ABSTRACT

Title of Dissertation:	THE EFFECTS OF INTERACTIVE WHITEBOARD INSTRUCTION ON EARLY NUMERACY SKILLS OF STUDENTS WITH AUTISM SPECTRUM DISORDERS
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The purpose of this research was to examine the effects of interactive whiteboard instruction on early numeracy skills of students with Autism Spectrum Disorders (ASD). Four students diagnosed with ASD between the ages of five to seven years old participated. They were taught early numeracy skills, specifically one-to-one correspondence and representation of numbers, using an interactive whiteboard (IAW) and discrete trial training (DTT). A multiple probe design across subjects was used to determine the effectiveness of the IAW instruction. It was predicted that students with ASD would acquire, maintain, and generalize the early numeracy skills taught using the IAW. Results revealed the IAW with DTT was effective for teaching early numeracy skills to students with ASD. The introduction of the intervention resulted in all participants meeting the established criteria. All students generalized the target early numeracy skills to a different setting and with different materials and the results were maintained over time. The findings of the study support the effectiveness of the IAW, coupled with DTT, to teach early numeracy skills to students with ASD. This study met

the evidence standards for single case design addressed by What Works Clearinghouse. Implications for practice include the consideration of using the IAW to teach a variety of academic skills as well as developing interactive lessons based on each student's needs. Future research should focus on generalization of skills gained using IAW instruction.

THE EFFECTS OF INTERACTIVE WHITEBOARD INSTRUCTION ON EARLY NUMERACY SKILLS OF STUDENTS WITH AUTISM SPECTRUM DISORDERS

by

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Dedication

This dissertation is dedicated to all of the children with autism spectrum disorders who have inspired my life's passion and work.

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Chapter 1: Introduction

The prevalence of autism spectrum disorders (ASD) has increased dramatically in recent years. According to the Centers for Disease Control and Prevention (CDC, 2014), 1 in 68 children have been diagnosed with ASD across American communities. According to the *DSM-V*, individuals with ASD primarily experience deficits in communication and social interaction, as well as exhibit repetitive behaviors. These deficits impact individuals learning and educational performance in different ways. As explained by Gabriels & Hill (2002) that individuals could struggle with processing of information, verbal language, academic skills including reading and writing, understanding of non-verbal language, and interpretation.

As a result, most individuals with ASD have difficulty learning and performing academic skills in schools including numeracy skills. A lack of success in the classroom due to their deficits may lead to poor self-confidence, decreased academic performance across all subject areas, and an inability to complete many daily life tasks (Estes et al., 2011).

As the prevalence of ASD increases, there should be education reforms that focus on educating all students in inclusive settings and meeting the Common Core Standards. To provide appropriate services to individuals with ASD, it is critical for educators to understand their needs and strengths so they can find creative ways to develop and implement effective, individualized instruction for their students. Thus, it is important for both general and special educators, as well as other educational professionals and researchers, to develop effective tools and interventions that serve individuals with ASD (Constable, Grossi, Moniz, & Ryan, 2013).

This chapter discuss several topics that provide the grounds and rationale for the proposed study. The chapter begins with an exploration of the major deficits of individuals with ASD, followed by an in-depth explanation of the deficit, in particular, the culture of autism and the interest system of individuals with ASD. The chapter provides an overview of ASD and the characteristics of students with this diagnosis, multisensory instruction, and the use of technology, specifically interactive whiteboards (IAWs), in instructing students with ASD. The chapter concludes with the purpose statement and research questions that guided this study, along with definitions of key terminology.

Autism Spectrum Disorders

In the 1980s, mental health professionals diagnosed approximately 1 in 2,500 people with ASD (Miles et al., 2003). In 2007, the CDC found the rate had increased to 1 in 150 among children in the United States. In 2009, the Autism Society of America found that about 1.5 million Americans had some form of ASD and predicted the number would increase to 4 million by 2019. Current statistics indicate this prediction may have merit, as studies found increasing rates of ASD all around the world. In fact, a newly updated report published by the CDC (2014) concluded that 1 in 68 children were affected by ASD in the United States and that ASD could affect any individual irrespective of race, ethnicity, or socioeconomic status.

Sicile-Kira (2004) defined ASD as a neurodevelopmental disorder that usually appears by the age of three. The National Institute of Mental Health (2012) also classified ASD as a neurological disorder that might affect the functioning of the brain, and they noted that individuals usually receive an ASD diagnosis between 18 months and three years of age. ASD is almost five times more prevalent in boys as compared to girls (CDC, 2014). The *DSM-V* reported that individuals with ASD must demonstrate at least three symptoms from the social/communication area and two characteristics from the restricted interests/repetitive behaviors area to receive the ASD diagnosis. Additionally, individuals with ASD may be under or overly sensitive to particular tastes, touch, sounds, smells, colors, or light (CDC, 2014).

With its newest edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-V*), the American Psychiatric Association (2013) folded the subtypes of autism—including autistic disorder, Asperger syndrome, and pervasive developmental disorder not otherwise specified (PDD-NOS)—into one broad category labeled *autism spectrum disorders*. According to DSM-V, the term *spectrum* refers to a broad range of symptoms and the levels of impairment that individuals with ASD can have (CDC, 2014).

The *DSM-V* described three levels of severity among individuals with ASD based on social communication impairments and restricted, repetitive patterns of behavior. Individuals who have the first level of severity require support only if they exhibit (a) deficits in social communication that cause noticeable impairments, (b) difficulty initiating social interactions, (c) clear examples of atypical or unsuccessful responses to the social overtures of others, and (d) decreased interest in social interactions. Additionally, individuals with the first level of severity demonstrate a marked lack of flexibility in their behavior, which can cause significant interference with functioning in one or more contexts, difficulty in transition between activities, as well as problems of organization and planning that obstruct independence (American Psychiatric Association, 2013).

Individuals diagnosed with the second level of severity tend to require substantial support. These individuals show deficits in both verbal and nonverbal social communication skills. Also, social impairments obvious even with supports. Individuals with ASD have limited initiation of social interactions and abnormal responses to social interaction from others. Additionally, they show inflexibility of behavior, difficulty coping with change, distress and/or difficulty changing focus or action, and other restricted/repetitive behaviors that appear repeatedly and interfere with functioning in many daily situations (American Psychiatric Association, 2013).

Individuals diagnosed with the third level of severity tend to require very substantial support. According to DSM-V individuals show severe deficits in verbal and nonverbal social communication skills. These deficits cause severe impairments in functioning, very limited initiation of social interactions, and less response to social interaction from others. Additionally, they show inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors clearly interfere with functioning in all individuals' life aspects. (American Psychiatric Association, 2013).

The major deficits associated with ASD impact the diagnosed individuals' developmental progress. Social deficits often emerge very early on and continue as the children grow older. Egel (2012) reported that deficits in joint attention skills have a major impact on the acquisition of early skills and make it difficult for individuals with ASD to demonstrate receptive and expressive language and engage in everyday human interactions; play; imitation; sustain a conversation; and understand non-verbal expression such as body language and tone of voice.

The communication deficits of individuals with ASD can also include difficulties comprehending spoken language, including following simple directions and responding to questions and instructions which influence their progress and outcomes (Egel, 2012). Repetitive and stereotypical behavior is another major deficit in individuals with ASD and can impact individuals' performance during academic instruction (Egel).

Autism Spectrum Disorder is a lifetime disability with no known cure (CDC, 2014) that can have a significant impact on the social and educational experiences of diagnosed individuals. With the number of children diagnosed with ASD increasing and the severity of the symptoms, it is imperative that educational professionals have the knowledge, understanding, and ability to provide effective instruction and support for these individuals.

The culture of autism. Several researchers have attempted to provide insights into autism and the individuals with ASD. Their purpose is to integrate the known characteristics into patterns of behavior that might inform practice and help to better understand ASD. The first attempt to create a comprehensive picture was completed by Mesibov, Shea, and McCaskill (2012) who developed a cognitive profile they defined as "the culture of autism." They defined this culture as the "patterns of thinking and behavior that characterized individuals with ASD" (p. 101). According to Mesibov, et al., ASD functions as a culture because it yields characteristic and predictable patterns of behavior among diagnosed individuals and professionals who educate students with ASD are like cross-cultural interpreters. The professionals need to understand both ASD and non-ASD cultures and be able to teach and translate the expectations and procedures of the non-ASD environment to the student with ASD. This requires that teachers of students with ASD understand the patterns of behaviors of their students and the associated strengths and deficits (Mesibov et al.).

One of the predictable patterns of behavior within the culture of autism and relative strength is a preference for processing visual information, a heightened attention to detail, and a strong sense of order. Highlighting these characteristics will help to increase the comfort levels of individuals with ASD and motivate them to participate in assigned learning tasks (Mesibov et al.). The cultural of autism is the foundation for the Treatment and Education of Autistic and Communication Handicapped Children (TEACCH) approach, a long existing educational program that encourages professionals to understand the strengths and unique needs of individuals with ASD (Mesibov, Shea, & Schopler, 2005).

Murray, Lawson, and Lesser (2005) also attempted to understand multiple cognitive explanations of individuals with autism. They provided an explanation for the differences between individuals with and without ASD. They indicated that individuals with ASD are more likely to have autistic interest systems, meaning they can focus their attention intensely on a limited range of topics. This unique characteristic results in individuals with ASD are often performing very well at tasks that require acute attention to detail. On the other hand, people without disabilities are more likely to have polytrophic interest systems, meaning they can divide their attention across many subjects and the focus is thus less intense (Murray et al. 2005). The interest systems explanation supports the notion that when understanding individuals' characteristic and motivation are present, it is clear that people might perform well on educational setting with appropriate instruction (Murray et al.).

Murray et al. suggested that irrespective of individuals' levels of functioning, educational professionals who work with students with ASD should motivate connections with others, start where the child is, and ensure students acquire connections through the pursuit of individual interests. Murray et al. also stressed understanding the nature of autism and due to their diagnosis, providing experiences through their senses might increase their motivation and attention. Based on these explanations, Keay-Bright (2011) also stressed that tactile interaction could play an important role in enhancing sensory experiences and that utilizing instruction with more tactile interaction could lead to more active playfulness for students and especially students with ASD.

Using the culture of autism can help one understand the characteristics and diagnosis of ASD provided by the DSM-V as a way to understand autism and autistic interest systems. The culture of autism clarifies that individuals with ASD have their way of understanding the world and learning new concepts. Considering this notion, along with the tenets of interest system, educators should seek new and innovative methods of instruction that will help to ensure that students with ASD have a more interactive and productive learning experience (Murray et al., 2005; Mesibov et al., 2012). These explanations stress that the development of instruction is based on understanding the individuals' strengths and needs. Thus, providing instruction with visual, audio, and tactile components may increase opportunities for academic success.

Multisensory learning. For students with ASD, attention is a prerequisite to successful learning, and sustaining their attention is critical. According to Murray et al.

(2005), research indicates that teachers can use educational activities to evoke sensory curiosity by including visual dynamics, audio effects, and music. The authors noted that evoking sensory curiosity could be substantial for providing motivational and interesting experiences for students with ASD. As a result, they will have more optimal levels of sensory stimulation. Therefore, it is essential to provide interactive environments with more sensory stimulation when teaching students with ASD.

Multisensory learning is one of the earliest teaching techniques, first mentioned by Montessori in 1912 and defined as any learning activity that combines two or more sensory strategies that include visual, auditory, kinesthetic, and tactile senses (Montessori & George, 1964). According to Moustafa (1999), multisensory instruction focuses on learning experiences through all the senses that are helpful in reinforcing memory. It has a long history in pedagogy, and many professionals have modified multisensory instruction in order to make learning affluent and more motivating for students (Moustafa, 1999).

Technology and the Instruction of Students with ASD

Practitioners who have worked with students with ASD and other disabilities have been using technologies to accommodate or improve functioning for several decades. These technologies have been referred to as assistive technology (AT). According to IDEA 2004, AT identified as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities (20 U.S.C. 1401(1)). The array of AT devices and software is vast and designed to address the needs of a heterogeneous population as well as are available in a variety of categories to address functional capabilities of students with disabilities.

However, in the past 5-10 years, educators have begun to use technology to provide academic instruction to students with ASD (Smith et al., 2005). Studies indicate that technology is helpful in delivering instruction to individuals with ASD as it enables educators to adjust their instructional plan based on each individual's needs (Spence-Cochran, & Pearl, 2012; Moeller & Reitzes,2011). Students with ASD have also shown a particular affinity for technology (Smith et al.). As Kientz, Goodwin, Hayes, and Abowd (2014) explained, this affinity may largely, result from the fact that technological devices are more predictable and do not require social interactions.

Kientz et al. also revealed a number of reasons that interactions with computers could be preferable to traditional instruction with students with ASD. The reasons include that computer-based instruction is useful because it helps teachers provide routines that are easily understandable, have clear expectations, and deliver appropriate reinforcements or consequences for students' responses, which can promote additional connection with educational and assistive technologies, such as video cameras, computers and adaptive hardware, software application, and tablets devices by allowing individuals to make choices and take control over the pace of learning. According to Kientz et al., some computer programs allow teachers to select and match content to an individual's cognitive ability, make that content relevant to students' current environment, and use photos to help generalize the content to the real world. These programs also enable teachers to break down learning experiences into small and logical steps that allow students to progress more rapidly. Kientz et al. added that the data collected by computers could be useful for assessing students' progress towards established learning objectives.

In a review of assistive technologies (AT) for students with ASD, Spence-Cochran and Pearl (2012) summarized 24 evidenced-based practices (EBPs) that were identified by the National Professional Development Center for Autism Spectrum Disorders based on adopted criteria for EBP (Honner et al., 2005; Nathan & Gorman, 2002; Odom et al., 2004). The main goal of the review was to evaluate specific practices and interventions under an AT umbrella that have been found to be effective. The 24 EBPs included computer-assisted instruction, picture exchange communication systems (PECS), speech-generating devices, video modeling, and visual support. Spence-Cochran and Pearl found the research on assistive technology tools could help reduce functional limitations among individuals with ASD. Additionally, they found technology provided more learning opportunities that matched an individual's needs across multiple settings. These findings indicated technological devices and software may be effective tools in interventions designed to enhance learning for individuals with ASD. However, the study also revealed a lack in technology implementation in classrooms across the country. As a result, the researchers focused their efforts on providing guidance to professionals and identifying strategies to increase implementation that can be constituted as an evidenced based practice. More research is critical to establish new EBPs with assistive technologies designed for students with ASD (Spence-Cochran & Pearl).

Interactive whiteboards (IAWs). A relatively well-established educational technological innovation are interactive whiteboards or IAWs. The IAWs were developed by Xerox Parc around 1990 and were the most widely installed interactive whiteboard in the world (Thompson & Flecknoe 2003). IAWs were initially created for office environments and now represent a new learning technology for classroom environments. In 1991, SMART Technologies made a giant step in the advancement of touchscreen technology by creating the SMART Board, which connects a base computer to a projector and displays an exact image of the computer screen onto the board. Users can use their fingers as a computer mouse or pick up a SMART pen or eraser to write and manipulate the content displayed on the board.

The device is a large, touch-sensitive board controlled by a computer, IPad, and tablet connected to a digital projector. According to Gray, Thomas, and Lewis (2010), IAWs are the third most common technology device in K-12 schools. A national survey of elementary and secondary public school teachers revealed that 97% had computers in their classroom, while 48% had a digital projector, and 23% were equipped with an IAW in their classroom (Gray et al.).

In recent years, IAWs have emerged as a unique technological device with many features that provide an interactive learning environment. Smith, Higgins, Wall, and Miller (2005) discovered the boards promoted flexibility, efficiency, and versatility in lessons; provided opportunities for multimedia and multi-sensory presentations; and served as a motivational tool for students. All of these features of the IAW are critical in developing effective interventions for individuals with and without disabilities. Smith, Higgins, Wall, and Miller (2005) concluded that,

> [I]nteractive whiteboards can be effective tools for initiating and facilitating the learning process, especially where pupil participation and use of the board is utilized. The way in which information is presented,

> through color and movement in particular, is seen by the pupils to be motivating and reinforces concentration and attention. (p. 866)

IAW software includes many tools and applications that can help teachers get the most out of their interactive lesson. The IAW software includes a smart start center, search engine, shade screen, magnifying glass, a floating box of tools, a virtual keyboard, and a video player and recorder (SMART Technologies, 2013).

The IAW works with any program that can be downloaded or is available on the main computer. Some applications commonly used with the interactive whiteboard include Microsoft PowerPoint, Excel, and Word, as well as AutoCAD (SMART Technologies, 2013). Uses for the IAWs include teaching, training, conducting meetings, and presentations. In 2007, educators represented the largest number of IAW users, and more than 800,000 IAWs have been sold in over 100 countries (Thompson & Flecknoe).

The SMART Board is currently the most widely used IAW in classrooms throughout the United States (SMART Technologies, 2013). The technology of interactive whiteboards (IAWs) allows teachers to develop a brief and focused lessons and helps them move in their lessons with more flexibility (Moeller & Reitzes, 2011; Benson & Lunt, 2011). The IAW is one of the unique devices that can be used as a multisensory approach to education, as it provides combinations of sensory activities and allows students to experience a rich interactive instruction by seeing, hearing, and touching during instruction.

Studies of students with and without disabilities have found that when an educator teaches an interactive lesson, like those presented on IAWs, students have more of a desire to participate and exhibit more excitement about learning (Abuhmaid, 2014;

Allsopp et al., 2012; Turel & Johnson, 2012). According to Shenton and Pagett (2007), students enjoy learning when lessons and presentations are new and different. It is in these environments that learning becomes a natural outcome of student involvement. Students need to be active and engaged, so they could learn and fully understanding concepts in many skills (Heacox, 2012).

Integrating IAWs with EBPs. The IAW has shown promise in promoting engaging learning activities for students and teachers of students with ASD can integrate an IAW with other EBPs. Odom, Cox, and Brock (2013) conducted a review of EBP interventions for individuals with ASD and provided the criteria for an EBP as follow: (a) two high quality experimental or quasi-experimental design studies conducted by two different research groups, or (b) five high quality single case design studies conducted by three different research groups and involving a total of 20 participants across studies, or (c) there is a combination of research designs that must include at least one high quality experimental or quasi-experimental design, three high quality single case designs, and be conducted by more than one researcher or research group. Odom Cox and Brock's results demonstrated visual supports, DTT, time delay, prompting systems, reinforcement, and task analysis were effective and met the evidence-based criteria with all learning domains and across all age groups. These supports can serve as EBPs in academic, behavioral, communication, play, social, and transitional settings. Professionals should take advantage of effective instructional procedures with integration of other tools to help students develop the skills they need to enhance their academic outcomes.

An IAW can support a number of the above instructional procedures, such as visuals supports, discrete trial training (DTT), time delay, prompting systems, reinforcement, and task analysis. Beauchamp and Parkinson (2005) suggested the touch-screen technology of the IAW is more enticing to students than traditional blackboards or overhead projectors and have many functions that tend to pique students' interest. Beauchamp and Parkinson suggested the highly visual and engaging components of the IAW can capture the attention of students with ASD and motivate them to participate.

Researchers have used IAWs effectively to teach a variety of skills to students with ASD and other disabilities, as well as those without disabilities (Mechling, Gast, & Thompson, 2008; Yakubova & Taber-Doughty, 2013). A few educators have used IAW to teach students with disabilities including ASD daily living skills, sight words, and letter sounds (Yakubova & Taber-Doughty, 2013; Mechling et al., 2007; Campbell, 2009). However, educators have not yet used IAWs to teach early numeracy skills.

Teaching Early Numeracy Skills with IAWs

The National Council of Teachers of Mathematics (NCTM; 2000) defined the term *numeracy* as an understanding of how numbers represent specific quantity and volume. Understanding numeracy can be reflected in a variety of skills (e.g., counting, distinguishing between sets of different quantities, addition and subtraction), and so educators often use the term *numeracy* to refer to a broad scope of number concepts and skills (NCTM).

In 2002, the National Association for the Education of Young Children (NAEYC) and the NCTM published a joint statement on the importance of early mathematics education, in which they affirmed that "high-quality, challenging, and accessible mathematics education for students are a pivotal foundation for future mathematics learning" (NAEYC & NCTM, 2002, p. 1). According to Johannes, Van Luit, and

Schopman (2000), early numeracy is essential for the learning of mathematics skills (i.e., addition, subtraction, multiplication, division) and the development of more advance mathematical concepts. Dev, Doyle, and Valente (2002) stated that computational skills are necessary not only for everyday life but for future learning of more complex mathematical skills. As Dev et al. stressed that children should understand (a) the basic concepts of early numeracy (e.g., that numbers represent specific quantities), (b) the procedures for solving problems, and (c) strategies for determining when to use this knowledge in order to achieve high level of math concepts.

According to NCTM, teachers can and should integrate early mathematical learning into students' everyday activities by adding some patterns, quantity, and space for the instruction. It is important to give students opportunities to practice their skills in mathematics which could support the connection between students' performance in the subject as well as the acquisition of knowledge in school (NCTM, 2003). Bisanz (2011) noted that additional research on numeracy and early mathematical skills is necessary to formulate the program and objectives of early numeracy education.

Early mathematical instruction and students with ASD. Research indicates that mathematics is one of the core academic subjects in schools; however, students with disabilities tend to be less proficient in developing key mathematical skills (Jitendra & Xin, 1997; Woodward & Baxter, 1997; Xin & Jitendra, 1999; Zentall, 1990). The main deficits of students with disabilities might have the major impact on the mathematical proficiency including cognitive abilities. Despite these challenges, some children with ASD do show an interest in learning mathematical skills, but simply need support and modification to be able to demonstrate them effectively (Egorin-Hooper, 2012).

Kroesbergen and Van Luit (2003) conducted a meta-analysis of 58 studies of mathematics interventions for elementary students with special needs. The researchers selected interventions in three different domains: preparatory mathematics, core competencies, and problem solving strategies. Most of the studies implemented interventions in the domain of basic skills like early numeracy and basic math skills. Kroesbergen and Van Luit reviewed and analyzed many types of interventions and found that, generally, computer assisted intervention (CAI), reciprocal peer tutoring (RPT), self-instruction, and concreate manipulatives were the most effective; with self-instruction and direct instruction demonstrating the most notable impact on student learning. Additionally, they found that the use of the computer as an aid to the instruction to be most effective (Kroesbergen & Van Luit, 2003). The authors also discovered the use of CAI could be very helpful when students need the motivation to complete certain kinds of problems (Kroesbergen & Van Luit). They research revealed that with the computer, children could practice and automatize math facts and receive feedback. Importantly, Kroesbergen and Van Luit stressed that computer instruction cannot be effective without teacher guidance.

Research specific to students with ASD found that these students tend to lack an understanding of abstract concepts (Wisniewski & Smith, 2002) and support the use of manipulatives and computerized instruction would increase these students' understanding of key mathematical concepts (Wisniewski & Smith). Egorin-Hooper (2012) confirmed the use of manipulatives could help increase learning in children with ASD and stated that manipulatives, convert problem solving, hands-on learning, clarify steps, tactile input, and visuals, are strategies that can be used to incorporate math concepts into instructional activities.

Summary

In summary, when considering the main deficits of individuals with ASD, including social communication impairments and restricted, repetitive behavior and their impact on students' performance, professionals should consider the developmental nature of each student's condition including strengths and needs. Individuals with ASD have basic brain differences that affect the ways they experience the world (CDC, 2014). Understanding the culture of autism and an individual's intellectual and behavioral characteristics is the starting point for developing effective instruction in the classroom.

Researchers have identified both assistive technologies and a broader set of EBPs that have been effective with students with ASD and technological tools have the potential to provide new avenues of intervention by providing visual, auditory, and sensory cues or prompts that may increase opportunities for individuals with ASD to learn more academic skills in the classroom. The integration of IAWs into classroom instruction with other EBPs has the potential to enhance teaching academic skills to students with ASD. Research indicates that IAWs might be a way to teach students with ASD because the devices have features that address these students' characteristics and allow students to engage in instruction using all of their visual, auditory, kinesthetic, and tactile senses. Importantly, prior to this study, IAWs had not been investigated as a support for teaching early numeracy skills to students with ASD.

Statement of the Problems and Research Purpose

There is a research foundation that supports the utilization of the different instructional procedures used in this current investigation. These procedures include the use of technology (specifically IAW), DTT, and reinforcement to teach students with ASD. However, there is a limited of research available on the integration of these instructional procedures when teaching early numeracy skills. Few studies have examined IAW to teach academic skills to students with disabilities and ASD. Additionally, no studies have examined IAW plus DTT to teach early numeracy skills to students with ASD. The current study sought to teach four students with ASD using the combined effects of the IAW with the integration of evidenced based instructional procedures in the teaching of early numeracy skills. The study differed from previous studies, as it examined the acquisition, generalization, and the maintenance of the targeted skills.

Research Questions and Hypotheses

This study will address the following research questions:

1. To what extent does an IAW technology affect the acquisition of early numeracy skills among students with ASD?
2. To what extent does an IAW technology affect the generalization of early numeracy skills among students with ASD?
3. To what extent does an IAW technology affect the maintenance of early numeracy skills among students with ASD?

I hypothesized that (a) IAW technology and DTT will increase the acquisition of early numeracy skills; (b) IAWs will support generalization of responding across presentation formats and settings; and (c) students will maintain these increases over time.

Definition of Key Terms

***Assistive technology*.** Assistive technology identified as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities (IDEA, 2004).

***Autism*.** Autism is a developmental disability characterized by impaired social interaction and communication skills, and by restricted and repetitive behavior (American Psychiatric Association, 2013).

***Autism spectrum disorder (ASD)*.** ASD is a complex developmental disability that typically appears during the first three years of life and affects a person's ability to communicate and interact with others. Autism is defined by a certain set of behaviors and is a "spectrum disorder" that affects individuals differently and to varying degrees (Autism Society of America, 2014).

Generalization. Generalization is the ability to perform and apply learned skills in new conditions or contexts (Alberto & Troutman, 2013).

***Interactive whiteboard (IAW)*.** The IAW is a touch-sensitive, interactive projection display that allows the user to manipulate content on the screen with the touch of a finger. It also has an electronic pencil of different colors as well as an electronic eraser that individuals can use to manipulate the information presented on the board the board connects to a digital projector and displays images from a connected computer screen

(SMART Technologies, 2013). There are multiple manufacturers of IAWs, offering a variety of specifications and capabilities at a range of prices. For the purposes of this study, the acronym IAW will refer to both SMART boards and interactive white boards.

Technological devices. Technological devices are any tool used as an educational intervention, such as iPads, iPods, iPhones, laptops, or desktop computers.

Chapter 2: Review of Literature

This chapter presents a review of the literature relevant to the previously stated research questions. The chapter includes three sections: (1) research on using technology to teach individuals with ASD, (2) research on using IAWs in general education, and (3) research on using IAWs to teach individuals with ASD and other disabilities.

The main purpose of this review is to understand what researchers have already discovered about using technology, specifically IAWs, to teach individuals with ASD and to identify gaps in the existing literature on the topic. The review will also include an examination of literature that has addressed the conceptual framework of the study, which involves the integration of multiple strategies (e.g., visual support, computer instruction, applied behavior analysis, and IAWs) into the instructional strategies for individuals with ASD.

Method

When conducting this review, I performed electronic searches of relevant literature on the use of technology and IAWs in classrooms serving individuals with and without ASD. The inquiries discussed in this paper were published between 2003 and 2015. I narrowed my research to the last decade for many reasons. First, schools began using the most common version of the IAW or SMART board (i.e., white-board technologies with flat and touch screens) in 2003. In addition, a number of inventions and evolutions in technology for individuals with special needs, including ASD, took place between 2004 and 2015.

I selected peer-reviewed articles for this analysis through electronic searches of the databases ERIC, EBSCO, Education Research Complete, and PsycINFO and used the following search terms: *autism, ASD, Asperger*, *technology, SMART board*, *interactive whiteboard*, *UDL*, *visual support*, *academic skill*, *math*, *reading*, and *disability*. Due to the limited number of studies on IAWs and individuals with ASD, I decided to broaden my topic by searching for articles on other disabilities that supported my review. In this second search, I used the terms *visual support*, *UDL*, *technology*, *and other disabilities* to support my conceptual framework. I then narrowed the results by selecting studies with the following three criteria: (a) published between 2003 and 2015, (b) employed empirical and descriptive designs, and (c) focused on using IAWs with typical students in addition to using any type of technology-based intervention for individuals with ASD. The primary purpose of my search was to find studies in which IAWs and technology were the main interventions. I included studies that were both quantitative and qualitative. The results yielded 16 studies that fell into three categories: (a) technology, (b) IAW, and (c) qualitative and quantitative research on IAWs. Tables 2.1, 2.2 and 2.3 provide summaries of the studies from each category.

For the purposes of this study, the term *technological devices* refers to any tool used as an educational intervention, such as iPads, iPods, iPhones, laptops, or desktop computers. Each of these devices is flexible in operation and widely used in modern society. According to data collected by the U.S. Department of Education, National Center for Education Statistics [NCES] (2010) in 2009, 97% of teachers had one or more computers located in their classroom, and 54% could use their own computers into the classroom. Additionally, internet was available for 93% to 96% of both the classroom computers as well as teachers own computers. According to NCES, the ratio of students to computers in the classroom was 5.3 to 1. IDEA states that "each public agency [school] must ensure that assistive technology devices or assistive technology services, or both are made available to a child with a disability which means the child's right to school-purchased technology, and your right to technology training by the school" (IDEA, 2004, § 300.105). As a result of the regulations and laws, many schools offer technology devices to students for use in the classroom to support their educational progress

Overview of the Studies

A summary of each study is presented in Tables 1, 2 and 3. A total of 16 studies met the criteria for inclusion in this literature review. Four of the 16 studies focused on using different types of technology devices to teach students having ASD (Bereznak, Ayres, Alexander, & Mechling, 2012; Carlile et al., 2013; Mechling, Gast, & Cronin, 2006; Mechling, Gast, and Seid, 2009). Five studies investigated using IAWs to teach individuals with ASD and other disabilities (Yakubova, & Taber-Doughty, 2013; Mechling et al., 2007; Mechling et al., 2008; Campbell, 2009; Allsopp et al., 2012). Seven studies addressed the effects of using IAWs with traditional students (Thompson & Flecknoe, 2003; Shenton & Pagett, 2007; Gillen et al., 2007; Higgins, 2010; Turel & Johnson, 2012; Tsung-Ho et al., 2012; Chen, Chiang, & Lin, 2013). The following review of the literature is divided into three sections: (a) using technology to teach individuals with ASD, (b) Using IAWs with Traditional Students, and (c) using IAWs to teach individuals with ASD and other disabilities.

Table 1

Summary of Reviewed Literature for Technology Devices with ASD

Citation	Purpose	Design	Sample	IV	DV	Acquisition	Generalization	Maintenance	Procedures	Analyses	Results
Bereznak, Ayres, Alexander, & Mechling (2012)	To evaluate using the iPhone as a self-prompting tool for teaching vocational and independent living skills	Single subject	Three HS males with ASD	The use of the iPhone as a self-prompting tool	Increase daily living and vocational independence	Yes	No	Yes	Multiple probes across behaviors	Visual analysis of the data change across phases	The iPhone was an effective self-prompting tool for teaching daily living and vocational skills.
Carlile et al. (2013)	To help children independently structure leisure time using the iPod	Single subject	Four children with ASD	Using activity schedule on iPod to teach leisure skills	Participants independently structured leisure time using iPod	Yes	Yes	Yes	Multiple probes	Visual analysis of the data change across phases	All participants independently completed each component on the activity schedule.
Mechling, Gast, & Cronin (2006)	To evaluate the effect of presenting preferences items or reinforcements via computer-based videos vs. tangible items	Single subject	Two students with ASD	Presenting high preference items paired with choice via computer	Task completion	Yes	No	No	ABAB multiple treatments across participants	Visual analysis of the data change across all phases	The duration of task completion was shorter when reinforcement was presented via computer.
Mechling, Gast, and Seid (2009)	To examine the effectiveness of using a PDA with picture, auditory, and video prompts in increasing the steps that students with ASD completed independently	Single subject	Three HS students diagnosed with ASD	A PDA with picture, auditory, and video prompts of three cooking recipes	Task completion of cooking	Yes	No	Yes	Multiple-probe design across three sets of cooking recipes	Visual analysis of the data change across phases	Using a PDA as a self-prompting tool was an effective strategy for increasing rates of multi-step task completion among students with ASD.

Note. PDA= Personal digital assistant, ABAB =Reversal Design, HS= High school, IV= Independent variables, DV= Dependent variables

Table 2

Summary of Reviewed Literature for Research on IAW with ASD and Other Disabilities

Citation	Purpose	Design	Sample	IV	DV	Acquisition	Generalization	Maintenance	Procedures	Analyses	Results
Allsopp et al. (2012)	To assess how teachers used IAWs in their instruction and their perceptions	Qualitative	Six teachers	IAW	Teachers' perspectives on the use of IAW	N/A	N/A	N/A	Classroom observations, individual semi-structured interviews, focus group interviews, and field notes	Qualitative analysis of the data	Teachers were positive about the potential of IAWs to enhance teaching and noted that IAWs made it much easier
Campbell (2009)	To examine the effectiveness of teaching letter sounds in small group via SMART Board	Single subject	Three students with LD	IAW and constant time delay	Letter sound	Yes	No	Yes	Multiple probes	Visual analysis of the data change across all phases	The results showed intervention was effective across all students.
Mechling et al. (2007)	To assess the effect of using a SMART Board to teach sight word reading	Single subject	Three adults with moderate ID	IAW with constants time delay	Sight word reading	Yes	Yes	No	Multiple probes	Visual analysis of the data change across all phases	The intervention was effective and affected non-target skills.
Mechling et al. (2008)	To compare the use of a SMART Board and flashcards in teaching sight words.	Single subject	Three adults with moderate ID	IAW	Sight word reading	No	No	No	Adapted alternating treatment design (AATD)	Visual analysis of the data change across all phases	Both IAW and flashcards were effective, but participants showed greater percentages with the IAW.
Yakubova, & Taber-Doughty, (2013)	To examine the effect of multicomponent intervention using a SMART Board on daily living skills and engagement	Single subject	Two students w/ASD and one w/ID	Video molding and self-monitoring via the IAW	Daily life and engagement	Yes	Yes	No	Multiple probes	Visual analysis of the data change across all phases	The intervention was effective across all participants.

Note: IV= Independent variables, DV= Dependent variables, ID = Intellectual disability, IAW= Interactive whiteboard

Table 3

Summary of Reviewed Literature for Research on IAW with Traditional Students

Citation	Purpose	Design	Sample	IV	DV	Procedures	Analyses	Results
Chen, Chiang, & Lin (2013)	Investigate the influence of IAWs on the learning of fourth-grade science students.	A quasi-experimental design	64 students, 32 experiment groups, 32 controls	IAW	Learning of fourth-grade science	All students participated in four weeks of instruction: experimental group IAW, control group traditional instruction.	ANCOVA	The results showed that using IAWs yielded significantly higher achievement levels for fourth-grade natural and life sciences students than those earned by the students who experienced the traditional lecture.
Gillenn et al. (2007)	To investigate how IAWs function as a communicative and pedagogic tool in classroom interactions and how teachers use them to achieve instructional goals.	Qualitative	Four teachers working in urban primary schools	IAW	The function of IAW in the classroom	Video recorded each teacher (16 lessons overall) and also interviewed all four teachers	Qualitative analysis	The IAWs helped teachers easily deliver a lively, varied, complex, interactive lesson. Teachers indicated IAWs would have a positive effect on instruction.
Higgins (2010)	To raise levels of literacy and mathematics achievement for students aged 9-11.	Mixed method	Students in over 200 classrooms aged 9-11	IAW	Literacy and mathematics achievement	Students' achievement levels, structured lesson observations, and the perceptions of teachers and students	Students' scores and qualitative analysis of observations	Students' achievement levels on national tests were highly significant the respondents' perceptions of the IAWs were overwhelmingly positive.
Thompson & Flecknoe (2003)	To evaluate the effectiveness of an IAW during math instruction with 225 elementary students in a primary school	Mixed methods	225 elementary students	IAW	Math scores	The instructor used the IAW as much as possible to teach numeracy and literacy lessons and support other curriculum areas.	Math scores on RM assessments and qualitative analysis of a behavior-monitoring sheet	Fifth-grade students' test scores improved while the instructor used the IAW, and they had a positive reaction toward the IAW during instruction.

Note: IV= Independent variables, DV= Dependent variables, IAW= Interactive whiteboard

Table 3 [*Continued*]
Summary of Reviewed Literature for Research on IAW with Traditional Students

Citation	Purpose	Design	Sample	IV	DV	Procedures	Analyses	Results
Shenton & Pagett (2007)	To investigate the effects of IAWs	Qualitative	Seven teachers	IAW	How teachers use IAW in the classroom	Structured classroom observations and taped, semi-structured interviews of the teachers and students	Qualitative analysis of the observation, and interviews	Use of the IAW supported a more cross-curricular approach to literacy and increased student engagement. Teachers used the device differently, and students noted that the IAW made lessons more enjoyable and exciting.
Tsung-Ho et al. (2012)	Examine factors that influence and concern the support and lack of teaching and learning interactions related to the use of IAWs.	Case study	One teacher and 29 second-grade students	IAW	Teaching and learning interactions	Data from participants' use of IAWs during instruction for the six months prior to the experiment	A chi-square test for independence to examine the associations among the factors	Teachers integrated many types of multimedia and interactive designs into their learning activities by using IAWs. In addition, the results showed with certainty that the integration of IAWs into the teacher's instruction enhanced the overall instructional presentation.
Turel & Johnson (2012)	Explore teachers' beliefs about IAW use for teaching and learning.	Qualitative	174 teachers	IAW	Teachers' beliefs	A questionnaire	Qualitative analysis	The results indicated that educators used IAWs to teach a variety of subjects, and all respondents believed IAWs helped learning and instruction

Note: IV= Independent variables, DV= Dependent variables, IAW= Interactive whiteboard

Using Technology to Teach Individuals with ASD

In this section, I reviewed research studies that used different types of technology to teach students with ASD different skills. The type of technology used in the following studies included iPhones, iPods, personal digital assistants (PDA), and computers. All of the studies employed a singlecase design methodology.

Bereznak, Ayres, Alexander, and Mechling (2012) used a multiple probe across behaviors design to explore the use of iPhones as self-prompting tools for teaching vocational and independent living skills to three high school students with ASD. All of the sessions included a baseline and intervention component and conducted at the school living center and in the teacher's room. The researchers focused on teaching research participants three targeted tasks including using a washing machine, making noodles, and making copies. Bereznak et al. divided each task into multiple steps across all conditions to support and simplify the data collection system, and used a video recording depicting an adult modeling each target behavior to develop the video prompts. After some modification and adaptation, the researchers uploaded the video prompts to the iPhone and trained the students to use the device with instructor prompts.

The baseline sessions began when the participants could use the iPhone independently. During these sessions, Bereznak et al. (2012) collected data on each step the students performed correctly or incorrectly without using the iPhone. During the probe session, the researchers gave each student multiple opportunities to initiate each step of the target tasks, allowing five seconds of latency. If the student was unable to initiate a step or responded incorrectly, the instructor completed the step and then asked the student to complete the next step. The researchers also conducted multiple maintenance sessions without using an iPhone. Bereznak et al. collected reliability data on both the dependent and independent variables for an average of 21% of the baseline and intervention sessions for each of the participants. The data showed high agreement across all conditions.

The overall results of the study indicated all three of the participants demonstrating improved performance across all of the behaviors and an increase in the number of steps that they performed independently (Bereznak et al., 2012). The change in the data from the baseline to the probe sessions was very clear, as was the change in both the levels and trends. Bereznak et al. study supported the use of an iPhone as a self-prompting device to teach daily living and vocational skills to individuals with ASD. The results indicated that using an iPhone for video prompting in the classroom is effective and suggest that the practice might be a useful tool in helping students with ASD develop and enhance other skills.

One of the major strengths of the study conducted by Bereznak et al. (2012) was that it provided six demonstrations of effect when each individual with ASD controlled the iPhone. However, the researchers could have improved the study if they had collected generalization probes as well as more maintenance data. Additionally, it would have been helpful if the authors had assessed the social validity of their findings.

Carlile, K. Reeve, S. Reeve, and DeBar (2013) explored additional ways that technology could support individuals with ASD. Carlile et al. used an Activity Schedule application installed on an iPod Touch to teach leisure skills to four individuals diagnosed with ASD. The main goal of this study was to help children independently structure their leisure time using the device. The researchers selected four 8-to-12-year-old boys with ASD to participate in this study and established 15 activity schedules for use during the inquiry (Carlile et al., 2013). The Activity Schedule on the iPod included many icons that helped the children select each activity. The researchers collected the data as the participants independently completed the steps of each scheduled activity. Additionally, they conducted baseline, intervention, and generalization probes in the participants' classroom and collected both pre- and post- generalization sessions in the participants' general education classroom (Carlile et al., 2013).

At baseline, none of the participants completed the activity schedule; however, during the maintenance session, all of the students completed their activity schedules independently (Carlile et al., 2013). The researchers collected interobserver agreement data on all conditions and they obtained 100% agreement across all activity schedule components (Carlile et al., 2013). They also obtained a mean of 98% (range 80–100%) agreement for on-task behavior across participants. In addition, the researchers collected IOA on procedural integrity data, which was 100% (Carlile et al., 2013).

The results showed all of the participants autonomously finished each component of the activity schedule, which suggests that the iPod Touch can serve as a useful technological tool for teaching different skills to individuals with ASD. These skills might include following scripts, receptively identifying stimuli, transitioning in hallways, and participating in inclusion settings (Carlile et al.).

Mechling, Gast, and Cronin (2006) demonstrated that providing reinforcement could serve as a strategy for integrating technology into instruction for students with ASD. Mechling et al. evaluated the effect of presenting preferences, items, and reinforcements via computer-based videos for the duration of time that students spent completing a task. Two students diagnosed with ASD participated in this study. Mechling et al. developed an intervention using videotapes of preferred items and a stimulus for each student. During the first treatment, which served as a baseline, the researchers placed tangible, preferred items in front of the student while the student engaged in a task (Mechling et al.). However, during the second treatment, which served as the intervention phase, they used the computer to present reinforcement for the students (Mechling et al.). The researchers recorded the length of time it took the students to complete each task and measured how long the students spent on each treatment. The overall results indicated the duration of task completion was shorter when the researchers presented students with reinforcements and preferred items via the computer (Mechling et al., 2006). The findings support the practice of providing reinforcement via computers. The approach may also be useful in different formats, depending on each student's unique needs.

Although, the study showed positive results, the study had a number of limitations. First, an ABAB design was not a strong approach for this type of study, as using tangible items during the A phase and computer during the B phase might influence the conclusion of the study. The carryover of the learning might have affected students' responses from phase A to B because they might have known they would receive reinforcement. In addition, the researchers did not collect generalization or maintenance data and did not assess social validity which weaken the conclusion of the findings.

In a different study, Mechling, Gast, and Seid (2009) demonstrated that professionals could use a personal digital assistant (PDA) to help individuals with ASD develop new skills. Specifically, Mechling et al. sought to use a PDA with picture, auditory, and video prompts to increase the steps that students with ASD completed independently. Mechling et al. selected three male high-school students diagnosed with ASD to participate in the study based on their IEP goals to increase self-management. The main behavior task for this study involved using self-prompting PDAs to complete three cooking recipes (Mechling et al.). The researchers conducted each phase of the study at the students' high school living room, where students at the school learned to cook and complete other general tasks. Mechling et al. developed a video recording and picture of an adult model demonstrating each step of the target tasks. They then uploaded the video and pictures to the PDA devices (Mechling et al.).

Mechling et al. (2009) utilized a multiple probe design across each cooking recipe. The researchers collected data during the probes and PDA conditions over the steps of the tasks that each student completed. To collect baseline data and establish a stable data trend, the researchers assessed the number of steps it took for the participants to complete each task and correct and incorrect responses without using the PDA for at least three sessions. They then presented each student with a PDA, and the instructor collected data on their correct and incorrect responses as well as the numbers of steps to complete the task. During the maintenance sessions, the researchers collected data on the students' task completion without the PDAs to determine if the students maintained the skills they acquired during the intervention. The researchers also assessed the reliability of the data collection on 25% of all of the probes and PDA sessions (Mechling et al.). The inter-observer agreement equaled 99% (Mechling et al.).

The overall results indicated that using a PDA as a self-prompting tool was an effective strategy for increasing rates of multi-step task completion among students with ASD (Mechling et al., 2009). The data from the baseline-to-PDA sessions demonstrated that all of the participants improved their level of task completion across the three cooking recipes (Mechling et al.). The changes in trends and levels were evident in the data from all of the participants during intervention and maintenance sessions. The results of Mechling et al.'s study suggest that PDAs can be effective tools for teaching self-prompting. PDAs are flexible devices that allow teachers to incorporate voice prompts and other devices into instruction, and teachers might use such devices to help students improve a variety of skills, based on their IEP goals.

Based on the single subject design used for this study, it was critical to measure the intervention's social validity. During the last probe session of this study, students received a portable DVD player, PDA, and picture cookbook followed by the question, "What would you like to use to cook a new recipe?" All participants had the opportunity to select which device they wanted to use to cook a new recipe. All participants selected the PDA. The students' selection of the PDA provided data supporting the social validity of the study (Mechling et al.).

Overall, Mechling et al. conducted a strong study by selecting an appropriate design, assessing social validity, measuring acquisition, generalization, and maintenance, and providing a detailed description of the procedures. However, the data for generalization and maintenance would have provided stronger evidence for the effect of the intervention if the authors had collected more than one data point.

In conclusion, the aforementioned studies indicate that using technological devices during interventions for students with ASD allowed those students to access the unique features of these tools and suggest there is a myriad of ways that these interventions are appropriate for use with individuals with ASD. Educators can use a number of technological devices to teach a variety of skills. The research findings from Bereznak et al. (2012), Carlile et al. (2013), Mechling et al. (2006), and Mechling et al. (2009) showed that educators had used iPads, iPods, and iPhones to teach key competencies (e.g., communication, daily living, leisure, and vocational skills) to individuals with ASD.

These four studies offer greater clarity about how educators can use technology more effectively with individuals with ASD. Understanding the features of each technological device is critical to developing an appropriate intervention that matches the strengths and needs of students with ASD. Finally, the results from these studies serve as motivation for professionals to think more about using these devices to teach a variety of skills in many areas of learning for individuals with ASD.

Using IAWs with Traditional Students

In this section, I reviewed research studies that evaluated the use of the IAW with traditional students. In this current study traditional refers to that the studies were conducted in general education classroom and all participants both teachers and students were attending regular classroom. These studies evaluated the IAWs using quantitative and qualitative methodology. The studies have explored many aspects of the IAWs, such as how teachers use them in the classroom, teachers' and students' perceptions of the devices, and the direct influence of the IAW on students' performance.

Thompson and Flecknoe (2003) evaluated the impact of using an IAW during math instruction with 225 elementary students in a primary school. The researchers used a mixed methods design to determine if an IAW could positively influence student achievement. After teachers used an interactive math program called Easiteach Maths to present the lesson on the IAW, Thompson and Flecknoe employed both the RM Snapshot Assessment and observations of student behavior to assess students' performance and responses after the lesson. The teachers used the IAW as much as possible to teach numeracy and literacy lessons and to support other curriculum areas (Thompson & Flecknoe). Also, qualitative data were collected by using multiple sources. All participants were interviewed to identify their attitude towards lessons that used the IAW as well as students' behavior was recorded while using the IAW.

The overall results according to an assessment from the RM Snapshot was the fifth-grade students' test scores improved during the time that the instructors utilized the IAW (Thompson & Flecknoe, 2003). IAW based teaching helped students as evidenced by their rapid progress through national curriculum levels. Thompson and Flecknoe concluded that students achieved significant gains when teachers used the Easiteach Maths IAW program. Specifically, the researchers found that students showed a 14% improvement in achievement assessment in the first semester, a 22% improvement in the following semester, and a 39% improvement overall. All participants, regardless of prior achievement scores, made comparable gains. The results demonstrated an improvement in overall math scores within two academic quarters (Thompson & Flecknoe).

In addition, the analysis of the observation indicated that students' behavior improved while the IAW was being used as well as students were motivated and on task. Students' interviews indicated most students felt the IAW helped them understand concepts as well as finding it enjoyable. In general, most students demonstrated a positive reaction toward IAWs, an increase in motivation, and more opportunity for students to participate and collaborate (Thompson & Flecknoe, 2003).

Thompson and Flecknoe's work marked a first step in conducting research to evaluate the effectiveness of the IAW in the classroom. However, this study did not perform statistical analysis to compare the results of the assessments with existing data. More statistical analysis is critical to obtain additional information about students' scores on the assessment. In addition, collecting generalization and maintenance data would provide a measure of the effectiveness of the IAW over time. This study attempted to provide additional qualitative descriptive results. However, more information was needed regarding observation analysis and student interviews.

Shenton and Pagett (2007) also investigated the effects of IAWs. Seven teachers in six schools in England were participated in the study and all of them had the IAW in their classroom to teach literacy. The main purpose of this study was to examine how teachers were using IAWs in teaching literacy based on the perspectives of both teachers and students. Shenton and Pagett attempted to address many questions as follow: How are IAWs being used in primary school literacy classrooms? How is IAW use being supported and resourced in primary school literacy classrooms? How is IAW use impacting on classroom literacy practice? and On what area/s of literacy practice have IAWs had the most impact? A qualitative method was used to conduct data from multiple sources including structured classroom observations and taped, semi-structured interviews of the teachers and students (Shenton and Pagett).

During the investigation, three themes emerged: (a) the use of pre-prepared screens, (b) multimodal texts, and (c) the opportunity for integral assessment. The overall data indicated all the IAWs were being used effectively during teaching of literacy objectives. Images, photographs, and videos had been used for story writing and discussion. Also, children were able to participate in an opportunity for integral assessment such as a teacher's prepared multiple choices spelling game (Shenton and Pagett).

Shenton and Pagett concluded that when the IAW use showed to have some benefits, such as supporting a cross-curricular approach, increasing student's engagement, and teachers used the device quite differently. The data suggested that the teachers recognized the impact of the IAW on their teaching. Specifically, teachers reported their children were "highly motivated, totally interested and focused," and those visual learners were able to "remember more with IAWs and Literacy Learning 5 may be understand more" (Shenton & Pagett, 2007, p. 133). The teachers also reported specific examples of increases in student interaction, and the students noted the IAW made lessons more enjoyable and exciting, but also helped them to concentrate better (Shenton & Pagett). Interestingly, the data showed that participants expressed their increased motivation in many terms such as ''it's more enjoyable'', ''it makes you concentrate better'' and ''it's exciting, it's fun, it's like magic'' (Shenton & Pagett, 2007, p. 133).

Shenton and Pagett demonstrated that using interviews and observations to gain information about IAWs is important and can provide critical results. However, there were two major limitations evident in the study. First, most of the teachers in Shenton and Pagett's study had short experience or training on the use of the IAW, which might have influenced their responses during interviews, particularly their statements about the challenges they faced when using the IAW. Second, the researchers selected only a small sample of teachers for the study. To improve the reliability of the results, future investigators should conduct more in-depth investigation that will provide more valuable data to support the findings from interviews and observations. Interviewing a large number of teachers and observing more classrooms can support and give a better understanding of the relationship between using IAW in the classrooms and student achievement. Importantly, evaluation or comparison between teachers' and students' responses who received instruction using the IAW compared to traditional instruction might add more information to the literature.

Gillen, Staarman, Littleton, and Mercer (2007) attempted to explore the relationship between the IAW and the educational practices, communicative processes, and educational objectives. This study examined how IAWs actually functioned conducting classroom observations in elementary school. Specifically, this study according to Gillen et al. aimed to answer many questions: How IAWs actually function as a communicative and educational tool in classroom interactions? How they are used by teachers to pursue their educational goals? and How they are used to build shared frames of reference and common knowledge? Gillen et al. observed and interviewed four teachers working in urban schools in Southern England. The researchers' video recorded each teacher during two math or science lessons. They also interviewed all four teachers to reconstruct how they accounted for their use of IAWs during instruction. In addition, the researchers collected supplementary data by interviewing teachers who were interested in IAWs and interested in the project (Gillen et al., 2007). In order to analyze that data, Gillen et al. used case studies data resulted from observing two lessons in one of the schools. The first step on the data analysis involved an exploratory of all data and transcripts. The second step comprised of an exhaustive evaluation of video and transcript data in order to build outline on each topic themes (Gillen et al.).

As indicted by Gillen et al., the results showed that teachers used digital photographs from the previous lesson that allowed students to be engaged and continuity participated of lessons. Also, the IAW was helpful for presenting instructional texts as well as encourage students to think about other implications (Gillen et al.).

According to Gillen et al., the overall results of this study demonstrated that IAWs helped the teachers plan and deliver enjoyable, appropriate, and interactive lesson as well as have a positive effect on what teachers can do in the classroom. Also, educators may use the IAW effectively to support and established, conventional style of teaching (Gillen et al.).

One of the main problems in this study was school site selection. The researchers chose school sites based upon their existing relationships with the project team and the schools' expressed interest in taking part in the study. Such convenience sampling could have had a significant influence on the validity of the results. On the other hand, as Gillen et al. (2007) used a qualitative case study design, they collected data from many sources, such as interviews and observations, as well as from supplemental sources like video recording and interview with other teachers interested in IAWs. The finding of this study added more information on the use of the IAW by teachers in the classroom as well as supported the idea of using the IAW effectively.

In England, the UK government funded an initiative that focused on embedding technology in the literacy and numeracy strategies. This initiative created the installation of IAWs in the classrooms over than 80 elementary schools in England. Higgins (2010) attempted to examine the project by presenting a critical analysis of the findings. The main purpose of the research was to measure the impact of the IAW initiative on national test results. A multi-method approach was used which included complementary qualitative and quantitative methods. Higgins utilized multiple sources of data, including students’ achievement test, structured lesson observations, and interviews of teachers and students, to understand the impact of the IAW on participants’ perceptions, changes in classroom interaction, and students’ achievement.

This study reported many results based on each data source as well as answering the research questions. First, in regard to the use of IAW for teaching literacy and mathematics, teachers completed a weekly self-report of their use of the IAW. Descriptive data showed the teachers used the IAW in over two-thirds of their lessons in the first year, and their used changed three-quarters on the second year of the project. In addition, the data showed the IAW was used more frequently during mathematics lessons in contrast with literacy (Higgins).

In order to evaluate changes in patterns of classroom interaction, Higgins observed 184 lessons of a random sample of 30 teachers. Also, the focus of structured observations was on analyzing the differences between lessons where teachers taught with and without the IAW as well on any changes in patterns of interaction. The overall analysis indicated that the use of IAW did make a change of classroom interaction. Also, there was a faster pace in the IAW lessons as measured by the number of discussion moves in contrast with the non-IAW lessons including explanations, questions, evaluations, and answers (Higgins).

The analysis of the structured interviews of teachers and students indicted that both teachers and students had positive perceptions about the impact of the IAW. Also, teachers reported that the IAW helped them to achieve their teaching goals as well as believed that using the IAW in lessons positively affect students' motivation to learn. Interestingly, students reported that the IAW helped them to pay attention during lessons due to the use of resources and multimedia available on the IAW (Higgins).

The national achievement tests were completed after approximately five to seven months of use of the IAW. The results indicated that the mean raw test scores in the IAW schools were slightly higher than in the control schools. Also, the test scores showed statistically significant margins for mathematics and science. However, the effect size in each case was small. On the other hand, students' scores decreased in the following year for both the intervention and control groups (Higgins, 2010).

According to Higgins, the introduction of the technology might have been beneficial for learning. However, in the current investigation, the indicators used to measure outcomes did not capture the changes in the results. In addition, the national test performance represented only a limited assessment of learning, which focused on a narrow range of quantifiable outcomes. Higgins suggested that utilizing technologies in classroom might be beneficial for such as develop deeper knowledge, positive attitudes, creative and flexible learners, and/or better social learning opportunities, although data were not collected that supported this conclusion.

This study attempted to evaluate the direct influenced of using the IAW in the classroom. Many data sources were used to make the conclusions including quantitative and qualitative data. This was a strength of the study. The qualitative data provided enriched information regarding the interactions in the classroom as well as the teachers' and students' perspectives. However, adding more information on the way the data were analyzed might strengthen this study and the results presented. In addition, the statistical analysis methods were missing in the study. More information was necessary to understand the calculation of the effect size and the significant of the findings.

Another study conducted by Turel and Johnson (2012) used a quantitative descriptive research method to evaluate teachers' perceptions and their use of IAWs. Data were collected from teachers via questionnaire. Turel and Johnson developed questionnaire that included 26 items from strongly disagree to strongly. The questionnaire items classified along with the existing literature into three themes. These themes included items related to the effects of IAWs on teaching and learning, items addressing the motivational issues of IAWs, and items concerning the usability of IAWs. The main goal of the classification was to acquire a meaningful understanding of the main dimensions of the IAW use (Turel & Johnson).

Turel and Johnson focused on some critical issue regarding the IAW research: the use of appropriate questionnaires based on existing research, and instructional theories and strategies associated with the use of IAWs. The researchers developed their questionnaire to avoid the limitations of previous studies and to answer the following research questions: What are the main sources of IAW training for teachers? What IAW training topics do teachers need? How much are the teachers using each IAW feature? What are the teachers' perceptions about their IAW use? and Is there a relationship between teachers' IAW use frequencies and self-reported competencies, discipline areas, and perceptions? (Turel & Johnson).

There were 174 teachers with IAW experience who participated in study and teaching at different educational levels ranging from grades six to twelve. The study examined teachers' responses based on their area of teaching that included computer science, foreign language (English), mathematics, science, social sciences, and Turkish Language and Literature (Turel & Johnson). They attempted to analyze their findings by using three methods. A descriptive analysis was utilized to perceive the existing status of teachers' IAW use, teachers' general perceptions about using IAWs, and Cronbach's Alpha coefficients for each theme based on the rules for internal consistency and reliability. Finally, Chi-square tests of independence were used to analyze the relationships between variables including frequency and duration of the IAW use, IAW competencies, and teachers' perceptions (Turel & Johnson).

The major results of the study indicated that educators used IAWs to teach a variety of subjects, and all respondents believed that IAWs helped to facilitate learning and instruction. All teachers indicated they had a portable IAW in their classrooms and the majority of teachers (62%) reported using IAWs more than seven hours per week. Also, a high percentage (79%) reported they had 'frequently' or 'always' used IAWs in their courses as well as used a wide range of IAW features (Turel & Johnson). The results implied that most respondents (67%) had received IAW training at an educational institution. Additionally, Turel and Johnson indicted that nearly 25% of all participants reported they needed IAW training in technical knowledge and skills, teaching methods related to IAW, and designing IAW activities.

Turel and Johnson also studied the teachers' perceptions and attitudes about the IAW use by looking at instructional effects, motivational effects, and usability. The results showed overall teachers had positive understanding (3.79/5.0) about the use of IAWs and they overwhelmingly agreed (77%) that using IAWs helped their students' learning in general. Importantly, the findings indicted that most teachers believed that the

IAW provided time efficiency during instruction and teachers agreed that using an IAW was interesting, engaging, and enjoyable for both teachers and students (Turel & Johnson).

Overall, the results indicated that teachers had positive perceptions about the use and the effectiveness of IAWs in general. Turel and Johnson's study afforded in-depth knowledge related to the use of IAWs in the classroom. The results were valuable for better understanding the relationship between using IAWs, teachers' training, and teachers' perspectives. In addition, this inquiry performed statistical analysis which strengthened the results of the questionnaire and provided statistical analysis of the findings.

However, as suggested by Turel and Johnson, a qualitative analysis would have been helpful in clarifying the underlying reasons for the significant differences emerging between the teachers who most and least frequently used IAWs in their classes. Additionally, the study might be strengthened if the researcher conducted an analysis of students' test scores or performance who received instruction using IAW. If this study used a statistical test that measured the association between students' performance and teachers' perception, it might give more understanding and value to the results the study.

Tsung-Ho, Yueh-Min, and Chin-Chung (2012) developed an analysis method that provided rich insights into technology-mediated teaching and learning interactions. The main purpose of this study was to investigate the associations among IAWs and teaching and learning interactions. According to Tsung-Ho et al. a quantitative analysis of classroom observation records with a total of 683 instructional events was conducted by using a descriptive statistics and a chi-square test to detect the association between interaction factors. Tsung-Ho et al. identified four interactions factors to analyze the data: (a) IAW-Supported Teaching (IST), (b) IAW-Supported Learning (ISL), (c) Teacher-Supported Learning (TSL), and (d) Student Interactive Learning (SIL).

Tsung-Ho et al. conducted a case study of 1 teacher and 29 second-grade students (17 males, 12 females). The researchers completed a quantitative analysis of classroom observation records to examine IAW use and determine which factors might influence teaching and learning interactions related to the use of IAWs. All of the participants had used the IAWs for only half a year before the project. The researchers used the data from the instructional events to determine whether IAWs influenced teaching and learning interactions, then performed a chi-square test for independence to examine the relationships between the factors (Tsung-Ho et al.).

In general, the results of this study suggested that the IAW supported student learning as well as largely increased the learning efficacy. In regard of the associations between the factors, the results showed that IST and TSL were the main factors that controlled over ISL and SIL in this study. All six paired factors' associations were significant and supported the nature of reciprocal interactions between teachers and students. The findings also point out that there were over 90% instructional events that concurrently comprised both IST and TSL behaviors that related to teaching and learning interactions (Tsung-Ho et al.).

The overall results of this study indicated that teachers integrated many types of multimedia and interactive designs into their instruction by using IAWs. As a result, this improved the quality and quantity of teaching by enabling teachers to feel more confident using the IAW and have more time to lead the students' learning (Tsung-Ho et al., 2012).

In addition, the results showed the integration of IAWs into the teacher's instruction can enhance the overall presentation of instruction (Tsung-Ho et al.).

The overall analysis of this study afforded great outcomes regarding teaching and learning interaction factors related to IAW technology. In addition, Tsung-Ho et al. used appropriate statistical methods to analyze the data and examine the association between factors. However, additional multiple-case studies of different curriculum and participants would provide greater understanding of the interactions among the teacher and students during the utilization of the IAW. A comparison between more than one case study may yield additional information that could strengthen the outcomes as well as provide support for more discussion about using the IAW.

In another exploration of IAWs in Taiwan, Chen, Chiang, and Lin (2013) investigated the influence of IAWs on the learning of fourth-grade science students. The main goal of this study was aimed to explore the influence of different instructional methods, specifically the use of the IAW instruction compared to the traditional lecture-based instruction. Chen et al. based their inquiry on multiple intelligence theories and utilized a quasi-experimental design. They selected students in two 4th-grade classes as research subjects. The instructional content included a unit on the positions and phases of the moon which were part of the elementary school natural and life sciences curriculum. Students underwent four weeks of instruction. A total of 64 students participated in the study. One class of 32 students constituted the experimental group, which received instruction via the IAW. The other class of 32 students was the control group, who received traditional lecture-based instruction. The researchers determined that the two groups of subjects had no significant differences in terms of their academic grade based on the evaluations for the previous year (Chen et al.).

The instructional activity of the experimental group included six components. The first component started with using IAW to display a film. The teacher then taught students about the changes in the moon's position using a software-simulated moon in the night sky on the IAW. During the second component, the teacher used digital learning instructional materials and used the IAW to teach students about the changes in the moon's position over the course of a day. The third component involved the use of the IAW to display a moon observational record chart, and in the fourth section, the teacher used the IAW to dynamically display the change in the moon's shape and engage in interactive instruction with students. The teacher then used the IAW to present digital learning instructional materials (including images and videos) to teach students about differences in the moon's surface patterns in the process of its phase change. Finally, the teacher summarized the names of the moon's phases and the sequence of the changes, and used software to simulate the dynamic changes in the shape of the moon in 30 days (Chen et al.).

In order to explore the influence of different instructional methods on students' learning achievement, statistical analyses were used including one-way analysis of covariance (ANCOVA) and the homogeneity coefficient for the within-group regression. The results indicated that after controlling for the effects of the covariates on the dependent variables, significant differences occurred between the post-test learning achievement scores of the two groups. Thus, these data demonstrated significant differences in learning accomplishments between the students taught using the IAW and those taught according to a traditional lecture-based instructional model. Importantly, students in the experimental group had an adjusted mean score of 74.572 on the learning achievement tests, which was higher than the adjusted mean value of 60.553 for the control group (Chen et al.).

The study also conducted an ANCOVA to identify the differences in achievement after experiencing the IAW instructional model among students in the experimental group who had different types of strong intelligences. The results suggested that the interactive whiteboard instruction was more beneficial for students in the weak logical-mathematical intelligence group than for those in the strong logical-mathematical intelligence group (Chen et al.).

Additionally, the students in the experimental group were asked to complete a learning-feedback questionnaire. The questionnaire included four aspects: course content, teaching method, environment and equipment, and interactive learning, as well as open-ended questions. The results from the questionnaire suggested that most of the students agreed that the IAW was beneficial for understanding of material and formation of concepts (Chen et al.).

Overall, the results demonstrated that using the IAWs resulted in significantly higher achievement levels for fourth-grade natural and life sciences students than those earned by the students who experienced the traditional lecture instruction. Chen et al. concluded that using the IAWs to integrate information and communication technologies into classroom instruction enhanced students' performance, as well as instructional quality, the variety of instructional material, presentation, and interactivity. Importantly, this study was the first attempt to investigate the direct influence of the IAW on the learning effectiveness. This study added critical information to the literature on using IAW. Also, this study attempted to provide essential information by collecting additional information using a questionnaire.

Researchers have found that consistent use of IAWs results in extensive benefits; however, few researchers in the United States have compared the results of using IAWs in schools to the rate of the schools' investments in the technology to confirm the supposed benefits associated with IAWs. Although many studies have taken place in the United Kingdom because of the rapid and substantial investment into IAWs, these inquiries mostly relied on the short-term evaluations, perceptions, and opinions of teachers and students (Smith, Higgins, Wall, & Miller, 2005), which made it difficult to draw conclusions about the direct effectiveness of IAWs and especially students' performance.

In conclusion, both qualitative and quantitative studies exploring the use of IAWs with traditional students have shown the devices can be effective tools in classrooms. Teacher practice and student behavior when IAWs are available in the classroom have shown how the technology can influence and enhance learning in the classroom. Researchers employed several approaches in their investigation of IAW use in traditional classroom settings. Most of the research was based on teacher and student perspectives and the examination of the interaction between teaching and IAWs. However, most of the current research did not examine the direct influence of using IAW with students. In addition, most of the studies were short-term, and it is critical to conduct a longitudinal study with typical students to examine the long-term effects of instruction using IAWs.

It is important to note that most of the literature reviewed relied on perception, which did not allow for empirically based conclusions about the effectiveness of IAWs. In addition, much of the evidence was anecdotal, or based on case studies, which makes it difficult to generalize. Existing studies often employed methods such as focus groups, surveys, and interviews. In addition, much research to date has not taken into account the context in which teachers use IAWs (DiGregorio & Sobel-Lojeski, 2009).

Using IAWs to Teach Individuals with ASD and Other Disabilities

In this section, I review research studies that used the IAW to teach students with disabilities including ASD as well as one qualitative study that explored the use of the IAW with students with disabilities. Four studies used the IAW as the main intervention tool, and the skills taught included letter sounds, sight words, and daily living skills. Four out five of the studies employed a single case design methodology. A qualitative method was used for the study that explored the use of the IAW with students with disabilities.

Researchers have also explored the use of the IAW as an intervention with students with ASD or other types of disabilities. For example, Mechling, Gast, and Krupa (2007) conducted a study with three high school students diagnosed with intellectual disabilities. Mechling et al. used a multiple probe design across three word sets with each of the three students to evaluate the effectiveness of an IAW. To this end, Mechling et al. attempted to measure the students' ability to (a) read target grocery words, (b) match a picture of a grocery item to a target grocery word, (c) read other students' target grocery words through observational learning, and (d) match grocery item photos to observed grocery words. During instructional sessions, each student sat in a horizontal row of chairs positioned approximately two feet from the front of the IAW. The instructor sat behind and to the right of the students and positioned the computer hard drive and projector behind students and to the left of the instructor (Mechling et al.).

The instructor presented all words on PowerPoint slides on the IAW during screening, probing, and computer assistance instruction (CAI) using a 14-point Times New Roman font in lower-case letters (Mechling et al.). Each target word was centered at the top of the slide, and an arrow button was located on the bottom right side of the slide. Each slide displaying an image of the target word and three other images words showed directly after the target word slide. Images were placed on each angle of the slide with the target word centered in the middle of the slide. In addition, multiple exemplars of several images were attached to each target word. If the student touched the correct image, the program automatically moved to the next target word. The IAW's settings were programmed that each touch worked as one left mouse click. Moreover, a transparent "action button" was placed on the correct image, which also was hyperlinked to the next student's target grocery word (Mechling et al.).

During probe sessions, the Mechling et al. (2007) created three PowerPoint presentations for each word set to vary the order of words and trial presentations across the three students. Target words were displayed randomly intermixed sequences with known words equally dispersed. During probe trials, the instructor advanced the PowerPoint presentation to the first slide, which contained one written word, provided the task direction, "what word?" and waited three seconds for a response (Mechling et al.). Instantly after the trial to read the word, the instructor moved to the next slide presenting the non-identity matching task with the same word (Mechling et al.).

Mechling et al. (2007) conducted small group instruction three to four days a week in the morning or afternoon. Individual sessions lasted approximately 15 minutes, and group sessions took about 30 minutes. As a part of the intervention, the instructor used the IAW technology and a 3-second constant time delay (CTD) procedure. The CTD is a response prompting, near errorless learning approach that provides frequent opportunities for the student to respond and for the teacher to provide immediate feedback or consequences for student responses (Dogoe & Banda, 2009).

The IAW with CTD was used to teach students to read and identify image-to-printed-word matching tasks. During probe conditions, instructors assessed students' ability to read target and non-target printed words as well as match images to target and non-target printed words. A pretest and posttest was used to evaluate students' generalization ability by examining students' matching performance from object to printed word and printed word to object. Also, a final generalization posttest conducted after the last target-word probe condition. Finally, a probe conditions conducted as a maintenance in order to check previously presented target and observational words (Mechling et al.).

The results of Mechling et al.'s (2007) study indicated that use of the IAW resulted in the quick acquisition of skills and proved effective for all students across each set of words. After receiving instruction through the IAW, students met criteria within one to four sessions (Mechling et al.). Students demonstrated increased correct reading and matching of each set of target words using the IAW with the 3-s CTD procedure (Mechling et al.). It was clear from the data that teachers could use CAI with IAW and a 3-s CTD procedure to teach students with intellectual disabilities including individuals with ASD to (a) read target grocery words and (b) match grocery item photos to target grocery words (Mechling et al.). In addition, the results showed the effectiveness of the IAW and a 3-s CTD procedure in teaching students with moderate intellectual disabilities to read and match other students' target words through observational learning during small group instruction arrangement (Mechling et al.).

Mechling et al. (2007) collected inter-observer agreement and procedural reliability data for 33% of all sessions conducted during the research study. The results showed that the mean of inter-observer reliability was 99% across all participants and conditions when recording student responses, 99% for target and observational learning, and 99% during small group CAI. In addition, the results support the use of IAWs when teaching multiple students at one time.

The major strengths of Mechling et al.'s (2007) study were that it demonstrated the effectiveness of using the IAWs as a tool to teach small group students at one time as well as the use of the IAW resulted in observational learning of non-target information. The researchers also used maintenance phases to assess the impact of the intervention. All students were able to reach the criteria for each of their target sets of words. For all participants, the range of their responses during all maintenance probe sessions (range, 80% - 98%). One limitation of the study was that the instructors did not teach the skills in a functional manner. In addition, future research should compare rates of acquisition with and without the use of technology.

Based on the results of Mechling et al. (2007), Mechling et al. (2009) conducted a follow-up study with the same participants. In a group setting, the participants learned different functional sight words from the same grocery list used in the previous study, with the help of the IAW and flashcards. According to Mechling et al., all of the words were considered equal difficulty and were selected based on each student IEP goals. The researchers identified 18 multi-syllabic, compound words and multiple words unknown to the students from a screening list of 122 grocery aisle marker words selected from sampling three major grocery store chains in the area (Mechling et al., 2009).

Mechling et al. (2009) conducted flashcard group instruction and IAW group instruction on the same day, with one session in the morning and the other in the afternoon (4.5 hours between sessions), two to three days per week. The researchers counterbalanced instructional procedures across days, with no more than two consecutive sessions of one procedure to control for time of day and order effects. Each session consisted of 36 trials of either flashcard or IAW words. A group instructional session occurred only if all three students were present, and the researchers presented the sessions so that each student received one turn during each block of the three trials and no more than two consecutive trials per student (Mechling et al.). The researchers placed the first letter of a student’s name in small 10-point font at the bottom right of the slide or the back of the index card containing the target word to cue the instructor to gain the attention of the target student. Mechling et al. used a 3-s CTD procedure with both flashcard and IAW instruction. Target words for each student served as observational words for other students. The researchers evaluated observational learning (learning the target words of other students) during probe sessions to compare learning of words with the two modalities (flashcards and IAW) without direct instruction (Mechling et al.). The researchers recorded the percentage of correct responses for the target words and observed targets words.

The results indicated the IAW and flashcards produced the same level of skill acquisition for the target words; however, the percentage of correct responses for the observed targets was much higher in the IAW condition (Mechling et al., 2009). The researchers collected inter-observer agreement and procedural reliability data simultaneously on 33 % of all sessions across conditions (Mechling et al.). The mean of inter-observer agreement across conditions was 98%, 98% for target and observational probe sessions (range, 94%–100%) and 98% during small group IAW and flashcard instruction (range, 94%–100%). A major limitation of Mechling et al.'s (2009) study was that the researchers selected the same respondents who had participated in the previous study to receive a similar intervention. As a result, the students' familiarity with the tools and processes they used in the first experiment may have influenced the results of the second study (Mechling et al.).

Campbell and Mechling (2009) utilized an IAW to teach letter sounds to three kindergarteners with disabilities other than ASD in a group arrangement. The main goal of this investigation was to evaluate the effectiveness of using the IAW and combined with a 3-s constant time delay procedure in a small group arrangement to teach letter sounds to three students with learning disabilities. Campbell and Mechling also measured how much information instructors could teach using observational learning and by incidentally providing students with information that they did not teach explicitly. The researchers used a multiple probe design to evaluate students' acquisition of non-target letter sounds through observational learning. After screening for known letters and sounds, the researchers selected 18 letters that the participants did not know. Each student received three sets of two letters and learned the sound and name for each character through the IAW.

Campbell and Mechling (2009) evaluated the observational learning and incidental learning of related non-targeted information during small group instruction and followed the work of Mechling et al. (2007), which evaluated observational learning of sight words taught to students with intellectual disabilities. The researchers conducted sessions four to five days a week that lasted ten minutes for individual sessions and 20 minutes for small group sessions. Small group sessions only took place if at least two of the three students were present. Maintenance probe sessions were collected of previously presented targeted and non-targeted stimuli. A reliability data were collected for interobserver agreement and procedural reliability data on 33% of all sessions. The mean of interobserver agreement 99% across all participants and conditions when recording student responses were, 99% for target and probe sessions (range, 98%–100%), and 98% during small group CAI (range, 93%–100%) (Campbell & Mechling).

The results demonstrated the effectiveness of using CAI with the IAW and a 3-s CTD procedure in teaching letter sounds to students with learning disabilities. Also, an inspection of students' percentage of unprompted correct responses, it is indicated that all of the students met the criteria on the sets that the researchers directly taught and maintained their skills for all of the letter sounds and names.

For the observational learning, the results indicated students achieved 25% to 100% of correct letter sounds and 83% to 100% of letter names through observational learning of the sets they were not directly taught. The data showed all students learned some of others students' target sounds through observation when presenting instruction via the IAW. This study suggested that instructors can effectively and efficiently present information using new technologies like large screen IAWs. The technology allows for the computer-based presentation of information, and using of many interactive features including animation, sound, and interaction help to presents information on a large screen that could be viewed in small or large groups (Campbell & Mechling).

Campbell and Mechling's study added critical information to the previous body of knowledge and supported the notion that students could acquire knowledge through observational learning that incorporated an IAW. However, evaluating the time it takes to acquire the information when taught directly is very critical to improve the result of the study. Finally, assessing generalization, maintenance, and social validity might be necessary to strengthen the findings of the study.

Yakuova and Taber-Doughty (2013) used self-operated video modeling via a SMART Board, a self-monitoring system, and a system of least prompts to increase participants' performance of three daily living tasks. The main purpose of this study was to examine the effectiveness of using the IAW on skill acquisition and interaction behavior to students with ASD and intellectual disability. The intervention package consisted of self-operated video modeling, self-monitoring, and a system of least prompts. Specifically, students learned to operate and view a video modeling clip, perform the chain of the skills following the analysis of the target behavior, and self-monitor their task performance using the IAW (Yakuova & Taber-Doughty).

Baseline and intervention activities completed twice per week in students self-contained classroom. Yakuova and Taber-Doughty recorded occurrence and non-occurrence of behaviors during all sessions from a position that enabled them to observe each student interact with the IAW and perform each task step. For the reliability purpose, a second observer was present and collected data during all sessions.

Yakuova and Taber-Doughty held a pre-training phase for two sessions during which they taught students how to use the IAW and access instructional files from their electronic folders. The researchers developed a sample video modeling clip for cleaning a desk and a self-monitoring checklist to train students to operate the IAW. The first step on intervention was the pre-training, where students accessed and watched the sample video using the IAW including cleaning the desk, and then self-monitored their performance. A system of least prompts was used if students responded incorrectly, missed a task step, or need additional prompts to access materials using the IAW. Each participant completed five sessions for each target tasks using the IAW and the self-monitoring checklists. Generalization probe was conducted immediately following intervention. Each student were asked to complete the same learned tasks in untrained bathroom. During this condition, video clips, self-monitoring checklists, and the system of least prompts were not used during generalization probes. Results indicated that all students were able to acquire and independently perform each task and engage in using the IAW. The findings showed that each student demonstrated high level of performance over baseline levels and continued during the generalization probes (Yakuova & Taber-Doughty).

Overall, Yakuova and Taber-Doughty conducted a strong research study and their results strongly supported the use of IAWs when teaching students with ASD. One of the major strengths of this study is that immediately following intervention, the researchers found that the students' response generalized to a second setting in which the participants were untrained. Yakuova and Taber-Doughty also assessed social validity before and after the study by asking the students and their teacher about their perception about using IAW. The researchers first asked the teacher “yes/no” and open-ended questions, and then requested that she completed a teacher satisfaction assessment. The assessment provided an opportunity for the teachers to share their opinions on students’ performance by using the video modeling and the IAW. Also, each student conversely was asked to respond to questions about their previous experiences using the IAW and their positive and negative feeling about using video modeling, self-monitoring, and the IAW (Yakuova & Taber-Doughty). Overall, the results could have been stronger if the authors had provided more replications of the effect.

By using different research methods, Allsopp et al. (2012) conducted an exploratory study regarding the use of IAW with students with disabilities. The main purposes of this study were to understand how teachers used IAW in their classroom, to learn about their perceptions of this technology for students with disabilities, and ascertain teachers’ perceptions of training needs related to the effective use of IAWs. Additionally, Allsopp et al. attempted to examine how other factors including teacher training and confidence, technical support, and lesson preparation and practice time, might reduce the use of IAW.

A purposive sampling technique was used to identify participant teachers based on many two factors; establishing collaborative relationships and expressing interest in learning about and using IAWs in their classrooms. Six teachers at four partnering school sites, who taught a range of students with disabilities, participated in this study with no previous experience using IAW. The study occurred over one academic year (Allsopp et al.).

The researchers collected data using multiple sources including classroom observations, individual interviews, focus group interviews, and field notes. According to Allsopp et al., field notes focused on recording teacher actions and student responses as well as identifying various ways the IAW was used. Also, interview questions were conducted immediately after each observation and designed to prompt teachers' thinking about their utilization of the IAW. Finally, three focus group interviews were conducted to obtain critical information related to teachers' experiences, ideas, questions, and concerns (Allsopp et al.).

Qualitative and descriptive methods were used to analyze the data collected through the study. Interviews and focus group data were coded into three themes: practice, implementation, and professional development. An iterative coding process was utilized for the individual and group interview data. Finally, a descriptive analysis using a coding system for each teacher action, student action, and type of interactive technology was used to analyze observational data.

The results from this study were summarized into two categories: (a) teachers' uses of the IAW for students with disabilities, and (b) teacher perspectives on using the IAW for students with disabilities and effective professional development. For teacher practice, the data showed, few teacher actions related to modeling through the IAW occurred when concepts and skills were shown visually through teacher-developed presentation slides projected on the whiteboard as well as teachers mostly used the pen or highlight tool as they modeled for emphasis. In terms of students' responses, the data suggested that students were less engaging when participating in small groups compared to individually or as a large group. In regards to the type of interactive tools used, only 12 tools (6%) actually were used by teachers during observations sessions (Allsopp et al.).

Many teaching and learning practice themes found from the data on teacher perspectives. According to Allsopp et al, these themes included: interactivity which was the most important characteristic of the IAW, the ability to provide both explicit instruction and immediate student feedback also was a key aspect of creating interactivity through the IAW, the ability for using the IAW to differentiate instruction, to use visuals to generate student interest/attention, and to make data-based instructional decisions.

The overall results indicated that teachers were overwhelmingly positive about the potential of IAWs to enhance their teaching. In addition, the teachers noted that IAWs made it much easier to (a) differentiate their presentations of concepts through visual tools like highlighting and intro cues and (b) gain students' interest and attention. On the other hand, the results suggested that most of the teacher believe that they needed more training to effectively integrate the IAW (Allsopp et al.).

In addition, the qualitative results of Allsopp et al.'s (2012) study provided more in-depth knowledge and information related to teachers and their implementation of the IAW in their classrooms. Data were collected from many sources and the analysis of the data added critical information and clear image regarding the actual of use of the IAW in the classroom. Triangulation was used to verify the credibility of data. , The study provided specific information on how teachers use the IAW in their classroom as well as their perspectives. As a result, the findings of this inquiry have very high credibility. Despite the important findings of the study, additional examination might provide valuable results. This include, as this study completed within one school year, an evaluation of students' performance may provide a valuable information. Also, in term of methodology, some critical assessment tools (e.g., member check and external auditor) that measure credibility were missing, which might have improved the study.

In sum, each of these four studies used IAWs as the main intervention with the integration of other teaching strategies like CTD or prompting. All of the researchers conducted the interventions using a single subject design; however, the dependent variable differed in each study. Three out of the four studies focused on academic skills, while one study examined daily living skills. The results of the four studies supported the use of the IAW as a tool for teaching a variety of skills to individuals with disabilities.

Each of the four studies also used observations to determine how instructors were using IAWs in the classroom, and several focused on students with disabilities. While one article focused on how IAW technology affected students with mild learning disabilities learning literacy skills (Campbell & Mechling, 2009), another examined the effective uses of IAWs for teaching literacy skills using grocery-related sight words and images (Mechling et al., 2007). Both of these studies supported the use of IAWs in small groups or one-on-one for students with disabilities. Two of the studies found that IAWs helped some students focus on the task as a result of using the large screen size as well as other students were able to acquire non-target skills in observation learning situation (Campbell & Mechling, 2009; Mechling et al., 2007). Additionally, the qualitative data from Allsopp et al. (2012) study added more information on how teachers used IAW to teach students with disabilities as well as their perspectives.

The results of the studies indicated that the IAW could be useful when teaching individuals with disabilities, including ASD, across multiple domains and within different age groups. However, it is unclear whether instruction using IAWs alone is as effective as when teachers use it in conjunction with other procedures like prompting or constant time delay. Thus, when developing interventions that include the IAW, it is important that they are functional for individuals with ASD and support generalization.

Discussion

This review of the literature on IAWs affirms there are only a few researchers who have explored the use of IAWs with students with ASD. The findings from the studies that do examine the topic support the use of many technological interventions, such as IAWs and other technology devices, and visual support in the classroom to enhance the performance of individuals with ASD and other disabilities. In addition, the results supported the conclusion that technology can be effective for a variety of learning domains, age groups, and disabilities. However, it is critical to determine how best to integrate technology into the learning process.

Recent research has not yet examined any interventions based on the combination of assistive technology, visual support systems, and UDL principles. More evidence-based data are essential for researchers to determine whether using technology can enhance the development of a range of skills for individuals with ASD.

This comprehensive review also revealed a dearth of research that investigated the use of IAWs when teaching individuals with ASD. Moreover, the studies that did explore this phenomenon involved group settings and did not explore individualized teaching. To date, only a few studies have examined the acquisition of academic skills using technology, an approach that has proved critical for individuals with ASD. In addition, most of the studies evaluated the use of IAW but did not assess acquisition, generalization, and maintenance which is critical to be investigated in the current research study.

Based on the results found in each study, there is solid ground on which to conduct and develop effective interventions for individuals with ASD. Not only did each study find IAWs to be effective for instruction in some way, but the inquiries also demonstrated that IAWs can be effective in general education classrooms and in special education settings. Since the findings in previous studies supported the use of IAWs in multiple educational settings, the current study sought to pinpoint the effective uses of IAWs for students with ASD in the classroom setting.

Of course, technology alone will not impact student achievement. However, when teachers combine technology with high-quality, effective instruction, students will have the potential to reach higher levels of achievement, motivation, and engagement. Although prior researchers have identified the limitations of the IAW in promoting student engagement, generalization skills, and interaction, the current inquiry extends the research on the features of IAW to teach academic skills to individuals with ASD, specifically early numeracy skills. In addition, the intervention was based on the unique needs of individuals with ASD, and the most critical part of the study examined the acquisition and the generalization of the skills over time. This investigation examined the effectiveness of the IAW as one such technological tool and the results will likely motivate and encourage more teachers and educational professionals to use IAW in ASD classrooms in the future.

Chapter 3: Methodology

This chapter describes the methods used in the present study. It begins with the participant selection process, a description of the participants, and a description of the setting of the study. The chapter provides information on the experimental design and describes the independent and dependent variables, post-intervention probe, generalization, and maintenance procedures.

Participant Selection and Characteristics

Prior to the initiation of this study, permission to conduct research was procured from the University of Maryland, College Park Institutional Review Board (IRB) and the public school system in which this research was conducted. After IRB approval, I emailed multiple school principals who had a program for students with ASD in the approved public school system. After one principal expressed interest in the study, I reviewed my research proposal with the principal and the administrative staff of the school. Permission to conduct the present investigation was obtained immediately from the school principal. Upon discussion with the chairperson of the autism program at the school, two self-contained classrooms for students with ASD were recommended for the study.

Next, an informational letter and consent form (see Appendices A and B) were sent to the parents or legal guardians of 9 out of 11 students across the two classrooms based on teacher recommendation. The letter provided information on how to contact me so parents could obtain additional information and ask specific questions. It should be noted the consent form included a statement that only students who met the selection criteria could participate in the study. Out of nine consent forms sent to parents and legal guardians, six were returned granting permission for their child to participate.

After permission from parents/legal guardians was obtained, I completed both the Eligibility Criteria Questionnaire (see Appendix C) and the Student Assessment Checklist and Summary (see Appendix D) for each student by reviewing each child's record, observing the students during the school day, and discussing student characteristics with the two teachers. The most current assessment information from the students' records was obtained regarding their level of performance as well as the severity of their autism. This information was recorded on the Student Assessment Checklist (see Appendix D) to include, when available: (a) a score on the Childhood Autism Rating Scale (CARS-2; Schopler ,Van Bourgondien, Wellman, & Love, 2010) to determine the severity of the autism; (b) a teacher score on the Autism Spectrum Rating Scale (ASRS; Goldstein & Naglieri, 2012); (c) a parent score on the Autism Spectrum Rating Scale (ASRS; Goldstein & Naglieri, 2012); (d) a score on the Comprehensive Inventory for Basic Skills II (Brigance CIBS II); and (e) an IQ score and the name of the test used.

The following eligibility criteria (see Appendix C) were assessed for the six students based on his or her current information and teacher interviews: (a) Does the student have an autism diagnosis based on the fourth or fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR or DSM-V; American Psychiatric Association, 2013)? (b) Is the student between 5 and 12 years of age? (c) Does the student have a behavior intervention plan (BIP)? (d) Is the student able to match a picture to an identical picture in an array of three pictures? (e) When requested to touch an object, is the student able to respond correctly? (f) Is the student compliant to physical prompts? (g) Is the student able to attend to a task for 5–10 min? (h) Does the student have at least one IEP goal that addresses early numeracy skills?

The selection pool process resulted in only four students who met the requirements for participation in the current study. These four students were diagnosed with autism spectrum disorders (ASD), were enrolled in a mid-Atlantic suburban public school district, and attended a public elementary program for students with ASD. The participants' students were ranged in age from 5 to 7 years. Also, all of the participants attended a self-contained classroom for students with ASD. The selection criteria targeted a specific population, namely students who were moderately affected and had no behavior problems that interfered with learning. Two of the students received instruction in the kindergarten classroom for students with ASD, and the two remaining participants received their instruction in a first grade classroom for students with ASD. Based on their teachers' feedback, there was no evidence that the students had experience using IAW to learn academic tasks although several had some experience using the IAW during library or free time for story reading. For example, the librarian used the IAW to read story for kids in small group. More details information regarding each student selected to participate in the current study is summarized below.

Student 1. Student 1 was a 5 year, 10-month old female in kindergarten; this was her second year in the ASD program. She had a diagnosis of ASD based on multiple assessments. She met the criteria of ASD in the DSM-IV-TR and the Autism Spectrum Rating Scale for both teacher and parent. Student 1 was found to have a mild-moderate level of autism severity based on the CARS-2. She was cognitively below age level based on the Battelle Developmental Inventory (2nd ed.), the Carolina Curriculum for

Preschoolers with Special Needs (CCPSN) (2nd ed.), and the Early Childhood Skill Development Guide as a part of the Maryland Model for School Readiness (MMSR). In summary, Student 1 demonstrated skills that were solidly in the 2- to 3-year-old range and demonstrated needs in the areas of pre-academic, adaptive, gross motor, social emotional, and receptive and expressive language.

Student 1 was verbal and spoke using four or five words and phrases as well as gestures and vocalizations. She used her phrases to make requests, labels, and comments. She used basic sentences like "I want___ please" to indicate toys, food, and drinks. She demonstrated active listening associated with routine task behaviors such as directing her focused attention to the speaker and responding to stories read aloud. She could answer questions such as "Who is it?" and "What is it?" and consistently expressed her wants and needs throughout the school day. When requested, she consistently matched a picture to an identical picture in an array of three pictures, sorted pictures and objects by varying attributes including color, and identified expressively and receptively all of the letters of the alphabet. Student 1 followed multi-step directions that were part of her daily routine and attended to tasks for 5–10 minutes with some verbal and physical prompts to remind her to stay on task. She knew the names of her classmates, imitated some actions during small-group activities, and identified many of her own body parts. Student 1 used an activity schedule for her daily routine and used pictures to help with words she did not know. She recognized, enjoyed, and riffled through a variety of books. She liked to select books, listen to the story, and could, with some support, retell sequences and answer "wh" questions. She responded particularly well when stories had accompanying music, pictures, or actions. Student 1 received academic instruction on a one-to-one basis and in small group instructional arrangements.

As for early numeracy skills, Student 1 participated in math-related activities like counting, sorting, and measuring. She could receptively identify numbers (1–10) when asked and wrote some numbers from 0 to 10 without support. However, Student 1 needed prompting to complete the early numeracy tasks of one-to-one correspondence, rote counting from 1-20, matching numerals to a set of 0 to 5, and stating the numbers 1 to 10 when presented randomly. Additionally, Student 1 was unable to match sets of items to corresponding numbers and unable to understand the concepts of more and less.

Some behavioral concerns reported by her teacher included non-compliance and stereotypies. These behaviors sometimes interfered with her optimal functioning in the classroom. Student 1 repeated song scripts such as “Five Little Monkeys” and was easily distracted during familiar tasks, but she was usually able to return to the task when prompted. When performing a new task, she became distracted easily or defiant by getting teary and saying “no.” Additionally, Student 1, who had allergies, sometimes scratched her outbreaks and started crying when she did not want to do something or when she was tired.

Student 2. Student 2 was a 7 year, 1-month old female in the first grade; this was her second year in the ASD program. She had a diagnosis of ASD based on multiple assessments. She met the criteria of ASD in the DSM-IV-TR and the Autism Spectrum Rating Scale for both teacher and parent and was found under the mild-moderate level of autism severity based the CARS-2. She was cognitively below age level based on both the Leiter International Performance Scale (3rd Ed.) (Leiter-3) and the Early Childhood

Skill Development Guide as a part of the Maryland Model for School Readiness (MMSR). Academically, Student 2 was found below grade level on both the Kindergarten Literacy Assessment and the Early Math Assessment. In summary, Student 2 demonstrated skills primarily within the three- to four-year-old range and demonstrated needs in the areas of pre-academic, adaptive, gross motor, social emotional, and receptive and expressive language.

Student 2 was verbal and spoke using two- to four-word phrases. She used her phrases to make requests, labels, and comments. She used basic sentences like "I want___, please" to indicate toys, food, and drinks. She answered questions such as "who is it?" and "what it is?" and consistently expressed her wants and needs throughout the school day. Also, she used a communication ring with words and pictures including, yes, no, I want, help, bathroom, snack time, etc. to assist in explaining herself. When requested, she consistently matched a picture to an identical picture from an array of three pictures and sorted pictures and objects by varying attributes, including color. Student 2 knew all the letters of the alphabet, 18 sight words, and was learning to write letters and words. She followed a variety of 1–2 step, familiar routine directions and attended to tasks for 5–10 minutes with some verbal prompts to stay on task. She knew the names of her classmates, imitated some actions during small group activities, and identified many of her own body parts. Student 2 used an activity schedule for her daily routine, and she loved to participate in group circle time and attended typically for up to 10 minutes. She was eager to work and loved cutting and gluing. Student 2 was most successful when there were visuals to assist her in learning. She enjoyed listening to books and reading with the teacher, and she received the most academic instruction in the class, including reading and writing letters and words, but needed verbal and physical assistance.

As for early numeracy, she could state the numbers from 1 to 10 and was making progress in the area of writing numerals. However, she had trouble remembering numbers expressively at times, specifically the numbers 3 and 4, and she had trouble counting the requested number of objects (from 1-10), often over counting the number. Student 2 had difficulty attending to tasks independently, as she often played with materials instead of staying on task. She could recognize and name a square, a circle, and a triangle, though she could not differentiate between 2D and 3D shapes. Student 2 was unable to make sets of requested items, and she did not understand the concepts of more and less. She counted with one-to-one correspondence reaching five, but needed verbal prompting.

Some behavioral concerns reported by her teacher included limited eye contact, noncompliance, and stereotype behaviors. These behaviors sometimes interfered with optimal functioning in the classroom. She exhibited impulsivity and had to be watched carefully to keep her on task. She frequently mouthed objects, including instructional materials. Student 2 did not like to be told "no" and would scream or cry briefly in an attempt to get her way.

Student 3. Student 3 was a 6 year, 7-month old female in the first grade; this was her second year in the ASD program. Student 3 had a diagnosis of ASD based on multiple assessments. She met the criteria of ASD in the DSM-IV-TR and the Autism Spectrum Rating Scale for both teacher and parent. Student 3 was found to have a mild-moderate level of autism severity based on the CARS-2. She was cognitively below age level based on both the Leiter-3, and the Early Childhood Skill Development Guide as a part of the Maryland Model for School Readiness (MMSR). In summary, Student 3 primarily demonstrated skills within the two- to three-year-old range and demonstrated needs in the areas of pre-academic, adaptive, gross motor, social emotional, and receptive and expressive language.

Student 3 was verbal and spoke using two- to four-word phrases. She used her phrases to make requests, labels, and comments. She used basic sentences like "I want___ please" to indicate toys, food, and drinks. She answered questions such as "Who is it?" and "What is it?" and consistently expressed her wants and needs throughout the school day. When requested, she consistently matched a picture to an identical picture in an array of three pictures and sorted pictures and objects by varying attributes including color, and she could name all of the letters of the alphabet. Student 3 followed a variety of one- to two-step, familiar, routine directions and attended to tasks for 5–10 minutes with some verbal prompts needed to stay on task. She knew the names of her classmates, imitated some actions during small-group activities, and identified many of her own body parts. Student 3 used an activity schedule for her daily routine. She enjoyed looking and listening to books and responded well when stories had accompanying music, pictures, actions, or other multimedia presentations, such as on the Smart Board during library time and on the iPad. Student 3 received academic instruction in small groups and individually.

As for early numeracy skills, she could state the numbers 1–20 when asked to count and she could identify numbers 1–10 when asked receptively. She consistently counted with one-to-one correspondence up to five. She was able to write some numbers from 0–10 without support. Student 3 had not learned to make sets of items beyond five when requested and did not understand the concepts of more and less.

Some behavioral concerns reported by her teacher included limited eye contact, non-compliance, stereotype behaviors, and echolalia. Student 3 repeated questions and her favorite TV cartoon scripts. Student 3 was easily frustrated throughout the day. When she became frustrated, she struggled to follow directions, had trouble attending to tasks, refused to do work, even when given an extrinsic motivator to work toward, and often cried, screamed, and disengaged from the task. These behaviors sometimes interfered with her optimal functioning in the classroom.

Student 4. Student 4 was a 5 year, 9-month old male in kindergarten; this was his first year in the ASD program. Student 4 had a diagnosis of ASD based on multiple assessments. He met the criteria for ASD in the DSM-V and the Autism Spectrum Rating Scale for both teacher and parent. Student 4 was found to have a severe level of autism severity based the CARS-2. He was cognitively below age level as well as below developmental level based on many assessments such as the Frog Street Assessment and the Early Childhood Skill Development Guide as a part of the Maryland Model for School Readiness (MMSR). Also, the Behavior Assessment System for Children (BASC-2) had been completed, and the results showed Student 4 was below normal limits. In summary, Student 4 demonstrated skills solidly in the 1- to 2–year-old range and demonstrated needs in the areas of pre-academic, adaptive, gross motor, social emotional, and receptive and expressive language skills.

He was verbal and typically spoke in one- to two-word phrases; however, he did not typically use spontaneous verbal language to make comments or requests. He used a communication ring of pictures and words to make requests. Regarding articulation, he was primarily at the 1- to 2-year-old level. He could express himself using words and phrases but most of the time would not unless prompted to by an adult. Student 4 repeated what he wanted to say when he needed something from an adult. Student 4 did not understand nonverbal cues and had not learned to interpret his social surroundings. He followed two-step directions, but often required multiple re-directions to follow through with tasks. When requested, he matched a picture to an identical picture in an array of two pictures and sorted pictures and objects with teacher support. He only recognized 20 out of 52 upper and lowercase letters receptively. He did not know any letter sounds. His academic performance was overall inconsistent. He followed the daily routine with no difficulties and attended to tasks for 5–10 minutes with verbal prompts to stay on task. Student 4 received most of his academic instruction individually including math skills and writing letters and words.

As for early numeracy, Student 4 could recognize shapes consistently and state the numbers 1 to 10, but he did not receptively recognize the numerals with their quantities. Student 4 had not learned to make sets of items and did not understand the concepts of more and less. He needed prompting for one-to-one correspondence, rote counting to 10, matching numerals to a set of 0 to 5, and recognizing the numbers 1 to 5.

Some behavioral concerns reported by his teacher included non-compliance and stereotypic behaviors. These behaviors sometimes interfered with optimal functioning in the classroom. Student 4 was easily distracted and occasionally walked away from activities to other areas of the classroom. It was often difficult to gain his visual attention. Student 4 showed a lack of focus and no motivation to learn.

Setting

The elementary school in which this study was conducted was located in a large, suburban public school district in a mid-Atlantic state. The 2016-2017 student population was 1,087 students. 22% of the students had limited English proficiency, 56% of the students received free and reduced meals, and 19% of the students received special education services (Maryland State Department of Education, 2016).

The special education kindergarten and first grade classrooms were the settings where the baseline, intervention, post-intervention, generalization probes, and maintenance conditions were conducted for the four participating students. Both classrooms included a high teacher to student ratio, with three teachers in each classroom; one was the special education teacher and the other two were teacher assistants. The kindergarten class had five students and the first grade class had six students, all having IEPs and receiving special education services. Each classroom was divided into specific areas or stations, which included a small group area, a large group area, a one-to-one instructional area, the teacher's desk area, a play area, and the students' desks. The one-to-one instructional area included a table that allowed a teacher and the student to face each other. The IAW was located in the front of both of the classrooms (i.e., in front of students' desks?) as a part of the large group area.

Upon discussion with classroom teachers, the one-to-one instructional arrangement corner in each classroom was used to conduct the baseline condition for it was isolated from the other students. Two of the students (Student 2 and Student 3) were in the first grade classroom, whereas the other two (Student 1 and Student 4) were in the kindergarten classroom. For all four participants, the intervention condition was conducted in the kindergarten classroom because the IAW area was more isolated in the front of the classroom as compared to the first grade classroom, which minimized disruptions from other students; the IAW in the first grade classroom was not used because of possible student distractions. The area where the IAW was located was used for the intervention, post-intervention, and maintenance conditions in the kindergarten classroom because of the need to use the IAW. The group table in each classroom was used to conduct generalization probes.

The investigator picked up and dropped off first grade students at their classroom before and after instruction. Each instructional session involved me, the primary investigator, and one student. All experimental conditions were conducted by the primary investigator: baseline, intervention, post-intervention probes, generalization, and maintenance.

Upon discussion with teachers, an agreement was made that the best time to conduct the study, which was considered a non-instructional time, was between 8:30 a.m. and 9:00 a.m. before the beginning of the first instructional block of the schedule, where all students used the bathroom after breakfast and prepared for morning group circle.

Design

This study used a single case design (SCD) methodology to assess the effects of the intervention package across the four participants. SCD research was used to document the functional relationships between the independent and dependent variables (Horner et al., 2006). A multiple probe design (Kennedy, 2005; Tawney & Gast, 1984) across participants was used to evaluate the effectiveness of using an IAW to teach early numeracy skills in a one-to-one instructional arrangement. This design was used for its many features. The baseline data are collected in a systematic, intermittent basis until the intervention is introduced. Testing probes, which are trials operationally identical to pre-intervention baseline measures, are conducted intermittently on the targeted skills to allow the researcher to determine if the targeted skills changed prior to the introduction of the intervention (Kennedy, 2005; Horner et al.; Tawney & Gast, 1984).

The multiple probe design was used across the four participants. The design was used to measure the acquisition, generalization, and maintenance of early numeracy skills as a result of the IAW intervention. Specifically, the baseline condition was an assessment of the skills selected to be taught, namely counting with one-to-one correspondence and representation of numbers (i.e., understanding that a number refers to an item or a set of items) (Jimanez, Broder, & Saunders, 2012).

Five baseline sessions were obtained on each of the four participants. Given stable and low level baseline results under 50% for all participants, I randomly selected the first student to receive the intervention. When the first student reached the criteria of 60% accuracy or better for one session during the intervention, a baseline probe was collected for Students 2, 3, and 4. Then, I randomly selected the second participant to receive the intervention. An additional three baseline sessions were collected to establish a trend and level to ensure Student 2's performance remained under 50%. The same sequence of baseline procedures was repeated for Student 3 and Student 4 when the criterion of 60% accuracy or better for one session was reached by the preceding participant during the intervention condition.

Experimental control was demonstrated when (a) probe performance on untrained early numeracy skills remained stable or at a low level during baseline before the introduction of the IAW and (b) the level of performance on early numeracy skills increased after implementation of the IAW intervention began. Tawney and Gast (1984) indicated that in order to demonstrate the functional relationship between the introduction of the intervention and a change in the behavior, the response of each subject stays at or near baseline level across occasionally conducted probe trials, and a targeted behavior increase after the implementation of the intervention.

Additionally, the implementation of the multiple probe design was based on the criteria established by Kratochwill et al. (2010). This current study was implemented carefully to meet the evidence standards by ensuring that; first, the independent variable was systematically manipulated, with the researcher determining when and how the independent variable conditions change. Second, each outcome variable was measured systematically over time by more than one assessor, and the study collected inter-assessor agreement (i.e., interrater reliability) in each condition and on at least 20% of the data points in each condition (e.g., baseline, intervention) and the inter-assessor agreement met minimal thresholds. Third, the study included at least three attempts to demonstrate an intervention effect at three different points in time or with three different condition repetitions. Fourth, for a condition to qualify as an attempt to demonstrate an effect, the condition had a minimum of three data points (Kratochwill et al., 2010).

Dependent Variable

The primary dependent variable in this study was the percent of correct responses on early numeracy skills, specifically the ability to count a specific number of items (one-to-one correspondence) and to select a number from an array of three that equals the amount of items counted (representation of numbers) during baseline, intervention, post-intervention, generalization, and maintenance conditions. The responses were recorded on a data sheet (refer to Appendix E) according to the experimental condition for five requests/trials per session. Across all experimental conditions, a correct response occurred when a student responded correctly and independently to the specific instructions "count the items" (i.e., pictures of apples or cars) and "touch the number of items" when given three options from number 1 to 5 for Student 4 and three options for numbers 6-10 for Student 1, 2, and 3. An incorrect or no response was recorded as a (-) on the data sheet. The percent of correct responses per session was calculated by dividing the number of correct responses by the number of total trials and multiplying by 100.

Baseline

During baseline conditions, each participant was taken to the one-to-one instructional area in his or her respective classroom with the student facing me, the experimenter. Materials included 10 individual pictures of apples, 10 individual pictures of cars, and individual numbers from 1 to 10 printed on index cards. A randomly selected number of pictures (from 1 to 5 for Student 4 or 6 to 10 for the other participants) was placed in front of the student horizontally. A selection of three numbers (one being the correct number of displayed pictures) was placed above the row of pictures. Each participant was asked to count the apples or cars and touch the number of items counted. A (+) was recorded on the baseline data sheet if the student responded correctly and independently (i.e., touched the correct number corresponding to the number of pictures displayed) within a 5-second latency and then moved on to the next trial or ended the baseline session if five trials had been completed (one for each number in the set). If the student did not respond or responded incorrectly within the 5-second latency, a (-) was recorded, the trial was terminated, and the next trial began or ended baseline if five trials had been completed. Baseline conditions continued for five requests per session (one request for each number whether in the set of 1-5 or 6-10) until the student achieved a stable level of performance that was below 50% accuracy for five consecutive baseline sessions. When the first student completed the baseline and showed a stable level of performance below 50% accuracy, I began intervention with the first student, while the second, third, and fourth student remained in baseline conditions (Horner et al., 2005). All baseline sessions were videotaped by placing a smart phone on a tripod situated approximately 3 to 4.5 feet away from the student.

Independent Variable/Intervention/Instruction

The independent variable was the use of an IAW and discrete trial training to teach early numeracy skills to the four participants. Students were exposed to the use of the IAW to learn early numeracy skills for the first time in one-on-one instruction. The specific early numeracy skills targeted during the investigation were counting with one-to-one correspondence with numbers 1-5 or 6-10 and representation of numbers (i.e., understanding that a number refers to an item or a set of items). Once these early numeracy skills had been identified, lessons using SMART Notebook collaborative learning software were developed. SMART Notebook, an interactive software, allows educators and professionals to develop interactive lessons that make a rich learning environment by using design and delivery features and a multitude of digital resources (see Appendix F). Also, SMART Notebook software connects to a full ecosystem of various content, tools, and support that compliments the use of IAW or SMART Board (SMART Technologies, 2013). The intervention was developed to help each student acquire the targeted numeracy skills. A number of pictures and a corresponding array of three numbers from 1-5 or 6-10 were randomly displayed on the screen for each trial, a feature of the lesson on IAW. Each trial enabled the participants to experience interactive activities during instruction, allowing them to (a) touch the screen while counting the displayed pictures, (b) hear auditory and see visual feedback simultaneously as the students touched each picture (i.e., a clicking noise sounded and a rectangular frame appeared around each item's picture) and (c) receive visual feedback for correct responses or incorrect responses. If the student touched the correct number corresponding to the number of pictures displayed, the number flipped around and a happy face appeared. If the student touched the incorrect number, the number flipped around and a big "X" appeared on the screen. Criteria for mastery of target skills during the intervention condition was set at 100% correct responses for one session or 80% or better correct responses over three consecutive sessions.

A one-on-one instructional session was conducted each school day for each student. Instruction using the IAW was based on discrete trial training (DTT), a method of teaching in simplified and structured steps (Smith, 2001). First, the IAW notebook software was set up individually for each student, displaying 1–5 or 6–10 pictures of apples or cars. Next, I brought the participant to the IAW in the kindergarten classroom. Instruction was given to the student on a one-to-one instructional format, and the student stood facing the IAW next to me, the experimenter. Then, pictures of the designated items (e.g., three apples, seven cars) were randomly selected and displayed horizontally on the IAW screen underneath three randomly selected numbers (e.g., 4, 1, 3 or 7, 6, 9), one being the correct response. The student was requested to count the items and touch the correct number of items. The student was expected to touch the number of corresponding items from the array of three using his or her finger within a 5-second latency. If the student responded correctly (counted the number of pictures and touched the correct number within the 5-second latency), the number turned 180 degrees and a happy face was displayed immediately, I verbally praised the student for the correct response, and a (+) was recorded on the data sheet. The student then moved on to the next trial or ended instruction if five trials were completed, one for each number in the set of 1-5 or 6-10. If the student did not respond or touched an incorrect number during the 5-second latency, prompting procedures were implemented in which the student was (a) immediately provided with a full physical prompt by taking the student's hand and guiding him or her to touch each picture of the displayed items while verbally counting the number of items, (b) immediately provided a full physical prompt to touch the correct number in the array of three numbers, and (c) provided with verbal reinforcement (e.g., "Yes, that is the number 6") while the number flipped around and a happy face appeared. A (P) was recorded on the data sheet. The student then moved on to the next trial or instruction ended if five trials had been completed. Instruction continued (five requests/trials per session) until the student responded correctly to at least 80% or better for three consecutive sessions or one session at 100% correct. All intervention sessions were videotaped identically as in baseline conditions and to collect interrater reliability and fidelity of implementation.

Post-Intervention

Post-intervention probes. Post-intervention probes were implemented in the kindergarten classroom for all four participants using the IAW. Data were obtained for at least three sessions from the date each student reached the acquisition criteria during the intervention condition. The post-intervention probes were conducted for three consecutive sessions and involved the same procedures described in the intervention, but without the prompting procedures. If the student responded correctly (counted the pictures and touched the correct number within the 5-second latency), a happy face was displayed immediately, verbal praise was provided, and a (+) was recorded on the data sheet. The student then moved on to the next trial or ended instruction if five trials had been completed. If the student did not respond or touched an incorrect number during the 5-second latency, the number flipped around and a big "X" appeared on the screen, a (-) was recorded on the data sheet, and the student moved on to the next trial or ended instruction if five trials had been completed. Post-intervention probes (five requests/trials per session) were conducted for three consecutive sessions for each participant. All post-intervention sessions were videotaped identically to baseline conditions and to collect interrater reliability.

Generalization. Generalization probes were assessed during the baseline condition and immediately following the post-intervention probes to determine the percent of correct responses in a different area in the classroom from the baseline, intervention, post-intervention, and maintenance locations. The generalization probes during the baseline condition and after the post-intervention probes were conducted in the group area of the kindergarten classroom for Student 1 and Student 4 and in the group area of the first grade classroom for Student 2 and Student 3; neither classroom area included the IAW. The generalization probes were completed by using the same materials as in the baseline condition including 10 individual pictures of apples, 10 individual pictures of cars, and individual numbers from 1 to 10 printed on index cards. Procedures identical to baseline procedures were followed in that no prompting and no reinforcement were provided. A randomly selected number of pictures and three numbers were presented for the student to count and touch, respectively. Each student participated in one generalization probe of five trials each during the baseline condition and in two generalization probes of five trials each immediately following the post-intervention probes. All generalization sessions were videotaped identically to baseline conditions and to collect interrater reliability.

Maintenance. Maintenance probes were conducted after the generalization probes in the kindergarten classroom only using the IAW for at least one probe ranging from one to seven days following the date each student reached the criteria during the intervention condition. The same procedures described in the post-intervention probe condition were used for all maintenance sessions. All maintenance sessions were videotaped identically to baseline conditions and to collect interrater reliability.

Reliability

Inter-observer reliability. Inter-observer reliability involves assessing the extent to which two independent observers agreed on the type of response a student made using the same definitions and procedures (Gast, 2010). Historically, the minimum acceptable inter-assessor agreement is 80%, based on a percentage of agreement (Kennedy, 2005). To allow for objective comparison, a research assistant scored reliability independently from me, the experimenter. Prior to the start of the study, a sample of student participation in baseline and intervention conditions was shared and discussed with the assistant that specified the type of data collection used in the study and the definition of the behavior for the dependent measurements.

The measurement of inter-observer agreement was completed from the video recordings of each of the five conditions to determine the reliability of the data collected and is presented in Table 4. To this end, an independent observer scored 72% of the baseline, 50% of intervention, 75% of post-intervention, and 50% of both generalization and maintenance sessions within each condition. Reliability was calculated using the following formula: smaller number of correct responses recorded divided by the larger number of correct responses recorded multiplied by 100 (Gast, 2010). Results of inter-observer agreement were 100% across all five conditions.

Table 4

Inter-Observer Reliability Information across All Students within all Experimental Conditions

Condition	# of Sessions	% of IOA Sessions	% Agreement
Baseline	32	72%	100%
Intervention	24	50%	100%
Post-intervention Probes	12	75%	100%
Generalization Probes	12	50%	100%
Maintenance	14	50%	100%

Treatment fidelity. To measure the procedural consistency with which the intervention was implemented, 50% of all intervention sessions were scored from the videotape for procedural reliability using a rubric that included each step of the intervention (Appendix G). An independent research assistant was trained to collect the instructional procedural data by explaining the checklist and viewing videotapes of the procedures. Treatment fidelity was calculated by dividing the number of steps implemented correctly by the total number of steps and multiplying the quotient by 100 (Gast, 2010). The results showed the mean total of all steps correctly implemented for all instructional sessions observed was 97% (range, 93% to 100%).

Calculating effect size. In order to estimate the effect size of the intervention in the current study, the percentage of non-overlapping data (PND) was calculated using the following steps. First, I identified the highest baseline point. Second, I counted the number of intervention points that exceed the highest baseline point (non-overlapping). Third, I calculated the proportion of non-overlapping to the total number of intervention points. Finally, I calculated the mean across each condition (Parker, Vannest, & Davis, 2011). Also, PND was used to estimate the effect size of the treatment. The use of non-overlap methods share the benefit of being visually accessible as well as showing an effect as compared to the score of mean or median level shifts across phases (Parker et al., 2011). According to Scruggs, Mastropieri, and Casto (1987), when using PND scores to estimate the effectiveness of treatment, the following guide can be used to interrupt the results: (a) highly effective when the score is above 90, (b) moderately effective when the score is between 70 and 90, (c) mildly ineffective with scores between 50 and 70, and, (d) ineffective when the score is below 50.

Chapter 4: Results

Results of the investigation are presented in which data relevant to each condition are displayed across the four participants. The effects of using an IAW and discrete trial training for teaching early numeracy skills (one-to-one correspondence and representation of numbers) are presented in Figure 1 for all four students. The progress of each student's performance during each condition is presented as follow.

Student 1

As illustrated in Figure 1, baseline data for Student 1 were collected on five sessions (1 through 5) with low level responding. Student 1's average during baseline was 24% (range, 20% - 40%) correct. On session 6, the instruction condition was introduced for five sessions (6 through 10). In the instruction condition, Student 1 had changes in both trend and the level of responses with a mean of 68% correct responses (range, 40-100%) until she mastered the criteria on sessions 8-10 by achieving 80% or better for three consecutive sessions. Post-intervention probes were collected on three consecutive sessions following instruction (11 through 13) to measure the targeted early numeracy skills using the IAW but without prompting. Student 1's mean for correct responses was 93% (range, 80% -100%) for three consecutive post-intervention sessions.

Generalization probes for Student 1 were collected for one session during baseline and two sessions immediately after the post-intervention probes without the IAW. Student 1's correct responses during the baseline generalization probe was 20% and increased after the post-intervention probes to an average of 80% correct (range, 60% - 100%). Maintenance data were collected using the IAW on five sessions conducted after the generalization probes on the 20th, 27th, 29th, 33rd, and 37th session and the mean was 100% correct.

Overall, visual inspection of the data showed Student 1 had a stable trend with a low level of responding during baseline. When the instruction was introduced, Student 1 had a level change compared to the baseline, and she established an ascending trend within the 8th session. For the post-intervention probes, generalization, and maintenance conditions, Student 1's data showed an increasing change in the level of responding from the baseline condition.

Student 2

Student 2's baseline data were collected on nine sessions (1 through 11) with stable and low level responding. Student 2's mean during baseline was 27% (range, 20%-40%) correct. On session 12, the instruction condition was introduced using the IAW on six sessions (12 through 17). In the instruction condition, Student 2's behavior changed in both trend and the level with a mean of 57% (range, 20%-100%) correct responses. Post-intervention probes were collected on three consecutive sessions (18 through 20) to measure the early numeracy skills post-instruction using the IAW but without prompting. Student 2's mean for correct responses was 87% (range, 80%-100%). Generalization probes were collected without using the IAW on one session during baseline and two sessions immediately after the post-intervention probes condition. Student 2's correct responses during the baseline generalization probe was 20%, but increased after the post-intervention probes to an average of 90% correct responses (range, 80% -100%). Maintenance data were collected on three sessions using the IAW on the 27th, 29th, 33rd, and 37th session. The mean was 95% correct responses (range, 80% -100%).

Overall, visual inspection of the data showed Student 2 had a stable trend with low level responding during baseline. When the instruction was introduced, Student 2 initially had no level change two sessions after the baseline, however, she established an ascending trend within the 14th session. For the post-intervention, generalization, and maintenance, Student 2's data showed an increasing change in the level of responding from the baseline condition

Student 3

Baseline data were collected on 10 sessions (1 through 17) for Student 3 and the data were stable with low level responding. Student 3's mean during baseline was 22% (range, 20% - 40%) correct. On session 18, the instruction condition was introduced and data were collected on three sessions (18 through 20). During the instruction condition, Student 3 had immediate changes in both trend and the level. The mean for the three sessions of instruction was 87% (range, 80% - 100%) correct. Post-intervention probe data were collected on three consecutive sessions (21 through 23) to measure the early numeracy skills post-instruction using the IAW without prompting. Student 3's mean for the post-intervention probes was 93% (range, 80% - 100%) correct for 3 consecutive probe sessions.

Generalization probes were collected without using the IAW on one session during baseline and two sessions immediately after the post-intervention probe condition. Student 3's correct responses during the baseline generalization probe was 20% and increased after post-intervention probes to an average of 80% correct across the two generalization sessions. Maintenance data were collected on four sessions using the IAW on the 27th, 29th, 33rd, and 37th session. The mean was 95% correct responses (range, 80% - 100%).

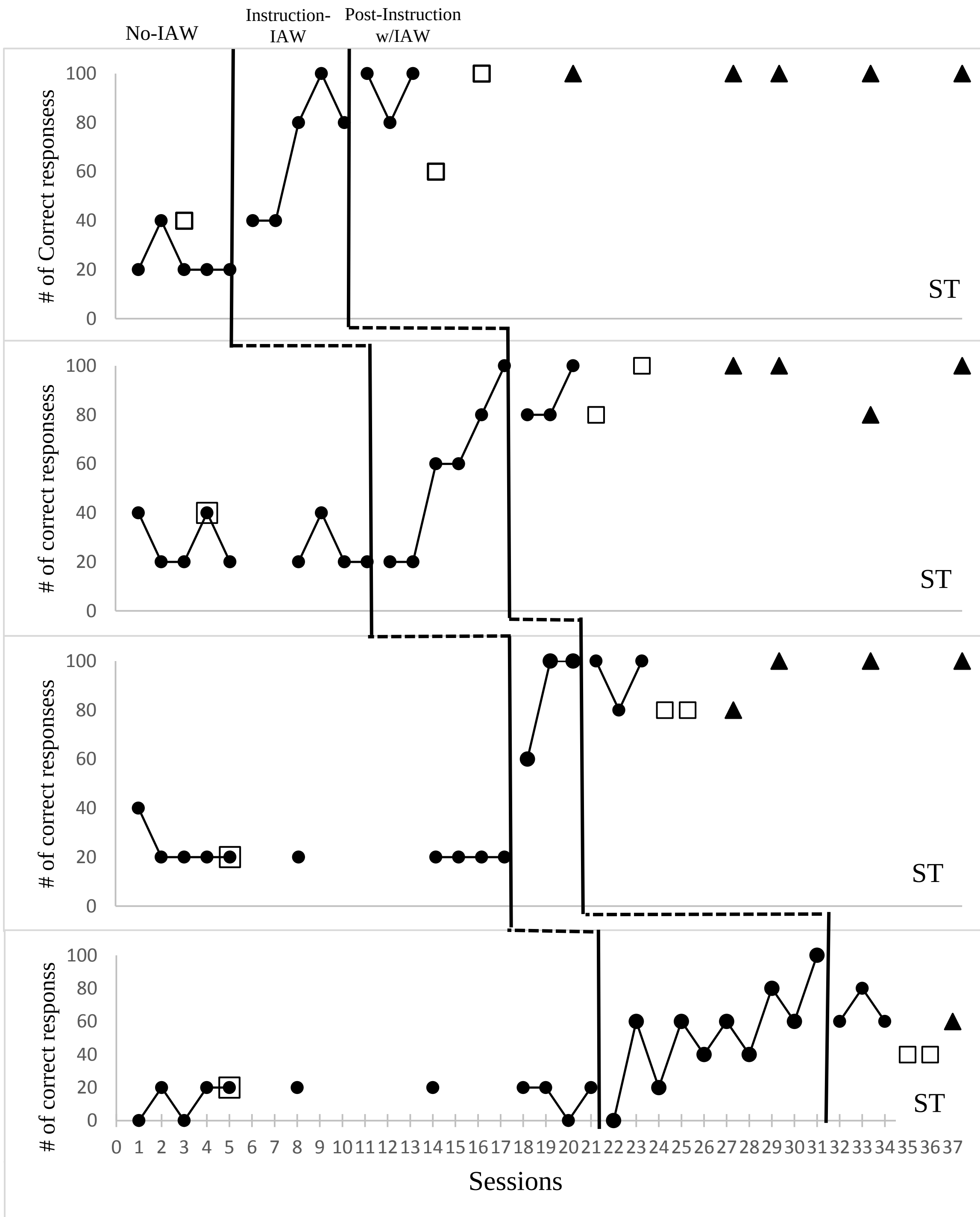
Overall, visual inspection of the data showed Student 3 had a stable trend with low level responding during baseline. When the instruction was introduced, Student 3 immediately has changed over the baseline level as well as displaying an ascending trend within the first session during instruction. For the other three conditions, Student 3's data showed change with increasing levels of responding from the baseline condition.

Student 4

Baseline data were collected on 11 sessions (1 through 21) and Student 4's average during baseline was 14% (range, 0% - 20%) correct. Data were collected during instruction when the early numeracy skills were taught using the IAW on ten sessions (22 through 31). The mean for the 10 sessions of instruction was 52% (range, 0% -100%) correct. Post-intervention data probes were collected on three consecutive sessions (31 through 33) to measure the early numeracy skills post-instruction using the IAW without prompting. Student 4's mean for correct responses was 66% (range, 60% - 80%) for 3 consecutive probe sessions.

Generalization probes were collected without the IAW on one session during baseline and two sessions immediately after the post-intervention probe condition. Student 4's correct responses during the baseline generalization probe was 20% and increased after the post-intervention probes to an average of 40% correct. Maintenance data were collected on one session using the IAW on the 37th session with 60% correct.

Overall, visual inspection of the data showed Student 4 had a stable trend with low level responding during baseline. When the instruction was introduced, Student 4 displayed variable data that ranged from 0% to 100% correct. There was no change in the level compared to the baseline, but he established a clear pattern of an ascending trend during instruction. For the other three conditions, Student 4's data showed a change in responding from the baseline condition to post-intervention, generalization, and maintenance conditions.



Note. Multiple probe design across participants with percentage of correct responding of the dependent variables during baseline, instruction, post-instruction, generalization, and maintenance conditions. • = Baseline without using IAW; • = Instruction with IAW; • = Post-instruction with IAW; □ = Pre/post Generlization probes without IAW;▲ = Maintenace probes with IAW.

Effect Size

In order to estimate the effect size of the intervention and support the conclusion about the visual inspection of the data, the percent of non-overlapping (PND) data points between each condition and the means across all participants are reported in Table 5.

Table 5.

Percent of Non-Overlapping Data Points across Conditions and Participants

Conditions	PND mean	Standard Scale
Baseline vs. Intervention	76.6 %	Moderately effective
Baseline vs. Post-intervention	100%	Highly effective
Baseline vs. Maintenance	100%	Highly effective
Baseline vs. Generalization	100%	Highly effective

Chapter 5: Discussion

This chapter discusses the findings of the three research questions addressed in this study: (l) To what extent does IAW technology affect the acquisition of early numeracy skills among students with ASD? (2) To what extent does IAW technology affect the generalization of early numeracy skills among students with ASD? and (3) To what extent does IAW technology affect the maintenance of early numeracy skills among students with ASD. A summary of the results with their contribution to the literature is discussed. Implications and Limitations of the current research are discussed, and some suggestions for future research and practitioners offered.

Summary of the Results

The results of this study confirm and broaden the literature to show the IAW technology and the instructional strategies used in this investigation were effective in teaching early numeracy skills to four students with ASD. First, I was able to use the IAW and implement the procedures as intended with high level of reliability. Treatment fidelity data obtained in this investigation showed the instructional sessions were achieved with high levels of accuracy. This finding replicated previous research showing that IAW technology can be implemented reliably in one-to-one instructional situations to teach early numeracy skills to students with ASD (Yakuova & Taber-Doughty, 2013).

Second, the IAW technology was highly effective in teaching early numeracy skill to the four students with ASD. Even though children with ASD usually face difficulties in the area of language, cognitive, social, and emotional skills, the IAW with the integration of DTT and reinforcement were effective strategies for teaching early numeracy skills to the children with ASD. Even with Student 4, progress on early numeracy skills was shown even though he took a longer time to reach the instructional criteria, required additional instructional prompts, and displayed fewer correct responses during post-intervention, maintenance, and generalization conditions. Introduction of the IAW resulted in all students reaching the criteria levels of 100% correct responding for one session or better during instruction, and post-intervention results were considerably higher than baseline levels and comparable to intervention results. Furthermore, these results were maintained over time and each participant generalized responding in a different setting than in baseline conditions.

Research Question #1: Acquisition of Early Numeracy Skills

The results of the current study showed all participants learned the targeted early numeracy responses by reaching the mastery criteria (100% correct responding for one session or 80% or better for three consecutive sessions). Additionally, all students participated in three sessions of post-intervention probes that were conducted without prompting. Three of the four participants performed within the mastery criteria at a very high level (range 80% to 100%) for three consecutive sessions. Only one student, Student 4, performed lower than other students reaching the criteria of 100% correct for only one session.

The findings of this research study replicate and extend previous research that investigate the utilization of the LAW in instructing and teaching a variety skills to students with disabilities. Prior research demonstrated the IAW was effective in teaching letter sounds (Campbell & Mechling, 2009), daily living skills (Yakuova & Taber-Doughty, 2013), and sight words (Mechling et al., 2007; Mechling et al., 2008). This study also expanded the research base by teaching early numeracy skills to young elementary school students, specifically kindergarten and first graders.

The IAW has also been shown to be effective when instruction was delivered with instructional procedures such as constant time delay, a system of least prompts prompting system, and task analysis. This study expanded on the previous instructional methods used with the IAW to show the effectiveness of discrete trial training. The introduction of the IAW in this study resulted that all students reached desired criteria for on the targeted early numeracy skills for 100% accuracy for one session or 80% or better for three consecutive sessions during the intervention condition. Previous studies also reported similar findings with the exception of the study conducted by Mechling et al. (2008) where they compared flash card instruction to instruction using the IAW. However, the results showed that students performed better when instruction was presented using IAW. In all but the Mechling et al. investigation, students reached a criterion level of 100% accuracy. These studies and the current study demonstrated that students with disabilities including ASD can master target skills by learning them via IAW instruction. Most importantly, the findings from previous researchers (Campbell & Mechling, 2009; Mechling et al., 2007; Mechling et al., 2008; Yakuova & Taber-Doughty, 2013) showed the IAW was effective in teaching individuals with disabilities including intellectual disabilities and learning disabilities. Only one study had participants with ASD similar to current investigation (Yakuova & Taber-Doughty, 2013). This study had four participants with the ASD diagnosis.

Some procedural differences between previous studies and this study comprised of the number of instructional sessions for criteria for mastery before students moved to the next condition (Campbell & Mechling, 2009; Mechling et al., 2007; Mechling et al., 2008; Yakuova & Taber-Doughty; 2013). Also, the numbers of conditions that students participated in were different in each study with a notable difference in generalization and maintenance conditions. Yakuova and Taber-Doughty (2013) required students to participate in baseline, pre-training, intervention, and generalization conditions. Students in the Mechling et al., (2007) investigation participated in pretest/posttest, instruction, and generalization conditions, while Campbell and Mechling (2009) had students participate in baseline, instruction, and maintenance conditions. However, in the current study, all students participated in baseline, intervention, post-intervention probes, generalization, and maintenance conditions. Although each of the previous studies (Mechling, et al., 2007; Mechling, et al., 2008; Campbell & Mechling, 2009; Yakuova & Taber-Doughty; 2013) used different instructional procedures and instructional arrangements, there was no obvious preferences or difference in any study, as participants in all studied including the current study reached a high level of correct responding during the intervention condition using the IAW. It is important to mention that the baseline and intervention for Students 2 and 3 in the first grade classroom were conducted in two different environments. It is difficult to rule out how much the environment contributed to the changes in student behavior. However, there was an attempt to ensure that both classrooms were similar in layout, number of personnel, and equipment.

It is important to mention the possible variables that were likely to have positively influenced the findings of this current investigation. These variables may explain how quickly students learned the target skills as well as provide an indicator of the power of the use of the IAW and discrete trial instruction. First, one key variable that may have caused the students to reach the desired criteria within short periods of time is that the IAW is multisensory. The lesson was developed using SMART Notebook collaborative learning software and each instructional session enabled the participants to experience interactive activities during instruction, allowing them to touch the screen while counting the displayed pictures, hear auditory and see visual feedback (i.e., simultaneously as the students touched each picture, a clicking noise sounded and a rectangular frame appeared around each item's picture), and receive visual feedback for correct responses or incorrect responses. If a student touched the correct number, the number flipped and a happy face appeared. If a student touched the incorrect number, the number flipped and a big "X" appeared. These features were observed to be interesting and reinforcing to the participants and may have contributed to their learning of early numeracy skills. This affirms Keay-Bright's (2011) statement that stressed tactile interaction could play an important role in enhancing sensory experiences as well as the statement by Murray et al. (2005) that sensory curiosity can be evoked by providing motivational and interesting experiences for students with ASD. Given evidence regarding the unique needs of students with ASD, students can learn better when instructions are presented visually, auditory, tactile, and vestibular and allow them to simultaneously use many of their own senses including seeing, hearing, and touching the IAW. Furthermore, Moustafa (1999) stated multisensory instruction focuses on learning experiences through all the senses which is helpful in reinforcing memory. According to Murray et al. (2005), it is essential to provide interactive environments with more sensory stimulation when teaching students with ASD which may explain the success of the participants in learning the targeted early numeracy skills.

The second variable that may have influenced the results of this current study was the instructional delivery. It is critical to state that using the IAW by itself may not influence students' learning in isolation. All other researchers used the IAW with other instructional procedures (Mechling, et al., 2007; Mechling, et al., 2008; Campbell & Mechling, 2009; Yakuova & Taber-Doughty; 2013). In this current study, the specific instructional procedure should be considered when interpreting and generalizing the finding results. The instruction involved DTT which incorporated specific attentional cues, error correction, physical prompting, and reinforcement which influenced the students' correct responding of early numeracy skills. The instruction was delivered systematically and consistently to ensure that physical prompting and error correction was used for incorrect responses and students received continuous verbal and visual reinforcement for each correct response immediately after each independent and prompted response. Also, the DTT provided structured and consistent repetition of procedures that were important for students with ASD to learn new skill.

The third variable that may have influenced the results of this study was previous knowledge of some early numeracy skills and the amount of time (school experience) in the program. Having some previous knowledge of number identification, counting, and one-to-one correspondence may have influenced the effectiveness of the intervention in combination with being in the program for over one year. In this study, Students 1, 2, and 3 had been attending the school for their second year, whereas Student 4 had attended for only a few months. Students 1, 2, and 3 were able to perform more advanced early numeracy skills such as identify numbers (1–10) when asked receptively, write some numbers from 0–10, and consistently count with one-to-one correspondence up to five in addition to learning the targeted skills at a much faster rate than Student 4. Additionally, none of the students had a behavioral intervention plan so there were few behavior issues that might have interfered with their learning of the numeracy concepts.

The fourth variable that may have positively influenced students' ability to learn the target skill was that teaching occurred in the natural environment, specifically in the students' classroom. This study was similar to only one other study using the IAW in the natural environment (Yakuova & Taber-Doughty, 2013).

The results obtained in this investigation not only confirm, but expand the current database for teaching early numeracy skills to students with ASD. These findings are essential because its provide further support to the area of multisensory instruction inherent in using IAWs (Keay-Bright, 2011; Murray et al., 2005) and showing that IAW is effective in developing the early numeracy skills of students with ASD.

Research Question #2: Generalization of Early Numeracy Skills

Generalization is the ability to perform and apply learned skills in new conditions or contexts (Alberto & Troutman, 2013). Once each student reached the criteria during the instructional condition and completed three post-intervention probes unprompted, generalization probes immediately were conducted. Generalization probes measured the students' correct responding on the targeted early numeracy skills by using the baseline materials. Generalization was conducted in the same classroom where students were taught the early numeracy skills, but testing was conducted in a different area (the small group area). It would have been interesting to see if students could generalize their skills in other classrooms or in other natural environments – such as lunch or unified arts. Unfortunately, there was no attempt to assess generalization across settings outside of the classroom or with different instructors due to school restrictions. However, as students mastered the numeracy skills during instruction, they were also successful in applying their learned skills in a new situation. Three students (Students 1, 2, and 3) correctly responded with a mean of 83% (range, 60% - 100%) after intervention, whereas Student 4's performance averaged 40% correct responding, but still greater than baseline levels. It was the goal of this study that all participants would fully benefit from the intervention. However, I feel Student 4 had difficulty learning the material for many reasons including the short time he had attended school, the absences from school during the research implementation, and his severe range of ASD based on the CARS-2.

The generalization results were close to the few reported percentages for generalizations in the studies by Mechling et al. (2007) and Yakuova and Taber-Doughty (2013). Also, in this current study, generalization was conducted immediately after instruction similar to Mechling et al. (2007) and Yakuova and Taber-Doughty (2013). For example, Mechling et al. indicated participants generalized objects to printed words with an average of 85.2% correct and printed words to objects with a mean of 88.9% correct. Yakuova and Taber-Doughty (2013) reported that participants were able to generalize cleaning a mirror with a mean of 100% correct, cleaning a sink with 96.7%, and cleaning the floor with 100% correct having been taught these skills using an IAW.

Research Question #3: Maintenance of Early Numeracy Skills

Maintenance is the ability to perform a response overtime (Alberto & Troutman, 2013). Maintenance probes for early numeracy skills were conducted for three students approximately four sessions after the students reached the criteria during instruction and completed both post-intervention and generalization probes. One maintenance probe was conducted for Student 4 because of lack of time. It is important to remember that the maintenance probes were collected using the IAW, but no instruction was provided.

Overwhelmingly, students maintained the target skills they were taught. The results from the current study are similar to the maintenance reported in previous studies. Only Mechling et al. (2007) and Campbell and Mechling (2009) conducted maintenance probes over time. Previous studies conducted only one maintenance probe and the current study conducted five probes for Student 1, four probes for Student 2 and Student 3. Thus, the number of sessions was different from the current study as one of the main goals of the current study was focused on maintenance skills overtime and the result suggested that IAW impact student's maintenance of skills. Additionally, the current study continued collecting maintenance probes for students 1-3 as students 4 remained in the instructional condition and took longer time to meet the criteria than the other participants. Campbell and Mechling (2009) conducted only one probe and reported that students' correct responding was 100%. Additionally, Mechling et al. (2007) collected three maintenance probes and reported that students responded correctly on targeted words with an average of 94.7% and responded correctly with an average of 87% during observational learning.

Limitations

Although this study showed the IAW technology was an effective method for teaching early numeracy skills to students with ASD, some limitations exist. First, each participant demonstrated the ability to generalize the target responses to a different setting with only one instructor, and generalization was only assessed within the same classroom but in a different area of the classroom. Based on this configuration, one cannot determine if the participants would have responded differently to other instructors, different school settings, and novel material.

Second, each participant acquired, generalized, and maintained early numeracy skills when taught using the IAW. However, it cannot be determined exactly what variables were responsible for individual differences. Several possibilities for these differences exist including the variation among participants' characteristics, previous knowledge, and time attending the school may have affected the speed with which students acquired the new skills (one-to-one correspondence and presentation of numbers). For example, Student 1, Student 2, and Student 3 were taught other skills using DTT and constant time delay procedures. Thus, these three participants had a prior history with errorless learning strategies. This was not evident for Student 4 who was attending school for the first year and it had not yet been determined which instructional strategies worked best for him.

Third, it should be noted there were contingencies that occurred for participation. Because instruction took place in the natural setting, reinforcement may have affected the rate of students' responses during each condition. For example, when classroom teachers asked students to work with me, they usually said "if you do a good with Mr. [ ], you will get a happy face". In addition, each student received reinforcement for each correct response that was programmed directly from the IAW, and the verbal reinforcement from the investigator. Thus, it is possible that redundant reinforcers could account for correct responses for each of the participants.

Fourth, the current investigation was completed within three months. However, the school was closed for a total of 11 days within this time frame. In addition, each participant was absent a minimum of three days. Also, students participated in different activities such as field trips and picture day. All these absences may have influenced the length of the investigation as well as the final findings, particularly for Student 4 because he remained in the baseline and intervention conditions longer that the others and had the most difficulty learning the early numeracy skills. Thus, it cannot be determined exactly what variables were responsible for correct responses as well as individual differences.

Fifth, I did not collect social validity data via teacher questionnaires. These data might have provided information on any overall changes the teachers recognized after students participated and receiving instruction in the study.

Finally, the intervention of the current study was conducted only in the kindergarten classroom. This required the investigator to pick up and drop off Student 2 and Student 3 from their first grade classroom. Transitioning students to a new environment should be considered when interpreting the results. As showed by the results, Student 2's performances during the first two intervention sessions were similar to her baseline performance. Student 2 was possibly confused and surprised about being in a new classroom as she showed lower responses during the beginning of the instruction condition. However, she became more comfortable after the first two sessions. On the other hand, Student 3 sometimes required her teachers to be with her during the intervention sessions based on her daily mood and she became distracted with new people and new environments which possibly had some influenced on the student's performance.

Future Research

This investigation provides information relevant to conducting future research that focuses on using the IAW to teach early numeracy skills for students with ASD. Specifically, the type of instruction used in this investigation may be effective for teaching students other academic and more complex skills. Research should be conducted on whether the instructional package and/or target skills can be modified to meet the needs of each individual with ASD and how it might influence students' progress toward more advanced skills. For example, in the future, research should be conducted in settings where the conditions approximate the normal environment and minimizes the opportunity that redundant reinforcers are present with naturally occurring distractions.

The acquisition of early numeracy skills may increase the likelihood that students with ASD can function in less restrictive environments. However, it is important to investigate if these results would have been obtained in an inclusion setting where instruction may have been presented to a larger group of students. As a result, this may increase the probability that students with ASD might benefit from receiving instruction in inclusion classrooms with their peers. Because early numeracy skills are critical to responsible curriculum-based instruction, it is critical that teachers use effective instructional procedures that increase opportunities for acquisition as well as produce generalized responding. Also, it is a critical when teaching students with ASD to assess generalization of skills in the natural environment by using different materials to conclude if students can use and apply learned skills in a meaningful situation.

Despite the fact that the IAW was an effective for teaching early numeracy skills to students with ASD, it is important to mention there was variance in students' performance. For example, the number of sessions needed to reach the criteria of the target skill varied across students. Future research needs to examine these factors by investigate all external and internal events that might affect the experimental and students' variability.

The focus of this study was using the IAW as one type of advanced technology available in classrooms. Despite the success of the intervention, it is important for future researchers to be aware of concerns regarding the availability and the operation of the technology in the classroom including the version of the IAW. For example, the IAW used in this investigation was old; it was separate from the projector and, when standing in the front of the projector, a shadow appeared which made some students confused. Also, if students did not touch the screen with some force to indicate their response, the number on the screen did not flip to show whether the response was correct. Another issue that may have possibly influenced students' responses is that on occasion students may have felt their response was a wrong answer because nothing happened when they touched the screen. As a result, they tried to touch another number or sometimes I had to remind the students to touch the number hard or had to help the student physically. When using the IAW in the classroom, researchers should ensure the equipment is current, as well as to test that all of the features of IAWs are working and nothing can influence students' responses.

Future research also may consider the use of open-ended interviews or questionnaires to get feedback on the differences in students' responses before and after utilizing IAW.

Finally, the students' generalization of early numeracy skills to a different setting was assessed in this investigation. However, generalization can be one of the most difficult application to acquire with students with ASD due to their need. Thus, more research is needed to focus different strategies that might enhance and increase the generalization particularly target and non-target information when the IAW being used to teach academic skills.

Implications for Practitioners

Results indicated that the IAW instruction was an effective intervention for teaching early numeracy skills to young students with ASD and increased the acquisition of new skills. The findings suggest important implications for using the IAW as a type of available technology in classroom for teaching academic skills such as early numeracy. It is important to mention that the IAW has many features, which allow teachers to develop lessons using many software programs. One practical implication is training teachers to develop lessons based on their IEP goals and curriculum using the IAW. Thus, a teacher can benefit from the features of the IAW to deliver interactive lessons that meet students' needs. Also, as the IAW is usually located in a different area of the classroom, another implication is that teachers might use the IAW as one location for instructional rotations during day. Finally, new technology devices are available in most classrooms with many features that allow for interactive presentation of information including visual, audio, and interaction, so these motivating features might support students' with and without disabilities preference to use over traditional methods for delivering instruction that promote students' performance.

Conclusion

The purpose of this study was to examine the effectiveness of the IAW as a technology for teaching early numeracy skills to students with ASD. It was predicted that students with ASD would acquire, maintain, and generalize the early numeracy skills taught. The study confirmed that the IAW was an effective method for teaching early numeracy skills for children with ASD. This study added evidence to the previous research that supports the use of technology, especially the use of the IAW to teach individuals with ASD. Also, this current study attempted to meet the evidence standards for single case design (SCD) that was addressed by What Works Clearinghouse (WWC). The present study met the WWC standards of SCD by having a minimum of four participants, three replications/demonstrations of the effect, the IV was responsible for the change on the DV, and interobserver reliability was conducted for more than 20% for each condition. Thus, IAW technology with the instructional procedure DTT utilized in the current study was easy to use and implemented with a high level of reality and validity. In conclusion, with plan, accuracy, and training, the IAW could be usable, practicable, and achievable tool that teachers use in their classroom.

APPENDIX A: Introduction Letter to Families

Introduction Letter to Families

Dear Parent or Guardian,

My name is Fayez Maajeeny, and I am a doctoral student in Counseling, Higher Education, and Special Education at the University of Maryland. I have received my master's degree in Special Education and have worked for many years with students with autism spectrum disorders (ASD). My mentor and research advisor is Dr. Frances Kohl, who has worked extensively in the area of special education for over 30 years and worked with program personnel for students with disabilities in many public school system.

I am writing to inform you and your child about a research project that I am conducting. All students in your child's classroom will be sent a permission form to participate; however only those students who meet the eligibility criteria will be invited to participate in the study. I am developing an intervention for individuals with ASD as a part of a research project for my doctoral dissertation. Through this study, I will investigate whether early numeracy skills of students with ASD can be improved by using an interactive whiteboard to present instruction.

The study will occur during non-instructional times of each student's school day. Depending on the task, there will be no more than a 10 minute intervention session each day. It is anticipated that your child will participate in the study from September to January for no more than 20 consecutive school days. An adult such as the teacher or aide will be present for all research activities. There is no cost for your child to participate and his/her participation is strictly voluntary. If you would like to have your child participate, please complete the attached consent form and return it to your child's teacher. You can also contact me if you have any further questions.

Sincerely,

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APPENDIX B: Parent or Guardian Informed Consent Form

Parent or Guardian Informed Consent Form

Project Title	The Effects of Interactive Whiteboards (IAWs) on the Development of Early Number Skills of Students with Autism Spectrum Disorder (ASD)
Purpose of the Study	The purpose of this study is to determine the effectiveness of using interactive whiteboards (IAWs) when teaching the following early number skills: recognizing numbers; counting items; creating sets of objects for children with autism spectrum disorders (ASD). The study will examine if whiteboards increase a child's learning of basic number skills and help the student maintain the skills over time. We are inviting your child to participate in this research. All students in your child's classroom will be sent a permission form; however, only those students who meet the eligibility criteria will be invited to participate in the study.
Procedures	The research will involve: Parent permission: Before reviewing any record or obtaining any information about a possible participant, your permission must be given. Review of Records: 1. Review of your child's current test results to verify that your child is classified has having ASD and 2. Review of your child's IEP to document the IEP goals related to the basic number skills. Observation: I will observe your child during instruction in math as well as other activities during the school day. I will also discuss your child's knowledge about numbers with his or her teacher to help determine which number skills to address in the study. Instruction: I will provide one-to-one instruction with your child using the interactive whiteboard to improve his/her number skills. Each session will last no longer than 10 minutes and will take place during the school day with other students present. I suspect the instruction will take 20 school days. Each session will be observed by a research assistant to make certain that all procedures are followed accurately. All instruction will be videotaped.
Potential Risks and Discomforts	There are no known risks to your child participating in this study.
Potential Benefits	There may be no direct benefits to your child; however, there is the potential that your child will increase his/her number skills. We also hope to learn in general about how students with ASD learn using an Interactive white Board.

Confidentiality	All data that are collected will be stored digitally on the investigator's personal computer and will be password protected. Each child's information, assessment results, and progress during the instruction will be stored with a code and only two lists of children's names and their codes will be kept. I will have one and Dr. Kohl will have the other. All video recordings will be stored digitally on the investigator's personal computer and will be kept in a locked office accessible only by Mr. Maajeeny and Dr. Kohl. The recordings will be viewed only for research purposes by the investigators. Video tapes will be destroyed after the project is completed. Results of your own child's assessments and progress during the white board instruction will be available to me, Dr. Kohl, and your child's teacher. Any reports or discussion of results will present information about all children participating in the study and your child's identity will be protected to the maximum extent legally permitted
Right to Withdraw and Questions	Your child's participation in this research is completely voluntary. If you decide to allow your child to participate in this research, your child may stop participating at any time. Your child will not be penalized in any way for deciding to stop participation. Your child may be terminated from the study if he/she has not completed all of the assessments and/or has more than 3 consecutive absences during the instructional time. The study is being conducted by Mr. Fayez Maajeeny, as part of his doctoral studies at the University of Maryland: College Park, under the supervision of Dr. Frances Kohl, Associate Professor. You may contact me or Dr. Kohl if you have any questions about the research project. **Fayez Maajeeny, Doctoral Candidate** **Department of Counseling Higher Education and Special Education** **3119-E Benjamin Bldg.** **University of Maryland, College Park** **(301) 405-8429** **Dr. Frances Kohl, Associate Professor** **Department of Counseling Higher Education and Special Education** **University of Maryland** **College Park, MD 20742** **(301) 405-6490** **flkohl@umd.edu**
Participant Rights	*If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:* **University of Maryland College Park**

<table>
<tr><td></td><td colspan="2">Institutional Review Board Office
1204 Marie Mount Hall
College Park, Maryland, 20742
E-mail: irb@umd.edu
Telephone: 301-405-0678

This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.</td></tr>
<tr><td>Statement of Consent and Release of Archival Data</td><td colspan="2">Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to allow your child participate in this research study. You will receive a copy of this signed consent form.

I grant permission to Prince George’s County Schools (PGCPS) to release the data to researchers at University of Maryland for use in the “The Effects of Interactive Whiteboards (IAWs) on the Development of Early Number Skills of Students with Autism Spectrum Disorder (ASD).” I affirm the data will be used sorely for this research study.

If you agree to allow your child to participate, please sign your name below.</td></tr>
<tr><td rowspan="4">Signature and Date</td><td>NAME OF MINOR PARTICIPANT
[Please Print]</td><td></td></tr>
<tr><td>NAME OF PARENT
[Please Print]</td><td></td></tr>
<tr><td>SIGNATURE OF PARTENT</td><td></td></tr>
<tr><td>DATE</td><td></td></tr>
</table>

APPENDIX C: Eligibility Criteria Questionnaire

Students Eligibility Criteria

School:
Teacher/Classroom:
Student:

Question	**Yes or No?**	**Comments**
1. Does the student have an autism diagnosis based on the 4th or 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR or DSM-V; American Psychiatric Association, 2013)?	Yes No	
2. Is the student between 6 and 12 years of age?	Yes No	
3. Is the student without a behavior intervention plan (BIP)?	Yes No	
4. Is the student able to match a picture to an identical picture in array of three pictures?	Yes No	
5. When requested to touch an object, is the student able to respond correctly?	Yes No	
6. Is the student compliant to physical prompts?	Yes No	
7. Is the student able to attend to a task for 5-10 minutes?	Yes No	
8. Does the student have at least one IEP goal that addresses early numeracy skills?	Yes No	
Total Yes Responses:		

APPENDIX D: Student Assessment Checklist and Summary

Student Assessment Checklist and Summary

Student name	
Date of birth	
Special education eligibility (category)	

Test/Assessments	**Score – result**	**Date of assessment**
Childhood Autism Rating Scale (CARS-2; Schopler Van Bourgondien, 2010)		
Autism Spectrum Rating Scale (ASRS; Goldstein & Naglieri, 2012) - TEACHER		
Autism Spectrum Rating Scale (ASRS; Goldstein & Naglieri, 2012) - PARENT		
Comprehensive Inventory for Basic Skills II (BRIGANCE CIBS II)		
IQ Test (TBD)		

Present Level of Performance

Student strength	**Student needs**

Observation

APPENDIX E: Data Collection Sheet

Data Collection Sheet

Student name:

Baseline ( )
Intervention ( )
Post-intervention ( )
Maintenance ( )
Generalization ( ) Location:

Task: **one-to-one correspondence (number to items)**

(+) correct (-) incorrect / no response (P) Prompt

Date	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Total correct	% Correct

APPENDIX F: Sample of the Intervention Using the IAW

APPENDIX G: Treatment Fidelity Rubric

Treatment Fidelity Rubric

Treatment Fidelity Rubric Date: ______ Observer: _________ Time: _________			
Instructions: Put a checkmark in the column labeled Yes or No depending on whether the researcher completed the task.	Yes	No	Comments
1- Intervention takes place in the designated setting and during the designated activity/routine.			
2- All necessary materials (IAW, data collection sheet, video tape, chair, table, instruction area) and devices are organized, prepared, and set up before start the lesson.			
3- Instructor turns on IAW.			
4- Instructor gives first task request.			
5- Instructor reinforces, corrects, or prompts for first request.			
6- Instructor gives second task request.			
7- Instructor reinforces, corrects, or prompts for second request			
8- Instructor gives third task request.			
9- Instructor reinforces, corrects, or prompts for third request			
10- Instructor gives fourth task request.			
11- Instructor reinforces, corrects, or prompts for fourth request			
12- Instructor gives fifth task request.			
13- Instructor reinforces, corrects, or prompts for fifth request			
14- Intervention is terminated after set number of instructional trials or after designated criteria are met.			
15- Instructor thanks student and transition student to next activity.			

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