	○	○	○	○

How do you think the use of instructional software impacts the math performance of your students?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The use of instructional software improves the math performance of my students. (8)	○	○	○	○	○
The use of instructional software increases student engagement. (5)	○	○	○	○	○
I don't know how the use of instructional software impacts the math performance of my students. (3)	○	○	○	○	○

APPENDIX K

SURVEY ROUND THREE

UNLV COLLEGE OF EDUCATION | Department of Educational & Clinical Studies

Round Three

Did you complete Rounds One and Two of the survey?

- ○ Yes
- ○ No

Please indicate to what extent you agree with the responses to the following questions. The mean and standard deviation of each response on the second round of the survey are indicated in parentheses after each statement.

List at least five types of instructional software that you commonly use in math instruction for students with disabilities.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I use ALEKS during math instruction for students with disabilities. (Mean = 3.06, Standard Deviation = 1.34)	○	○	○	○	○
I do not use instructional software during math instruction for students with disabilities. (Mean = 2.33, Standard Deviation = 1.30)	○	○	○	○	○
I use Kahoot during math instruction for students with disabilities. (Mean = 3.07, Standard Deviation = 1.53)	○	○	○	○	○
I use ST Math during math instruction for students with disabilities. (Mean = 2.07, Standard Deviation = 1.18)	○	○	○	○	○

List at least three methods you use to select instructional software for integration in your classroom.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I select instructional software based on the content and capabilities of the software (e.g., formative assessment, reports, differentiation). (Mean = 4.13, Standard Deviation = 0.62)	○	○	○	○	○
I select instructional software based on what has been purchased or recommended by my school or district. (Mean = 4.27, Standard Deviation = 0.57)	○	○	○	○	○
I do not use any specific methods to select instructional software. (Mean = 2.27, Standard Deviation = 0.77)	○	○	○	○	○

List at least three barriers you have encountered relative to the effective use of instructional software.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Lack of time for training, integration, and student use is a barrier to the effective use of instructional software. (Mean = 3.87, Standard Deviation = 0.96)	○	○	○	○	○
Lack of technology is a barrier to the effective use of instructional software. (Mean = 3.07, Standard Deviation = 0.93)	○	○	○	○	○
Cost is a barrier to the effective use of instructional software. (Mean = 3.33, Standard Deviation = 1.01)	○	○	○	○	○

What supports do you need in order to effectively integrate instructional software during math instruction?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Additional technology is needed to integrate instructional software during math instruction. (Mean = 3.27, Standard Deviation = 1.00)	○	○	○	○	○
Training and support are needed to integrate instructional software during math instruction. (Mean = 4.20, Standard Deviation = 0.65)	○	○	○	○	○
No supports are needed to integrate instructional software during math instruction. (Mean = 2.27, Standard Deviation = 0.85)	○	○	○	○	○

How do you think the use of instructional software impacts the math performance of your students?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The use of instructional software improves the math performance of my students. (Mean = 4.13, Standard Deviation = 0.62)	○	○	○	○	○
The use of instructional software increases student engagement. (Mean =4.07, Standard Deviation = 0.68)	○	○	○	○	○
I don't know how the use of instructional software impacts the math performance of my students. (Mean = 2.20, Standard Deviation = 0.91)	○	○	○	○	○

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APPENDIX L

PARTICIPANT REMINDER EMAIL ROUND ONE

To: Survey Participants
From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your willingness to assist with this study!

One week ago you received an e-mail message with information on how to participate in the study described below. If you have already completed the initial round of the survey, thank you! If you have not yet had a chance to complete the survey, please review the information below and follow the steps listed to begin the survey.

The purpose of this study is to examine the integration of instructional technology in secondary math classrooms with students with disabilities. You are being asked to participate because you meet the following criteria:

> *General education teacher or special education teacher with a standard teaching license and a minimum of three years of experience teaching students with disabilities in co-teach and/or resource settings. In addition, participants must be currently teaching secondary math to students with disabilities in co-teach and/or resource settings and have used instructional software with students*

You will be asked to complete a demographic questionnaire and three rounds of a survey. Each round of the survey will have questions, and the study will take a total of approximately 30 minutes to complete.

To begin, please access the consent form, demographic questionnaire, and Round One of the survey by clicking on the link below:
https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_2hNy9zm8SQYG1Jr

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!
Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator

APPENDIX M

PARTICIPANT REMINDER EMAIL ROUND TWO

To: Survey Participants

From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your willingness to assist with this study!

One week ago you received an e-mail message with information on how to participate in the second round of the survey. If you have already completed the second round, thank you! If you have not yet had a chance to complete the survey, please click on the link below to begin the survey:

https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_7WIzJjHnqtGl6Fn

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

APPENDIX N

PARTICIPANT REMINDER EMAIL ROUND THREE

To: Survey Participants

From: Joseph Morgan, Ph.D. (principal investigator) and Joice M. Higa (student investigator)

Greetings and thank you for your willingness to assist with this study!

One week ago you received an e-mail message with information on how to participate in the final round of the survey. If you have already completed the final round, thank you! If you have not yet had a chance to complete the survey, please click on the link below to begin the survey:

https://unlvhospitality.az1.qualtrics.com//SE/?SID=SV_1B1r1tgE2asEkux

For questions regarding the study, please contact Joseph Morgan, Ph.D. or Joice M. Higa at 702-895-3329.

Thank you again for your willingness to assist with this study!

Joseph Morgan, Ph.D. (principal investigator)
Joice M. Higa (student investigator)

REFERENCES

Bardecki, M. J. (1984). Participants' response to the Delphi method: An attitudinal perspective. *Technological Forecasting & Social Change, 25*, 281-292. doi:10.1016/0040-1625(84)90006-4

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CURRICULUM VITAE

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EDUCATION AND PROFESSIONAL CREDENTIALS

Degrees

Ph.D.	(2017)	University of Nevada, Las Vegas	Special Education

Dissertation: *Instructional Math Technology in Secondary Special Education: Teacher-Reported Practices and Perceptions*

Disability Emphasis Areas: Learning Disabilities and Emotional/Behavioral Disorders
Leadership Emphasis Area: Technology

M.Ed.	2011	University of Nevada, Las Vegas Areas of Emphasis: Mild/Moderate Disabilities, Teaching English as a Second Language	Special Education
M.B.A.	1997	University of Hawai‘i at Mānoa Area of Emphasis: International Management	Business
B.A.	1993	University of Hawai‘i at Mānoa Certificate in Spanish	Russian

Licenses

State of Nevada	Teaching License
Endorsement	Special Education Generalist (Grades K-12)

Certifications

National Board Certified Teacher - Exceptional Needs Specialist
(anticipated completion date May 2018)

Clark County School District Certified Mentor

Advanced Training

State Monitoring SEIF Training, Clark County School District, 2017
Special Education Instructional Facilitator Training, Clark County School District, 2017
State Monitoring Training, Clark County School District, 2016
Picture Exchange Communication System, Clark County School District, 2016
Infinite Campus IEP Compliance Trainer of Trainers, Clark County School District, 2016
Infinite Campus Special Education IEP Advanced, Clark County School District, 2016

Autism, Clark County School District, 2016
Alternate Assessment, Clark County School District, 2016
Collaborative Institutional Training Initiative (CITI) Modules, 2016
Crisis Prevention Institute Training, Clark County School District, 2015
Special Education Instructional Facilitator Training, Clark County School District, 2015
Foundations of Mentoring II, Clark County School District, 2014
Foundations of Mentoring, Clark County School District, 2014
Implementing the NVACS Shifts, Clark County School District, 2014
Infinite Campus, Clark County School District, 2014
SpringBoard Advanced Institute, Clark County School District, 2013
Promoting Successful IEPs, Clark County School District, 2013
Inclusive Practices, Clark County School District, 2013
Unwrapping the Common Core State Standards, Clark County School District, 2013
Assistive Technology Supports for Academics, Clark County School District, 2013
SpringBoard Initial Institute, Clark County School District, 2012
Inclusive Practices, Clark County School District, 2012
Classroom Suite, Clark County School District, 2012
Portable Word Processors, Clark County School District, 2012
Supporting Students Who Struggle with Written Expression, Clark County School District, 2012
Issues/Concerns of the Special Education Teacher in an Inclusive Classroom Setting, Clark County School District, 2012
Manifestation Determinations, Clark County School District, 2012
IEP Scheduling, Clark County School District, 2012
Smart Boards for Special Education Classrooms, Clark County School District, 2012
Collaborative Institutional Training Initiative (CITI) Modules, 2011
Curriculum Engine, Clark County School District, 2011
Taking Regular Ed Curriculum to Special Ed, Clark County School District, 2011
Classroom and Behavior Management Strategies, Clark County School District, 2011
Writing Behavior Intervention Plans, Clark County School District, 2011
Writing Individual Education Programs, Clark County School District, 2011
Classroom Management, Clark County School District, 2010
Behavior Intervention Plans, Clark County School District, 2010
CHAMPS Behavior Training, Clark County School District, 2010
Secondary Social Skills for Autism, Clark County School District, 2010
CORE Reading Academy for Special Educators, Clark County School District, 2010
Podcasting in the K-12 Classroom, Clark County School District, 2010
Project Management Certificate, Langevin Learning Services, 2000
Instructional Design Certificate, Langevin Learning Services, 2000
International Management Certificate, Pacific Asia Management Institute, 1997
Financial Supervisor Certificate, Institute of Financial Education, 1997
Business Writing Certificate, Institute of Financial Education, 1997

PROFESSIONAL EXPERIENCE

2008 - present Clark County School District
Special Education Instructional Facilitator (2015 - present)

	Teacher, Grades 6 - 8, Lawrence and Heidi Lawrence and Heidi Canarelli Middle School (2010 - 2015) Guest Teacher, Grades K - 5, Various elementary schools (2008 - 2010)
1999 - 2000	First National Bank of Marin Curriculum Developer and Training Supervisor
1996 - 1999	American Savings Bank Senior Corporate Sales Trainer (1997 - 1999) Project Analyst and Bank Technical Trainer (1996 - 1997)

TEACHING

University of Nevada, Las Vegas

Spring 2016	ESDP 411	Students with Disabilities in General Education Settings
Summer 2015	ESP 724	Math Methods in Special Education
Spring 2015	ESDP 411	Students with Disabilities in General Education Settings
Fall 2014	EDSP 462	Math Methods for Students with Mild Disabilities
Summer 2014	ESP 724	Math Methods in Special Education
Spring 2014	ESP 722	Multicultural Perspectives in Special Education (Developed syllabus)
Spring 2014	ESP 724	Math Methods in Special Education (Guest lecture on Procedural Knowledge)
Spring 2014	ESDP 411	Students with Disabilities in General Education Settings

SCHOLARSHIP

Publications

Higa, J. M. (in preparation). Integrating instructional math technology in secondary math instruction for students with disabilities. Target journal: *Journal of Special Education Technology*.

Higa, J. M. (in preparation). Action steps to support the use of instructional math technology in special education. Target journal: *Journal of Educational Administration*.

Presentations

Ewoldt, K. B. & Higa, J. M. (2016, October). *Effective integration of technology during the writing process*. Poster presented at the Council for Learning Disabilities Conference, San Antonio, TX.

Higa, J. M. & Ewoldt, K. B. (2016, August). *Use of technology in written expression*. Poster presented at the University of Nevada, Las Vegas Doctoral Summit, Las Vegas, NV.

Higa, J. M. (2015, October). *Technology-based math interventions to improve outcomes for students with disabilities*. Panel presented at the Council for Learning Disabilities Conference, Las Vegas, NV.

Ewoldt, K. B. & Higa, J. M. (2015, April). *Adapting face-to-face accommodations for K-12 online students with learning disabilities*. Poster presented at the Council for Exceptional Children Convention & Expo, San Diego, CA.

Morgan, J. J., & Higa, J. M. (2013, October). Teaching students with learning disabilities to track academic progress data. Panel presented at the Council for Learning Disabilities Conference, Austin, TX.

SERVICE

Special Education Department Chair, Lawrence and Heidi Canarelli Middle School, 2014 - present

Member, Leadership Committee, Lawrence and Heidi Canarelli Middle School, 2015 - present

Program Facilitator, Peer Mentoring Program, Lawrence and Heidi Canarelli Middle School, 2014 - present

Mentor Teacher, Clark County School District, 2014 - present

Higa, J. M. & Simon, P. (2017, April). *Infinite Campus IEP Help Camp*. In-service training for teachers in Clark County School District, Las Vegas, NV.

Higa, J. M. & Simon, P. (2017, March). *Infinite Campus IEP Help Camp*. In-service training for teachers in Clark County School District, Las Vegas, NV.

Higa, J. M. & Simon, P. (2016, February). *Infinite campus IEP compliance*. In-service training for teachers in Clark County School District, Las Vegas, NV.

Guest Reviewer, *Intervention in School and Clinic*, 2014

Model Classroom Teacher, Clark County School District, 2012 - 2015

Cooperating Teacher, College of Southern Nevada, 2012 - 2015

Lead Teacher, University of Nevada, Las Vegas, 2012 - 2015

Member, School Improvement Committee, Lawrence and Heidi Canarelli Middle School, 2011 - 2015

Facilitator, ZAP Tutoring Program, 2011 - 2015

Higa, J. M. & Ewoldt, K. B. (2012, May). *Spectrum of services.* In-service training for teachers at Lawrence and Heidi Canarelli Middle School, Las Vegas, NV.

Member, Technology Committee, Lawrence and Heidi Canarelli Middle School, 2010 - 2011

Tutor, William V. Wright Elementary School 2009 - 2010

HONORS AND AWARDS

Galaxy of Stars Award, Clark County School District, 2014

Rave Review Recipient, Clark County School District, 2014

Rave Review Recipient, Clark County School District, 2013

The International Honor Society of Beta Gamma Sigma, 1997 - present

The Honor Society of Phi Kappa Phi, 1992 - present

Golden Key National Honor Society, 1992 - present

Phi Eta Sigma National Honor Society, 1990 - present

PROFESSIONAL MEMBERSHIPS

Council for Exceptional Children since 2015

Council for Learning Disabilities since 2013