THE IMPACT OF USING ASSISTIVE TECHNOLOGY ON WRITING PRODUCTIVITY OF YOUNG WRITERS WITH AUTISM

by

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A Dissertation
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of
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DEDICATION

This dissertation is written in memory of my granddaughter Zanna, whose brief candle was extinguished all too soon, and my sister who is watching and cheering from above!

It is dedicated to my mother, whose strength and determination will always guide me; to my Uncle TL who modeled how to live and how to die; to my grandchildren, Trentin, Makenzie, Lucas, S. J., and Wynn… my future.

It is also dedicated to my students, past, present, and yet to come, especially Carelle, Kyle, Cullen, Robbie, Sarah, Rasheka, Hudson, Avery, and Caty, to name a very few! They are inspirations for us as they demonstrate the difference AT can make in young lives.

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My students who filled me with inspiration and a desire to improve the lives of future students with special needs and;

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ABSTRACT

THE IMPACT OF USING ASSISTIVE TECHNOLOGY ON WRITING PRODUCTIVITY OF YOUNG WRITERS WITH AUTISM

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A single subject study with multiple baselines across participants was used to explore the effect of giving access to picture-to-text software for writing to young students, with moderate autism, and documented difficulties with written language. For this intervention study, three participants, who had strengths in visual processing and who were motivated by technology, responded to picture prompts by typing for three minutes under two conditions. During baseline participants were given a blank document with picture-to-text software and a bank of randomly positioned words below the writing area. For the intervention condition, the participants had access to a similar word bank with a picture above each word as well as word placement according to sentence structure, auditory feedback, and color cues. During the 21 writing sessions, scores earned for number of sentences written, percent of correct word sequences (CWS), and number of incorrect word sequences (IWS) was analyzed to determine significance between the

baseline samples and samples generated using words with corresponding pictures. An assistive technology assessment, participant and parental surveys, scoring sheets, and fidelity checklists were used to gather additional information. Inter-rater reliability and fidelity of treatment were determined.

During intervention sessions, participants wrote an average of three more sentences, earned an average of 52% more percent CWS and decreased number of IWS by an average of 42 errors. For the three participants the mean of percent of non-overlapping data (PND) was 92% for number of sentences, which is considered a large effect; and the mean PND was 89% for percent CWS, which is considered effective. Randomization tests were also run and two out of the three dependent variables, number of sentences and CWS were found to be statistically significant. These results extended other research studies with young students with moderate autism by adding the use of pictures to computer enriched instruction that was found to be effective for improving writing products for similar students.

1. INTRODUCTION

This chapter states the importance of writing and the impact that writing difficulties can impose upon students with disabilities such as autism. It includes the purpose of this study and the research questions. The chapter concludes with terminology used in this study.

Statement of the Problem

The importance of writing is documented throughout literature. "The reward of disciplined writing is the most valuable job attribute of all: a mind equipped to think" (National Commission on Writing, 2003, p. 11). Through this key skill, students are enabled to communicate thoughts, demonstrate their knowledge, and share information learned from the writings of others (Hauth, 2012). As mentioned in Graham and Harris (2013) with 45 states adopting *Common Core State Standards* (Common Core State Standards Initiative, 2012) "… writing is now a central player in their efforts to improve education" (Graham & Harris, 2013, p. 28). Writing must be used as a tool to integrate, analyze, and assimilate facts learned in other content areas such as social studies, science, and other subjects. "Writing is viewed as a tool that works in unison with reading, thinking, and content to promote learning" (Graham & Harris, 2013, p. 29). Without this important skill, students with disabilities can be at a disadvantage throughout their lifetimes (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008; Graham & Perin, 2007; Hauth, 2012; Mason & Graham, 2008).

Young children and children with disabilities such as specific learning disabilities (Forgrave, 2002; Mason & Graham, 2008; McCutchen, 1995; Silio, 2008; Zhang, 2000), emotional disabilities (Cerar, 2012; Hauth, 2012; Mastropieri, Scruggs et al., 2009; Regan, Mastropieri, & Scruggs, 2005), writing disabilities, (Cullen, Richards, & Frank, 2008; Hetzroni & Shrieber, 2004) and autism (Asaro, 2008; Myles et al., 2003; Pennington, Ault, Shuster, & Sanders, 2010; Yamamoto & Miya, 1999) can experience intense frustration with writing. There are four complicated processes involved with the physical act of writing: visual motor integration, motoric actions, orientation on the paper, and motivation (Janzen, 1996). Additionally writing also involves the cognitive skills of generating ideas, organizing them, creating a flow, and revising. When struggling with handwriting, spelling, and mechanics, often more of the student's cognitive resources are depleted leaving fewer resources for the higher-level thinking processes required for writing (Bourdin & Fayol, 1994; McCutchen, 1995).

Emergent writing. To share ideas is a vital need that usually begins early in life with gestures and babbling. Eventually children begin to document their ideas through scribbles (Fang, 1999) and pictures, eager to reveal their identity to others, both as individuals and as writers (Capello, 2006). Olshansky (2006) contends that early efforts of marks on paper, including crude drawings and scribbles, must be honored for the messages that are intended. To honor children's early writing efforts, emphasis must remain on the message rather than on handwriting, mechanics, and spelling. As Kissel states, "The goal in introducing young children to writing is to create writers for life - not to create a life where children hate writing" (2008, P. 56). As they grow, publishing for a wider audience requires that young writers use conventional spelling and mechanics to enhance comprehensibility. Premature emphasis on mechanics and spelling, before children with disabilities are developmentally ready, can destroy writing enjoyment.

Fang (1999) identified two strands found in research that focused on emergent writing in the 1990s. The first research strand focused on the development of spelling from scribbles to using shapes that resemble letters. The focus of the second strand included socio-cultural aspects which is integral in the process of writing. "It shows us that the development of writing involves the assimilation of the mechanisms of culturally elaborated symbolic forms and the use of these complex symbolic devices to represent and reconstruct human experience" (Fang, 1999, p. 179). It is this second strand that concentrates on the roots of early writing growth and developmental approximations of emergent writing (Fang, 1999) and that he exhorts researchers to explore. Investigating patterns children use for encoding their ideas and organizing personal experiences can reveal much information about their growth in both writing and oral communication. Research in this area is vital to help teachers make their instruction intentional, methodical, and effective as they guide children to communicate through writing (Fang, 1999).

Handwriting. One component of written language is handwriting. Although for many people, handwriting appears to be a simple skill, the involvement of motor and cognitive processes is very complex (Graham &Weintraub, 1996; Jones & Christensen, 1999). Before an individual can even begin to put marks on a paper, he/she must know letters and sounds and how they relate to words. It includes fine motor skills of drawing accurate shapes and patterns with spacing, which differs between letters and words.

Jones and Christensen (1999) described the cognitive and metacognitive complexity involved in handwriting, which may be a relatively minor, but important, component of the entire writing process. In their study of 114 students with the mean age of about 6 1/2, they measured the writing speed and accuracy. An assessment measuring the quality of written expression was also given. Students who scored lower in both those measures were chosen to be in an intervention group along with a group of others who acted as controls. Through their research, Jones and Christensen determined that after controlling for reading skills,

> …approximately 53% of the variance in story writing scores was accounted for by speed and accuracy in writing letters. Therefore, it appears that for children in the early years, orthographic motor skills involved in handwriting have a significant effect on their ability to generate written text. (p. 47)

They also mentioned Stanovich's (1986) "Matthew effect" which described how the cycle of poor fluency in reading discourages reading. This decreases practice which "… delays the development of automaticity and speed at the word recognition level" (p. 364). This reiteration promotes avoiding the task and thereby increases the negative effect on reading. Jones and Christensen suggested that this cycle can also pertain to writing acquisition. Graham and Weintraub (1996) also point out that one handwriting variable, which is scarcely addressed in research, is the effect that poor handwriting has on the students' attitudes towards writing, which may negatively contribute to the

“Matthew effect”.

In a study of first graders having difficulties with writing and handwriting, Graham, Harris, and Fink (2000) provided 15 minute handwriting sessions aimed at improving fluency and accuracy. The control group of peers was taught phonological awareness. Results indicated a causal relationship between handwriting and composition.

Handwriting fluency is very important to develop, “…so that the mechanics of producing text do not interfere with the process of composing text” (Graham & Weintraub, 1996, p. 7). A student who struggles to remember how the letter “a” is formed and must force muscles to perform closely enough to make the lines fairly recognizable, may forget the intended message by the time the letter or word is complete. The lack of writing fluency, in combination with the orthographic coding required in handwriting, have significant effects on ability to generate text (Jones & Christensen, 1999). Lack of “automaticity in handwriting means that the scarce cognitive resource of attention is available for the more complex aspects of text generation such as ideation, sequencing of ideas, and monitoring for accuracy” (Jones & Christensen, 1999, p. 45). If fluency were increased by introducing technology, would there be a positive effect on the generation and quality of the resulting written products?

Writing. The complex skill of writing is essential throughout a child’s schooling and beyond (Beck & Featherston, 2003; Easterbrooks & Stoner, 2006; Mastropieri, Scruggs et al., 2009; National Commission on Writing, 2004 & 2005). “Writing well is a critical skill functioning as a method of clear communication as well as a path to achieving higher levels of prosperity” (Easterbrooks & Stoner, 2006, p. 95). As Graham and Perin (2007), Berninger et al. (2008), and others have indicated, the consequences of persistent writing difficulties can negatively affect all academic performance throughout the school career, as well as, limiting opportunities for employment.

Cutler and Graham (2008) surveyed teachers across the United States to find instructional practices currently used to teach writing. Although the National Commission on Writing (2003) recommended to integrate technology in the instruction of writing, years before, Cutler and Graham's (2008) survey found that 67% of the teachers who responded use computers less than once a month. Yet, research supports the positive effect that computers can have on the quality of writing for students (Bangert-Drowns, 1993; Goldberg, Russell, & Cook, 2003; Graham & Perin, 2007).

It was interesting to note in Cutler and Graham's (2008) survey that the most frequent emphasis in writing instruction was on basic writing skills, including the lower level skills of spelling and mechanics, which remain important for conventional writing. Planning, writing strategies, and revision, which are higher level writing skills, were the focus less than several times a month for around 50% of the teachers (Cutler & Graham, 2008). Could delegating the lower level skills of spelling and mechanics to the computer provide young writers with more time and energy to develop the higher-level thinking and writing skills?

Barriers to writing. Behrmann (1994) lists some of the writing barriers experienced by students who have mild disabilities as "… mechanics: spelling, grammar, and punctuation errors; process: generating ideas, organizing, drafting, editing, and revising; and motivations: clarity and neatness of final copy, reading ability, and interest in the process of writing" (Behrmann, 1994, p. 78). Troia and Graham (2003) also described the "extraordinary difficulty" (p.78) struggling writers have with translating their thoughts into text, especially with mechanical errors, such as spelling, capitalization, and punctuation. One of the questions asked by Graham and Harris (2009) was, if spelling and handwriting difficulties were eliminated, would writing performance be enhanced? Although they were specifically referring to speech-to-text or dictation software, could there be another way to diminish those two barriers, such as word processing with picture-to-text and/or word prediction? Among the accommodations, for struggling writers, that Troia and Graham mention is the use of the keyboard. This investigation focuses on two of those problems mentioned by Behrmann, Troia and Graham, and Graham and Harris that often plague struggling writers − difficulty with the fine motor movements of handwriting and the inability to spell words.

The discussion section of Cutler and Graham (2008, p. 915) cited Persky, Daane, and Jin (2003) as reporting that, "by fourth grade, two out of every three children in the United States do not write well enough to meet classroom demands." In the United States, many adolescents cannot write well enough to be successful in college or in a job (Mason & Graham, 2008). How can students with severe writing disabilities bridge the chasm between the emphasis on celebrating meaning in early writing to the need for conventional spelling, word usage, and mechanics required for publishing as they mature?

Technology. Some researchers investigated using computer-based learning for academic skills such as reading. Heinmann, Nelson, Tjus, and Gillberg (1995) revealed significant change, $t\ (8) = 2.85$, $p <$ than .05, for students with autism who used an interactive multimedia computer program. More recently, Whitcomb, Bass, and Luiselli (2011) documented the improvement of reading accuracy of a nine year 10-month-old boy with autism after using an online, early reading program. In another study, multiple baseline design across tasks, a 12-year-old with autism significantly improved reading sight words with a computer-based intervention (Yaw et al., 2011). With success found by using computer programs to enhance the reading skills of children with autism, could computers also help with writing development?

Various studies have considered the effects of technology on writing products. Zhang's (2000) study maintains that software can free students from concerns about handwriting so they can focus on the development of ideas and paragraph structure. Although these students may want to generate written products that are neat and legible, it is often impossible for them to accomplish this task without AT. Behrmann (1994) described how AT could help these students overcome the barriers to writing. "…valuable instructional time can be focused on generating ideas and text rather than on mechanical re-copying and rewriting" (Behrmann, 1994, p. 80). MacArthur (2009) discussed research that explores the computer writing applications that students can use for transcription and revision in order to communicate their thoughts in writing. The elimination of tedious recopying, by using word processing, can encourage revision of writing products (MacArthur, 1996; Troia & Graham, 2003). As a result of many studies, MacArthur and others found that providing students access to word processing without specific instruction in writing and revising had no effect on decreasing the number of mechanical errors such as spelling, punctuation, and capitalization, or increasing the quality of student-generated writing. Combining strategy instruction with the writing process has been shown to positively influence the written product of struggling writers (e.g. Danoff, Harris, & Graham, 1993; MacArthur, Schwartz, & Graham, 1991, as reported by Graham & Harris, 2009). The substantial base of research on word processing used in conjunction with specific instruction indicates that struggling writers benefit more from using the word processor than do average writers (Bangert-Drowns, 1993; Graham & Perin, 2007). However, as mentioned before in the national survey by Cutler and Graham (2008), teachers reported that computers and word processors are not often utilized for writing in many school settings.

Beck and Featherston (2003) compared written products that were completed by seven, 8-year-old students using paper and pencil versus written products that were typed using a computer program. The students more frequently chose to use computers over paper and pencil and the use of the computer produced a positive effect on their writing. When using computers, student motivation increased, story construction was better, and students were more likely to take risks when writing their stories. Zhang (2000) involved students with learning disabilities (LD) in the fifth grade and Hetzroni and Shrieber (2004) included three junior high students with writing disabilities using computers for written products. Cullen et al. (2008) studied seven fifth-graders using a combination of computers that incorporated software with text-to-speech, spell check, and word prediction. The first two and the last studies were completed in small group settings and the third was in an inclusion setting with typically developing peers. Whereas, the students in the first study were just classified as reluctant writers, the students in three other studies had been formally diagnosed and had Individual Education Programs (IEPs). All four studies concluded that the use of technology for students with difficulties in writing had a positive effect, including the reduction of the concerns of legibility and spelling in their writing samples.

In the Technology for Learning Disabilities Project Evaluation Report (Hallows & Connolly, 2007), a two year study with pretest-posttest design, students' ability to employ accepted writing conventions and organization components was assessed, when students with learning disabilities had consistent access to and use of AT. The group using technology scored significantly higher on all 13 assessment areas, and the teachers reported an even more important impact being the positive reversal in student feelings about writing. Beck and Featherston (2003) also noted a positive change in students' attitudes, in that when using computers, students were motivated to write more and to revise their text.

MacArthur (2000) described a variety of studies with results indicating the positive benefits of long-term training in, and use of, word processors with special software. At that time, he mentioned that research on AT used for writing was limited. MacArthur's research has spanned from the initial introduction of educational technology when dual floppy drives were new and exciting advancements (MacArthur & Schneiderman, 1986) to the current upsurge of interactive technologies available for today's students (MacArthur, 2009). Although in 2009, MacArthur found a greater number and variety of research studies dealing with AT, he still mentioned that research for AT continues to be limited when compared with research on reading.

"The availability of word processing may be the most important application of assistive technology for students with mild disabilities" (Behrmann, 1994, p. 78). Many researchers have studied word processing, word prediction, and spell check along with speech recognition, organization, and outlining programs. The National Council of Teachers of English and International Reading Association (1996) and others recognize the myriad of new skills that must be mastered for today's students to be considered completely literate. Even with all the innovations, basic writing skills, effective use of language, and skills for critical reading and writing have continued to be the fundamental focus.

The effects of using technology can be either positive or negative depending on use by teachers and students. A word processor alone will not necessarily result in improved writing (MacArthur, 1996; MacArthur, 2009). If typing speed is below writing speed, students may get frustrated when trying to use a computer for writing. In a study about children using home computers, Kimmerly and Odell (2009) found that the students ages 8 to 10 in their study averaged five words per minute (WPM). Herold, Alant, and Bornman (2008) studied the effects of word prediction on spelling accuracy and typing speed. Although spelling accuracy did increase, the time it took for a student to review each list of words and choose the correct word increased the time to complete the task.

MacArthur (2009) describes four important elements when considering the use of computers for writing instruction. Students must be given the opportunity to learn and practice typing skills so they can become fluent. MacArthur strongly suggests that the entire writing process should be completed using the computer in order to reap all the benefits of word processing. Students must learn strategies that help with planning, writing, and revising, and teachers should make sure student writings are published, which is a key motivation for writing.

Lacina and Block (2012) sent a survey to 17 of the largest school districts in the United States asking if the 11 research based-strategies were being implemented in at least 50% of the middle school classrooms in their districts. It also included a rating scale that asked about the writing proficiency of their students as compared with students from previous years. Out of the 13 districts that responded, word processing was reported to be used in at least 50% of middle school classrooms in only seven of the districts, yet 50% of the surveys indicated "the introduction of technology as the single most important action taken by their school districts in the past decade" (Lacina & Block, p. 13). Although the surveys indicated the importance of using technology for writing, a great many students do not have the benefits that technology can provide in their writing development.

The background included in this research is in the area of written language, which spans the gamut from emergent writing to the development of written language. Some of the great difficulties for students with autism include the fine motor skills and physical sensations of handwriting. In the study of Myles et al. (2003) the writings of 16 children and youth with Asperger Syndrome (AS) were compared with 16 neuro-typical peers. Scores for written language were similar in both groups, however, students with AS had significantly fewer letters and fewer words that were legible. Of the words written by students with AS, only 71.09% met the criteria for legibility whereas, 87.80% of the words were legible for those without AS. Many students with autism cannot transcend the handwriting obstacles and aversions, in order to develop the cognitive processes required to commit thoughts to paper. Students with disabilities such as autism need strategies and tools to help them with the writing process. Students with autism often have technological insight (Stokes, Wirkus-Pallaske, & Reed, 2000; Wirkus, Comer, Swenson, & Weingarten, 2009) and visual processing strengths (Wirkus et al., 2009), and therefore, would be prime candidates for using assistive technology (AT).

Students with autism. “Autism is a neurobiological disorder of development that causes discrepancies or differences in the way information is processed” (Janzen, 1996, p 5). This unique processing affects the individuals’ use and understanding of language for communication and for interaction with others. It also affects relationships with people as well as reaction to events and environmental experiences. Sensory stimulation such as pain, noise, textures, taste, may overwhelm a child with autism causing atypical responses that are difficult for the child to manage or for others to understand or tolerate, much less, address appropriately. For a child with autism, learning and thinking in typical ways will probably be unachievable (Janzen, 1996).

Center for Disease Control and Prevention (CDC, 2013) reported a 78% increase in autism diagnoses since 2007. Only 12 years ago, the prevalence of finding a child on the autism spectrum was 1 in 150, whereas four years ago it was found to be 1 in 88 children. Research is needed to identify strategies and tools that can assist this growing number of students develop the writing skills they will need to be successful in life. In earlier decades students with disabilities were often excluded from general education classrooms and high stakes assessments. Because all children benefit from diversity in the classroom culture, which includes children from many different backgrounds as well as a wide variety of abilities and challenges (Mastergeorge, 2007), there has been an emphasis on inclusion. Both general educators and special educators are now challenged to find tools and strategies that help more students with disabilities, including autism, perform and accomplish tasks at an age-appropriate level in general education classrooms.

A global publications analysis by the Interagency Autism Coordinating Committee (IACC)/Office of Autism Research Coordination (OARC) in 2012 investigated autism research in the past 30 years. This federal committee coordinates efforts related to Autism Spectrum Disorder (ASD) for the United States. The objective of this recent report was to identify historical trends relating to the seven critical research areas identified in their strategic plan and to determine the resulting impact of this research. Their findings that related to this current research indicated that although 20 -30 years ago little was known about autism, it has recently become a "top national health priority" (IACC/OARC, Introduction, 2012). After close to 20 years of relatively stable growth in research about ASD, sharp increases were noted starting in 1999 and 2005. The growing awareness of how individuals with ASD impact families and societies has resulted in burgeoning autism research of which the key priorities include: (1) methods for early diagnosis, (2) a clearer understanding of the biology and risk factors, and (3) development of "… effective treatments, interventions, services and supports that can reduce disability and enhance quality of life for the affected individuals and families across the lifespan" (IACC/OARC, Introduction, 2012). Technology was listed as a research topic under treatments and interventions, which was included as high priority for research. Just before 2007, research on technology-based interventions and supports climbed steeply to surpass research on medical and pharmaceutical interventions. Until 2010, it was the second most researched topic in the subcategory of autism treatments and intervention research. From the perspective of individuals with autism and their families, intervention and treatment research is the highest priority because of its potential to dramatically enhance their quality of life. As a result of a closer look at the subcategory of technology-based interventions and support, augmentative and alternative communication (AAC) was the first mention followed by general computer applications and software. Using software and computer applications as a tool to enable one to complete a task that he or she would be otherwise unable to accomplish, AT interventions, were not specifically mentioned. Such tools as picture-to-text word processing, text-to-speech, and word prediction software programs were not listed. In emphasis and number, the research targeting behavioral interventions historically has far surpassed any other intervention research for individuals with autism. Although that trend continues, recently, technology interventions have incurred the steepest increase as compared to the other six categories of intervention (IACC/OARC, 2012).

Information that can be found on the website maintained by the Autism Society of Northern Virginia (2010) contains descriptions and characteristics of individuals with autism. For individuals with ASD, the Autism Society's website emphasizes the importance of early diagnosis and treatment in order to enhance school success and the possibilities of independent living as an adult. Two of the treatment recommendations made by the Autism Society Panel of Professional Advisors (2000) were to:

- Take advantage of these children's predisposition by incorporating visual structure, as well as the predictability of routines and schedules.
- Address deficit areas such as language comprehension and ability to communicate.

The panel also expressed the need for more applied research to identify effective interventions and methods of approach for children with ASD.

Janzen (1996) wrote:

> The areas of impact are communication, relationships, response to sensory stimuli, and learning which can exacerbate confusion and can be expressed unexpectedly by behaviors that are repetitive, withdrawn, aggressive and/or self-injurious. Individuals “with autism share a common symptom cluster, a common learning style, and predictable problems that affect their ability to communicate, socialize, and function in the world. (p. 11)

Each individual demonstrates characteristics of autism in a unique combination and intensity.

After describing brain research on individuals with autism and showing how their brains work differently, Williams and Minshew (2010) describe some ways that the environment can be adapted to help these individuals. The first change would be to reduce verbal confusion by using fewer words so that the most important factor is clearly communicated. This reduces the possibility that the child will misunderstand. The second suggestion addressed the difficulties that individuals with autism have with learning abstract concepts. When teaching, the prototype should be emphasized first, extreme examples should follow understanding. The third suggestion centers on pairing visual information and auditory information with explicitly taught connections.

Children with autism have a great deal of difficulty comprehending spoken language, which compounds characteristic social limitations and renders successful interaction with others problematic (Preis, 2006). In contrast, memory, perception of visual stimuli, and spatial relationships are often strengths for individuals with autism. In a study with participants who were 5 to 7 years old (3 girls, 2 boys), results demonstrated that although picture symbols did not make a significant difference in the acquisition stage, for generalization and maintenance, pairing pictures with verbal commands were more effective than using verbal commands alone (Preis, 2006).

Students with autism and writing. McCoy (2011) describes students with autism as having great difficulty in the area of writing. In addition to fine motor control, tactile defensiveness, difficulty with muscle control, inhibited connection to others, difficulties with communication and other areas of developmental delays intensify difficulties with handwriting (McCoy, 2011). As well as the motivating factor, assistive technology may circumvent handwriting issues (Broun, 2009; Heinmann et al., 1995; Jerome, 2009). As visual learners, McCoy suggests that when a student with autism has difficulty writing, if they could draw pictures, perhaps a discussion of the details included in the picture could help that student expand their writing. Another strategy mentioned, to assist students with autism in the struggle with connecting details in writing, was to provide a word bank.

Students with Autism and visual supports. “Pictographic and written cues support children's understanding of verbal and social cues, thus making it easier for them to learn, communicate, interact, and develop self-control” (Quill, 1995, p. 10). Quill (1995) defined “Visually cued instruction” (p. 10) as supporting instruction by using pictographic and written language. She described organizational aids that used pictures to identify the sequence of a schedule as a checklist for an activity and a means to convey environment and material organization. Pictures can also help children with autism develop skills such as self-care, cooking, directions for a task, and instructions for community jobs. Quill also maintained that, “Pairing spoken language with pictographic or written language symbols during instruction in various cognitive, language, and academic tasks increases the likelihood that the child will extract meaning from the information” (p. 15). Using pictures and written outlines to identify concepts and sequence in content subjects and graphic supports in instructional material can be very helpful for students with autism. Graphic supports can also be utilized to facilitate development of communication skills, social skills, and assist with managing behaviors for students with autism (Quill, 1995).

Prelock (2006a) emphasizes the value of utilizing visual supports to capitalize on visual strengths of children with autism. Pictures offer more enduring, concrete clues to the meaning of written words which can parallel their style of processing. Whereas, Prelock was referring to augmentative communication, can pictures also help students with autism communicate in writing?

Many individuals with autism have an impressive propensity to memorize and manipulate visual information; however, even though the words, notes, numbers, or pictures may be inscribed in their memories, often the information has been disengaged from meaning. The presentation of visual information with clear organization and highlights of critical components, progressions and relationships can make use of an information processing strength (Janzen, 1996). Visual presentations systematically provided can assist students with autism. Using them meaningfully can help compensate for deficiencies common to those who have autism (Janzen, 1996). In her book, *Thinking in Pictures and Other Reports for My Life with Autism* (1995), Dr. Temple Grandin wrote of the importance images had in her life and had in the lives of many others who have autism.

"The potential of graphic symbol systems to facilitate language and communication in children with autism and PDD at other levels of language ability remains largely uninvestigated, although numerous clinical reports highlight the merit of this strategy" (Quill, 1995, p. 12). Boucher and Lewis (1989) assessed the memory component by using textual commands with participants who could read and understand text. They suggested that perhaps pictures could be used with students having autism, but who are unable to read text.

Purpose

The focus of this study is to explore the benefits of giving young, struggling writers with autism access to a computer with picture-to-text software that can support writing. Although many researchers have studied word processing and AT features in the past 25 years, this researcher could not find studies investigating the effects of using picture-to-text software for children with writing difficulties. Can the visual and auditory support of picture-to-text software allow young writers who have disabilities, such as autism, to communicate more easily and more effectively in writing?

In order to surmount writing difficulties and decrease possible aversion to writing, children can be given an arsenal of tools and strategies at the earliest sign of frustration with writing. AT, which has been mandated as being considered for students with disabilities (Quinn, Behrmann, Mastropieri, & Chung, 2009), can help those students succeed in the development of the writing skills that are necessary throughout life. Research is needed to determine which tools and strategies can be effective for writers with disabilities, such as autism.

From Waldo's (1902) investigation of the educational impact of the typewriter, the question about using technology to increase writing quality and productivity has been an area of interest for over a century! Many authors identified barriers to writing which included difficulties with spelling and handwriting, such as, Behrmann (1994), Jerome (2009), MacArthur (1999), MacArthur (1996), and McCutchen (1995). From putting letters and words in a document to using features such as spell check, word prediction, deletions, "drag and drop" can all add to the ease of organizing, drafting, editing, revising, and producing a neat final copy of a written product. Most of these topics have been included in one or more studies using technology. Although picture-to-text software has been around for 15 years and visual cues have been found to help children with autism, research could not be found that studied the effects of picture-to-text software for writing with children with autism.

In order to better understand interventions used to help students with disabilities, single subject research design (SSRD) has been used for over 40 years (Kennedy, 2005). SSRD was used by many researchers, including Asaro (2008); Flannery and Horner (1994); Pennington et al. 2010; who used SSRD for students with ASD; Flannery and Horner (1994); Shurr and Taber-Doughty (2012) Silio (2008); and others. Kennedy (2005), Alper and Raharinirina (2006); Mastropieri, Berkeley et al. (2009); and other researchers found SSRD to be an effective method for studying interventions with children with disabilities. The meta-analysis by Odom et al. (2003) specifically examined research studies that used single subject SSRD for students with autism. In those 37 studies the primary SSRD used was multiple-baseline experimental designs which have added to the knowledge base about effective practices for students with autism (Odom et al., 2003). Three single subject studies involving writing and students with disabilities were used as models for different aspects of this research.

The purpose of this research was to determine the impact of picture-to-text software on the writing performance of young writers who have autism and who have experienced difficulty with expressing thoughts in writing. The research questions were:

1. Will using picture-to-text software increase the number of sentences with a subject and predicate in writing samples of young writers with moderate autism?

2. Will using picture-to-text software increase percent of correct word sequence (CWS) in writing samples of young writers with moderate autism?

3. Will the use of picture cues over most words decrease the number of errors in writing samples of young writers with moderate autism?

Terminology

Words can have a variety of connotations. In order to maintain a common understanding for this study, the terms used are defined below.

Assistive technology (AT). According to the Assistive Technology Act of 2004 “The term ‘assistive technology device' means any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities. (Section 602, 1; Department of Education, Office of Special Education Programs’ (OSEP’s) IDEA Website, 2010). In this paper, the reference to AT also includes software that would be on a device such as a computer being used as "an AT device" to enable participants to more accurately reflect their thoughts in writing.

Autism spectrum disorder (ASD). The website for the American Psychiatric Association describes Autism Spectrum Disorders as “a range of complex developmental disorders that can cause problems with thinking, feeling, language, and the ability to relate to others” American Psychiatric Association (2012). The website continues to explain that the severity and combination of symptoms, ranging from mild to severe, is unique for each individual with autism. Characteristics include difficulties with communication and interactions with people and things. Repetitious sounds, rapid movements, and extreme behaviors can be additional traits. It mentions that Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) is also included in ASD and is used to describe children with a milder form of autism. Children with PDD-NOS often display some, but not all, characteristics of individuals with autism, having fewer or less obvious repetitive behaviors. A student with autism is considered to have ASD. For the purposes of this study the researcher has determined that children classified as having moderate autism are those children who have some significant deficits in expressive and/or receptive communication skills. Children classified as having severe autism are those children who are non-verbal or who have minimal skills in expressive and/or receptive communication skills.

Computer enriched education. In 2005, Anohina investigated the terms commonly utilized in describing the use of computers in education. According to Anohina, the term *enriched* is applied to indicate that technology is used as a tool maintaining the need for a teacher to create and deliver the learning materials. Computer assisted instruction (CAI) implies that the technology is used to present material, guides, questions, and answers. It can also check the knowledge of the learner, which provides a more independent learning environment. This study uses picture-to-text software as a tool for an individual to create a writing sample, thereby providing a computer enriched education that facilitates the production of written language.

Curriculum based measure (CBM). CBM is a measurement used to monitor skill development in academic areas such as reading and writing. CBM can detect relatively small increments of progress.

Correct word sequences (CWS) and incorrect word sequence (IWS). CWS is a research based CBM for writing accuracy awards points for pairs of words written in a correct sequence. This includes proper capitalization, spelling, end punctuation, and syntax. Each error is considered an IWS.

Emergent writing. This is the beginning stage of writing. It starts when a child grasps a writing instrument and begins to put marks on something and continues as a child realizes that the marks represent an idea. The child begins to notice, or is taught that Western writing is in the direction from left to right horizontally across the page. Then the child includes letters or letter groups to represent words in a type of "creative spelling." As a child progresses, more of the letters they use begin to correspond with the sounds in words.

Picture-to-text. Picture-to-text software automatically pairs simple pictures above each word. A person types each letter of a word. When the spacebar is depressed, the word or group of letters is assigned to a button below the writing area of the word or words. If the group of letters is a word that can be illustrated by a simple picture, the picture will appear above the text. If a group of letters does not represent a real word, no picture will appear. The word or word/picture pair also appears in the writing area. Picture-to-text software also includes auditory feedback each time a word is chosen and whenever the writer chooses the listen button. Words can also have a colored frame that may indicate a part of speech to help students with sentence structure.

Prompt or cue. In this study, the writing prompt was the script read to the participant just before he or she began a writing sample. The writing prompt was paired with a picture printed on a 4 inch x 5.5 inch piece of card stock that acted as a visual sentence starter to help the participant think of something about which to write (see Figure 1).

Figure 1. An example of a visual sentence starter used to help students coalesce thoughts.

In this study, the word "cue" generally referred to a picture or color that helped a child attach meaning to the words presented. The cues provided in picture-to-text software were pictures, colors, and auditory feedback.

The word "prompt" was also used to indicate a word or phrase, gesture, and/or picture that helped the participant continue working, control impulsivity, and/or adjust behavior. At times, the word "cue" was used as a synonym for the word "prompt". The degrees of prompting or cueing are as follows: minimal= (1-2) gestures or visual cues only; moderate= (3-4) visual cues, verbal cues, and/or gestures; maximal= (5 or more) visual cues, verbal cues, and/or gestures.

Sentence. According to online Oxford Dictionaries (2013) a simple sentence is "a set of words that is complete in itself, typically containing a subject and predicate, conveying a statement, question, exclamation, or command, and consisting of a main clause and sometimes one or more subordinate clauses." In this study, to be considered a sentence, a subject and a predicate were required. In writing samples where words appeared to be randomly typed, a subject, a predicate, and one other word that extended the meaning to convey a thought were required.

Visual cues. Pictures were included over text in order to provide comprehension clues to the meaning of the words. Pictures were included in the assent forms, in directions, and in the scripts used with the participants. Pictures were also used in the intervention with a picture over most words that were typed or in the pallet. Other visual cues used were colored borders around the picture buttons to indicate parts of speech, and a strip of paper with two or three colored boxes.

Word pallet. In the software, PixWriter v3.2, by Slater Software (2010), a pallet is a grid of words found below the writing area from which a student may select words. In this software, the word pallet can have pictures over each word or words without pictures. This is similar to a word bank, a word array, or an electronic word wall.

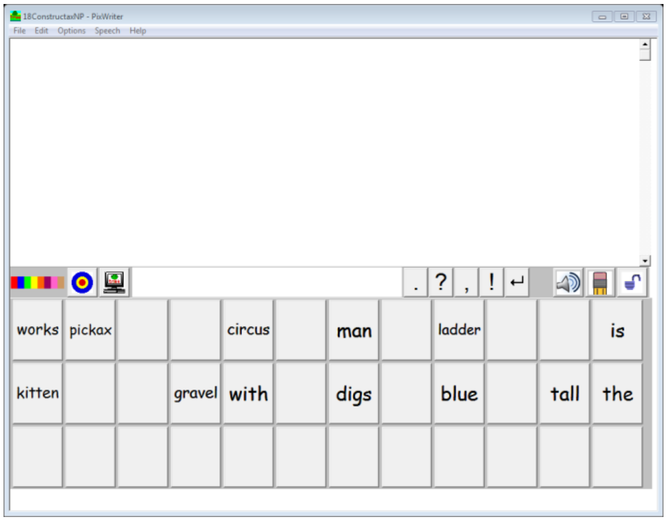


Figure 2. A sample of the writing word pallet without pictures used in Phase A.

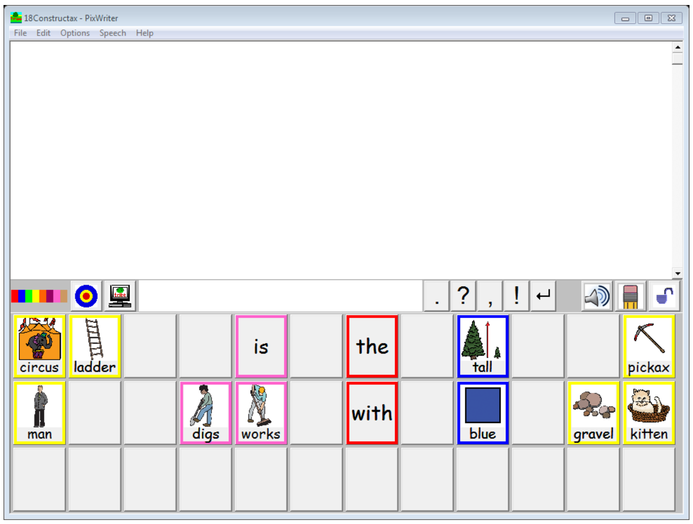


Figure 3. A sample of the writing word pallet with pictures and color borders used in Phase B.

Made with Literacy Support Pictures™ and PixWriter™ software, www.suncastletech.com

Writing difficulties. Children learning to write may struggle with one or more problems making the writing process frustrating and unsuccessful. The inability to easily produce recognizable lines and letters on a paper can make the writing process very arduous and sometimes actually painful. Putting the words together into a group of words that makes sense while following the rules of grammar and remaining on the paragraph topic can be exhausting and or unattainable for children with the combination of a disability such as autism and writing difficulties.

2. LITERATURE REVIEW

This chapter describes literature of academic research in writing. It begins the investigation of the body of literature through several meta-analyses and continues by recounting what researchers have found about writing skills, barriers to writing, and the role technology can play. Autism is also investigated especially with respect to strengths with technology and visual aids/pictures. Current research has studied some effective practices that can be used with students with autism in the area of writing. Research designs that have been used in the area of special education are explored and studies with similar objectives are compared.

Meta-Analyses for Writing Research

To delve into current research involving AT, picture-to-text software, writing, and young children with autism, this researcher found a number of meta-analyses helpful. Alper and Raharinirina (2006), Okolo and Bouck (2007) and MacArthur (2009), analyzed studies involving AT covering the last seven to 25 years. Graham and Harris (2009) reviewed the writing research completed in the last 30 years. They focused on studies dealing with the writing process which included many studies involving Self-Regulated Strategy Development (SRSD) that was developed by Karen Harris (Graham & Harris, 1993). Odom et al. (2003) and investigated research about strategies found to be effective for young children who had autism.

In 2006, Alper and Raharinirina completed a literature review of peer-reviewed journals published in the 15 years between 1988 and 2003. They focused on the use of AT with and by students with special needs. Almost 40% of the studies employed single subject design. It was interesting to note that less than 15% of the studies investigated writing software and less than 3% of the studies had participants with ASD. Okolo and Bouck (2007) wrote a comprehensive review of scholarly articles from 2000 to 2006 in order to identify and describe AT research, understand the AT base of knowledge, pinpoint strengths and weaknesses, and to propose a course of action for future research. Almost half of the studies targeted either students with speech/language disabilities (29%), or students who had reading disabilities and/or learning disabilities (18%). In 32% of the studies, literacy pursuits using AT were under investigation. There was no delineation between studies about reading and those that included writing. During those seven years, only three studies included participants with autism (2%). Although Graham and Harris (2009) wrote that research using SRSD includes many students including students with typical writing abilities, those identified with writing difficulties, as well as students with labels such as learning disabilities (LD), attention deficit and hyperactivity disorder (ADHD), Asperger's syndrome (AS), and students with behavior disorders (ED), it was not clear how many studies had students with each disability.

In existing research, although research for students with autism is beginning to expand, the number of students on the autism spectrum is rising, as is the need to help them develop important academic skills such as writing. Pennington (2009) mentions that because academic research for students with autism remains limited, “the teacher should consider those practices deemed effective for all students struggling in a content area. These data serve as a logical starting point because students share more characteristics than they present exceptionalities" p. 18.

Graham and Perin (2007) in *Writing Next* describe the literacy crisis across the United States as "…poor writing proficiency should be recognized as an intrinsic part…" (p. 3). They conducted a meta-analysis on the current research comparing the statistical effect sizes of different strategies and practices. The consistent use of word processing as a support for writing was fifth in the list of the 11 elements included. Graham and Perin note that each element has "… shown clear results for improving students' writing" (p. 5). They also suggested that flexible combinations of the elements will bolster writing development for all students including those with writing difficulties.

In the list created by Graham and Harris (2013) of evidence-based writing practices verified by studies in their meta-analysis was the recommendation to have all students use word processing, not only for publishing, but for their primary tool for writing. This was verified in a total of 28 studies that were listed in two meta-analyses included in Graham and Harris, Graham, Kiuhara et al. in press and Graham and Perin, (2007) "The use of word-processing equipment can be particularly helpful for low-achieving writers" (Graham & Perin, 2007, p.17). Although using a word processor was generally found to have a moderate effect size on writing quality (effect size = 0.51), it had a much more positive impact on students with writing difficulties (effect size = 0.70).

In 2012, Graham, McKeown, Kiuhara, and Harris completed a meta-analysis of writing for elementary school students. Out of the 10 studies investigating the use of word processing on writing that reported effect sizes, the average effect size (ES = 0.47) was found to be significant. When examining the effect sizes and noting the population of students that were targeted, the largest effect sizes were found in the two studies that involved Struggling Writers (ES = 1.05, Zhang et al., 1995) and (ES = 1.46, Englert, Zhao, Dunsmore, Collings, & Wolbers, 2007), corroborating Graham and Perin's (2007) statement about the positive impact that occurs when students with writing disabilities use word processors.

In the meta-analysis by Morphy and Graham (2012), they found:

> From 77 independent effects, the following average effects were greater than zero: writing quality (d = 0.52), length (d = 0.48), development/ organization of text (d = 0.66), mechanical correctness (d = 0.61), motivation to write (d = 1.42), and preferring word processing over writing by hand (d = 0.64). (p. 641)

It was interesting to note that of the 18 research studies investigating the effect of word processing on writing that were included in Graham and Perin (2007), only two were conducted after 1997, and the most recent was published in 2003. In the meta-analysis by Morphy and Graham (2012), 66% of the studies that fit the inclusion criteria were written before 1996 and only 15% were written after the year 2000.In another meta-analysis, eight of the studies involving word processing were conducted before 1998 verifying the need for more, current writing research for this "effective writing treatment" (Graham, McKeown, Kiuhara, & Harris, 2012).

Odom et al. (2003) conducted a synthesis of single subject research studies from 1992 to 2002 to find evidence-based strategies for children found to be on the autism spectrum. Because of the increase in identification of autism in young children who need early intervention, the studies generally targeted students who were six years of age and younger. Using visual supports as prompts or reminders was put in the category "Emerging and effective practices" (Odom et al., 2003, p. 166). If pictures can help children with autism as prompts or reminders, could pictures and or symbols also be used to help these children communicate in writing?

In examining 18 years of peer-reviewed research literature from 1994 to 2011, Pennington and Delano (2012) only found 15 studies that targeted interventions and strategies to help increase writing skills for individuals with autism. Although use of technology was not a specific objective in any of the studies, technology was included in eight of the studies. Of those studies, three included presenting students with an array of words created on the computer. The students used a mouse to choose words that would create a sentence or simple story (Basil & Reyes, 2003; Pennington et al., 2010; Yamamoto & Miya, 1999). While none of the studies investigated picture-to-text software as a word-processing tool for students with autism, in two of the studies participants responded to a picture and the third study, Pennington et al. (2010), several pictures were paired with words in the array. In two of the studies words were also placed strategically according to parts of speech and sentence construction.

Encouraging Accommodations

Word walls, including electronic word walls, visual cues, color cues, and computers have been the topic of recent studies involving students with autism and intellectual disabilities. These promising accommodations are of great interest to this study.

Word walls. Narkon, Wells, and Segal (2011) describe word walls as being one strategy for helping students with both reading and writing. Many teachers incorporate word walls by allocating an area in the classroom to list new or important vocabulary words for easy retrieval by all students. It becomes interactive when students use it to learn new words, to practice reading and writing words, to be reminded of words they are learning, and/or to help them spell words in their writing. Narkon et al. (2011) described a scenario in which a teacher of students in a resource class was trying to teach vocabulary to students with learning disabilities (LD) and with autism. The teacher noticed that many of her students were better able to attend with the addition of visual prompts/cues, and repetition. The computer was another factor that increased focus and vocabulary retention.

Harmon, Wood, Hedrick, Vintinner, and Willieford (2009) studied 44 seventh grade students' perceptions of word walls both before and after using one for vocabulary instruction. Although initially most students did not see it as a helpful tool, after using one for six weeks, 80% of those students responded that it was an important tool that was used by teachers and students. After the initial use of the word wall, vocabulary instruction included discussion of color, and after that, symbols to help students learn the words and associate appropriate ways to use them. "…All students stated that the word wall with colors and symbols was more useful because it helped them remember word meanings" (Harmon et al., 2009, p. 405). The article reported that other students said, "… The word wall was helpful when completing classroom assignments, especially those activities that contained writing tasks" (Harmon et al., 2009, p. 406).

Narkon et al. (2011) then explained how electronic word walls can be created in order to help students in both reading and writing. Electronic word walls can have an advantage of incorporating, not only pictures with words, but also auditory feedback. They can be used for independent activities to increase repetitive practice, ongoing study, and use during independent reading and writing. The electronic word wall was found to be motivating as well as effective and provided active involvement in the process of learning and using vocabulary.

Visual cues. Visual cues have been found to be helpful in many ways. Meadan, Ostrosky, Triplett, Michna, and Fettig (2011) listed some of the goals that can be attained using visual supports with children with autism. Visuals could serve as reminders of rules and behavioral expectations, as well as, utilized to assist them to remember the order of events in a day, individual steps in directions, to know what choices were available, and understand how their environment was arranged.

For students with autism who have a need for structure and predictability, picture schedules have been found to be effective strategies. In 2000, Bryan and Gast investigated the effect of using graduated guidance and visual activity schedules with four students who had autism and were between seven and eight years old. With graduated guidance and the picture activity books, all four participants were quickly able to learn the illustrated procedures. Once guidance was faded, each was able to independently follow the visual schedule to maintain on-task behavior. Later, when the picture schedule book was not provided, the on-task behavior dropped significantly but rose again with the reintroduction of the picture schedule book.

Preis (2006) studied the benefits of pairing verbal requests and commands with pictures or symbols for five students with autism between the ages of five and seven years old. The students were familiar with using pictures to help with organization, schedules, and item identification, but had never used picture communication specifically for following directions. Although the results were not conclusive, it was noted that when given pictures in addition to a direction from a novel clinician, generalization was achieved more readily than when the pictures or symbols were not used. Maintenance measures also seemed to be more effective when pictures were paired with words.

Visual aids and pictures. Wirkus et al. (2009) note that visual processing is typically a strength for individuals with ASD. Using visual aids and pictures can often help students with ASD understand messages behind text, both receptively and expressively. Wirkus et al. also point out that pictures matched with words may initially unlock the meaning of, and ability to, produce text for some students with ASD. These students often understand far more than they are physically able to write. Wirkus et al. highly recommend the presentation of text with any visual representation system because of the particular interest in words and letters exhibited by many individuals with ASD. A tool that follows Williams and Minshew's (2010) third suggestion for helping individuals with autism is technology that pairs text with pictures. That type of tool may make the written word easier for these students to understand and compose.

PECS. The Picture Exchange Communication System (PECS) utilizes pictures to facilitate both receptive and intentional expressive language for individuals with autism with the goal of developing spontaneous, interactive communication (Heflin & Alaimo, 2007). Physical prompting, from behind the child, is used in the initial stages. Prompting is faded and/or delayed as the child is trained in stages to use pictures to communicate wants and needs.

Kravitz, Kamps, Kemmerer, and Potucek (2002) extended to the literature to demonstrate the effectiveness of using PECS icons to increase spontaneous communication over three different environments for a six-year-old girl with autism. They also explained the combination of research procedures found to be effective with students with autism including use of child preference, time delay, environment rearrangement, and use of differential reinforcement.

The use of PECS was found to have a positive effect on communicating a request and increase verbal output of two 9-year-old participants with autism (Travis & Geiger, 2010). Although Howlin, Gordon, Pasco, Wade, and Charman (2007) were studying the effects of PECS teacher training on student use of the symbols and initiation of communication, they found that, overall, the 84 children, with a mean age of 6.8 years, did increase the use of PECS symbols for communication when teachers had initial training and support.

In two studies, both static pictures and video modeling were found to be effective in helping students with cognitive disabilities complete a complex task (Alberto, Cihak, & Gama, 2005; Cihak, Alberto, Taber-Doughty, & Gama, 2006). Cooper-Duffy, Szedia, and Hyer (2010) identified the use of pictures as an important tool for helping students who have significant cognitive disabilities. "Every student should have an effective way to communicate his or her understanding of the content, and ask questions or make comments about the content (Cooper-Duffy et al., 2010, p. 34)." AT with pictures could make active academic participation a possibility for these children.

Although Cooper-Duffy et al. (2010) were referring to using pictures with augmentative communication devices, Slater in 2002, and Shurr and Taber-Doughty in 2012 studied the effect of using picture symbols to increase reading comprehension. In a multi-probe, single subject design across participants, Shurr and Taber-Doughty (2012) paired age-appropriate stories with picture strips. They found using picture symbols with text that was age-appropriate, yet beyond the reading skill levels, increased reading comprehension of four middle school participants with moderate intellectual disabilities. Slater (2002) investigated the effects of adding pictures to textual materials on the comprehension of 10 elementary school students in a two-year study. The language delays for these students were significant and they were non-readers. They had a variety of disability labels in the areas of cognition, learning, and physical. Using the pictures in combination with text increased growth in reading comprehension for the students. Slater posed the premise that pictures chosen and put in a specific sequence could also help students to communicate thoughts in writing. Approaches such as traditional developmental and basal reading are not effective for imparting language arts skills on individuals with autism. "A more successful approach is one that accommodates the learning strengths and deficits common in autism-a holistic, visual approach taught in a meaningful context" (Janzen, 1996, p. 287).

Color cues. A strategy that has been found to help individuals using augmentative communication, to be able to “speak” with devices more efficiently is to have a colored border around words to indicate the part of speech. Wilkinson, Carlin, and Thistle (2008) conducted a study with 16 typically developing children and 10 children with Downs Syndrome. The researchers used color to indicate the type of symbols: foods were one color, clothing another color, and activities a third color. They found that when similar symbols had the same colors and were clustered together, participants could more quickly and accurately find the targeted symbol. In 2009, Thistle and Wilkinson compared the use of color in the foreground as opposed to background. Foreground color was found to be more effective in helping participants find symbols quickly and accurately. Picture-to-text software has a similar color feature to help writers find words more successfully.

Modeling and patterns. Modeling was explained by Prelock (2006a) to be an intervention used to train students with ASD. It is most effective when the modeling is repeated and person modeling is reinforced. Another intervention mentioned by Prelock was scripting and using a predictable pattern of events. With daily participation and frequent repetition, a student with autism can learn and use patterns.

Predictability. In order to learn more about the reason why consistency and structure in an educational setting has a positive effect on many students including those with autism, Flannery and Horner (1994) conducted single subject studies to determine if predictability could be key. Trainer behaviors targeted for data collection in Flannery and Horner’s study were noted to be positive statements, prompts, and remands. Although not included in the data collection, frequent redirection (every 5-10 seconds) was also given when problem behavior extended for a period of time. During the intervention phase assessing the effects of predictability, training included describing and modeling each step required in the task sequence, as well as set up and instructional assistance. Problem behavior did decrease during the predictability phase when each step of a task was described and demonstrated. In the second single subject study, Flannery and Horner added that there would be a demonstration of understanding by the participant as to what would come next. In this study variability occurred with the order of tasks and with the length of tasks rather than the content of the tasks. During both studies, problem behaviors decreased during the intervention sessions, indicating the importance of providing predictability for these two students with autism.

Computers. With inherent predictability, data collection capabilities, unique visual and auditory stimulation, swift feedback and reinforcement, computer-enriched instruction seems to be well matched for students with autism (Heflin & Alaimo, 2007). Because students with autism frequently are interested in technology, it can be used in a variety of ways including increasing motivation, improving response rate, attention, problem-solving, and increasing learning levels in many content areas (Heflin & Alaimo, 2007). Computers may eliminate a host of difficulties for students with autism such as memory of letter formation, fine motor skills for creating letters on paper, visual motor coordination, the uncomfortable sensory feedback of many writing implements and the feeling generated as they leave marks on paper, pressure required for writing with pencils or pens, hand fatigue, writing legibility, and spelling issues (Heflin & Alaimo, 2007). Students with autism who have tendencies toward perfection may be more satisfied with the precision of computer fonts. Other features found in computer software that can help students with autism are graphic organizers, activities for early literacy, grammar aids, tracking mechanisms, and features to assist with both reading comprehension and mathematics skills.

In a study conducted by Moore and Calvert (2000), 14 children with autism, age three to six, were randomly assigned a treatment condition designed to help promote vocabulary learning. One condition was behavioral and the other used computer software. The results reflected the predicted hypothesis. The children were more attentive (97% versus 62%) and were able to recall more nouns (74% versus 41%) from the computer presentation as opposed to when the teacher presented materials. Significantly more of the children were eager to continue learning vocabulary on the computer (57%), whereas, none of the children wanted to continue working with the behavior condition.

Newman, Marder, and Wagner (2003, section 6-4) wrote, “Computers can be an important educational resource that can support instruction in multiple ways, including for drilling academic concepts, word processing, activities created in spreadsheets activities, and accessing the Internet.” A report from the National Center for Special Education Research (Newman, 2007) concentrated on the school experience of secondary students with autism. Data were collected through surveys mailed to staff in the schools included during the first wave of the National Longitudinal Transition Study (NLTS) in the spring of 2002 (Wagner, Newman, & Cameto, 2004). Of interest to this study was the prevalence of the use of technology with students with autism reported by the teachers in contrast to the recognition of its use by the students themselves. The study indicated that the teachers reported 39 % of students with autism either had computer software designed for students with disabilities and/or a computer for activities when it was not available for other students (National Longitudinal Transition Study 2, 2009). However, in the tables found in wave one, 56.4% of youth with autism reported having access to computers rarely in their special education classrooms (NLTS2, 2009). Complementary to the findings of lack of computer use in the student surveys, the teacher surveys reported that even though computers were available in most academic classes, computers were rarely, if ever, used by any of the students in their classes. The most likely classes where students with disabilities might use computers for word processing are the language arts classes. In the 2002 surveys of NLTS, on pages 6-29 provide a breakdown of the percentages of students using computers for activities not permitted to other students, by disability, students with autism had the third highest percentage of use. Only students with orthopedic impairment and students with cognitive disabilities used computers more.

Assistive Technology

According to U. S. Department of Education National Center for Educational Statistics “The number of children and youth ages 3–21 receiving special education services was 6.5 million in 2008–09” (Aud et al., 2011, indicator 7). As Quinn et al (2009) pointed out, "Every one of them, in the development, review, and revision of their individualized education program (IEP), is entitled to the consideration of AT (assistive technology) devices and services” (Quinn et al., 2009, p. 1). These tools can facilitate participation in classroom activities with same age peers, and develop academic skills to their full potential.

Assistive technology research. Findings have been published to illustrate the need for intervention research using AT in writing instruction for young students with autism and other disabilities. Vostal, Hughes, Ruhl, Benedek-Wood, and Dexter (2008) analyzed the content of the articles published in the journal *Learning Disabilities Research and Practice*. Only 17% of the articles were related to written expression in the years from 1991-2007. This meta-analysis found that the writing topic most often studied was teaching skills to help with writing organization. Researchers also studied mechanics, grammar, and handwriting, but AT was not mentioned as a topic in those studies. In a comprehensive analysis of 11 journals focusing on the field of special education for the last 19 years, Mastropieri, Berkeley et al. (2009) found that although the largest category of articles published was research articles, only 15.9% were intervention research studies. Although they found research on reading in over 35% of the intervention studies, the academic area of writing was covered in only 14% of 15.9% that included intervention research. Mastropieri, Berkeley et al. reported that 69% of the intervention studies included grade level of participants, the mean grade level being 4.55 (*SD* = 3.1) and 10.9 years was the mean age of the participants in those studies was.

Graham and Harris (2009) note that students, with LD and others, who struggle with writing have difficulty with spelling capitalization and punctuation. They contend that the writing process for those students is undermined because handwriting is slow and laborious, often the created product is difficult to read. Without handwriting and mechanical fluency, writing energy and creativity are often eroded. The revision of ideas is overlooked with the concern for editing writing mechanics. Ideas are forgotten in their slow, painstaking efforts to write or type. Their strategy was not recommended for those types of students. Again it must be queried, could technology relieve some of their writing difficulties, releasing cognitive resources to employ the SRSD strategy?

Troia and Graham (2003) emphasized the effectiveness of writing help for students in the primary grades. Slavin and Madden (1989) suggested that perhaps earlier writing intervention could mitigate some students' growing aversion to writing. Asaro (2008) reinforced the need for exposing young children to exemplary writing instruction and strategies to maximize the development of writing skills for all children, especially for those who may be predisposed to experiencing writing difficulties. It was mentioned in Graham and Harris (2009) that writing research interests were beginning to be directed to students in the primary grades in order to develop interventions that would be more effective.

Students with Autism and Technology.

Williams, Wright, Callaghan, and Coughlan (2002) point out that computers add consistency, predictability, and a motivational factor to the learning environment for children with autism. Stokes et al. (2000) wrote about the dichotomy of limited attention to technology for individuals with ASD even though those individuals demonstrate a proclivity towards technology (Stokes et al., 2000; Wirkus et al., 2009). The focus of consideration and research of AT for individuals with ASD has previously more often been limited to augmentative communication (AAC) devices. Although oral communication and reading are tremendous needs, AT could also provide a significant positive impact to increase independent functioning with other challenging, academic areas, such as written communication. Bedrosian, Lasker, Speidel, and Politsch (2003) sought writing solutions for an eighth-grade student with autism who used AAC. In that study, a same age peer who had typical intelligible speech production and difficulty writing was chosen to work with the first student. A laptop computer with story writing software was used. It included the features of text-to-speech and the ability to add sound effects. They also used a story map that included symbols from the AAC device. Results indicated that there was a marked improvement of the story written independently by the student using AAC.

Many students with autism, learning disabilities (LD), and emotional disabilities (ED) struggle with writing assignments in school due to difficulties with spelling, mechanics, and fine motor components of hand writing. Graphomotor skills and the impact of organization and attention on written expression have been identified as characteristic weaknesses of individuals with high functioning autism and Asperger Syndrome (Whitby & Mancil, 2009). AT is currently available to alleviate struggles with spelling, mechanics, and handwriting allowing students to concentrate on the meaning behind the words they write (Behrmann, 1994; Zhang, 2000). Word processing, by its nature, alleviates many of the fine motor concerns. Spelling can often be addressed with spell checkers in word processing programs. Some students have such difficulty with letter combinations in spelling that eludes spell checker's capacity to suggest the desired words. Some technology, such as word prediction software, bases proposed words on many different combinations of creative spelling which can more accurately suggest words that have been approximated.

Wirkus et al. (2009) state "Computers are often highly motivating and engaging for students with ASD" (p. 30). When computers are used as a vehicle for learning, they often mitigate distractions and ambiguities found with other teaching methods. Computers provide elements shown to be beneficial for these students, including predictability, repetition, and the need for control.

Computers may help these students with the motor aspect of writing caused by difficulties with low muscle tone and fine motor coordination. Knowing that the government has mandated that AT must be considered for all students with disabilities, this available resource must be investigated as a possible solution to assist students with autism and other disabilities.

Assistive technology could be an educational tool needed by many students to realize their full potential, yet, in a study following 19 elementary students with cognitive disabilities or autism in grades two through six during science or social studies instruction, assistive technology was observed only 0.3% of the time (Soukup, Wehmeyer, Bashinski, & Bovaird, 2007).

Students with autism and technology for writing. In the early years of research for this dissertation, very few research articles about students with autism using technology for writing could be found. Recently, research for students with autism has expanded beyond the former concentration of behavior and augmentative communication into academics. Moores-Abdool (2010) conducted a literature review of articles describing current modifications and accommodations for students with autism. She found a great number of articles filled with advice and with ideas on how to work with students with autism, but with a lack of research basis. Ideas were plentiful spanning importance of structural teaching, setting up classrooms, transitioning, developing social skills, and supports for students with autism. Only one article written by Newman (2007) was found to mention the use of technology for students with autism.

A professional of over 20 years working with students with Autism Spectrum Disorder (ASD), Leslie Broun (2009) described reactions of students who have a great deal of difficulty forming letters, spacing them, and putting them on lines. It can be so laborious to complete a written assignment that the student may expend all energy on the physical act of putting letters on paper and have none left to think about the content or quality of the response. They often make answers as short as possible which, "… Can have a significant and long-term impact on academic achievement by diverting intellectual energy away from creative, imaginative, and well-structured ways of approaching a writing or composition task or communicating their thoughts in writing" (p. 15). She described the two major motor impairments of individuals who have autism as hypotonia (low muscle tone with limited strength) and the second is apraxia (the ability to think about a skilled movement and to execute it precisely.) The stress of handwriting may induce both active and passive avoidance behaviors in an effort to escape the task. She exhorts teachers to understand that using a keyboard as an alternative to writing by hand could be a viable option to allow students to demonstrate writing skills and produce written assignments. She further stated that, "… the thought process is the most important element" (p. 17) of literacy. If keyboarding allows a student to communicate thoughts and demonstrate academic skills, then, access to technology, training in its use, and encouragement to use it to complete tasks would seem to be an appropriate solution.

An analysis of scores such as learning, attention, graphomotor, and processing speed of 886 children with clinical disorders and normal intelligence were compared with scores from a control set of 149 typical children from the community (Mayes & Calhoun, 2007). In that study, 118 children with autism along with 724 children with Attention Deficit Hyperactivity Disorder (ADHD), 25 children with depression and/or anxiety disorder, and 19 with oppositional-defiant disorder were included. The results for children with autism and ADHD were similar in many respects, especially in the areas of written expression, graphomotor scores, and processing speed. In all of those areas, the scores of the children with autism and of the children with ADHD were significantly lower than the control group, as well as, the groups of children with oppositional defiant disorder, anxiety and/or depression. The researchers found that weaknesses in attention, graphomotor, and processing speed were often found together, and the combination was more often found in the children with autism and ADHD (67% and 58%) than in the control group (26%), anxiety and/or depression (33%) and oppositional defiant disorder (20%). With these findings they concluded that "… It is essential to evaluate these areas when assessing children who may have autism or ADHD because of the high probability of finding problems and the need to intervene if such problems are identified" (p. 480). Among the suggested interventions and accommodations were, as Mayes and Calhoun (2007, p.481) stated and other researchers reiterated, "…allowing the students to use a keyboard and word processors for written assignments, and teaching structured writing strategies" (Mayes & Calhoun, 2007, p.481; Danoff et al., 1993; Graham, Harris, & Larsen, 2001; MacArthur, 1996, 2000; Vaughn, Gersten & Chard, 2000).

Another approach to using a computer for writing is to present whole words that can be chosen to create sentences that convey meaning. Delta Messages was a multimedia program for Macintosh computers. It could be set up with words or phrases that could be selected to describe a cartoon picture on the screen. This software was used by Basil and Reyes (2003) to help students with severe disabilities acquire literacy skills. This software program was used as a scaffolded approach to writing and reading for six children, two of whom had the characteristics of students with autism. Although all participants, ages 8 to 16 years, were able to speak, their reading and writing skills were well below expected grade levels. The lessons in Delta Messages started with very simple word choices that created sentences. The lessons progressed and difficulty increased to help students create more complex sentences. The feedback that resulted included the visual presentation of the words, digitized recitation of the sentence, and animation of the cartoon picture. In three months, all six students improved literacy skills including the significant difference between creating a sentence with three elements to creating sentences with seven or more grammatical elements ($t = 8.29$, one tailed $p < 0.001$). Reading and writing were maintained and, in some cases, improved in the two follow-up assessments.

Pennington, Stenhoff, Gibson, and Ballou (2012) noted the limited research of writing interventions for students with autism, as well as the lack of research dedicated to writing skills beyond spelling. They did mention that much of the writing research involving students with ASD utilized computer assisted instruction (CAI). Although investigating CAI was not the primary focus of Pennington et al.'s study with Jaden, it included important information about using technology for academic instruction with students with autism. As other researchers have recommended, they also suggested pairing technology with evidence-based procedures and strategies.

As Behrmann (1994) noted about students with LD, according to Mayes and Calhoun (2007), for students with autism who struggle with handwriting, the most important accommodation may be access to word processing and/or computer. "The most obvious way to capitalize on the visual strength while circumventing the writing weakness is to teach keyboarding and word processing skills and allow the child to use a computer for written assignments" (p. 77).

Assistive technology for students with autism. Asaro-Saddler and Saddler (2010) completed a study with students with Autism Spectrum Disorder (ASD) in grades two and four. Their results indicated that young students with ASD were able to learn and apply strategies that improved their post-test writing. Asaro-Saddler and Saddler noted that the students did have difficulty with handwriting during their study. Wehmeyer (2006) suggests the exploration of technology and other features of universal design to determine the impact on the literacy of students who are more severely challenged. If strategies such as SRSD were combined with the use of word processing to help young writers with ASD, could the spelling and mechanics of the writing samples be improved even more?

In 1988 the Technology-Related Assistance for Individuals with Disability Act passed and was reauthorized as the Assistive Technology Act in 2004 (Tech Act) . Through this act, public awareness of the role that AT could play to improve lives of people with disabilities began to grow (Wallace, Flippo, Barkus, & Behrmann, 1995). Since the early 80s, technological possibilities to help students with writing deficits have grown tremendously. Currently, features such as spell check, text-to-speech, picture-to-text, word prediction, word cueing, concept mapping, and speech-to-text are widely available. These features have the potential to assist many students with disabilities, transforming their thoughts into legible writing with conventional spelling, organization, and mechanics.

Many research studies (Silio, 2008; Zhang, 2000; Hetzroni, & Shrieber, 2004; MacArthur & Schneiderman, 1986) have targeted students who have learning disabilities (LD) and have found strategies and tools to be helpful especially in the area of reading and, to a lesser extent, writing. Although many students with LD have been included in a great number of studies using AT for writing, students with other disabilities such as autism have not been a major focus. More recently, Mastropieri, Berkeley et al. (2009) found an increasing trend to study students with autism, but not specifically with assistive technology.

Soukup et al. (2007) used time sampling to collect data about the provided environments, accommodations, and modifications of 19 students with cognitive impairments or autism during science or social studies classes. AT was observed in only 0.3% of the classrooms they studied. More intervention research must be carried out and promoted to bring to light the positive effects AT can have in the lives of these students and, in turn, for the realization of the potential benefits to encourage greater use of AT for students with disabilities.

Research Design

"Special education research, because of its complexity, may be the hardest of the hardest-to-do science. One feature of the special education research that makes it more complex is the variability of the participants" (Odom et al., 2005, p. 139). Although randomized clinical trials may be desirable for scientific research, addressing simple questions with two large equivalent heterogeneous groups in order to establish a control group and an experimental group may be impossible for the highly unique characteristics of individuals with disabilities (Odom et al., 2005). Even one small category, such as autism, includes diverse combinations of characteristics within its continuum (Odom et al., 2005; Janzen, 1996) and the numbers of same-aged individuals with autism with similar characteristics is proportionally very small in any one school and/or district. Due to distinct contexts found in special education research and highly variable participant characteristics, Odom et al. (2005) suggested that the use of single subject design is a good fit.

Single subject research design (SSRD). In order to determine the best research design for this study, this researcher perused a number of resources from current literature. In a content analysis of Vostal et al. (2008) and a meta-analysis of Mastropieri, Berkeley et al. (2009), single subject design was found to have been used in other intervention research studies. Horner, Carr, Halle, McGee, Odom, & Wolery (2005) found the single subject research to be an ideal method for confirming the proposed relationships between variables in a study and for determining if a practice can be considered evidence-based. Odom et al. (2003) considered single subject research to be effective in research studies involving students with ASD.

The past 40 years, single subject research, which is both rigorous and scientific, has been used in the field of special education (Kennedy, 2005). Of the intervention research designs included in the study by Mastropieri, Berkeley et al. (2009), single subject research (50.5%) was used more than other designs such as group experimental design, quasi-experimental, or studies comparing pre-test with post-test design. Okolo and Bouck (2007) found that single subject research design was used in 21% of studies, which as they stated, "…seemed well-suited in the studies to the questions they addressed" (p. 27).

Kennedy (2005) described single subject research and its many variations "Single-case designs are used to demonstrate experimental control within a single participant" (p. 12). It is a rigorous design of experimentation using one person to maintain constant conditions. Then, there is a systematic introduction of the independent variable, and in some cases a withdrawal of that variable and a careful study is made by closely observing and describing the independent variables effect on the behavior of that individual. In single subject research design (SSRD) it is vital to make precise operational definitions and observations so that the experiment may be replicated, either with different behaviors, or with different participants. Those replications are compared and studied for consistency in order to establish a functional relationship (Kennedy, 2005).

Kennedy (2005) discussed ethics and advantages of multiple baseline design. In this research study it would have been difficult to reverse or withdraw the software condition without causing unnecessary frustration to the participants. Therefore, having each participant begin at a randomly chosen session in a series of sessions added randomization and increased internal validity. Although having a small number of participants can be a threat to external validity, Kennedy asserts that it is vital to determine first whether an intervention works, which can be done with small numbers of participants. As each participant becomes the control "group", as well as the intervention "group", the data from each participant becomes a replication. Each time the study is repeated successfully, external validity is verified. In the 2010 descriptive analysis of SSRD from the years 1983-2007 of Hammond and Gast, time lagged designs, including multiple baselines were use either more often, or as often as any other SSRD. Multiple baseline design was used more often, in those 25 years, than multiple probes. Thus, the current study used single subject research design with multiple baselines.

The experimental characteristic of single subject research makes it ideal for establishing the nature of relationships between the variables being studied (Horner et al., 2005). The behavior of each participant is compared both before and after the intervention is delivered, thus, the participant becomes both the unit of analysis and the control.

Horner et al. (2005) clearly describes the quality indicators for single subject research. In order to make replication possible, precise operational definitions of participants, settings, dependent variables, independent variables, and procedures are keys to the quality of single subject research. Fidelity of treatment controls for external and internal validity and social validity must also be documented (Horner et al., 2005) to be considered a quality study.

In single subject research, effect size cannot be reported in the same way it is done for larger studies. In order to determine effectiveness of intervention studied with a small number of participants is to calculate the non-overlapping data (PND). PND includes a combination of visual analysis and the determination of the data overlap between baseline and intervention (Scruggs, Mastropieri, & Casto, 1987). The following scale is an accepted standard: a treatment with a PND below 50% is considered ineffective; a PND that is between 50 to 70 is considered problematic; a PND that is found to be between 70-90% is considered to be effective; whereas, if a PND is greater than 90% the intervention is considered to have a large effect (Scruggs et al. 1987; Scruggs & Mastropieri, 1998; Scruggs & Mastropieri, 2013).

Similar studies. Yamamoto and Miya (1999) assessed the viability of using computer-based training to teach three students with autism ages six, eight, and ten, how to construct sentences with proper Japanese grammar. Before intervention each was unable to generate more than a two word sentence orally and was unable to write sentences; however, each participant could name and read the target words. Pretest-posttest design was used. A computer with a picture prompt and a grid containing choices of words to complete sentences was provided. Each grid contained four subjects, four verbs, four direct objects, and for particles, words to denote subjective or objective case. Before baseline data was collected students were shown how to use the mouse to make choices, correct errors, and indicate completion of the task. Then students were trained.

During training, correct responses were rewarded with the fanfare of applause. Incorrect responses resulted in a beep followed by a five second display of the correct response. The trial was repeated after the correct response vanished. Once criteria were met, three blocks with correct response rate of 100%, the posttest began. After three sentences were trained the students were able to create sentences that had not been trained and they were able to speak the three word sentences as well. In the second trial the word order was reversed but students needed further training to be able to complete the tasks the successfully. After training, students had a substantial increase in correct responses.

In 2010, Pennington et al. conducted a study to determine the effectiveness of simultaneous prompting to help three males with autism, from ages 7 to 10, write stories using a computer with an array of words set up to mirror sentence structure. Rather than type letters, the participant used the mouse to click on words to complete a story of four different sentences. Using a mouse to choose words from the array reduced the necessity of fine motor control needed for writing with a pencil or typing out words. Four of the words had pictures to illustrate the meaning, but the rest did not. Participants were instructed to create a story. If the participant did not choose the correct word or words in the correct order, or failed to begin writing within five seconds, the teacher initiated simultaneous prompting, which consisted of modeling the sentence construction by choosing words out of the array in the appropriate order. Both participants, who completed the sessions, made progress in both number of words and number of sentences written. During the pretest, Paul wrote seven words in two sentences and for the posttest he wrote 13 words in a total of four sentences. Caleb was unable to write any words or sentences in the pretest. In the posttest he responded with four words, but they did not make a sentence. Although the third participant was unable to complete the sessions because the school year concluded, the combination of simultaneous prompting with the use of CAI was found to be successful for the first two participants. Two suggestions for further study were to determine what effect having pictures paired with words and having a random arrangement of words would have on the stories of writers with autism. Note: the above study did not follow Anohina's (2005) definition of CAI. It more closely resembled computer enriched instruction because the software was used as a tool to help participants create a story.

In another study, using multiple probe design across behaviors/stimuli, research questions of Pennington et al. (2012) again focused on simultaneous prompting as a technique to help a student with autism learn to write a three sentence story using PixWriter software to alleviate handwriting issues. In the 2012 study of Pennington et al., the software was used to create pallets without pictures for a boy with autism aged seven. He had been unable to combine words that could be considered sentences before intervention and was able to do so with the combination of simultaneous prompting, the word bank pallets, and immediate auditory feedback while writing. After two to four weeks, he not only was able to write stories with the software, but both handwriting and oral stories improved as well.

Yamamoto and Miya (1999), Pennington et al. (2010), and Pennington et al. (2012) all used single subject methods to determine functional relationship between computer enriched education (the latter two with a strategy) and improved writing skills of young students with autism. Pennington et al. (2010) employed multiple baselines across participants. Yamamoto and Miya used pretest - posttest design while Pennington et al. (2012) used multiple probe design across behaviors/stimuli. Whereas, technology was not the major intervention, three of the studies, Yamamoto and Miya, Pennington et al. (2010) and Pennington et al. (2012) did use a software program that provided a pallet of words for the students. The students used a mouse to choose the words to build their sentences. Using combined elements from the three studies, the design of this study, single subject research design with multiple baselines across participants, added a new visual dimension to those previous studies.

In this study, the second strand Fang (1999) identified for writing research will be embodied in the writing samples produced with the assistance of technology. This second strand, which focuses on the message that represents thoughts and experiences to share, will be demonstrated by the 3 minute samples composed using picture-to-text technology.

In summary, writing is an important way for children to share ideas with others. Children with disabilities such as autism become frustrated with the formation of letters and spelling needed in the writing process. Young writers with autism often have deficits in the area of language comprehension and with communication skills. Tools incorporating visual cues, repetition, and predictability, such as computers, integrate areas of strength and can be used to assist those students in many areas including written language. Although studies addressing AT in the area of writing have been conducted, including studies involving word prediction, few published studies incorporating the visual cues such as picture-to-text for students with Autism were found.

Pilot Study. In designing a 2010 study involving the writing skills of students with autism, Kenney found three studies, Asaro (2008), which was described above, Silio (2008) and Herold et al. (2008). Silio's (2008) dissertation, two cohorts of students with specific learning disabilities were used to compare word prediction and text-to-speech software features, used first individually and then together. She used a multiple baseline design across subjects with the dependent variables of writing fluency; words written per minute; T units, to measure maturity of the syntax used; spelling accuracy; and a holistic scoring rubric. Data were collected during 15 minute writing probes during: Baseline; First intervention-one software feature alone, either word prediction or text-to-speech; Second intervention-both word prediction and text-to-speech; Maintenance probes were taken two, four, and six week maintenance probes after the final probe.

Rather than assessing student composition, Herold et al. (2008) concentrated on the effects word prediction had on the spelling of 80 fourth through sixth graders. They created carefully selected and comparable word lists that were dictated to participants who typed using different software features. That way, the AT, which alleviates writers' difficulties with spelling and handwriting, was assessed without adding the confounding variable of generating ideas for which writing strategies have been found to be effective. They found that, although spelling did improve, it took students longer to type using word prediction and, at times, students would choose words in the list that were not the word needed but close in spelling.

Herold, et al. (2008); Asaro (2008); and Silio (2008) all studied some aspects of writing. Kenney's (2010) pilot study contained many aspects found in Silio's research and to a lesser extent the studies of Asaro's and Herold et al. Using combined elements from the three studies, the pilot study, single subject research design (SSRD) with multiple baselines, assessed using picture-to-text and word prediction software on the written products of six children with mild to moderate autism. Although the study was originally designed to include younger children, the researcher noticed; during the recruitment of participants for the pilot study that younger students found were unable to communicate expressively with unfamiliar listeners, and therefore were not ready to express ideas in writing, thus, the lower limit of the original age range for the study was changed from six years to nine years and the total number in the participant pool was reduced to six children. Three children were classified as having mild autism and three were classified as having moderate autism (Kenney, 2010).

Two software programs, picture-to-text and word prediction, were used with six 10 to 11-year-olds, with autism who were divided into two groups stratified by language development and academic impact (Kenney, 2010). During baseline, participants typed using a keyboard to produce the writing sample. Three of the participants, all of whom were classified as having moderate autism, had great difficulty typing words with the keyboard. During the intervention, the picture-to-text word arrays, word banks, or pallets, as they are referred to by the software program used in this study, included 20 words with pictures in a 36 box pallet (see Figure 4). All 20 words were situated adjacent to each other with colored borders and proximity grouping to indicate the parts of speech, as has been found effective with students using augmentative communication devices (Wilkinson et al. 2008; Thistle & Wilkinson, 2009).

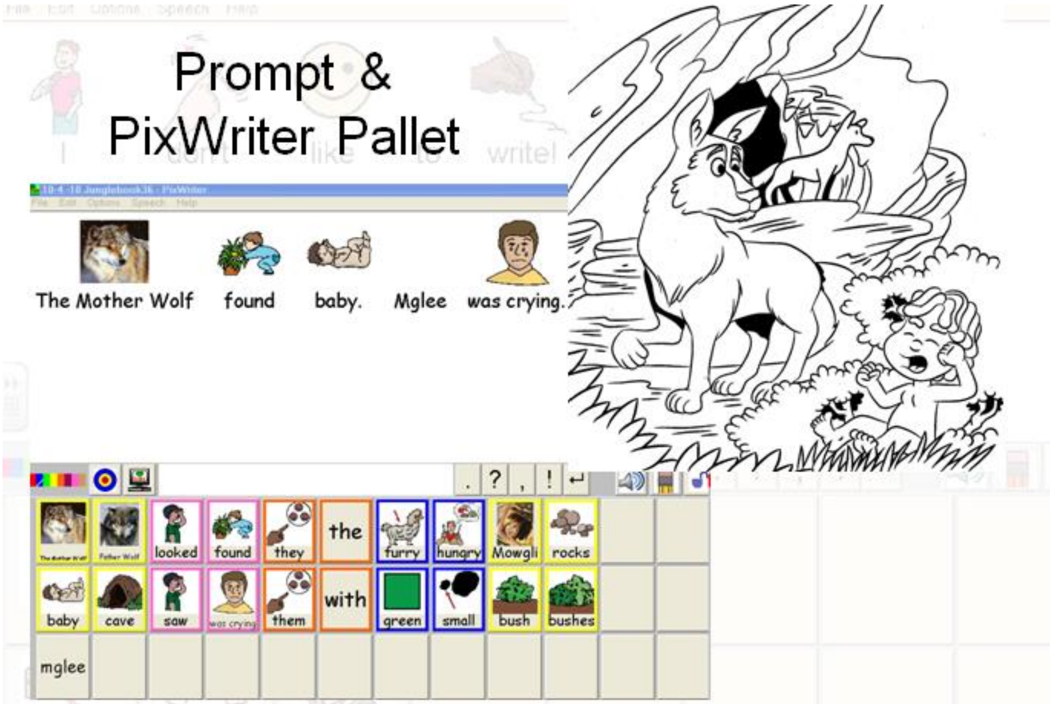


Figure 4. Pilot Prompt and Pallet used in Kenney, 2010.

Made with Literacy Support Pictures™ and PixWriter™ software, www.suncastletech.com

When describing balanced literacy activities for students with significant disabilities, Carnahan, Williamson, Hollingshead, and Israel (2012) entreat teachers to "avoid a 'readiness' model in which students must demonstrate certain skills before having opportunities to write" (p. 25). Technology, such as picture-to-text software programs with text-to-speech features, was suggested to involve those students who had not yet developed readiness skills in writing experiences. It was found that the participants with autism who had the most dramatic, positive changes in spelling, correct word sequence, and total number of words were those who started the study with the largest deficits in writing skills. It was also noted that higher scores generally resulted when participants were given access to the picture-to-text software. Children with autism generally respond more positively with consistency. In the pilot study, participants had to deal with three different conditions in 18 sessions. Because research with picture-to-text software for writing cannot be found, the subsequent study focused solely on picture-to-text software, which limited the number of conditions.

The resulting data (Kenney, 2010) suggested that the three participants with the greatest academic impact, Omar, Leopold, and Ms. Ladybug, demonstrated the most promising results when using picture-to-text software. In the pilot study, although all participants had some level increase in the majority of dependent variables, the most consistent and greatest improvements, when using one or both AT features, was with the increased level of percentage of correct spelling and CWS across all participants. All participants stated they preferred picture-to-text. Four out of six participants clearly relied on picture-to-text for the writing samples. Those participants who depended heavily on the picture-to-text feature had the lowest baseline scores and were more academically challenged (Kenney, 2010).

The goal of this current study was to discover if picture-to-text software could have a positive impact on the written output of young writers with moderate autism who had a history of difficulty with written expression.

Writing measures. Curriculum based measure (CBM) is an effective way to monitor progress as students learn different skills (Walker, Shippen, Alberto, Houchins, & Cihak, 2005). CBM measures were developed as a reliable, practical way to assess writing (Malecki & Jewell, 2003). Three to five minute writing probes reveal much about the writing skills of young students and Correct Word Sequence (CWS) (Malecki & Jewell, 2003) is a CBM that was used in a number of writing studies that measured students' writing skill growth.

In an effort to respond to frustrated teachers and psychologists regarding the accepted writing CBMs, Gansle, Noell, and VanDerHeyden (2002), studied 14 CBMs for validity, reliability, correlation between probe scores and teacher rank, and a number of currently used wide-scale assessments. Of the 14 measures applied to writing samples of third and fourth graders, total number of words written, words written in correct sequence, and number of simple sentences were included. The measure, words and correct sequence, was shown to have both correlation with criterion measures, good stability and validity. "Clearly, words and correct sequence is a good index variable for written expression as measured by criterion measures discussed here" (p. 496). Because of the difficulty with establishing inter-rater reliability for simple sentences, it was more difficult to use. In 2006, Gansle, VanDerHeyden, and Noell, replicated and extended the research finding total words written, words spelled correctly, words and complete sentences, and number of complete sentences "to be reliable and to have moderate validity coefficients with standardized tests" (p. 445). Correct word sequences, which are more difficult and time-consuming to score, produced the highest validity coefficient.

Three minute writing probes were used with 946 students grades one through eight in three school districts (Malecki & Jewell, 2003). The results of this study indicated that for students in the early elementary grades, the percent of CWS showed significant growth over time. Correct minus incorrect word sequence "(CMIWS) appears to be a good indicator of student performance at all grade levels, and for many purposes" (p. 390). This finding was also supported by the study of Espin, De La Paz, Scierka, and Roelofs (2005). McMaster, Du, and Petursdottir (2009) noted that "Perhaps the CMIWS, which is the most complex scoring approach that we examined, is too advanced for beginning writers (e.g., Many students received negative scores because they wrote many more incorrect then correct word sequences)" (p. 57). During the current picture-to-text study, the baseline CMIWS scores ranged between -111 and positive 23 for one student and between -81 and +16 for another; therefore, it was suggested that graphs of the number of IWS be used instead.

In 2000, Stecker and Fuchs studied the progress of 42 students with mild to moderate disabilities. When teachers used data from curriculum-based measures to adjust instruction, students outperformed the control group on global achievement tests. "The power of a CBM is that the tool provides teachers with a valid and reliable way to determine a student's level of performance, as well as the student's rate of progress toward specific performance goals" (Goo, Watt, Park, & Hosp, 2012, p. 34) .

McMaster, Du, Parker, and Pinto (2011) also described CBM as reliable and valid assessment tools. For young writers they suggested using number of words written (WW), incorrect words (IW), correct word sequences (CWS), and incorrect word sequences (IWS). The most common CBMs for elementary school writers are WW, word spelled correctly (WSC), and CWS (McMaster, Du, & Petursdottir, 2009).

3. METHODS

This chapter details the methods used for this intervention study describing the participant characteristics and selection, the setting, and sample size. Next, the intervention method is explained, along with the materials, deliverer, duration of the sessions, and researcher response to compliance issues. The measures are described, along with the sequence of the sessions, two phases of baseline and intervention, randomization, and data collection. Social validity with the participant survey and parental survey, inter-rater reliability, and treatment fidelity that are integrated to increase study's quality are outlined. Finally, the research design, independent variable, dependent variables, and description of data sources are delineated. The chapter concludes with an outline of data analysis procedures.

Participants

After the George Mason University's Institutional Review Board (IRB) granted permission for this research study (see Appendix A), and consent and assent forms were approved (see Appendix B and Appendix C), participants were sought. This researcher attempted to focus on younger participants with moderate autism. The younger children available, had extremely limited, or no, comprehensible, oral communication, and consequently were not developmentally ready to communicate in writing. Children who were older, or had enough academic skills to read words and type simple sentences independently, did not need pictures paired with text. Therefore, the participants included in this study were children between the ages of 9 and 10 years old, with academic abilities that were well below expected levels.

Recruitment of participants. Through a partnership with a local Autism Society, whose membership includes over 1000 families in an online support group, an invitation to join a research was sent to the list serve. The invitation included an explanation of the project, the eligibility requirements, the time requirements, and email contact information. A meeting was then arranged to outline more detailed information about the details of the study for parents. Parents who expressed an interest were provided a consent form and participants were given an illustrated assent form. The forms were explained and questions were answered. If a parent remained interested, arrangements were made for a time and place to conduct the AT screening (see Appendix D for the AT assessment and Appendix E for the participant surveys).

Parents who were unable to attend the meeting met with this researcher individually. The study was explained and all questions were answered. Then the electronic AT assessment was administered to determine if the child and this study were compatible. For those whose scores indicated compatibility, if the parent and child also indicated that they wanted to join the study, both parents and participants signed the approved university IRB consent and assent forms and the parent completed the first parent survey (see Appendix F). Contact information was shared in order to set up scheduled meetings.

Through parent responses on the surveys information was gathered about each participant. At school, all three students were in self-contained classes for a majority the academic portions of the school day. Each was reported to have enjoyed using computers, although none had demonstrated efficient keyboarding skills. Each participant was described as an emergent writer or had documented writing difficulties, including trouble with spelling and/or handwriting as documented in his or her IEP. Each parent agreed that his/her child disliked writing and had a tendency to avoid writing tasks.

Table 1

Description of participants in this study

Participants	Age	Grade	Ethnicity	Primary Disability	1 IEP Deficit
Dora F	(125 mos)	5	Caucasian	Autism	Writing
Abe M	(108 mos)	4	Caucasian	PDD-NOS	Writing
Boots M	(108 mos)	3	Caucasian	Autism	Writing

As demonstrated by responses from the AT assessment described on page 82 the participants chosen were able to repeat words modeled by an adult and label items in a picture. All three participants scored as well or better in visual comprehension skills than in phonemic awareness demonstrating a relative strength in visual comprehension.

Three participants were chosen. To protect the identity of these participants, pseudonyms were used. The first participant was Dora, the second participant was Abe, and the third participant was Boots.

Dora. Dora began private speech therapy at age 2 and started in a non-categorical preschool class at age 2.5. She was able to generate simple sentences independently, but she was very difficult to understand due to the speed and intonation used while speaking. As with most individuals with ASD, she exhibited unique skill levels. Dora, the only female was 10 years old and was about to begin the fifth grade at a private school for students with disabilities that included a special program designed for students with Autism. She was in the special educational setting throughout the school day.

Dora's scores were well above the scores of the other two participants, indicating a greater degree of academic skills. Dora demonstrated an ability to read more words, use phonemic awareness skills to decode, and, in addition, revealed a greater degree of visual comprehension. The word match items were four simple words that were to be matched to a picture. Dora matched all four words, whereas, Abe and Boots each missed one match.

While Dora could speak in phrases and simple, independently generated sentences, it was difficult for unfamiliar listeners to understand what she was saying because she uttered rapidly connected words with atypical intonation. She was able to articulate three syllable words and repeat words spoken to her. At times she had difficulty naming pictures. She could read and decode words on a third grade level, identify some grade level sight words from a field of three, but her teacher reported that she read and comprehended text at a lower first grade level. Her mother reported that that she didn't like to write; she didn't write sentences, and that she had not started to type using the keyboard yet.

Dora had difficulties in school from the beginning. Although she was considered well below grade level in the areas of both reading and writing, Dora enjoyed looking at magazines and books by herself. Her strengths were in reading a number of sight words, following simple directions, and navigating a computer using a mouse. She was interested in using a computer and was eager to begin computer activities. Her computer activities both at school and at home were usually games and the Internet.

When asked to write, Dora wrote her name and three simple words (4 to 5 letters in length) that related to the picture with moderate prompting. The letter formation she used was large but generally legible with good spacing, and she attempted to keep letters between the lines and created recognizable letter formation for many of the letters. She did have difficulty orienting a few of the letters between the lines and the hump of the lowercase “h” was almost as tall as the line making it difficult to recognize. The spacing between letters and between words was appropriate which added to the legibility. Accommodations provided such as access to fat pencils and pencil grips resulted in limited benefits. Her IEP at the time of this study contained no writing goals or AT accommodations.

She was able to understand symbols and pictures, however, due to improved reading skills, symbols were no longer required to assist in comprehension. At home she used a written schedule and crossed off events when they were finished.

A few of the challenges Dora experienced during this study involved a short attention span for less desired activities and extra time to answer questions. Her mother’s concerns were that Dora had difficulty connecting thoughts to words on paper.

During the initial AT assessment, Dora responded correctly to all four phonemic awareness items and the picture comprehension questions. She was able to self-correct in one of the phonemic awareness items, and combine pictures to gather meaning. She was able to vocalize several sentences about a picture that was presented and could write both her first and last names.

Dora typed using the keys by touching a key with her index finger and hunting for the next letter rather than using the buttons with words. She was able to type words when letters were sounded and cues were provided as to the general area on the keyboard to find the letter. She typed five words before clicking on buttons; however, after she was asked to use a mouse, she was able to do so. When asked to type about a picture using the keyboard she was able to type different three words with one misspelling. In total, she typed 12 words; the three words were typed four times each and the sentences had nothing to do with the picture. She typed four spelling errors and earned a CWS of 50%. When using the first pallet in the assessment, she chose 19 words and had a CWS of 36%.

Abe. Abe's mother explained that he had developed normally until he was about two years old when his behavior started changing drastically. Visiting many specialists was futile, until he was finally diagnosed with PDD-NOS. Abe's limited speech regressed. Later he began to repeat words, phrases, and sentences that he had heard from movies and TV, referred to as echolalia. He then progressed to repeating those phrases and sentences in appropriate situations. At the time of the study he had also begun using phrases and sentences in novel, situations and in original combinations that fit the context of the situation.

Abe started kindergarten at age 5. He had recently turned nine and had attended a local district-wide classroom for students with Autism for the last several years. As a rising fourth grader, Abe attended general education classes for specials, lunch, recess, and hands-on science projects

School was difficult for Abe from the beginning. His reading and writing skills were both well below grade level. Abe was able to read words with picture cues and in school was reading at a primer level, but his comprehension was poor. He preferred to read books with others rather than independently. He spelled phonetically and did not like to write. When asked to write he tended to delay beginning and became very distracted. One strategy that was successful for Abe was drawing one line for each word he was required to write. With those as cues and with moderate verbal prompting he was able to write a 3 to 4 word sentence.

Abe enjoyed using the computer at home for games, Internet, and educational reinforcement. He did those same computer activities at school with the addition of some writing activities. Strengths that Abe demonstrated were computer navigation and working with structure. He was able to point to drag a small target in order to select answer choices, classify plants and animals, and label the pictures. Additionally, he was able to respond appropriately to many questions and self-corrected several responses. Abe's mother suggested that with more scaffolding, he could be more successful.

Abe's impulsivity and tendency to avoid difficult work rendered academic activities challenging. Although he showed sensitivity to loud noises, when given a non-preferred task he would protest volubly. He could be redirected with quiet coaxing. He enjoyed playing Monkey Ball as a reward for working. With five minute warnings that the time for playing was almost finished, most times he was able to put the video control aside and come to the table to work without undue protesting.

When asked to write, he demonstrated an awkward pencil grip and had difficulty beginning the task. Once extra lines were added to the paper to indicate the number of words he had spoken, he wrote four words and spelled three correctly. He had difficulty keeping the letters between the lines. Five of the 15 lowercase letters extended beyond the middle line and five floated above the baseline. The tails of the “p” and “g”, which should have been below the line, were on the bottom line. The letter formation was tentative but generally legible. He was able to write all the letters of his first name but did not attempt his last name.

In the phonemic awareness items, Abe responded correctly one out of three times. He was more successful with the picture comprehension items earning a total of 11 points out of 20 and he could label items in a picture.

Abe had difficulty typing words with the keyboard. He was very focused as he found the letters to type the words “in” and “the” and a group of letters. He retyped the same phrase giving him no sentences but 33% CWS. When given the first word pallet without pictures, he independently chose two words that went together but refused to choose anymore giving him 50% CWS.

Boots. Boots started preschool at age 2, Boots was able to repeat words and simple sentences but rarely generated sentences independently. He recently celebrated his ninth birthday. Boots attended a local district-wide classroom for students with Autism. Boots was about to begin the third grade and joined his non-disabled peers in only non-academic classes, such as music and PE.

Boots, had been nonverbal until the age of seven. After two years of limited speech, his mother reported that, Boots' verbal communication had recently regressed during the summer break from school. At the beginning of the study, he was able to repeat a limited number of words and simple sentences, as well as other vocalizations, but rarely generated words or original thoughts. It was difficult for unfamiliar listeners to understand his speech due to articulation and intonation.

Academically Boots was achieving well below grade expectations in both reading and writing. Boots was able to recognize a limited number of simple words when pictures were included as cues. He had a voice output device and had access to a computer at school for drill and repetition of concepts and educational reinforcement. At times he used a computer at school for writing, which was very motivational for him. He enjoyed looking at books independently and his mother reported that he did enjoy writing with either a pencil or a computer; however, he needed a great deal of help with both mediums.

At home he used a computer for games and Internet as well as educational reinforcement, but he needed maximum support to be successful. His mother suggested that if he had more practice and different strategies, he might be more successful with writing. His mother had seen improvements in Boots' writing with the assistance of an occupational therapist and behavioral therapy.

When asked to write about a picture, he wrote only his first name four times, but it was very difficult to decipher most of the letters. However, when asked to sign the paper, he was able to write his first name and part of his last name. In the phonemic awareness section of the AT assessment, Boots answered one item correctly out of four. In the picture and comprehension section he was able to earn 12 out of 20 points. He labeled a few items in the picture but was not able to respond with a sentence.

When typing, Boots typed 12 random letters earning 0% CWS. When given the initial pallet for typing about the first picture, he chose 50 random words earning 4% CWS.

Member check. After the description of each child was complete, it was sent to the parent for feedback to ensure accuracy. Each parent had one or two minor comments that were incorporated into the final description.

Setting

This study took place in a large metropolitan area on the East Coast of the United States. Due to parent request, the researcher met each participant in the kitchen of their homes. The computers and materials were set up on the kitchen table. Each session was conducted with one participant and the researcher.

Between sessions, each participant was given the choice to go to another room in the house to engage in a familiar activity for a minimum of 15 minutes, to play with recreational activities on an iPad, or interact with the researcher in some quiet activities. Between sessions, Dora enjoyed playing on the iPad; Abe played Monkey Ball in another room; and Boots generally ran to another room and played actively. However sometimes Boots requested to play on the iPad close to the researcher.

The researcher conducting these sessions was an educator with a Master’s degree in the area of special education and 25 years of teaching experience, with 15 years spent in general education classrooms, five years working with students with special needs both in resource classrooms and in inclusion settings, with the most recent five years as an assistive technology specialist, training young students to use a variety of assistive technologies, including picture to text software.

Dependent variables

Writing samples, Camtasia screen recordings, audio recordings, and interview responses were used to collect data for the dependent variables researched, including the number of sentences typed, the percent of CWS, and the number of IWS. Excel spreadsheets and ChartDog 2.0, (Wright, 2010) on-line graphing software, were used to graph and analyze the collected data.

A researcher developed Scoring Sheet (see Appendix G) was used. The scoring sheet indicated the rater and had a table in which to paste the writing sample for markup. The columns provided a space for the data, including number of words, CWS, TWS, percent CWS, IWS, sentences, and IRR.

Number of sentences. In order to determine the number of sentences the guidelines in Appendix H were used. The minimum of a subject and a predicate placed side by side was necessary; however, in a writing sample that appeared to be random words without making sense, three words together were required to indicate that it was an actual thought communicated rather than a lucky random choice.

To measure the number of sentences written, the Scoring Sheet in Appendix G was used. The writing sample was pasted into the second column. First, the sample was read as written. Next, a red slash was inserted after each period included by the participant. Then, the reader looked for subjects and predicates that followed the rules set in Appendix H but did not have a period at the end. A red slash was inserted at those points. Finally, slashes were counted to indicate the number of sentences typed.

Percent correct word sequences (CWS). The second dependent variable was the score for CWS. To measure writing accuracy, points are awarded for each pair of words correctly sequenced with proper capitalization, spelling, punctuation, and word usage (see pp. 7 & 8 for further explanation.).

Using the Scoring Sheet (see Appendix G), carats were inserted to indicate each correct word sequences. For each incorrect sequence an under score was inserted. The percent of CWS was found by dividing the CWS by the sum of the IWS and the CWS.

Incorrect word sequence (IWS). The third dependent variable was the number of IWS. A pair of words that contained an error in spelling, punctuation, or syntax, was considered an IWS**.** One error could affect two pairs of words (see pp. 7 & 8 for further explanation.). As mentioned above, an under score was inserted to indicate each IWS.

Quality measures.

To ensure quality of a study social validity, inter-rater reliability, and fidelity of treatment should be incorporated. This study included all three of these measures.

Inter-rater reliability. Easterbrooks and Stoner (2006) used a point-by-point system on 20% of the written products; therefore, the point-by-point method was used in this study as well. A percentage of agreement was established through the following process. The first data collector was the researcher. The second data collector was a teacher with many years of experience teaching students with Autism. After the second data collector had satisfactorily completed the online Collaborative Institutional Training Initiative (CITI) course required of researchers by George Mason's HSRB, she was given a binder with data collection sheets and directions for collecting Correct Word Sequence (CWS), including:

• Procedures for Scoring Writing Samples University in Minnesota – RIPM Grant (October 4, 2005 update);

• Curriculum-Based Measurement: Directions for Administering and Scoring CBM Probes (Wright, 1992). and;

• Sail Into Literacy Monitoring the Progress of Writing: Correct Word Sequence (CWS) (Schechter, 2008.

Training. The two data collectors reviewed the scoring sheet for familiarity (see Appendix G.) and the rules (see Appendix H.). Together, they decided on clarifications that were needed in order to arrive at a common understanding for assessing number of words, number of sentences, CWS, and IWS. Both raters were trained to assess writing by using sentences unrelated to the research samples. Each rater independently assessed one sample at a time. The scored samples were compared and differences were discussed until greater than 95% agreement was achieved. Disagreements were debated and practice materials were used until the raters achieved 98% agreement or better for two consecutive samples.

Inter-rater reliability coefficients. Using a random number generator, 25% of writing samples to be verified by both raters were randomly chosen from each participant's set of samples for inter-rater reliability checks. The ratings were compared and discussed. Each time the scores were different, thought processes were deliberated and the final score was agreed by both. The rest of the samples were then rechecked to verify accurate results. The percentage was calculated by utilizing Point by Point Method (Easterbrooks & Stoner, 2006). The formula for Point by Point Percentage equals the number of Agreements divided by the number of Agreements plus Disagreements multiplied by 100. Scores of the trained independent observer were compared with the researcher's data to determine point by point inter-rater reliability which was found to be 96.09% with a range from between 85.7% and 100%.

Treatment fidelity. In order for an intervention to be evaluated for effectiveness, replicated by other researchers, and eventually implemented in classrooms, it is critical to have a clearly outlined design of treatment and a method to determine treatment fidelity (Harn, Parisi, & Stoolmiller, 2013). However, in the field of special education, with its wide variety of contexts and unique makeup of student groups, the design must also be flexible in order to adapt to each distinctive educational situation (Harn et al., 2013). Structural fidelity determines if the intervention is implemented as the researcher designed it. It includes the description of the intervention, time allotted, all the steps and material covered and the completion of the number of sessions prescribed (Gersten et al., 2005).

To provide structural fidelity, a list of procedures and scripts were followed (see Appendix I for Session Sequence & Materials and Appendix J for the Fidelity of Treatment Checklists). A set of visual cue cards was used for each training session to ensure that all features and steps were trained and the sequence was comparable (see Appendix K for the session management cards).

The sessions were recorded through Camtasia and audiotaped. The Fidelity of Treatment check lists were completed by the observer for each session. The researcher and observer reviewed all aspects of the study including all checklists, as well as examples and non-examples of items on the checklists. Discussions ensued until common understandings of target actions and items to be observed were developed. Structural fidelity was assessed separately. Points were given according to the number of items heard in the recording and viewed during the sessions. The formula used to determine fidelity of structure was the number of points earned divided by the number of total possible points, multiplied by 100.

The observer attended 18 sessions and used the recorded sessions to complete the fidelity of treatment checklist for 25% of the randomly selected sessions. There were nine items on the checklist that were required for every meeting, for each participant, and there were two items that needed to be included at the beginning and the end, as well as, one item that was required for the first session. The total items for structural fidelity were 258. A total of five sessions included one error each. 67 sessions were found to have 100% structural fidelity. The results indicated the fidelity of treatment to be 98% with a range of between 90.1% and 100%.

Social validity. Kennedy (2005) asserted the importance of estimating the satisfaction surrounding research through a social validity measure. Easterbrooks and Stoner (2006) used a simple survey given to participants, parents, and teachers, both before and after their studies. Questions similar to those used by Easterbrooks and Stoner (2006) were developed for this study.

For this research, social validity was investigated through four surveys. Two interactive, surveys with the child elicited feedback from the direct consumer and two parent surveys obtained feedback from the indirect consumers as described in Kennedy (2005). Social validity was assessed via electronic surveys that were given to each participant before the sessions began. During the final meeting, another electronic survey was given to each participant. Parents were also given an initial and a final survey for feedback on their impressions of the study. Initial and final responses of both participants and parents were compared.

Additional data sources. The interviews and writing sessions were audiotaped in order to accurately identify participant reaction to interview questions, the AT assessment, and the software used. The audiotapes were reviewed by the researcher and an independent observer to document fidelity of treatment and were destroyed upon the completion of analysis. Audio recordings were used as a backup during the two sessions that Camtasia software didn't work. Participants' written products were collected and analyzed after each session. The Camtasia recordings were reviewed to determine the participants' exact actions during the three minute timed writing sample. This process helped to verify precise beginning and ending of the sample. Although a stopwatch was used for each writing sample during the session, Camtasia software included a timer that was utilized to determine the exact three minute stopping point for each session. The recording pen was particularly helpful with the process of determining part of the fidelity of process by two raters. Using the pen, the raters could listen and return to precise points in question. During the validation of fidelity of process, each item could earn from zero to three points. The number of cues given the participant in a session resulted in fewer or no points given for that item.

Independent Variable

The independent variable in this research was the provision of a visual cue, or picture, over words. The visual cues (simple pictures) were supplied by a software program and paired with text in order to help convey meaning to the participant.

Picture-to-text software. A pallet of words, very similar to an electronic word wall described by Narkon et al. (2011) was provided by this software. The pallet consisted of 13 words within a 36 word pallet. During baseline, the words had no pictures and were not grouped according to sentence structure (see Figure 2). During intervention, the words in the pallet had a picture placed on top and the buttons were also color-coded (Wilkinson et al., 2008; Thistle & Wilkinson, 2009), and as found in the study of Pennington et al. (2010), grouped according to sentence structure and parts of speech (see Figure 3). In both phases, two distractor nouns, unrelated to the picture, were included. The participant could either choose a word from the pallet or type a word using the keyboard. When the participant typed a conventional word, a simple picture depicting the meaning of the word appeared on top of the text. If the word was misspelled, only the text was put in the typing area. The software then pronounced the word or letters that were typed. The software program used for this study was PixWriter 3.2 by Slater Software.

Materials and Validation of Materials

For this study, a number of materials were used, including an interactive technology assessment, two surveys for the participants, two surveys for the parents, a laptop, picture-to-text software, a screen recording software, a CWS scoring sheet, a fidelity checklist, a compliance checklists, collection of CWS Samples and non-examples of sentences, direction cards, training cards, a visual timer, a stop watch, a digital recorder, and a recording pen with specialized note taking paper for the researcher.

Electronic interactive assistive technology assessment. The participants were screened using a researcher-created electronic AT assessment. This assessment, created using smart notebook software, was first used in the pilot study with six participants and adjusted according to which items produced pertinent information. From this assessment, 30 items were used to establish the participant's attitude towards computers, and visual comprehension, and other relevant areas of experience and development. Each demonstrated an ability to understand pictures and was able to access a computer through a mouse or keyboard.

The observation of the responses from the AT assessment provided information about the skills of each participant; for instance, the researcher noted the ease with which each participant used the mouse, navigated the screens, and the degree to which each attended to the information. As the researcher completed the electronic AT assessment with each participant, a better picture of strengths, weaknesses, oral communication skill level, and reading/ pre-reading skills became more evident. It was important to determine the communication skill level of each, because many studies show concurrent development of children's awareness of oral and written language (Lee, 1993). Without some language skills a child may not be ready for written language. The interest in reading skills was due to the nature of the study. Children able to read would be less likely to need picture cues.

Table 2

Assistive Technology Assessment Scores for Participants

Participants	Typed # words	Typed % CWS	Buttons # words	Buttons % CWS	Phone mic A	Visual Comp.
Dora	12	50	19	36	100	100
Abe	9	33	2	33	25	67
Boots	0	0	50	2	25	75

Validation of the AT assessment. During the pilot study a number of items that had been originally included were found to be irrelevant to the writing skills that were under study. Items such as, "I have used word prediction." and listening comprehension items were withdrawn resulting in a more compact assessment.

Participant survey. Survey questions were embedded in the tech assessment with a set of 30 questions that were given in the beginning sessions and similar questions that were given after the last intervention session. Each child responded to the structured survey as part of the electronic assessment and was asked to respond orally or to move a circle to a picture or the picture to a circle to indicate the preferred answer. There were 13 questions, such as:

This is how I feel about writing.

Using the computer helps me to write.

I like to write with a pencil instead of using a computer.

This is how I feel about working on this project.

These items were read aloud while being presented on a computer laptop monitor with picture cues to help the participants understand the question. The participants had a choice of whether to respond orally or to move a circle to a Likert-type scale that included a range of four responses (Kennedy, 2005). Four boxes displayed a range of facial expressions from a big smile meaning the participant liked it or agreed with the statement to a big frown indicating that the participant disagreed with the statement. Four choices were presented requiring the participant to choose a response that indicated some measure of agreement or disagreement rather than having an option directly in the middle, which may not indicate any preference all. Three of the items were worded in such a way as to discriminate between carefully considered responses and impulsive or repetitive choices. Whereas one statement declared, "I can write better with a computer." Another stated, "I prefer writing with a pencil, not computer." Those responses were compared with items that indicated a reverse preference to see if the participant's actual preferences appeared consistent.

At the end of the study the participants had a similar format to choose items such as:

This is how I feel about typing with PixWriter.

I like to write with a pencil instead of a computer.

I like to hear a computer read to me.

This is how I feel about working on this project. (see Appendix E for the PDF version of both electronic Surveys.) Responses given in both interviews were compared. The responses for each item were summarized (Kennedy, 2005) and compared to determine if attitudes changed after using picture-to-text software.

Validation of participant survey. The survey items used with the participants were validated during a pilot study (Kenney, 2010). The order of the survey items was adjusted and several questions that were irrelevant to the study were deleted, particularly those that related to word prediction software.

Parental survey. A survey was given to the parent at the first meeting. Some of the items identified the child's age, time in school, and history about the child's difficulties in school. It also queried the child's reaction to writing tasks and some interventions that had been employed. A second survey with similar items, which included a number of open ended questions, also included a few items that pertained directly to the study experience. It was completed at the last session and answers were compared to determine any changes from the first survey.

Some of the parent multiple choice questions from the first survey were:

My child’s writing is

A. On or above grade level.

B. A little below grade level.

C. Well below grade level.

Which of these statements best describes your child’s feelings about using computers?

A. Avoids using computers as much as possible.

B. Uses computers to play games only

C. Uses computers to do some homework

D. Is excited about using computers

Some of the open ended items from the second survey were:

The best part of this study was …

When my child uses PixWriter …

When my child writes with paper and pencil …

In the beginning of the last session the parent was given a survey to determine if he/she felt the study was useful for his/her child (see Appendix F for both parent surveys). Responses were compared to determine if the parent felt that the software helped their child with writing and whether or not the child seemed to enjoy the activities included in the study.

Validation of parental survey. The parental survey was validated during the pilot study (Kenney, 2010). The items were found to collect appropriate and relevant information.

Hardware and software. Participants typed using a 15 inch HP laptop with a trackpad and an external mouse. The researcher provided a laptop that was equipped with Camtasia, a screen recording software, and PixWriter, a picture-to-text software with text to speech feedback. Two recording devices were used to record sessions, a small digital voice recorder and a Live scribe recording pen with special note paper that enabled notes to be uploaded to the computer for in-depth review.

Session management tools. In order to help the participants understand rules, directions, and remain on task, researcher created visual cue cards were utilized. The laminated cards were created using PixWriter software (see Appendices K & L). Some of the visual direction cues were put on and 8.5 x 11 sheet of card stock and others including the auditory prompt and training cards were put on 3x5 index cards, and together with a metal ring. These cards added consistency to the sequences, augmented the auditory directions, and reduced the number of extraneous vocal cues.

Validation of session management tools. During the pilot study cards were used and found to be very helpful. Rings were added to keep cards organized and ready for use.

Visual sentence starters. Researchers have employed a variety of types of sentence starters in writing research. Often verbal prompts are given however; Easterbrooks and Stoner (2006) used age-appropriate pictures gathered from magazines and newspapers as visual writing prompts. These prompts aided students and increasing the number of adjectives in their written products (Easterbrooks & Stoner, 2006). Visual sentence starters used in this study were validated by previous pilot studies as well as by the expert in the field as described in detail below. For each writing sample in this study a combination of a verbal prompt typed on prompt cards, (see Appendix K) and a picture cue that acted as a visual sentence starter (see Figure 1) were used to help the student generate sentences.

Validating visual sentence starters. During two pilot studies, conducted by this researcher, a number of types of pictures were used to help students produce sentences: colorful calendar pictures that were 8” by 12”, printed photographs that were 7” by 5”, printed pictures from the Internet depicting areas of interest for participants, pictures that were black and white versus pictures that were printed in color, and pictures of drawings by children were tried. Prior to meeting with the participants, this researcher and a professional educator working in the field of Autism, reviewed picture sentence starters that had been used in pilot studies. Of the approximately 100 pictures used, it was noted that participants seem to respond to colorful photographs and pictures from the Internet that were printed on one half sheet of typing paper. In the first two pilot studies, participants were given choices of pictures as writing prompts. Out of the pictures that were chosen by participants, 39 pictures were assessed with the following desired criteria and ranked by the two educators. The prompt that best fit the criteria was ranked 1 and the prompt that fit the criteria least was number 39. The criteria for pictures included:

- Color,
- Describable by a minimum of
    - Three or four nouns,
    - Two or three action verbs,
    - Two adjectives and,
    - Two colors.
- A minimum of three sentences could be created using the words.

The top 30 pictures were chosen and randomly assigned to a session. Each participant in this study wrote about the same picture in the same numbered session.

Writing pallets. Each visual sentence starter was used to design a 36 cell pallet in which, 11 words that reflected what was seen in each picture along with two distractor nouns were placed. The pallets in both phases contained button groupings that looked similar (see Figures 2 & 3) and contained similar types of words. Pallets 6 through 15 each had two formats, one with words placed randomly and without pictures. The second format had the identical words that were placed according to sentence structure, had pictures on top of the text, and had a color-coded boarder.

Except for the two distractors, each word in a pallet could be reasonably used in a sentence to describe that particular picture which was verified by another educator. To provide standardization, the words were presented in this order: three nouns; three verbs; two connecting words “the” and a preposition, two adjectives; and three other nouns. A distracting noun was placed in each set of nouns. The words for all Phase A pallets had no pictures and were randomly placed in similar groupings.

In the Phase B pallet, words were paired with pictures and organized according to parts of speech and sentence structure, similar to the templates used by Pennington et al. (2010) and the first experimental condition for the study of Yamamoto and Miya (1999). Each cell also included a colored border to identify the part of speech.

***Validating writing pallets*.**

The two educators compared each pallet with the visual sentence starter. The pallet was required to have the following types of words that could be directly related to what was seen in the picture.

    - Four nouns or pronouns
    - Two nouns that could not be found in the picture
    - Three verbs,
    - Two adjectives and,
    - One preposition
    - One article
- A minimum of three sentences could be created using the words.

Procedures

This section includes the description of the sessions for both training and data collection, including descriptions of Phases A, Phase B, and the Maintenance Phase. Modifications to the procedures used for one participant are also explained.

Before participants joined the study, the intervention points were randomly chosen to create three tiers. In this multiple baseline study, one participant was randomly assigned to each tier. The intervention was introduced in a staggered fashion so that while the first participant began treatment in session 6, the other two were still in baseline. The second participant started intervention in session 13 and the third continued baseline until session 15.

This study was comprised of two phases. Before each phase, training and modeling were provided to ensure that each participant understood the procedure, the expectations, and the use of the software features included in that specific phase. Phase A was Baseline with a 13 word pallet without pictures. During Phase B, the intervention phase, participants had access to pictures within the pallet, and four to five weeks after the last session; three maintenance probes using the picture-to-text features were conducted. During all writing sessions, the word pallet was located underneath the writing space. Data collected from the writing samples were graphed.

Ultimately, each participant met with the researcher individually, 9 to 10 times for a total of 24 sessions. Each session was audiotaped with one small digital recorder, an Echo recording pen by Livescribe (2011), and Camtasia Studio 7 (TechSmith, 2010) software was used to record the participants' keystrokes, and navigation on the computer as participants responded to an oral writing prompt with a visual sentence starter by using a PC laptop with PixWriter 3.2. Camtasia software, a digital tape recorders, and the pen were started at the beginning of each session.

First training session. Before the first baseline session, each participant was trained briefly to use the picture-to-text software. The picture option for the pallet was unavailable. Four instruction cards with pictures and text were used to add visual input and to ensure the four skills (choosing words, adding words, erasing words, inserting punctuation) needed for the writing samples were covered. (see Appendix L). The writing procedure was modeled for the participant, and then the researcher practiced with the participant. After the participant demonstrated all four skills with the pallet and created two to three phrases or sentences, a 15 minute break was given. The first 3 minute baseline session was started after the break.

Phase A- baseline phase. For each session in Phase A the computer was prepared with a blank document with the word pallet, without pictures on top of the text.

For each session, the child was shown a different 5 x 7 picture as a visual sentence starter to assist with ideas in order to create sentences. At the start of each three or four session meeting, the participant and the researcher greeted, reviewed the rules, recounted the number of sessions to do, “1 PixWriter then break, 2 PixWriter, then break, 3 Pixwriter then all done,” after which the script cards were read together. This procedure took about 3 minutes for the first session of the day and between 45 and 75 seconds for subsequent sessions. The writing prompt began when the first key was struck on the laptop and continued for three minutes.

While looking at a sequence of direction cards that included words and pictures to help the participant follow along, the following script was read.

Script: "Look at this picture. Think about it. Write three or more sentences to tell what is in the picture or to tell what could be happening. You will have three minutes, but if you need more time, let me know."

The participant then had time to write. The session was considered to be completed when either, three minutes had passed or the participant stopped typing, which ever was longer. After each session the participant was given a 15-minute break in which the participant was allowed to choose recreational activities on an iPad or another quiet activity. For a majority of visits three sessions were completed. Baseline data were collected for five sessions for Dora, 12 sessions for Abe, and 14 sessions for Boots.

Second training session. To introduce each participant to the intervention in a staggered way, six cards with pictures and text were used ensure all five skills needed for the writing samples were covered (see Appendix L). Clicking the listen button was added to the first four skills. Again the researcher modeled the writing procedure, and then practiced with the participant. After the participant demonstrated the ability to use the picture pallet to choose words, add words, erase words, insert punctuation, use the listening tool, and create two to four phrases or sentences, a 15 minute break was given.

Phase B- intervention sessions. As in Phase A, a similarly constructed 36 button pallet was presented with 13 of the buttons containing words that were paired with a picture over each word and organized in groupings according to sentence structure. The same prompt cards, with the prompt script, that were read during Phase A, were used in conjunction with different 5 x 7 picture sentence starter for each session (see page 96). The timing and procedure for beginning each writing sample was similar in both phases. Participants were directed to type for three minutes using the picture pallet. The participants were told that the session was over after writing for three minutes. After that, the participants were given a 15-minute break as described earlier, again, three sessions were conducted during each visit. Picture-to-text software with the picture pallets was used for the remaining sessions in Phase B.

Instructional interactions. If participants had difficulty transitioning from random choices of buttons having no meaning to demonstrating a realization that meaning could be involved instructional interactions needed to be applied to gain behavioral control of the participant. The scale brake in used on the graph to indicate discontinued sessions. Only after consultation of two very experienced practitioners, and some adjustment to the presentation and behavioral interventions, were the sessions in Phase B able to be continued. Calming techniques, explicit teaching, modeling, and practice were employed with an emphasis on color cuing. It took multiple sessions to demonstrate a readiness to be willing to use the pallets more independently. Verbal cues were needed for redirection for sessions 16, 17, and again in session 21; but the cues were decreased during maintenance. Some of the cues used were: “What’s in the picture?”; “What’s first?”; “What’s next?”; “Keep going.”; “A little bit more.”; “What else?” The number of cues and redirections required for the implementation to be successful in unexpected circumstances due to behavior were tallied (see Appendix M instructional interaction checklist). For the implementation of an intervention to be effective, there must be a balance between delivery with fidelity and adaptation to specific educational contexts and the characteristics of the student population (Harn et al., 2013).

Maintenance sessions. Four to five weeks after the final Phase B session, three maintenance sessions were conducted. During the maintenance sessions participants had access to the picture-to-text software with the picture pallets, using the same procedures as those during the intervention sessions described above. Camtasia recording software was again used to record how each participant typed their samples.

Procedures for randomization. In this study, randomization was included in several ways. First, the participants were randomly assigned the tiers or the order in which they would begin the intervention. Then, to randomly select the points of intervention for each participant, numbered cards from 6 to 16 were used. The researcher choose three random cards from a hat. Thus, the intervention starting points were six, 13, and 15. Pictures used as sentence starters to accompany the writing prompt were assigned a session number also at random.

Data Analysis

When data were analyzed, visual analysis and the percent of non-overlapping data (PND) were used. In the visual analysis, data points were analyzed for level, trend, variability, overlap, and immediacy of change, and consistency. After the data were collected, it was put in a software application called Microsoft Excel. Graphs were created for each of these areas;

- Number of sentences that contain the subject, predicate and possibly other words that made sense,
- Percent of CWS,
- Number of IWS,

The graphs of each participant were aligned vertically to show the different intervention points for the multiple baseline design. The data from the baseline were compared to the intervention phase and charts were assessed. The level of each phase was the mean of all data points in that phase. The trend described data within each phase by inserting a straight line that best fit between all points in one phase. When considering the trend, the slope and magnitude must be noted. The slope could be positive, flat, or negative and the magnitude could be high, medium, or low depending on the increase or decrease in the pattern of the data. The variability of data indicated how far data points deviated from the trend line or level of the phase. For this research, the overlap of the data determined how many data points in the treatment phase were not in the expected direction above or below the highest or lowest point in the baseline phase. The determination of immediacy of change was found by comparing the last data point in baseline to the first three data points during the intervention phase. Consistency was a comparison of phases with similar conditions and the data patterns of each. Noting how the pattern changed between phases with the introduction of the intervention revealed information about its effectiveness and indicated whether the effects were positive, negative, or neutral.

Park, Marascuilo, and Gaylord-Ross (1990) studied the question of the reliability of exclusive use of visual inspection of the data from single subject research. It was suggested that visual inspection should be used in conjunction with other analyses. For this study, visual analysis of the data graphs was compared with PND (Scruggs et al., 1987) and randomization tests were run.

For the PND, the percent of scores in Phase B that did not overlap the scores in Phase A was calculated for each participant by determining the number of treatment points higher than the highest baseline score over the total number of treatment points times 100. Because the desired direction for IWS was lower, the PND for IWS was calculated by using the number of points lower than the lowest baseline score over the total number of treatment points times 100. The accepted standard scale:

PND below 50% - ineffective,

PND 50 to 70 - problematic,

PND - between 70-90% - effective,

PND greater than 90% - large effect (Scruggs et al. 1987; Scruggs, & Mastropieri, 1998; Scruggs, & Mastropieri, 2013).

In addition to visual analysis and calculating PNDs, randomizations tests were used to examine the statistical significance of changes in the treatment phase. Todman and Dugard (2001) described randomization tests including one for multiple baseline studies with single subject design. The files described in Dugard, File, and Todman (2011) were used to conduct the randomization tests. According to required specifications, randomization was included in several ways. Each participant's name was put on a card that was matched to a randomly chosen intervention point between sessions six and fifteen. Picture sentence starters were randomly assigned to a session number. An additional requirement for the administration of the randomization tests was that the observation periods for each participant must be equal in number (Todman & Dugard, 2001, p. 58). Therefore, each participant completed a total of 21 writing sessions followed by three maintenance sessions four to five weeks later.

The macros in Excel version of Design Three, AB studies having one intervention and multiple baselines across students, were run to determine the probability that the results obtained were most likely caused by the intervention. Software evaluated all possible intervention points of all participants. Thus, having three intervention points for three participants, which is more practical, equated to the significance found after 20 possible intervention points.

Research Design

The design of this study was single subject research with multiple baselines across participants, (Kennedy, 2005). Because students with Autism respond better to stability and fewer changes, this design worked well for this study. Once the students were introduced to the picture-to-text software, the frustrating experience of withdrawing the intervention and writing without pictures was eliminated, which allowed for continued growth of their writing skills. Kennedy (2005) and other researchers consider this design to be ethically more appropriate, especially in educational settings.

4. RESULTS

The outcomes of this study examining the effects of picture-to-text software on the writing samples of emergent writers with moderate autism are presented in this chapter. First, the results of each of the dependent variables: Number of Sentences; Percent Correct Word Sequences; and Number of Incorrect Word Sequences are given for each participant. The results are based on the visual analysis, percent of non-overlapping data (PND), and randomization tests. Social validity results are also included. The chapter ends with a summary of the data analysis.

Number of Sentences

To be considered a sentence, a subject and a verb were required. In writing samples, where the majority of the words seemed to be randomly chosen, a third word was required to verify the communication of an idea rather than accidental success. Overall, all three participants produced more sentences in most Phase B sessions over the baseline sessions in Phase A. The average number of sentences written in Phase A was 0.6 (*SD* = 0.5), while the average number of sentences written in Phase B was four (*SD* = 1.6). The rise in level was notable, with an average 3.4 sentence increase. The average PND of Phase B over Phase A was 91.5%, (*SD* = 7.5). During maintenance, the average number of sentences was 3.5 (*SD* = 0.9) (see graph in Figure 5).

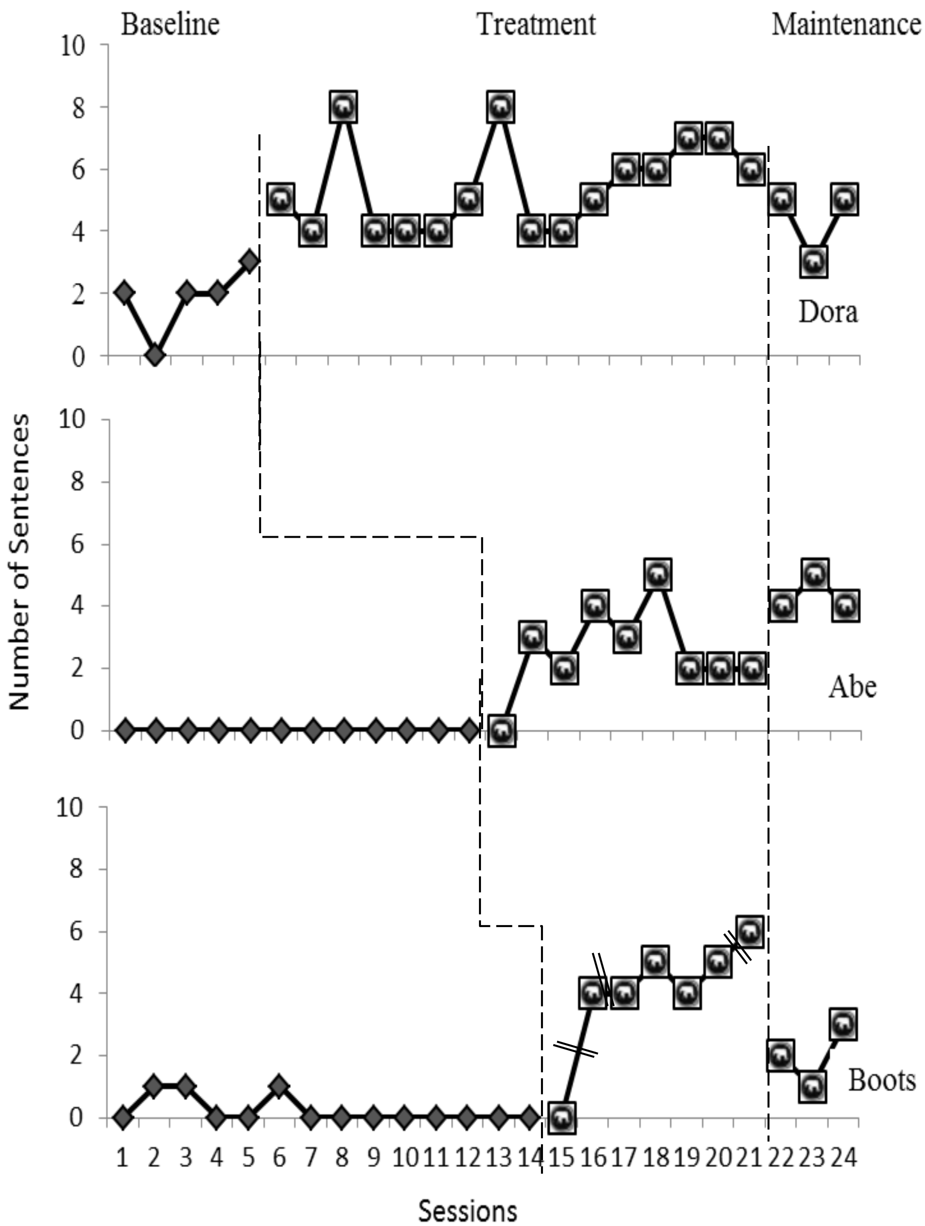


Figure 5. Participant graphs depicting scores of the dependent variable, Number of Sentences

Dora. Dora wrote an average of 1.8 sentences in Phase A, (*SD* = 1.09). During Phase B, when picture-to-text was introduced, she wrote an average of 5.4 sentences, (*SD* = 1.4). Dora had a medium rising trend line (Slope=+0.4/Intercept=+0.6) in Phase A and a slightly smaller rising slope (Slope = 0.11/Intercept= + 3.99) in Phase B. For Baseline, due to the outlying dip in session 2, (the data point was zero), the variability in the first three sessions was fairly large but stabilized in sessions three through five. Again in the first half of Dora's sessions in Phase B, variability was high but stabilized for the second half of that phase. Except for two sessions, session 8 and session 13, in which she wrote eight sentences each, the rest of her sessions were within approximately one sentence of the trend line. Starting with session 14 the variability was low. The PNDs for Dora in Phase B were 100%. Her positive change was immediate, with a jump in number of sentences from 3 to 5, occurring in the first intervention session, yet, the next session fell to four sentences and the eighth session rose to eight sentences. When addressing consistency, although Phase B contained a degree of variability, numbers of sentences were consistently higher than in Phase A.

During maintenance, Dora's mean number of sentences was 4.3, (*SD* = 1.2), which was greater than Phase A's mean of 1.8. Because of a dip in the second maintenance session, its trend was flat and variability was slightly smaller, two sentences, than both previous phases. Because the lowest score during maintenance matched the highest score during baseline, the PND was 66%. During maintenance session 23, in addition to choosing some of the words from the pallet, Dora spent time typing words. That caused the fourth sentence to be discounted because it had not been written during the three minutes causing more variability in those three sessions.

Abe. Abe wrote no sentences in Phase A, whereas in Phase B, he typed an average of 2.6 sentences, (*SD* = 0). Abe had flat trend line (Slope = + 0/Intercept= + 0) in

Phase A, but a medium rising trend line (Slope = + 0.1/Intercept= + 0.86) in Phase B. During Phase A, Abe had no variability because he typed no sentences. However starting with the second session in Phase B, he started writing sentences. The variability for Phase B was between zero and five sentences. Abe's PND of Phase B was 88.9% when compared to Phase A. There was no immediate change in the first treatment data point; however, there was an immediate change starting with the second treatment data point following the introduction of the picture-to-text software program. In Phase B, starting with the second treatment session, Abe's scores remained consistently above all scores in Phase A.

Abe's maintenance sessions had a higher level than both previous phases, mean equals 4.3, (*SD* = 0.6). The trend was flat and the variability was low. During maintenance Abe had 100% PND over Phase A. His maintenance scores were consistent remaining higher than all scores in Phase A.

Boots. For sessions two, three, and six, Boots typed one sentence each, but for the rest of Phase A, he had no sentences in his writing samples for a mean of 0.1 sentences, (*SD* = 0.4). However, in Phase B, he was able to write an average of four sentences when using picture and color cues in the pallets, (*M* = 4, *SD* = 1.9). In baseline, Boots had a negative trend line of (Slope = - 0.05/Intercept= + 0.59). In Phase B, he had steep rising trend line (Slope = + 0.71/Intercept= -8.86). The first six sessions in Phase A had some variability. During the last eight sessions in Phase A, Boots had no variability because he wrote no sentences. During the final six sessions in Phase B, Boots had low variability, writing between four and six sentences in Phase B. Boots had a PND of 85.7% when compared with Phase A. When considering immediacy of change, positive change began during the second session after the intervention was introduced and continued thereafter. Starting with the second data point in Phase B, Boots consistently wrote more sentences than in Phase A.

Boots' Maintenance Phase when compared with Phase A had an increase in level, mean = 2, (*SD* = 1). An upward trend, some variability, and an immediate decrease in the number of sentences when compared with Phase B, while the number remained higher than Phase A. PND for Maintenance over Baseline was 66% and two out of three of his scores during maintenance were consistently higher than Phase A.

Vertical comparison. When reviewing the graphs of the number of sentences for all three participants, the rise in level was notable when the intervention was put in place. There was a definite increase in the number of sentences by the second session in Phase B which was consistent for all three. While Dora's increased number of sentences began during the first session in Phase B, both Abe and Boots did not have an increase until the second session in Phase B. During Phase B, all three participants had an increase in the average number of sentences written. All three wrote more sentences during two out of three maintenance sessions than they had written during any three sessions in Phase A.

Percent Correct Word Sequences (CWS)

This measure was calculated by determining the number of pairs of words written correctly according to grammar, syntax, spelling, and punctuation. That number was divided by the total number of word sequences written.

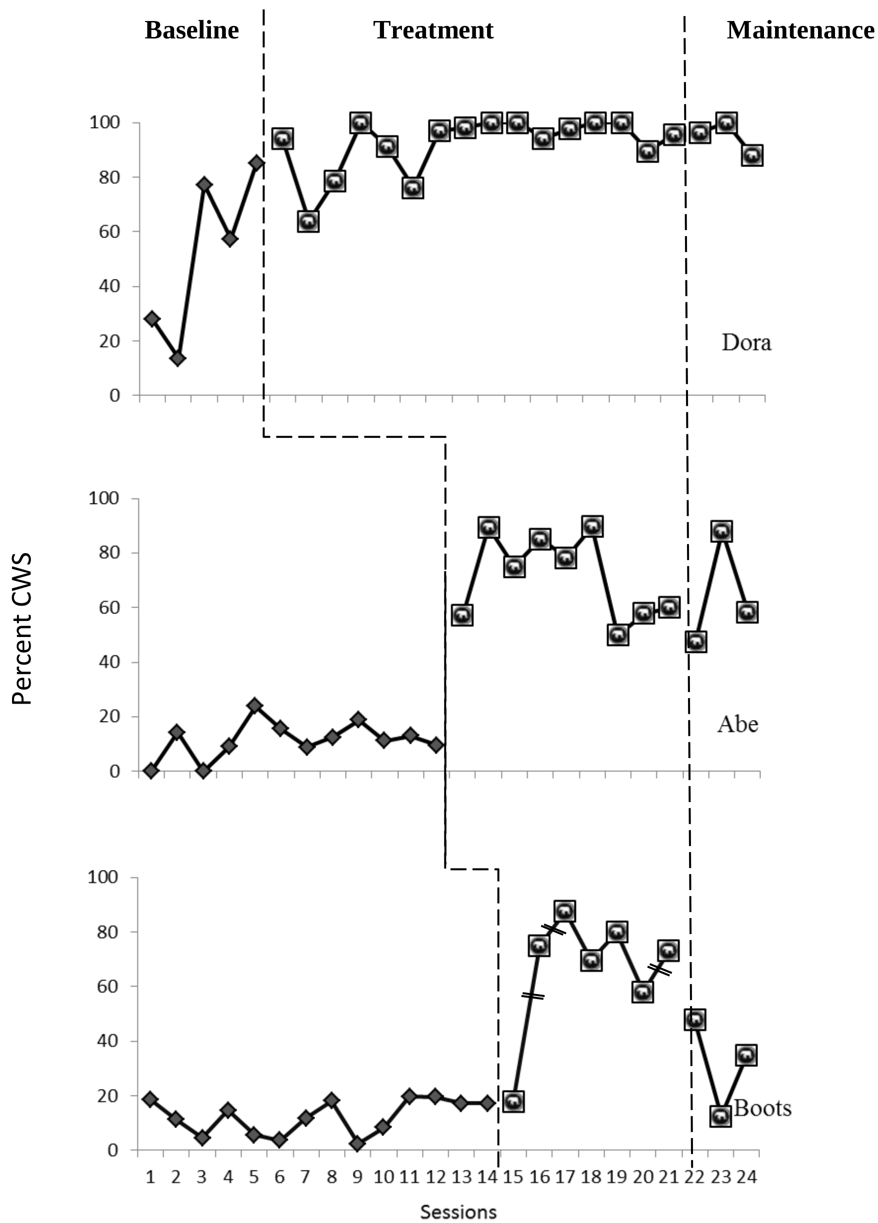


Figure 6. Participant graphs depicting scores of the dependent variable, Percent Correct Word Sequence.

For this measure, percent of CWS, all three participants had a substantial increase in level, from forty to sixty points. The scores for all participants in Phase A had a mean of 25.3%, (*SD* = 5.7), while in Phase B, the mean was 76.5%, (*SD* = 16.3). For PND, all three participants scored in the effective or very effective range, the mean PND was 89, (*SD* =.8). During Maintenance, the mean of CWS scores was 63.7%, (*SD* = 15), which was well above the mean of Phase A (see graph in Figure 6).

Dora. When analyzing at the Percent CWS for Dora, her mean level for Phase A was 52.3%, (*SD* = 3.9), with an escalation in level to 92.3%, (*SD* = 10.5) in Phase B. Dora had a sharp increase in her trend line of (Slope = + 15.8/Intercept= + 4.91) in Phase A and a lesser increase (Slope = + 1.09/Intercept= + 77.67), in Phase B, due to the ceiling effect. Dora's first two and forth sessions in Phase A resulted in very low scores with a substantial increase in the third and fifth sessions causing the variability to be high. Variability began leveling in session ten during Phase B. Dora's PND for Phase B was 81.3% over Phase A. In the measure, CWS, Dora's improvement continued but was not stable until the fourth session in Phase B. She did have one more score, in session 11 that fell below her top score in Phase A. Dora did not show immediacy of change, however after session 11 scores became consistently higher than the highest score in Phase A.

During Maintenance, her scores remained above all scores in Phase A, mean = 94.7, (*SD* = 2). During maintenance her trend was decreasing with low variability. PND during maintenance was 100% over Phase A.

Abe. Abe's mean level in Phase A was 11.4 %, (*SD* = 6.8) which increased to 71.4 %, (*SD* = 15.3), in Phase B. In Phase A, Abe had an increasing trend line of (Slope =

+ 0. 63/Intercept= + 7.3), while in Phase B the trend line went downward (Slope = -2.15/Intercept= + 107.9) due to variability of the data but all data points remained higher than baseline. Abe's variability was higher for the first six sessions of Phase A, with a span of 23 points but dropped and became more level during the last six sessions with a span of 10 points. His Phase B percent CWS scores were much higher than in Phase A, but with greater variability. Although in session 19 Abe's score dropped around 40 points, his last three scores in Phase B were steadier and were beginning to climb again. Abe had 100% PND in Phase B over Phase A. Abe's increase in scores was immediate and dramatic in Phase B and once treatment was introduced, his scores remain consistently higher than they were in Phase A.

During Maintenance, Abe's CWS decreased about seven percentage points to 64.7%, (*SD* = 21), which meant the levels were fairly close. Both levels were at least 53 points higher than his level in Phase A. Abe had a rising trend in Maintenance with continued variability. Abe's PND for maintenance over Phase A was 100%. His maintenance scores were consistently higher than Phase A scores.

Boots. Boots had a mean value of 12.3% CWS, (*SD* = 6.4), in Phase A which increased to 65.9% CWS, (*SD* = 23.1), in Phase B. Boots had a flat in the trend line for Phase A (Slope = + 0.51/Intercept= + 8.52), with the steeper positive trend line during Phase B (Slope = + 4.46/Intercept= -14.44). For Boots, the percent CWS scores varied from 2.3% to 19.8% rising and falling throughout Phase A. His scores in Phase B varied widely, beginning with 17.6% in the first session of Phase B, however; his last six scores varied to a lesser extent from 58.1% to 87.5%. Boots had 85.7% PND in Phase B over

Phase A. Boots' did not show immediacy of change with the first score in Phase B, however, the rest of his scores in Phase B showed a large increase. Other than his first score in Phase B, the rest of his scores remained consistently above the scores in Phase A.

Although during Maintenance, Boot's level was higher than Phase A, 31.8%, (*SD* = 17.9), it was lower than Phase B with a declining trend. Variability continued during Maintenance but two of his scores were at least 15 points above the highest point in Phase A. He had 66.66 % PND during Maintenance over Phase A. Boot's scores in Maintenance were not as consistent, two scores were above all scores in Phase A, but the middle score was not.

Vertical comparison. In comparison of graphs of all three participants, the data of the first participant Dora, began rising before the intervention was introduced. The other two participants had major increases only after the intervention in Phase B. Whereas Abe's increase was immediate, Boots' scores did not increase until the second session in Phase B. All three participants did demonstrate a rise in level once they had access to the picture-to-text software program.

Number of incorrect word sequences (IWS)

The Number of IWS shows the number of grammar, syntax, spelling, and punctuation errors in a writing sample. It was determined by calculating the CWS and subtracting that number from the total number of word sequences that were possible in a writing sample.

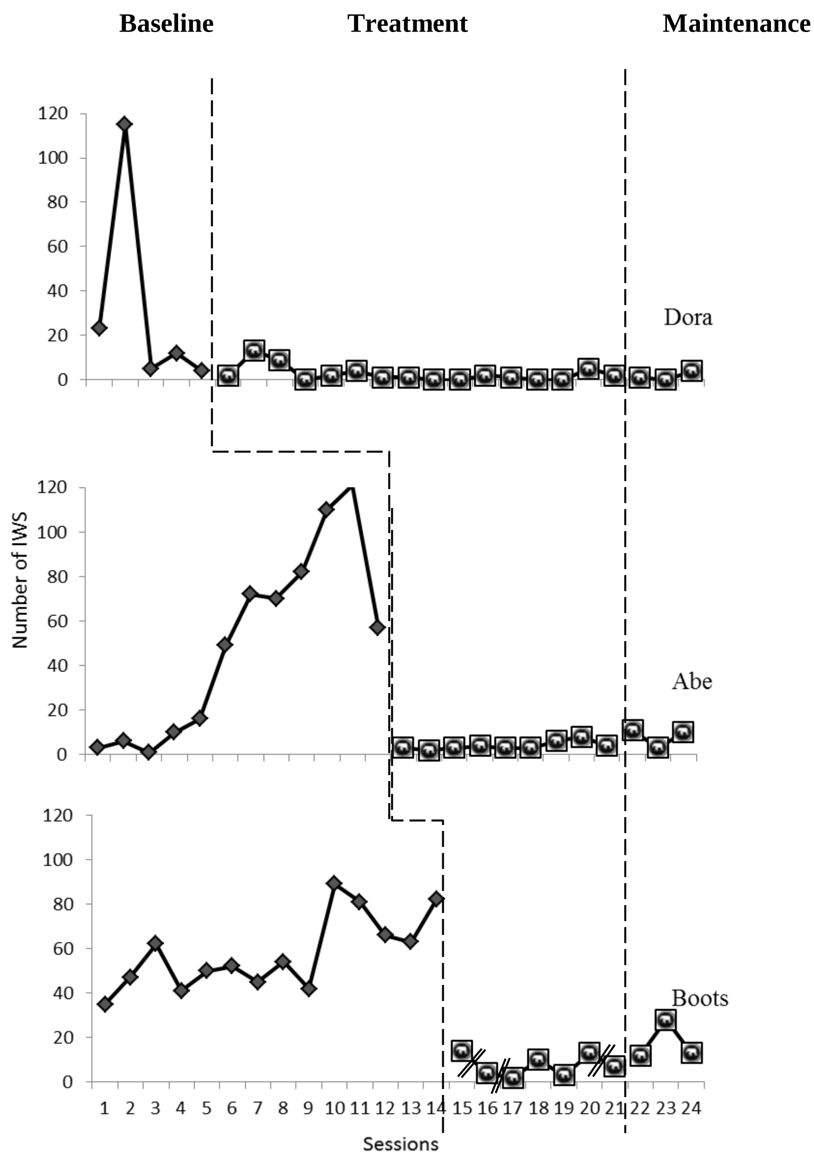


Figure 7. Participant graphs depicting scores of the dependent variable, Number incorrect Sequence Correct Word Sequence.

For this measure, all three participants had a level change of at least 29 points. The level decreased for the average number of IWS was significant. In Phase A, IWS was 46.5 with (*SD* = 35.5), however the average number of IWS decreased to 4.7, (*SD* = 3.5).

The average PND for this measure was 58.3, (*SD* = 52). It was greatly affected by Abe's refusal to choose more than a word or two during baseline which skewed his PND. During Maintenance, the average number of IWS was 9.1, (*SD* = 5.2), which was well below the mean in Phase A (see graph in Figure 7).

Dora. Dora's mean level for IWS was 31.8, (SD = 47.1), in Phase A. When given access to picture-to-text software, the mean value of IWS decreased dramatically to 2.6, (SD = 3.6). While Dora's trend line for number of IWS decreased sharply (Slope = -14.1/Intercept= + 74.1) in Phase A, during Phase B the trend line for number of IWS declined (Slope = -0.33/Intercept= + 7.07). Variability for the number of IWS in Dora's samples was greater in Phase A and lower in Phase B, especially from sessions 9 through 24. Dora's PND for number of IWS in Phase B was 75 % when compared with the data in Phase A. Dora did not show immediacy of change for number of IWS because her last data point in baseline was very low. When counting the number of IWS in Phase A the desired increase began three sessions before the intervention. In Phase B except for the three sessions 7, 8, and 20, the rest of her sessions had fewer than four IWS including 12 sessions with two or fewer IWS. The desired change became lower and more consistent starting in the fourth session of intervention, Phase B.

During maintenance Dora had a mean level IWS of 1.7, (*SD* = 2.1). She had fairly flat trend, fairly low variability, and 66.66% PND during Maintenance over Phase A.

Abe. In Phase A, Abe had a mean value of 49.8% IWS, (*SD* = 42.5). When given access to the picture-to-text software, the mean number of IWS decreased to 4%, (*SD* = 1.9). Abe's trend line in Phase A for number of IWS sharply increased; (Slope = +

10.27/Intercept= -17); but was almost flat in Phase B, number of IWS (Slope = + 0.45/Intercept= -3.65). Variability for IWS in Abe's writing samples was greater in Phase A and became more stable in Phase B. For Abe, because he started his sessions with very few words, he had 0% PND in Phase B when compared to Phase A. Abe's IWS had a steady increase in Phase A rising quickly after session 5, Abe's number of IWS immediately decreased once intervention began. For Phase B, most of his scores were consistent in the expected direction.

In his Maintenance sessions, Abe had a mean IWS of 8, (*SD* = 4.4). He also had a relatively flat trend, and low variability. Again due to his short response which limited the number of possible IWS, he had a 0% PND during Maintenance over Phase A.

Boots. Boots began Phase A with a mean average of 57.8 IWS, (*SD* = 16.8). In Phase B, his mean value of IWS dropped to 7.6, (*SD* = 4.9). The trend for Number of IWS in the Phase A samples Boots wrote was (Slope = + 2.85/Intercept= + 36.23), compared to Phase B, Number of IWS (Slope = -0.07/ Intercept= + 8.86). During Phase B, his trend line became more stable and level. Boots had wide variability in Number of IWS in Phase A, with greater stability in Phase B. Boots had 100% PND for Number of IWS for Phase B over Phase A. His scores showed a dramatic immediacy of change in this measure and remained consistently below Phase A scores.

During Maintenance, Boots had a mean of 17.7, (*SD* = 9) for Number of IWS. Boots had 100% PND for Maintenance over Phase A.

Vertical comparison. When analyzing the graphs vertically, variability was greater for Numbers of IWS in Phase A for all three participants. Scores for all participants consistently decreased and were more stable after the intervention was introduced in Phase B. The inconsistencies were that Dora's errors decreased before the intervention began and that Abe's IWS started out low; because, in the beginning, he chose very few words. For example, in session one he chose only three words and in session three, he chose only one word thereby, decreasing the number of IWS possible and skewing his PND. Without the first three sessions, his PND for Phase B over Phase A would have been 100%.

Randomization Tests Results

Randomization tests were used in this study for comparative purposes only in order confirm and further clarify the visual analysis results. According to the Dugard et al. (2012) Design 3 (AB Multiple Baseline) test, the prediction that students with moderate autism would write more sentences while using the picture cues in picture-to-text software pallet as compared to using a pallet without pictures was tested. The proportion of 2000 randomly sampled data arrangements giving the accuracy difference in the predicted direction at least as large as the experimentally obtained difference was 0.014. Therefore, the difference in the number of sentences written with picture cues was statistically significant ($p < 0.05$; one-tailed).

In addition, the prediction that students with autism would produce more correct word sequences (CWS) when using picture-to-text software pallet with picture cues as compared with using a similarly constructed pallet without pictures was also tested. The proportion of 2000 data arrangements sampled randomly, providing the accuracy difference in the predicted direction at least as large as the experimentally obtained difference was 0.004. Therefore, the increase in the number of CWS written while using picture cues was statistically significant ($p < 0.05$; one-tailed).

Finally, the prediction that students with autism would produce fewer incorrect word sequences (IWS) was also tested. The proportion of 2000 randomly sampled data arrangements randomly sampled, providing the accuracy difference in the predicted direction at least as large as the experimentally obtained difference was 0.07. Therefore, the reduction in the number of IWS when using a picture-to-text pallet with pictures, as compared with a pallet with no pictures, was not found to be statistically significant ($p < 0.05$; one-tailed).

Social Validity Results

Results were analyzed by comparing responses given in the first survey with responses given in the final survey. The responses of each child were also compared with the responses of the parent. Instructional interaction was also considered.

Participant's responses. During the last meeting the final electronic survey was administered. In both participant surveys, it was interesting to note that all three participants tended to choose the picture on the left, "I like it a lot", for most of the responses. Because the four response choices were always presented in the same order with the most positive response being the first offered, it was difficult to ascertain whether or not the participant responses were thoughtful, or whether the responses reflected an automatic preference for the first answer choice. For example, each of the mothers reported that their child did not like to write, yet, when asked if they liked writing with a pencil they tended to choose the response, “I like it a lot!” Thus, the results of the surveys must be taken with caution.

The exceptions to that predisposition were the five negatively worded questions such as, “I don’t like computers for writing.”; “I don’t like to write with a computer.”; “I prefer writing with a pencil, not a computer.”; “Writing with the computer is yucky!” For those questions the participants seem to be very puzzled. Rather than choosing an answer quickly, each hesitated, often repeating the question with a quizzical look, before choosing a response. For all five opportunities, Abe appeared to recognize the reversal and chose the response on the far right, “I don’t like it”. Ben chose the response on the far right, four out of five times, and Dora chose it three out of five times. For those five items, the participants’ responses appeared to be thoughtful rather than quick, repetitive choices of the first response available. After the study, two teachers of students with autism suggested that the survey should only have two choices, a positive and a negative. They felt having four choices with different degrees of negative and positive responses were too difficult for children with autism to understand. They also expressed concern for the negatively written questions. The initial survey scores were within two to four points (Dora-66; Abe-64; Boots-62) out of a possible 76. For the closing survey, all three participants’ scores declined (Dora-59; Abe-56; Boots-51).

When reviewing the exit questions that earned few or no points, it was noted that most of those responses were the ones that were unexpectedly worded. For both numbers 18 and exit 11 “I don’t like to use a computer, it is yucky,” Dora responded “Not sure.” For number 18 both Abe and Boots responded, “I don’t like it!” But exit 11 elicited the opposite response from Boots. Whereas Dora indicated for number 21, that she preferred a pencil and not a computer for the first survey, and for exit question 3 she indicated that she did not like writing with a pencil, both Abe and Boots responded, "I like it a lot!" Exit question seven was a similar question in that both Dora and Abe responded that they could write better with a pencil, whereas Boots responded that he did not write better with a pencil. Boots thought writing with PixWriter was good and said PixWriter helped him write better than a pencil. All three participants gave opposite responses to the similar questions, exit questions six and nine; they responded the pencil helped most and for the other question responded PixWriter helped most. Yet in exit question 18, all three responded they liked PixWriter a lot. Whereas, Boots indicated in question 16 that he did not like computers to read to him, he used the listen tool more than the other two participants. In exit question 17, Dora indicated she did not like to write with a computer, whereas, the other two responded with the double negative, meaning they did like to write with a computer. In all, there were ten questions about liking or writing better with a computer. Even with the negatively worded questions, 27 responses ended up being in favor of using a computer as opposed to three against using a computer. For questions with reference to liking to write with a pencil (which actually did not negate enjoying the use of a computer), the responses were 5 to 4 in favor of the use of a pencil. When asked which one helps most, requiring choosing between pencil and PixWriter, each participant chose one for the first question and then the opposite response later in the survey, for an even split. All three participants had a positive response about liking PixWriter, and although two participants were not sure if they liked the idea of participating in the study for the initial interview, all three reported enjoying this study at its conclusion. Indications from the surveys were that each of the three participants both enjoyed using the picture-to-text software and being in the study.

Parent responses. The initial survey supplied information used to describe the participants. The exit survey provided attitudes about the study. All three of the parents surveyed had positive feedback about the study. For the question asking about the best part of the study, Dora's mom replied, "The best part of this study was seeing her interest in learning computer." And Abe's mom enthusiastically wrote, "Watching my son write!" Boots' mom said that the best part was the new skills her son learned.

When asked about the adverse aspects, Dora's mom said that she had difficulty with changes in her routine; her mom believed that longer sessions and shorter breaks would be helpful. Abe's mom found it difficult not to be able to give him prompts and cues as she would have been inclined to do, whereas, Boots' mother wrote the word, "nothing" in the blank. All three mothers were enthusiastic about the writings that their children had generated. Dora's mother felt that the word bank made the most important difference for her daughter. Abe's mom recognized more detail and complexity in her son's writing. Boots' mother felt that using a computer helped her son by giving him a multisensory approach to writing. All three agreed that the study was beneficial and that the software had potential. Positive feedback from the parents indicated that the parents were glad that their children participated and hopeful that one or more aspects of the picture-to-text software could be helpful for their children.

Instructional interactions. Another aspect of social validity is student behavior.

While Dora and Abe each had periods of time when they wanted to stop working, they were able to be redirected with the researcher's observation of their preference, yet was able to redirect and get more written work. For Boots' extreme behavior, simple redirection was ineffective. It took consultation with two other professionals and fairly large adjustment to the researcher's interaction with Boots. While Boots was able to type simple sentences, he did express anxiety overtly, a minimum of three times, when working with the intervention. Taking time to investigate and obtain a more thorough understanding of the meaning behind his behavior, could give important insight into motivation of students with more severe autism.

Results Summary

The results of the three measures, Number of Sentences, Percent of Correct Word Sequences, and Number of Incorrect Word Sequences, indicate that picture-to-text software had a relatively positive effect on the writings of the three participants in this study. The effects for each of the participants, however, were individualized according to the academic skills and behavioral proclivities that each participant had at the time of this study. All participants had a distinct level change in the appropriate direction for each measure. Most of the trends for Phase B, the intervention phase, were in the desired direction. While Dora's Phase B trend increased in the desired direction, it followed the trend set in Phase A. This continuation of the baseline trend renders drawing a conclusion as to the functional relations between improved scores and the introduction of treatment, problematic. Another trend that did not follow that rule was Abe's Percent CWS. He had a fairly substantial drop in session 19, which caused the overall trend of Phase B to decrease. However, the first six scores and the last three scores in Phase B, if analyzed in two series, did have rising trends. For Phase B, in all measures, variability in the last three sessions stabilized for most participants. Boots' last three scores for percent correct word sequence in Phase B, although well above the scores in Phase A demonstrated moderate variability. The PNDs for all participants in the first two measures, number of sentences and percent CWS, were above 80%. For Number of IWS, although Boots had 100% PND, Dora had a PND of 75% and Abe had 0%. Both Abe and Boots showed immediacy of change by the second session of Phase B. Dora, however, showed improvement by the third session of Phase A, which was before the intervention was started. All participants consistently scored in the appropriate direction for all measures in Phase B. The maintenance measures, however, were not as conclusive.

5. DISCUSSION

This study investigated the effects of using picture-to-text software on the writing productivity and accuracy of young individuals with moderate autism. In this chapter the results of this study are reviewed in light of possible extensions of literature. The limitations and recommendations for future research follow. Finally the conclusion of this study will be expressed.

Results Overview

In this study, there were several encouraging results. There were noticeable level changes in the predicted direction for all replications (nine out of nine) of the dependent variables. Most of the trends for Phase B, the intervention phase, were either fairly level or in the desired direction (seven out of nine). Variability for all dependent variables in last three sessions in Phase B became more stable for most of the replications (seven out of nine). The PNDs for number of sentences was 100% for Dora; 88.9% for Abe; and 85.7% for Boots, all being towards the top end of effective, and Dora's was very effective. Looking at the percent CWS, Dora's PND was 81.3%; Abe's was 100%; and Boots' was 85.7%, Abe's being very effective while the other two were in the effective range. For the third and final measure, IWS, while Abe had 0% PND; Dora's scores were at 75% PND; and Boots' scores were at 100% PND, which showed greater variability among participants. Note, as mentioned in the results section, because Abe was resistant to writing for the first three sessions, and wrote only one to seven words, that limited the number of IWS possible. In sessions five through 12, he wrote from 21 words to 152 words per session, his IWS for those sessions were greater than any of the 12 sessions in Phase B. For all replications, except Abe's number of IWS, the PNDs in all three measures were in the effective or very effective range (eight out of nine). Even though Abe had 0% PND in IWS, due to the few number of words that he chose in the first three sessions, he did have 100% in the Percent CWS and 85.7% for numbers of sentences. While Dora showed improvement before intervention started, she continued at a higher rate after the intervention had begun. For Abe and Boots, positive change occurred by the second session of the introduction of the intervention. A majority of scores in Phase B for all participants was consistently in the predicted direction for all measures. The level of IWS (errors) decreased during the intervention, Phase B, indicating that accuracy was improved.

Maintenance measures for numbers of sentences remained high for Abe. Although the numbers of sentences in maintenance decreased for Boots and Dora over the Phase B mean, the mean number of sentences for their maintenance sessions were higher than their respective means of Phase A. Dora's and Abe's scores for CWS remained high in maintenance, whereas, Boots had one particularly lower score in maintenance, decreasing the mean below the mean of Phase B. In Phase B, the number of IWS remained low for all three participants, verifying an increase in accuracy.

Visual strengths by students with autism have been noted by a number of researchers and professionals (Cooper-Duffy et al., 2010; Heflin & Alaimo, 2007;

McCoy, 2011; Prelock, 2006a; Preis, 2006; Quill, 1995; Shurr & Taber-Doughty, 2012; Slater, 2002; Williams & Minshew, 2010). McCoy suggested that, because students with autism are often visual learners, capitalizing on that strength may help them improve writing. Using picture-to-text software and visual prompts, did take advantage of the participants' visual strengths. The results from this study corroborated McCoy's insight. Quill (1995) noted the value of combining pictures with text to increase comprehension for students with autism. Williams and Minshew (2010) found that brains in children with autism work differently. They suggest that visual information should be taught in conjunction with connections that are explicitly taught. Prelock 2006a added that using visuals, parallels the processing of many students with autism. Visuals provide distinct clues to help them attach meaning to words. Preis (2006) found that pairing pictures with words helped 5 to 7-year-olds better understand commands and verbal requests. Therefore, not only could pictures help in areas such as writing as was shown by the current study, it could also help students comprehend more and begin to analyze information in other content subjects. As students with autism begin to mature, having a firmer background of comprehension resulting from the early use of pictures paired with text, can in turn help when they start writing to learn. Cooper-Duffy et al. (2010) discuss possibilities of students with autism being more included in academic pursuits when pictures are used to increase comprehension. Being able to read along with peers as suggested by Slater (2002) and Shurr and Taber-Doughty (2012) and write as suggested by the current study will make inclusion a greater possibility for many more students with autism. As one living in the world of autism, Dr. Temple Grandin (1995) emphasizes the importance of visuals for individuals with autism. The current study confirmed that using visuals provided by picture-to-text software can introduce meaningful writing experiences for students with autism at the earliest stage possible, affording comprehension which is a vital part of both reading and writing.

Another visual aspect was studied by Harmon et al. (2009). The word wall that can be a universal help for many students, can also help students with autism. Picture-to-text software provides easily created electronic word pallets that can function similarly. As Harmon et al. found using color cues in pictures with words help students to integrate new vocabulary into their academic language. PixWriter can easily incorporate color cues, symbols, and/or pictures, along with auditory feedback. This can provide a personal "word wall" to a student who has difficulty with spelling, handwriting, and word recognition. The pallet can provide support for different stages, pictures can be included for emergent readers and writers, then when reading skills have developed, the picture support can be withdrawn. The current study indicated that the word wall concept helped Dora even without pictures. Once she realized that the words had meaning and that she could read the words, she started creating sentences more quickly than the others. Once pictures were included, Dora's responses included more sentences that were even more accurate and varied. Because Abe was reading or pre-primer level, he did not recognize the words in Phase A as having meaning but he was able to use the pallet as soon as the pictures were added. Once he identified the significance of the picture-word pair, he worked more slowly and carefully. Then he was able to write more sentences, with more CWS, and fewer IWS. At Boots' developmental level, he was less able to benefit from the picture pallet. Perhaps he required fewer items and more support.

Dependent Variables

In light of the results, the three dependent variables, a) numbers of sentences b) correct word sequences (CWS) and c) incorrect word sequences (IWS) indicated a generally positive change in the writings produced by these three children with moderate autism once picture-to-text software was introduced. Because of the unique academic levels of each participant, each showed positive indications but with different dependent variables and measures.

Number of sentences. Although Dora's results were not conclusive because improvement started during baseline, for the last eight sessions in Phase B she had a steady increase in numbers of sentences. During baseline she would type one sentence and repeat it. In Phase B, she started to introduce variety into her sentences by changing the subject, changing the predicate, and/or adding an adjective. In session 14, two of the four sentences Dora wrote were descriptive of the picture but more varied than any of her sentences before. For example "Curious George is sitting on the bed. The man is reading a book." Whereas, the following sessions return to a more familiar pattern of finding a comfortable sentence and perhaps changing one word. Had this been a teaching situation rather than research, teacher feedback, modeling (Prelock, 2006b), and explicit instruction advocated by Heflin and Alaimo (2007); Janzen (1996); Pennington, (2009); and Pennington et al. (2010) could have maximized a new development in her writing.

The demeanor of Abe, whose academic level was actually in the emergent writing phase, changed his once he could make sense of the words in the pallet. In Phase A, he was content to choose buttons quickly and randomly. Once pictures added meaning to the words, he became more committed to the task. Although his first attempt using picture-to-text did not result in a sentence, it was very close. “The racers car driving on the car” could have become an appropriate sentence with two changes. “The racers ~~car~~ (were) driving ~~on~~ (in) the car (.)” Once again, in an educational setting, appropriate instruction and feedback could have been an opportunity for increased writing development (Prelock, 2006b; Heflin and Alaimo, 2007; Janzen, 1996; Pennington, 2009; Pennington et al., 2010). Abe wrote no sentences during baseline. After the second session in Phase B, with picture-to-text, he wrote between two and five sentences in every session.

Pennington (2009) described a teacher’s quest to help a student with autism develop writing skills. He walked the reader through the scenario pointing out evidence based practices for students with autism that can be found at the National Professional Development Center on Autism Spectrum Disorders (2008), such as computer-assisted instruction (CAI), response prompting, and direct instruction. The teacher used word pallets from PixWriter software to help her student gain sentence writing skills. In this scenario the picture feature was turned off but the text-to-speech feature was used to give immediate feedback. In a mission to augment the sentence writing capabilities of three young boys with autism, Pennington et al. (2010) used a different picture-to-text software than was used in the current study. Again, they used the evidence-based practice of using computer created pallets. In the scenario described by Pennington (2009) and in the study by Pennington et al., using the computer was only part of the intervention to help develop writing skills. Pictures were used with four of the words in the pallets for the study by

Pennington et al. Explicit instruction on writing strategies, modeling cognitive processes, and response prompting (Graham et al., 2001; Mason & Graham, 2008) were the components under study. Yamamoto and Miya (1999) used pictures and pallets for students with autism to create grammatically correct sentences in Japanese. Again the key components were explicit instruction, modeling, and immediate prompting of the correct response. As Graham and Perin (2007); Pennington et al. (2010); Prelock (2006b); Prizant and Rubin (1999); and Prizant and Wetherby (1998) suggest, combinations of strategies and materials can be more powerful an intervention than using an isolated practice. Perhaps using explicit teaching, and response prompting in addition to the modeling, that was finally added to Boots' training could have averted his extreme behavior and may have had more lasting positive effects. However, in light of the results of this study, depending on the characteristics of the student with autism, picture-to-text software could be an invaluable addition to other evidence-based practices.

Correct word sequences (CWS). Dora started out as expected for this measure; however in session three she noticed that she could read the words in the pallet, and began putting them together in an appropriate way. Due to the instability of her baseline, her data was not conclusive; however, it is important to note that with the addition of pictures to the pallet, the CWS for the first six sessions with picture to text were between 63% and 100% which were higher than three of her baseline measures. Abe's increase was significant for all aspects of visual analysis except trend. The first six measures in Phase B were a great deal higher than the highest measure in Phase A, and had a positive trend. However, in session 19 Abe's performance dropped almost 40 points. The last three sessions in Phase B did begin a new positive trend, but because of the drop, the trend became negative. For this measure, during Maintenance, Abe was able to continue with all scores significantly higher than his scores in Phase A. Boots' scores for percent CWS were significantly higher in Phase B than the scores during baseline in Phase A. During Maintenance, two out of three of the scores were also above Phase A scores. Again, with the behavior difficulties in Phase B, additional cues were utilized to stabilize behavior and focus.

Incorrect word sequences (IWS). For the variable IWS, the numbers were expected to decrease. As in the other measures, Dora showed improvement before pictures were introduced; however, starting with session nine her scores became very stable and remained low for the rest of the sessions. The number of IWS for Boots dropped dramatically from the first session that the intervention was introduced, from 82 errors in the last session of Phase A, to 14 errors for the first session in Phase B, after pictures were introduced. This was an immediate positive change before his behavior impacted his performance. From an average of 57.8 errors in Phase A, Boots errors decreased to an average of 7.6. Because Abe wrote very little for the first five sessions in Phase A, the number of possible errors was very small. After the fifth session in Phase A, the number of errors climbed dramatically. Starting with the first session in Phase B, using picture-to-text software, Abe's score dropped from 57 IWS to three IWS, a considerable decrease in errors.

To address the research questions, the data indicated:

1. Picture-to-text software did increase the number of sentences that each

of these young writers with moderate autism typed.

2. Picture-to-text software also significantly increased the percent of CWS for two out of three participants.

3. The IWS (number of errors) did decrease with the use of picture cues over most words for two out of three participants.

As this study was designed, Abe’s academic level seemed to be a perfect match. He was able to read at a primer level, and was beginning to use echolalic phrases as a way to convey his thoughts, in unique ways that fit situations he encountered. Except for the one PND of IWS, most of Abe’s data clearly revealed that picture-to-text software significantly increased his ability to independently generate simple sentences, and increased the accuracy in his written products. While all three participants had positive results when using picture-to-text software, Abe’s results were the most significant.

Extension of Educational Research

During the review of literature conducted by this researcher, writing was found to be less represented in intervention research than other academic areas such as reading (MacArthur, 2000; MacArthur, 2009; Pennington, 2009). The current research adds another study to this base. Research has established that assistive technology can make a larger positive difference in the writings of students with disabilities than when used by students in general education (Bangert-Drowns, 1993; Graham & Perin, 2007). Graham and Perin (2007) found when students use technology; the improvement of writing quality differs between typical students and those with writing disabilities. They found that for students in general education the effect size was 0.51, whereas, for students with writing disabilities the effect size was 0.70 demonstrating the importance of providing technology for students with writing disabilities. The current study proposes using AT for students with moderate autism. Using technology can add a motivating factor to the learning environment (Beck & Fetherston, 2003; Heflin & Alaimo, 2007; Morphy & Graham, 2012; Williams et al. 2002; Wirkus et al., 2009). In the current study, while Boots' motivation by the computer was inconsistent, both Abe and Dora were motivated to use the picture-to-text software.

Throughout the literature search, no intervention study was found that included using the picture cues of picture-to-text software as a writing intervention. While Pennington et al. (2010) did include 4 pictures out of 12 words in their templates for students, the study was focused on examining the effect of simultaneous prompting (Pennington et al., 2010), and not the picture cues. This study included pictures for all words that were easily represented by a picture documenting the added benefits of including pictures to computer enriched instruction for writing that extends the studies by Yamamoto and Miya (1999), and Pennington et al. (2012).

Therefore the current study examined an aspect of assistive technology that has been available for use for 18 years and has been used in classrooms, for years, without being empirically researched. Picture-to-text software is called, what Smith, Schmidt, Edelen-Smith, and Cook (2013) called practice-based evidence (PBE). With the mandates that teachers include evidence-based practices (EBP), the time has come to verify that picture-to-text software can help many emergent writers, especially those with disabilities, to begin to develop such a vital skill.

Current research also combines the writing intervention of using picture-to-text software with students who have autism. Autism is an area of research that has recently expanded and is in great need of intervention research, especially in academic areas, such as writing.

Educational Implications

With legislation, including the Individuals with Disabilities Education Act Reauthorization (2004) which dictates that all students deserve a "Free Appropriate Public Education," the importance of providing classrooms that have been designed initially for access by students with every degree of ability cannot be overstated. From the first stages of planning classrooms, universal design must be incorporated with the combination of strategies, accessible materials, and assistive technology that will address all needs and learning styles (Godek, 2008). "When instructional content is truly designed to be accessible for all students, up-front and not after the-fact, using both technology and pedagogical strategies, then we can begin to make progress in ensuring access to the general curriculum." (Wehmeyer, 2006, p. 324). While inclusion may provide students with disabilities admission to the general education classrooms; without supports in place, such as effective strategies and AT, actual access to the curriculum will be hindered (Soukup et al. 2007). Providing assistive technology such as picture-to-text software in classrooms can help build more independent production of written text for some children with autism.

Jerome (2009) listed assistive technology features that should be considered for students with autism. Technology itself adds consistency to an activity or assignment.

Other features mentioned were navigational ease, a variety of access methods, auditory and visual cues, as well as, auditory and visual feedback (Jerome, 2009). Picture-to-text software included these features to bridge comprehension with text and assisted three young students with autism with the writing process. “Universal access to the general curriculum will change everything for students with disabilities” (Kluth, 2012, paragraph 4). Again, with the legal requirement to consider assistive technology (Quinn et al., 2009), and the proposals to include assistive technology along with pedagogical strategies, and accessible materials made by many researchers such as, MacArthur (1999); MacArthur (1996); Behrmann (1994); Wallace et al. (1995); Hetzroni and Shrieber, (2004); Pennington (2009); Wehmeyer (2006); Wirkus et al. (2009); and Jerome (2009), the message is clear. AT must be made available to students with disabilities.

The picture pallets used in this study were found to be more beneficial for students with autism who are reading on a pre-primer level, have difficulties with writing, respond well to visuals, and enjoy using technology. Picture-to-text software also has other levels of support that could help students at other early reading levels. Using picture to text software for students with moderate autism and other young students reading at a pre-primer level, could reduce frustration and help young struggling writers build more independence as they develop vital writing skills (Wehmeyer, 2006).

Limitations

This researcher found a number of limitations in this study, two of which were the study’s narrow focus and limited timeframe. Additional limitations were language limitations of younger children with autism, small number of participants, skill discrepancy, and difficult behavior. Another was the difficulty involved when trying to predict a research design and specific details that would work with students with autism. There were also difficulties with social validity when trying to predict the value of responses given by a child with autism.

Narrow focus. The narrow focus of this study, on the use of AT as a tool, did not allow for teaching and using writing strategies that have been shown to be vital factors in improving writing skills such as SRSD (Asaro, 2008; Cerar, 2012; Graham & Harris, 2009) and strategies such as response prompting, explicit teaching, and modeling (Pennington, 2009; Yamamoto & Miya, 1999). Yet, determining if using AT can help young writers is also important (Bangert-Drowns, 1993; Cutler & Graham, 2008; Graham, McKeown, Kiuhara, & Harris, 2012; Graham & Harris, 2013; Graham & Perin, 2007; Jerome, 2009; MacArthur, 1999; Morphy & Graham, 2012).

Time limitations. Three-minute writing probes did not allow participants to use the entire writing process. Because of time constraints, and a concerted effort to limit variability, writing strategies which have been shown to be successful with helping children write more effectively, were not included. The other time limitation was incurred by attempting to ensure that positive changes in the students' writings were not caused by natural growth and development over time. The 21 sessions in Phases A and B took approximately five weeks. Students with autism usually need more time and practice to gain new skills (Evansmcrae, 2012)

Language limitations. Much of the research suggested that early intervention with students with autism is important (Autism Society of Northern Virginia, 2013; Odom et al, 2003; & Troia & Graham, 2003). It is also recommended to provide intervention to younger children who have not developed an aversion to writing (Slavin & Madden, 1989), thus, helping them on a path to writing success. Janzen (1996) specifies communication and thinking as key deficits for individuals with autism. This researcher attempted to work with three students with severe autism who were six or seven years old. Unfortunately, without oral language, the younger children with severe autism that were identified for the study were not developmentally ready for written language. The youngest participant, Boots, who was nine and moderately challenged with autism demonstrated the lack of communication skills, which made the task untenable for him until given direct instruction and modeling. To reiterate, perhaps beginning with fewer items in the pallet (which can be easily accomplished with picture-to-text software) could have met Boots at a more appropriate level. Abe, who was less impacted by autism and who was at the next educational level, demonstrated the ability to work with the number of picture-word buttons provided.

Phase A input on the computer. During Phase A, there were two options for computer input. Students could use a keyboard or they could use a pallet without pictures. Because Abe and Boots were at a much lower level, it was thought that using a keyboard for Phase A would measure typing ability rather than the ability to create a meaningful sentence. It was decided that in order to have comparable measures between Phase A and Phase B, using a pallet for both and introducing pictures in the pallet as the intervention would be more appropriate. Since Dora's mother stated that she could not write sentences beyond copying from a model, and because her first two sessions corroborated that statement, pallets without pictures were used for Phase A.

It was thought that using the pallet in Phase A would work for all three participants. However, as children with Autism tend to do, Dora's actions were surprising. She demonstrated more knowledge of sentence construction than was thought she could write. Dora's relatively higher academic level may have influenced her ability to begin to respond before intervention. For Dora, as it was for Jayden, in the study of Pennington et al. (2012), it seemed that having the pallet of words was an intervention in itself. Starting in session three, Dora began to type some words. Until session 10 it was only a word or two, however seven out of the last 14 sessions she typed five words or more. She generally typed three types of words: short connecting words (up, in, is); gerunds (holding, dancing, blowing); and nouns (basket, road, ground). It was interesting to note that the sessions that she typed more words, she had fewer words total, because of the time it took her to spell the words. While Abe typed words in only two out of 12 sessions of Phase A, he typed words in 10 out of the last 14 sessions in Phase B. Generally he only typed one to three short words, however, out of the last three maintenance sessions; he typed four words in session 22 and three words in session 24. Did having pictures over most words encourage two of the participants to begin typing to augment their word choices?

Boots, on the other hand, did not type any words. He could recognize only a few written words, was only able to label items, and was unable to generate sentences independently. At this much lower academic level, Boots was considered to have pre-emergent literacy skills. To expect him to be able to write sentences before he was capable of generating independent thoughts may have been premature. As opposed to a research setting, in an academic setting, the teacher could realize the misfit and adjust the program accordingly. More support could have been added.

Number of participants. There were only three participants found who fit the eligibility requirements and were available for the study. Other parents were contacted, but their children either were not developmentally ready; were not age-appropriate; or their schedules precluded participating in the study. As the number of children on the autism spectrum escalates (Odom et al., 2003) it is also important to be able to thoroughly study a smaller number in depth to find out more about this growing population (Kennedy, 2005). Horner et al. (2005) mentions that the typical number of participants in single subject designs is three to eight and in the meta-analysis of SSRD for young children with autism, Odom et al. (2003) reported the number of replications in those studies to be an average of 3.8. Kratochwill et al. (2012) described the standards for single-case intervention multiple baseline research as including “a minimum of six phases (i.e., At least three A and three B phases) with at least five data points per phase” (p. 29). This study did follow those criteria.

It is important to note that only three data points were collected for the maintenance phase for all three participants. Because of the limited number of data points, the maintenance results should be interpreted with caution. It is designed to give an indication whether or not the effects of using picture-to-text software could extend without the consistent practice inherent in Phase B.

Skill discrepancy. Although a common cluster of symptoms surrounding communication, socialization, and daily functioning in their environments affect individuals with autism, additional individualized factors such as the relationship between cognitive capacities and the degree of autism, and a number of other factors result in the unique amalgamation of each individual (Janzen, 1996). The severity of autistic behaviors often varies widely from one individual with autism to another (Boucher & Lewis, 1989; Odom et al., 2003). The three participants exhibited a wide discrepancy of skills, from Dora, who could read text at the fifth grade level and demonstrated understanding at the upper first grade level, to Abe who could read at the pre-primer level, to Boots who was neither reading nor writing more than a word or two. Conversely, an advantage was catching a glimmer of how the participants at different skill levels responded to the intervention of picture-to-text pallets. Whereas Dora, seemed to be helped more by having a pallet of words that she could use, whether they had pictures or not, Abe's data clearly showed the pictures made a positive difference. Boots demonstrated a lack of readiness for the written pallet and the pallet with pictures. For him, more features and strategies included in the picture-to-text software were needed, such as color patterning for sentence structure. The data indicated that a continuum of strategies is needed to meet the needs of each individual. This reinforces the importance of matching characteristics of the interventions to the unique needs of each child with ASD (Prelock, 2006b).

This picture-to-text software was helpful to these participants on three different levels. In session 3, Dora' choices indicated that she may have begun to understand, although the words were randomly placed, that they could be chosen to relate ideas. When pictures were added to the pallet, Dora's scores increased for number of sentences and correct word sequences while the number of IWS decreased, indicating that although the pictures were helpful, they were not a necessity.

Of the three participants, Abe's experience best reflected the hypothesis of this research. Abe's reading skills were reported to be at the pre-primer level, yet his comprehension was below that level. Having very little reading ability and some understanding of words and how to put them together to create meaning, provided the situation in which picture-to-text software was most beneficial.

In the baseline phase, Boots was content to click randomly, run off to another area, and return and click more. When pictures were provided it made an immediate, dramatic decrease in the number of IWS (68 points). However, something happened in the next session and Boots was no longer cognitively or attentively available to provide writing samples.

Behavior. An essential concept of behavior is that it is a means of communication that responds to an environment in an effort to either establish equilibrium or stimulation and that it conveys the inner state of a person (Janzen, 1996). For young individuals with autism, this may be one of the only ways they know how to communicate. Bock, Bakken, and Kemple-Michalak (2009) described the challenging behavioral characteristics of students with autism. The participants in this study exhibited a number of those characteristics during the writing sessions. Stereotypic behaviors, self-stimulatory behavior, distractibility, impulsivity, and perseverative behavior affected the writing production for all participants. While Dora and Abe exhibited those behaviors, verbal or gestural redirection was usually successful during the three minute writing sessions. During the writing sessions, Boots, in particular, exhibited a significant amount of the behaviors listed above which caused interference. Running from the computer, touching things and licking his fingers, vigorous, rapid, repetitive, loud tapping on the table and/or materials, and shouting rapid verbalizations that were difficult to understand occurred throughout his baseline sessions. Boots, the most severely impacted participants of this study, exhibited challenging behavior. It is well known that individuals with Autism have difficulty communicating verbally. Behavior is a means of communication and it often has a logical, historical basis to the initial time it was used (Janzen, 1996). Behavior can be especially challenging when teaching a child with Autism. Characteristic behaviors associated with Autism such as self-stimulatory behaviors, distractibility, impulsivity, perseveration, aggression, all often with a much higher intensity than would be displayed by a typical child (Bock, et al., 2009). Individuals with moderate and severe Autism can develop one solution that is employed for a great number of problems that may arise (Janzen, 1996). This solution can often cause frequent, unexpected disruptions in a classroom situation or in a research situation rendering pure scientifically conducted research inherently problematic. The inability to predict the exact procedures to be used with a student with moderate or severe Autism, and necessity of using cues for redirection and other positive statements mentioned by Flannery and Horner (1994), may add to the "methodological shortcomings" mentioned by Prizant and Ruben (1999, p. 200 paragraph 6) of research found in the literature.

The most extreme behavior challenge was demonstrated by Boots in sessions 16, 17, and 21. After thoroughly enjoying the routine repetitive clicking, running away from the table for a number of seconds, returning to the haphazard clicking occurred in the first 14 sessions. In session 16 Boots started to type thoughtfully and then erased everything he typed. He chose additional words and then erased everything a second time. When the researcher tried to stop the erasures, he responded with a screaming exit and refusal to return.

At that point in the research, it would have been much easier to follow the advice of successful business tycoon Jamie Vollmer (2011). When addressing an audience of educators, he advised that schools should be run like a business. When asked by a veteran teacher about what he would do with inferior ingredients for his delicious ice cream. He said he would return them.

> We (educators) take them (blueberries/students) big, small, rich, poor, gifted, exceptional, abused, frightened, confident, homeless, rude, and brilliant. We take them with ADHD, junior rheumatoid arthritis, and English as their second language. We take them all! Every one! And that, Mr. Vollmer, is why it's not a business. It's school" Jamie Vollmer, 2011.

Should this blueberry be sent back? Instead, having been immersed in the field of education for over 30 years this researcher struggled for a way to reach young Boots. To balance the rigor of research with the challenge of including real individuals with autism and the unique makeup and behavior of each, more research was done. New resources including books, studies, and professionals with experience working with young students with autism were scrutinized for strategies found to be effective with students such as Boots.

Perhaps when Boots was presented with the unfamiliar situation a second time (the pallet with pictures), even though training had occurred, possibly the new expectations and experience of beginning to make sense of words were untenable for Boots. Possibly, since the research study occurred at the end of August, after vacation, and weeks without the structure of school, Boots may not have been ready for school tasks and atmosphere. Another possibility can be found in Janzen's (1996) explanation that, although individuals with autism have a phenomenal memory for visual information, it may exist without meaning unless key elements, sequences, and relationships are directly taught, clarified, modeled and practiced with immediate feedback given.

It became obvious that additional modeling, training, and other strategies found to be successful with students with autism needed to be added to the procedure for Boots in order to continue the sessions. For students with autism, the direct teaching of skills and concepts is paramount (Heflin & Alaimo, 2007; Pennington 2009), and because it is difficult for children with autism to add new behaviors to their repertoire, clear articulation of behaviors, explicit teaching, modeling and practice, along with feedback, may be required (Heflin & Alaimo, 2007; Pennington 2009). Heflin and Alaimo suggest that behaviors be divided into a series of routines linked together and combined with visual cues. As Boucher and Lewis (1989) and Zanolli, Daggett, and Adams (1996) discovered prompts and praise statements may be unavoidable. "Autistic children appeared to have more difficulty than controls in knowing when to turn round and come to the table to carry out the instruction. When behavior was intense, every 5 to 10 seconds, the tester had to add a command such as ‘Now!’ or ‘Come on’ (Boucher & Lewis, 1989, p. 107)!" It is, however, important to fade cues and prompts in order to avoid prompt dependency.

In their study which included students with writing difficulties, as well as, least one or two students with autism, Englert et al. (2007) discovered the positive effect (ES = 1.46) of cues built into a software that helped guide students through the writing process. The cues that picture-to-text software can bring to the educational experience of students with autism include: color coding studied by Wilkinson et al. (2008); predictability mentioned by Flannery and Horner (1994); text-to-speech encouraged by Bedrosian et al. (2003); word banks and strategic placement of words studied by Pennington et al. (2012) to name a few.

Simultaneous prompting which was used in the research by Pennington et al. (2010) and Yamamoto and Miya (1999) may have been an additional strategy to use to help Boots with writing. Obviously, the modeling and explicit teaching that those researchers also used did help Boots get through several sessions. In retrospect, the difficulties with dealing with behavior was only mentioned in a few studies (Boucher & Lewis, 1989 & Zanolli et al. 1996). This researcher wonders if other investigators did not encounter behavior as a problem or if dealing with behavior that is characteristic of children with autism caused a lack of fidelity of treatment information that seem to be excluded in many studies.

While many researchers have proposed a combination of strategies to help students with autism, Heflin and Alamo (2007) proposed that a common mistake is to combine several required skills too quickly. Boots may have been more receptive and more independent if training were more slowly and systematically delivered using a pallet with fewer picture choices, the color cues (Harmon et al., 2009), more teacher modeling in the beginning (Heflin & Alaimo, 2007), response prompting (Pennington et al., 2010; Pennington et al., 2012; Yamamoto & Miya, 1999) and a slower, steadier progression of building sentences.

To this practitioner, with experience using picture-to-text software, Boot's escape response communicated a need to return to a more basic pallet in order to truly understand and feel comfortable with the connection between choosing buttons and communicating ideas. More practice with a four button pallet that included one subject part of a sentence such as "I," followed by three predicate parts of the sentence such as, "play on the playground."; "like to swing."; "like to run." The subject part of the sentence could be bordered with yellow to indicate the presence of nouns or pronouns and predicate parts would be cued as pink to indicate the presence of verbs. A student would have a yellow block and a pink block or a piece of paper with a yellow square and a pink square. They would use that pattern and listen to the resulting sentences to eventually understand the idea of creating sentences.

Levels of writing skills. Boucher and Lewis (1989) stated and others have verified, "However, as is usual in such a group, individual children varied greatly in the severity of their specifically autistic behaviors, as well as in the presence or absence of additional problems (p. 101)." In this study, Dora began with being able to type words together that made a sentence, as defined in this research. Also she was able to read a greater number of words than the other two participants. From the very beginning, she started reading the word bank and for all sessions except session two, put them together in a way that made sense. In the beginning she would find a comfortable sentence and repeat it 2 to 4 times. Thus, her numbers of sentences and correct word sequences had a steady increase from session two through session five in Phase A. Although the pictures on top of the words were not essential for Dora, they did help her increase the level of numbers of sentences more quickly, and after the fourth session in Phase B, her responses were considerably more consistent than during Phase A. Because she had some reading and spelling skills, she was not limited to using only the words from the word bank. She added new words to create sentences that seemed more familiar to her than when using the words that were provided. For instance, she typed out the words “sitting”, or “standing” rather than using the provided word, “watching”; or adjusted a word such as “draws” to the word “drawing.” Toward the final sessions, Dora typed out more words to add to the word bank which took additional time, and wrote variations of sentences, both of which slowed down her sentence production. Knowing that her writing experience had been limited to copying text of others, it was encouraging to see her repertoire expand.

Unexpectedly, this researcher observed the benefits of picture-to-text software with students with autism on successive levels of academic skills. Each of the three participants represented a different skill level from the pre-emergent, Boots, to the emergent, Abe, to the early reader, Dora. Each one reacted to the intervention in a distinctive way. Boots responded more to the patterning of words; Abe used the picture cues; as expected, to help with comprehension; and Dora was aided by the word bank aspect of the word pallet both with and without pictures. As Horner et al. (2005) discussed, using single subject research enables the “nonresponder,” or participants who did not respond as expected, to add to knowledge about possible subgroups. It also provides the opportunity to investigate and identify adaptations to the intervention that could benefit more and varied participants. While Dora could not be considered a “nonresponder” because she, in fact, responded more quickly, she did offer the opportunity to broaden the knowledge base and consider other helpful adaptations for a child who had a higher reading level. Boots on the other hand started to be a “nonresponder”, but with a few adjustments, was able to respond and benefit from the intervention, again expanding the understanding of a broader range of students.

Social validity. Social validity, from the participant perspective, was difficult to determine from the survey responses. Many of their answers were quickly chosen and often were the first choice available. Only the questions that were worded with expectations of eliciting a negative response were answered more slowly, with more quizzical expressions, and had responses other than the first choice available. Did the responses reflect the feelings of the participants or were they made impulsively? Confidence in their responses was problematic.

It was also difficult to know for sure just what Boots’ extreme behavior indicated. Because he also exhibited signs of pleasure via body language, both before and after the three sessions in question, it didn’t seem to signify that the intervention itself was a cause of anxiety. He also was much calmer during the maintenance sessions, which were completed without behavior issues.

During this study, the quandary of rigorous research versus the reality of the unpredictability of the reactions of students with autism was manifested as well is the results when one investigates more deeply. Despite the practitioner's experience, careful planning, intense research, and three pilot studies in preparation for this research, there was not adequate anticipation of the consequences of Boots' behavior to the results of the study. Once his intense reactions, in session 16, 17, and 21, threatened continuation, the researcher had to decide what to do with this 'educational blueberry.' Providing extra modeling, cues, and re-directions before continuation changed the exact prescription of the procedure, yet it also presented an unexpected opportunity to learn more possibilities for students with pre-academic skills.

Recommendations for Future Research

It would be valuable to replicate this study with more participants with autism having characteristics that have been shown to respond well to this level of picture support, to include students reading on a pre-primer or primer level, who have difficulties with writing, have stronger visual skills, and are motivated by the use of technology.

This study could be extended to include young students with other disabilities such as learning disabilities and behavior disorders with the characteristics mentioned above and another possible extension would be to pair picture-to-text software with writing strategies that have been shown to be effective with struggling writers.

Simpler pallets with a limited number of words and additional supports may work with students having very little or no reading or writing abilities. On the other hand, one could investigate the use of word banks in writing for students who can read. Dora seemed to be encouraged to write by having the words below even when the words were out of order and had no picture cues.

Another area for future research could be the investigation of quality of sentences produced using picture to text software. At one time during the intervention each of the participants repeated sentences in their responses. For example, in session five Dora repeated the same seven word sentence three times. “the girl is looking at the sky.” In session 6 although her sentences were similar, she did change the subject. “The tractor is on the road. The man is on the road. And in session seven she wrote, “Buzz has a hat. Buzz has a game controller. Woody has a game controller.” In session 16 Abe wrote, “The SpongeBob is happy. The Patrick Star is happy. The SpongeBob is riding the unicycle the SpongeBob is yellow the snail is seeing the…” which was the greatest variety for any of the participants. Boots had very simple sentences and more repetition than the other two had. For example in session 19 he typed the following sentence seven times. “The monkey chases.” And then he wrote, “The bunny hops.” For a student who has probably never written a sentence, that was quite a feat.

Because research involving picture-to-text software as a writing tool for students with disabilities is extremely limited, a number of other potential research topics are recommended for future study.

- Use procedures similar to those in the studies of Yamamoto and Miya (1999) and Pennington et al. (2010) with training involving immediate presentation of the correct response and using pretest and posttest rather than multiple baselines.
- Study the effect of different picture-to-text software programs having different features.
- Consider combining simplified writing strategies and direct writing instruction, such as SRSD (Harris & Graham, 1993) with picture-to-text software for students with autism.
- Study the effect of the type of picture cues, such as photographs, cartoons, or stick figures, etc.
- Investigate the effects of using picture-to-text software with students speaking other languages.
- Address other features of picture-to-text software such as patterning and color coding with more limited choices for pre-emergent writers, such as Boots. Or perhaps a sequence with more limited choices and additional supports could be developed for training pre-emergent writers.
- Compare different types of picture-to-text software. Other software programs have different features that may make a difference. Photographs, drawings, abstract line drawings, with or without color, could be included in different pallets to determine which would make a more positive difference?

Conclusion

As Prelock (2006a) states “Communication is a vital skill for learning and establishing connections with others” (p. 399). The skill of writing is vital (Beck & Fetherston, 2003; Easterbrooks & Stoner, 2006; National Commission on Writing, 2004, 2005). It is needed from early elementary school throughout one's life. Children with disabilities need to be able to write. With these tools, teachers will be able to address the challenge to help children with disabilities perform classroom tasks at an age-appropriate level. If young writers with disabilities can be given effective tools to motivate them to practice and develop writing skills using strengths and bolstering weaknesses, they can become good writers rather than people who disdain and avoid writing. AT tools, such as picture-to-text software, can help individuals with disabilities, experience success as they begin learning to write, and can be a first step to writing independently and communicating thoughts in writing which could lead to better grades, improved self-image about academic endeavors, and to be better prepared for getting a job as an older teen or adult. For some individuals with autism, such as Carly Fleischmann and David Eastham, typing is their only means of communication.

Based on a literature review conducted by Prizant and Wetherby (1998), and Prizant and Rubin (1999) a list of caveats was developed to help guide practitioners to find interventions for individuals with ASD. Prelock (2006b) emphasized their importance. Some of the points were particularly poignant in light of this current research.

- Evidence supports that solutions are more effective if based on a range of approaches rather than one single approach.

> In fact, it has been our experience that it is more common to see children receiving multiple interventions and activities reflecting a variety of approaches and offering a variety of learning opportunities and social partners rather than one intervention alone. (Prizant & Rubin, 1999, p. 201, paragraph 11)

- Benefits of each intervention may be very different for each individual child with ASD.
- Persistent design problems are prevalent in current research, including uncontrolled variables.

After seeing some of the results from this study, Jacqualyne Evansmcrae, a special educator from a local high school, who has taught students with autism for 13 years, was amazed.

> I feel that it is remarkable that children with autism, using picture-to-text software and word prediction software showed any gain at all, especially when, the exposure to the programs was limited. It's encouraging knowing that some students can benefit, overcoming their rigidity in order to generalize skills. I would definitely be interested in seeing more information and possibly using this in my teaching. (Evansmcrae, 2012,)

When this study was conceived in 2009, the goal was to verify the importance of giving students with disabilities, in particular, those with autism, the tools needed to be able to participate in academic settings. Prelock (2006a) wrote that, “the use of visual supports can be critical to the communication success of children with ASD" (p. 450). Using visual supports can encourage engagement in an activity (Heflin & Alaimo, 2007). Prizant and Rubin (1999) wrote about the wide acceptance of using visual supports to benefit students with ASD. They outlined the history of using visual supports for schedules as having started in the 70s because it was known that individuals with ASD often had relative strength in visual processing. The use of visual supports was educationally validated, yet empirical research did not follow until much later.

> Had professionals waited for evidence from empirical research, it is possible that the implementation of such important and creative practices would have been significantly delayed and possibly not implemented at all. We still observe programs and professionals who do not use visual support strategies (to the detriment of their students) because of an inflexible adherence to the use of experimental validation as the sole criterion of choosing educational and clinical practices. (Prizant & Rubin, 1999, p. 203)

In light of the insight noted above by Prizant and Ruben, and as a witness to successful ventures with picture-to-text software in classrooms as supports for writing, this researcher realized that more research on this topic was warranted. This valuable tool, picture-to-text software, which may enable emergent writers with autism and other disabilities to communicate in writing, will be underutilized without research.

In the 2010 ABC story told by John McKenzie, on Medical Mysteries "Autistic Girl Expresses Unimaginable Intelligence- Carly Fleischmann" written by BellaLunaJessalynn (2010), Carly implores, that we help individuals with Autism to "find a voice." Without a computer, Carly's silence would have lasted longer, and would have been much more difficult to unlock. When she was 11 years old, a computer with word prediction became her only means of verbal communication, an even more vital tool for an individual with autism. At age 17, she now uses a computer with word prediction to communicate with people all over the world and to write a book. For other young students with moderate autism who have such great difficulty with communication of any type, picture-to-text software could possibly be a catalyst for beginning to communicate. It is imperative that we help individuals with autism. Giving them access to the technology tools that can help unlock their world is an important step. Although writing can be difficult for individuals with autism, technology can enable an important venue to emerge. Not only can it help children with autism learn and process material in many content areas throughout their schooling, more and more we have autobiographies written by people such as Temple Grandin, Luke Jackson, Liane Holliday Willey, Carly Fleischmann, and others. Those autobiographies, blogs, and YouTube messages can help them share their gifts and help us create a more realistic perspective of autism. David Eastham, a poet with autism was unable to reveal his thoughts, inner spirit, and his world until it was unlocked it age 19 with a small computer. It is vital that we find ways to help these children transcend their writing difficulties at earlier ages.

"Everyone has an inner voice. I found a way to let mine out." (Fleischmann, 2012). Assistive technology such as picture-to-text software may help more young students with autism, and other disabilities, discover their "inner voice."

APPENDIX A: IRB RESEARCH PERMISSION

GEORGE MASON UNIVERSITY

Office of Research Subject Protections
Research Hall
4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-4121; Fax: 703-993-9590

TO: Michael Behrmann, College of Education and Human Development

FROM: Aurali Dade
Assistant Vice President, Research Compliance

PROTOCOL NO.: 6992 Research Category: Doctoral Dissertation

PROPOSAL NO.: N/A

TITLE: The Impact of Using Assistive Technology on Writing Productivity of Young Writers

DATE: July 16, 2012

Cc: Susan Kenney

On July 16, 2012, the George Mason University Institutional Review Board (GMU IRB) reviewed and approved the amendment dated July 5, 2012 for the above-cited protocol following expedited review procedures. A copy of the revised approved consent document is attached. Please use this copy with the GMU IRB stamp of approval.

You may proceed with data collection. **Please note that any further modifications to your research must be submitted to the Office of Research Integrity & Assurance (ORIA) for review and approval prior to implementation.** Any adverse events or unanticipated problems involving risks to subjects including problems involving confidentiality of the data identifying the participants must be reported to the GMU ORIA and reviewed by the GMU IRB.

The anniversary date of this study is April 19, 2013. You may not collect data beyond that date without GMU IRB approval. Prior to that date, the GMU ORIA will send a reminder to you regarding continuing review procedures.

If you have any questions, please do not hesitate to contact me at 703-993-5381.

APPENDIX B: IRB CONSENT FORM

Writing Productivity of Young Writers with Autism

Approval for the use of this document EXPIRES

CONFIDENTIALITY

The data in this study will be confidential. While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your child's writing samples. All electronically, digitally, or personally recorded data, including the surveys, will be labeled with a name your child helps to choose. Your child's name will not be included on any collected data. Through the use of a code name, the researcher will be able to link your child's information to his or her writing samples. Only you, your child, and the researcher will know the code name.

PARTICIPATION

Your child's participation is voluntary, and he or she may withdraw (or you may withdraw him or her) from the study at any time and for any reason. If you do not agree for your child to participate or if you withdraw him or her from the study, there is no penalty or loss of benefits to which you or your child are otherwise entitled. There are no costs to you or any other party.

CONTACT

This research is being conducted by Susan Kenney under the direction of Dr. Michael Behrmann at George Mason University. Dr. Michael Behrmann may be reached at 703-993-3670 for questions or to report a research-related problem. You may also contact Susan Kenney at 703-578-0345 or shkmpower@gmail.com, regarding questions about this research. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT

I have read this form and agree that my child may participate in this study. I also agree to participate in this study by completing the survey.

I provide my approval for audiotaping of my child. ______ (Initials)

Parent or Legally Authorized Representative

____

(Print name) Signature Date of Signature

Approval for the use of this document EXPIRES

APR 19 2013

Protocol # 6992

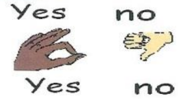
George Mason University

APPENDIX C: IRB ASSENT FORM

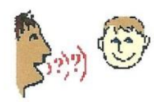
AUDIO TAPING
Can we audio tape you while you write? Can we audio tape you while we talk about writing? We want to know what you like about writing, and if the computer makes it better. We want to show other teachers and school people about how a student like you writes. Remember, we will not use your real name.

Is it OK for us to audio tape you for other teachers and school people to hear?

Is it OK to audio tape me teaching you so that someone can see if I follow the plan?



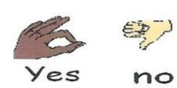
WHAT IF YOU HAVE QUESTIONS OR PROBLEMS?
Ms. Kenney is working with Dr. Behrmann at George Mason University to do this study. Your parents can call Dr. Behrmann (703) 993-3670 or call Ms. Kenney at 703-578-0345, or email at shkmpower@gmail.com if you or if they have questions or want to talk about any problems. Also, George Mason University has a special office that deals with people like you, who help with research studies. Your parents can call that office at 703-993-4121 if you have questions that we can't answer.



questions

George Mason University has looked at the way we are doing this study and has given us permission to do it.

ASSENT
I have read/heard this form and had my questions answered. I agree to help with this study. Circle your choice.



Print Name ______________________________

Sign Name ______________________________

Date of Signature ______________________________

Page 2 of 2

Most of these pictures were found in Pixwriter 3.0 by Slater software.
http://www.slatersoftware.com/pixwriter.html

The Impact of Using Technology on

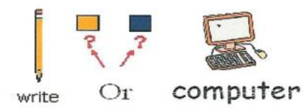
Originally developed by S. Kenney, 10/09, for GMU HSRB Version date: 7/2012

The Impact of Using Technology on Writing Productivity of

Young Writers with Autism

MINOR INFORMED ASSENT FORM - You can choose!

WHAT WE'RE DOING.
Can computers help you write? We want to know. We will get together 7 to 10 times at a quiet place for about 2 hours. You will see pictures that you can type about. Later, you will learn how to use a computer programs that might help you to write.



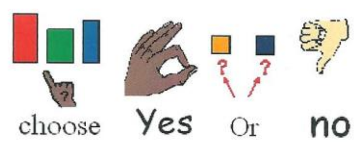
You can tell us what you think about writing. There will also be other fun things to do.

WHAT COULD HAPPEN?
Nothing bad could happen to you if you decide to help us with our study.

WHAT'S IN IT FOR YOU?
You won't get to keep anything for helping us. You will be able to try new software and see if, computers can help you.

YOUR INFORMATION WILL BE KEPT SAFE.
You will choose a name for your writing. No one else will know what words or sentences *you* typed, or what you said. They will only know that a child typed it or said it.

PARTICIPATION: YOU HAVE THE CHOICE.
You can choose to be in this study or not. You can say, "No," at any time, even if you have already started. We promise not to be mad.

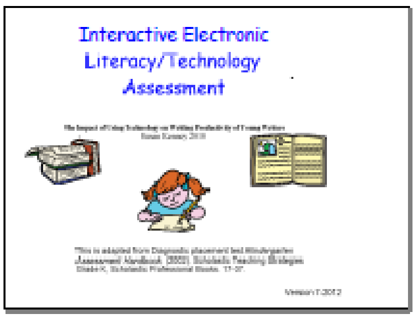


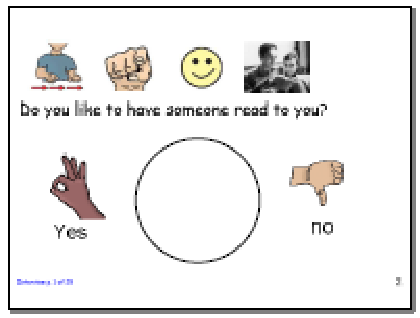
Most of these pictures were found in Pixwriter 3.0 by Slater software.
http://www.slatersoftware.com/pixwriter.html

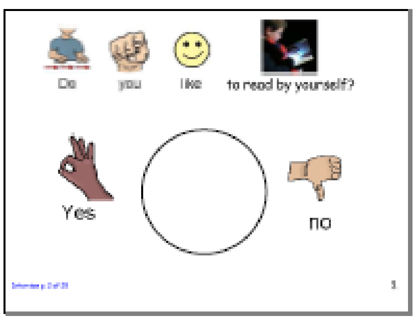
Originally developed by S. Kenney, 10/09, for GMU HSRB Version date: 7/2012

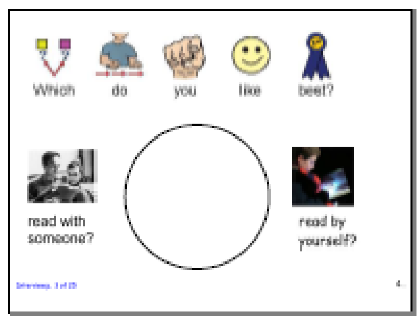
Made with Literacy Support Pictures™ and PixWriter™ software, www.suncastletech.com

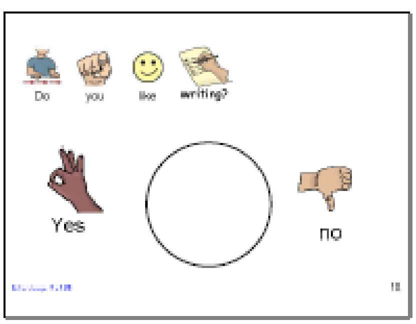
APPENDIX D: AT ASSESSMENT

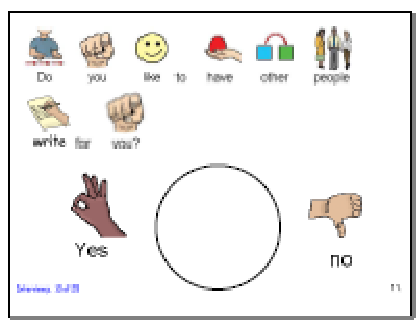


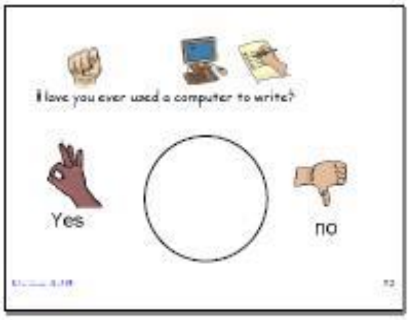


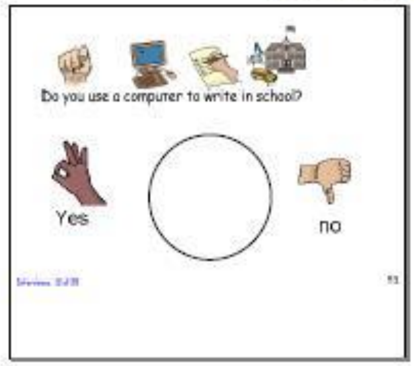


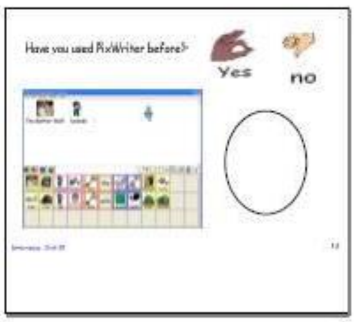


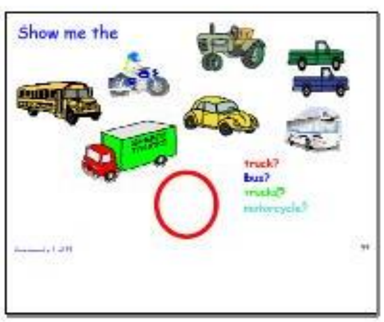




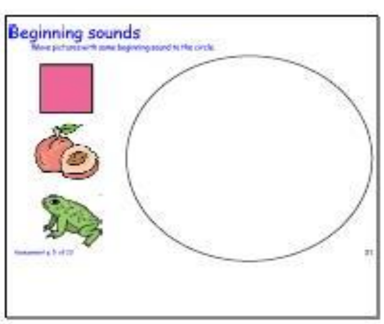

Have you ever used a computer to write?
Yes
no

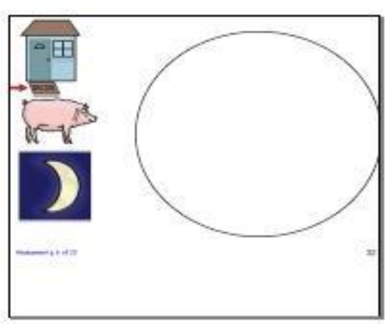

Do you use a computer to write in school?
Yes
no


Have you used PixWriter before?
Yes
no

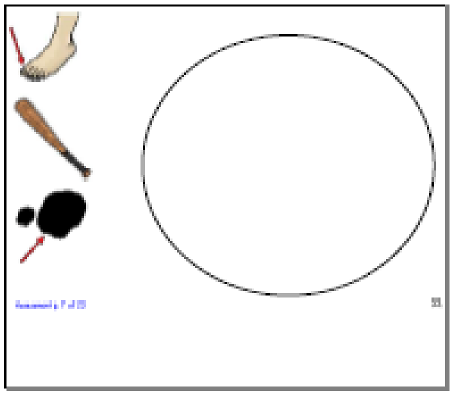

Show me the
truck?
bus?
motorcycle?

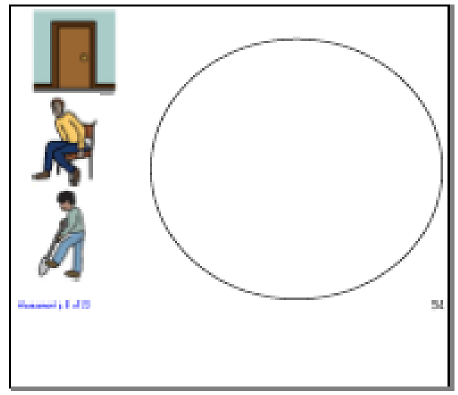

plants
animals

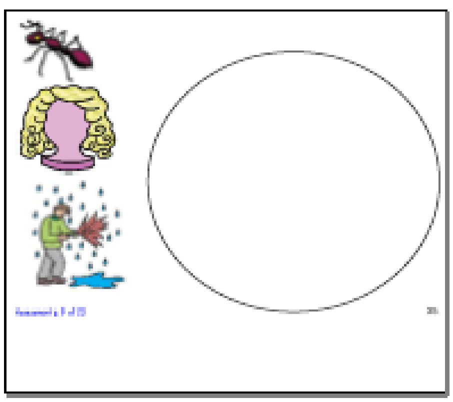

Beginning sounds

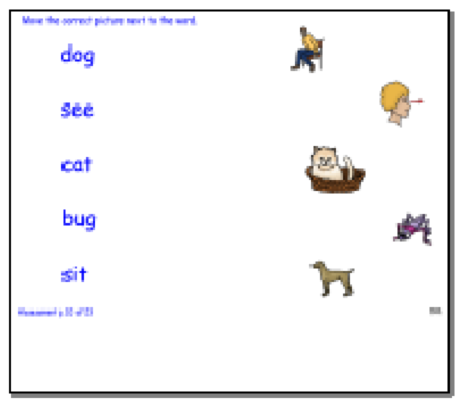


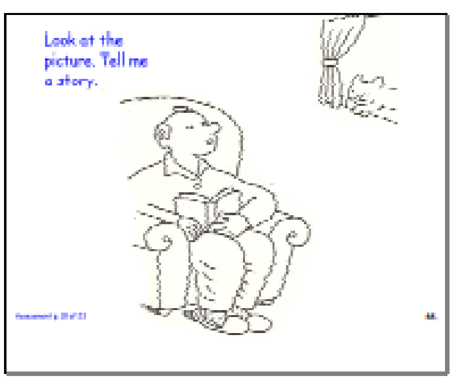
4

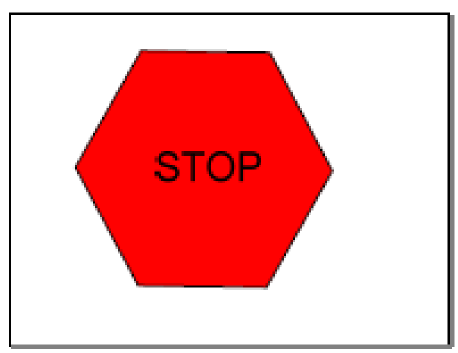






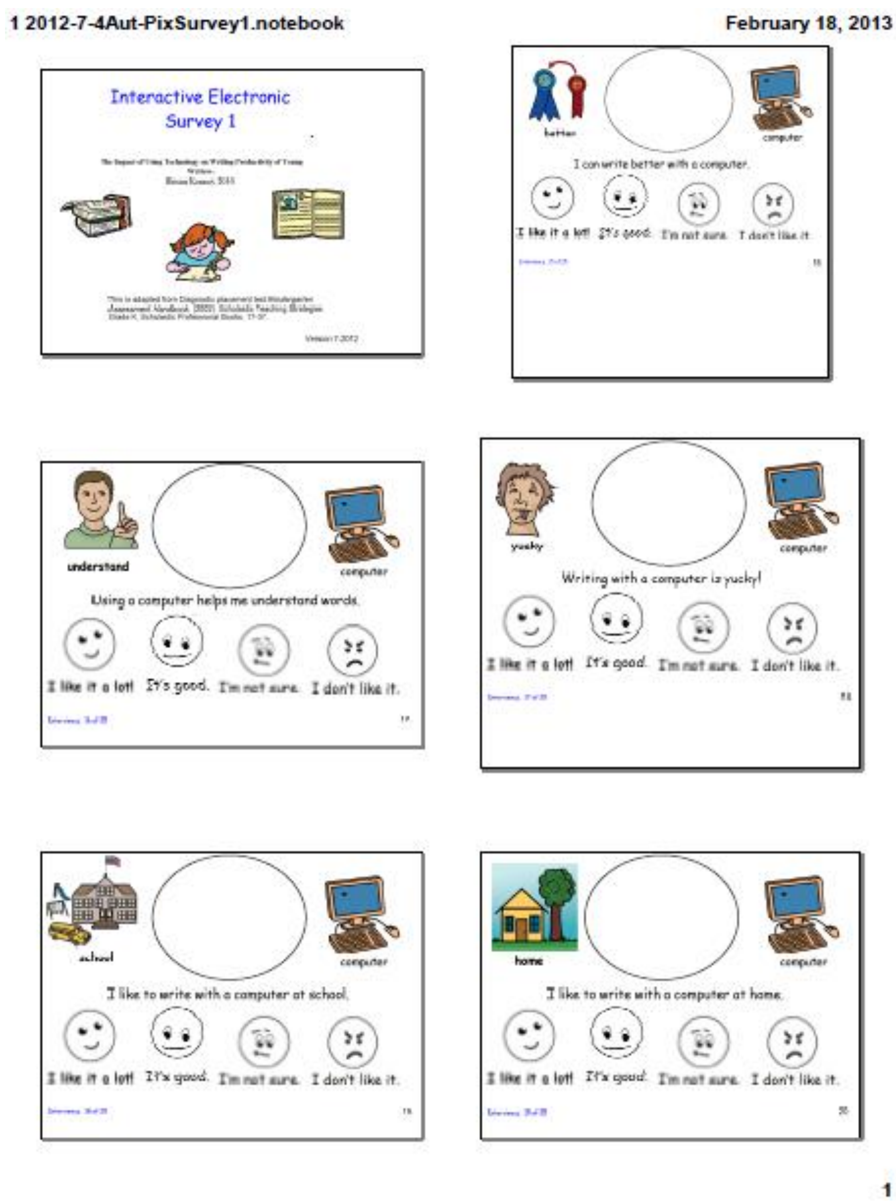

Move the correct picture next to the word.
dog
see
cat
bug
sit

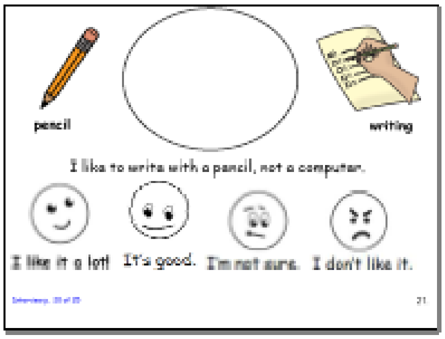

Look at the picture. Tell me a story.

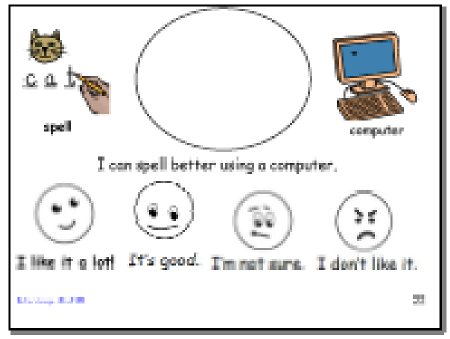

STOP

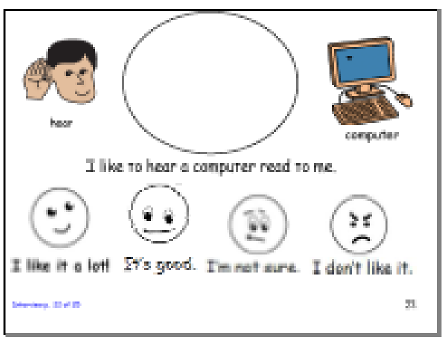
APPENDIX E: PARTICIPANTS' SURVEYS

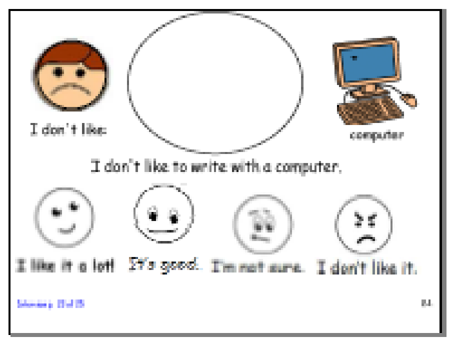
Participant Survey 1

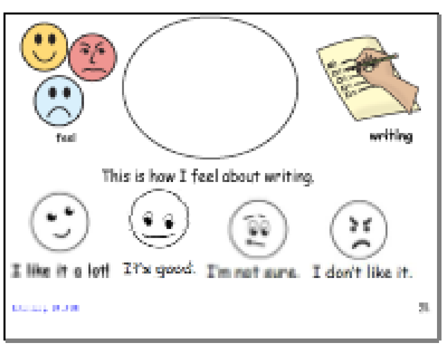


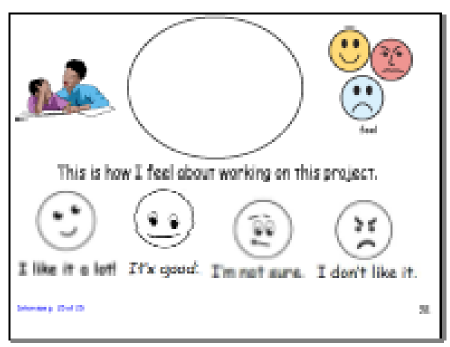

pencil
writing
I like to write with a pencil, not a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


spell
computer
I can spell better using a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.

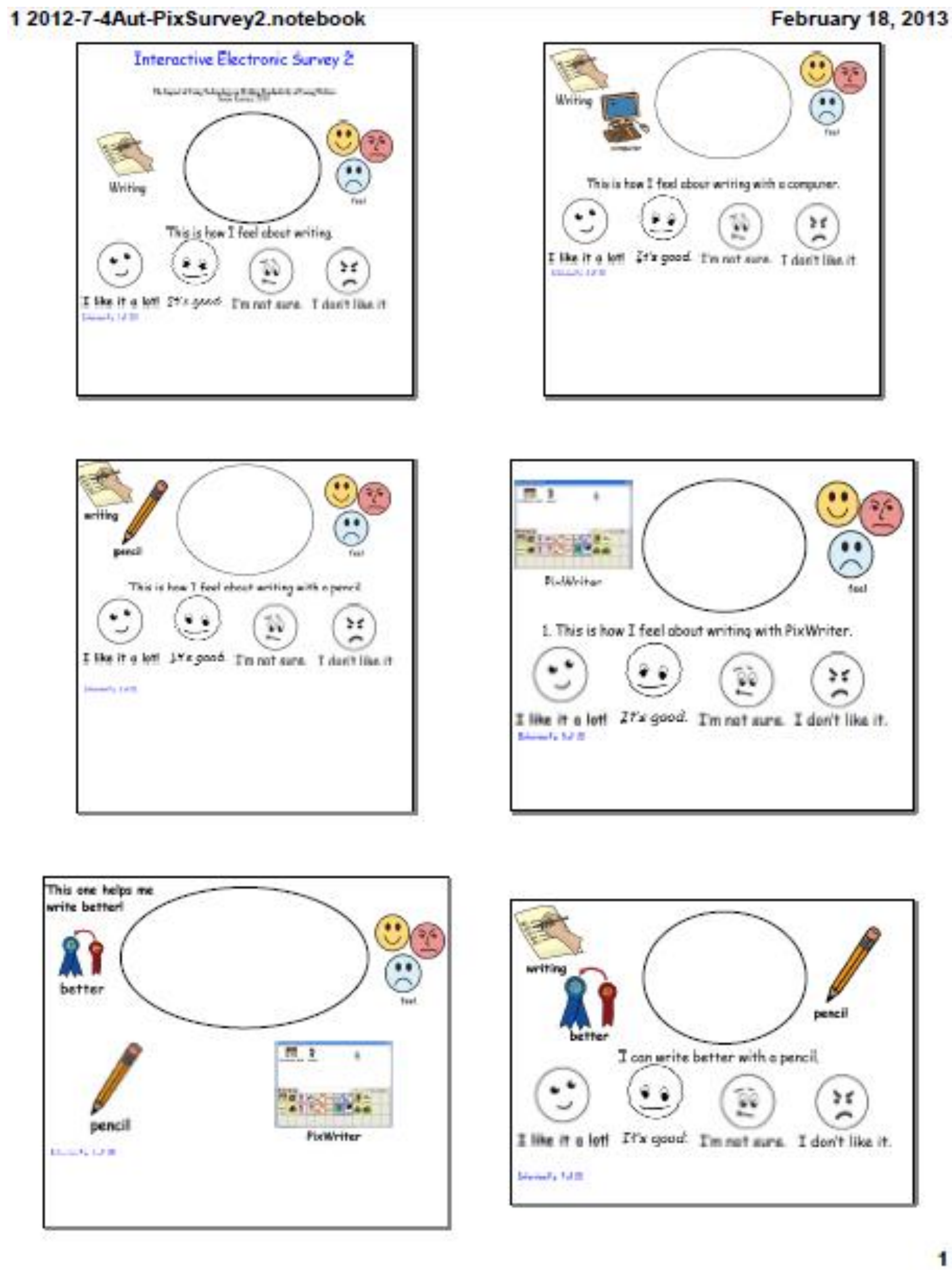

hear
computer
I like to hear a computer read to me.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


I don't like
computer
I don't like to write with a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


feel
writing
This is how I feel about writing.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


feel
This is how I feel about working on this project.
I like it a lot!
It's good.
I'm not sure.
I don't like it.

Participant Survey 2




writing
better
computer
I can write better with a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


I like this one the most!
Like
feel
PixWriter
pencil


understand
computer
Using a computer helps me understand words.
I like it a lot!
It's good.
I'm not sure.
I don't like it.

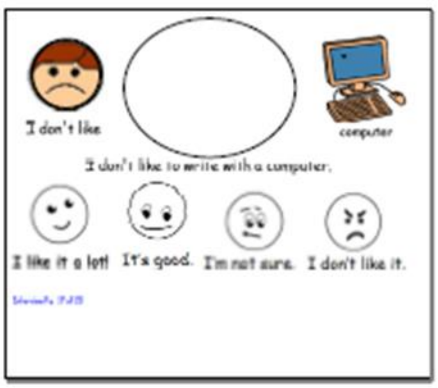

yucky
computer
Writing with a computer is yucky!
I like it a lot!
It's good.
I'm not sure.
I don't like it.


school
computer
I like to write with a computer at school.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


home
computer
I like to write with a computer at home.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


spell
computer
I can spell better using a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


hear
computer
I like to hear a computer read to me.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


I don't like
computer
I don't like to write with a computer.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


This is how I feel about writing with PixWriter.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


writing
feel
This is how I feel about writing.
I like it a lot!
It's good.
I'm not sure.
I don't like it.


This is how I feel about working on this project.

APPENDIX F: PARENT SURVEYS

Parent Survey 1

Surveys for Parents or Legally Authorized Representative

You have described your child as having some difficulty with writing. In order to understand your child's situation, please answer the following questions. Thank you for your time.

1. My child is
   - ○ A. 9 years old.
   - ○ B. 10 years old.
   - ○ C. 11 years old.
   - ○ D. 12 years old.

2. My child has been in school (including preschool)
   - ○ A. Less than 3 years.
   - ○ B. More than 3 years.
   - ○ C. More than 4years.
   - ○ D. More than 5 years.

3. My child has an IEP.

   Yes ○ No ○

4. What is your child's educational classification?
   - ○ A. Autism
   - ○ B. Asperger's Syndrome
   - ○ C. Other _________________

5. My child's classroom setting is:

- A. Full inclusion.
- B. Included in academic subjects (reading, math, etc.).
- C. Included only for non-academic subjects (PE, art, music, etc.).
- D. Push in for classes in area of strength.

6. My child currently has a hard time, with language arts, in school.

   Yes   No

7. My child started having trouble in school

   - A. Right away.
   - B. After a year.
   - C. After several years.
   - D. Never.

8. My child needs a picture to help him/her recognize words when reading or writing?

   Yes   No

9. My child has assistive technology and/or writing accommodations on his/her IEP

   Yes   No   What is assistive technology?

   If yes, please describe.

10. My child likes to:

    - A. Have others read to him/her.
    - B. Listen to books on tape.
    - C. Likes to look at books.
    - D. Likes to look/read alone.
    - E. Likes to look/read with others.

11. My child's reading is

    - A. Grade level or above.
    - B. A little below grade level.
    - C. Well below grade level.

12. My child likes to write.

- A. With a pencil.
- B. On a computer.
- C. No!

13. My child can:
    - A. Not write, but can dictate sentences.
    - B. String letters together for words.
    - C. Write a few words.
    - E. Write a 3 to 4 word sentence with prompts.
    - F. Write, unprompted, a 3 to 4 word sentence.
    - G. Write, unprompted, a 5 to 8 word descriptive sentence.
    - H. Write, a simple, unprompted, 3 sentence paragraph.

14. My child's writing is
    - A. Grade level or above.
    - B. A little below grade level.
    - C. Well below grade level.
    - D. Illegible.

15. My child's experience with computers at home includes: (mark all that apply)
    - A. There is no computer at home.
    - B. There is a computer but he/she can't use it.
    - C. There is a computer, but he/she can't use it, unless monitored.
    - D. There is a computer, which he/she uses for games & internet.
    - E. There is a computer, which he/she uses for homework.
    - F. There is a computer which he/she uses for educational reinforcement.

16. My child's experience with computers at school includes: (mark all that apply)
    - A. There is no classroom computer.
    - B. There is no classroom computer, but he/she has access to a computer lab.
    - C. There is a classroom computer but he/she doesn't use it.
    - D. There is a classroom computer used for games & internet, only.
    - E. There is a classroom computer used for drill and repetition of concepts.

F. There is a classroom computer used for writing.

17. Which of these statements best describes your child's feelings about using computers?
   - A. Avoids using computers as much as possible.
   - B. Uses computers to play games only.
   - C. Uses computers to do some homework.
   - D. Is excited about using computers.

18. When it is time to write, my child

19. My child would have more success with writing if

20. Some interventions and/or accommodations that have been used with my child for writing are

21. The results of the writing interventions and/or accommodations has been

22. What type of assistive technology accommodations are on your child's IEP?

23. My child/I have: (Check all that apply.)
   - Heard of Picture-to-text software, such as PixWriter or Writing with Symbols.
   - Seen a demo of this program.
   - Used this program.
   - None of these.

24. Please provide any additional comments about your child's writing.

Parent Survey 2

While answering these questions, think about how your child feels about writing after using PixWriter in this study. Thank you for your time.

1. My child likes to write more as a result of this study.

   Yes ○ No ○

2. When it is time to write, my child

3. The best part of this study was

4. The worst part of this study was

5. After seeing your child's work samples with picture-to-text software, PixWriter, do you see a difference in his/her writing? Please explain.

6. How do you think using picture-to-text program like PixWriter could affect your child's writing development?

7. Has this study been beneficial?

   Yes ○ No ○ (Specify.) .

8. Please provide any additional comments about this study and/or your child's writing.

APPENDIX G: CWS SCORING SHEET

P= Participant S= Session Rater ____________________

P S	Camtasia Check # of Words in 3 minutes	# of Words	CWS	TWS	CWS%	# IWS	# sentences	IRR
P-1 S-12	^SpongeBob^ is^ holding ^the ^star^.^ The^ Patrick Star^ is ^eating ^cookies^._ the ^SpongeBob^ is^ happy^. ^The ^Patrick Star ^is^ eating ^cookies^. ^The ^SpongeBob ^is ^dancing After 3 minutes on the gift.	24	26	27	96.3	1	5	
	Camt Check # of Words in 3 minutes	# of Words	CWS	TWS	CWS%	# IWS	# sentences	IRR
P-1 S-13								
	Camt Check # of Words in 3 minutes	# of Words	CWS	TWS	CWS%	# IWS	# sentences	IRR
P-3 S-1								

APPENDIX H: CWS EXAMPLES AND NON-EXAMPLE

A sentence is a group of words expresses a message and	Examples	Non-examples
• Contains a minimum of two words ○ A subject (who or what the sentence is about) and ○ A predicate (what the subject is or is doing)	sentence _boy ^looks_	Not a sentence ^The^ truck^ is
• If the placement of the words seemed illogical to the score, it was not scored as a sentence. (Pennington, Stenhoff, Gibson, & Ballou, 2012)	_big^ pumpkin ^smiles_.	yellow _is_big
• Words that were distractors in the pallet, were highlighted in yellow. Every distractor word chosen has an error mark both in front	_baby _looks^ mad_	_baby ^looks^ mad_.

and after it. It cannot be counted as a sentence. The picture did not have the baby.		
• For this study a sentence must include words that can logically be used to describe the picture presented. Sentences were highlighted in blue.	For a picture about SpongeBob a sentence could be the_the _the ^fish ^is^ yellow_._ SpongeBob _sponge _sponge _plane_ plane_ trees _trees	Not counted plane is yellow.
• If most of the words in the sample seem randomly chosen, although two words together may be considered a correct sequence but 3 or more words must be arranged appropriately to be considered a sentence	One sentence was counted. the_the _the ^fish ^is^ yellow_._ SpongeBob _sponge _sponge _plane_ plane_ trees _trees	A correct sequence is counted but not a sentence. _river_ sign _house _dinosaur ^chased
• if most of the words in the sample seem to be describing the picture, a noun and a verb may comprise a sentence.	For a picture with a man reading in a chair and a cat sleeping in the window _man^	_Man_plane_blue_reads No sentences

	reads_._ cat ^sleeps 2 Sentences	
• If a sentence contains the word "is" there should be a word that makes sense following it.	_ the^ truck^ is _drivg (driving) Sentence	the ^man ^is _fills Not a sentence
• If a sentence was in process at the end of the three-minute time limit, if the participant finished an appropriate sentence with two or fewer words it was counted as a sentence but the extra words were not counted in the word count.	Counted as a sentence but the word paper was not counted in the word count or in the sequence count. ._the^ girl ^is ^drawing^ on paper.	Not counted as a sentence ^The man is working.
• Missing end punctuation is counted as an error on both sides in the word sequence count but, it is not required for words to be considered a sentence. (Pennington, Stenhoff, Gibson, & Ballou, 2012)	^The_ the _truck^ is ^big _._ the^ truck^ …	^The_ the _truck^ is ^big _the^ truck^ …
• Unless the last word in a sample has an end punctuation, it does not have an error mark or carat, because there is no sequence.	^The_ the _truck^ is ^big _._ the^ truck^ is ^drivg (driving)	^The_ the _truck^ is ^big _.the^ truck^ is ^drivg_.(driving)

• Apostrophes are needed for possessive nouns and contractions	^The^ racers_ car _driving^ on ^the _car	^The^ racers^car _driving^ on ^the _car
• Multiple words on a button are counted as one word and no sequence mark is put between them.	There are 6 words and 7 CWS. ^The^ Curious George ^is^ chasing ^the^ bunny^.	There are not 7 words and 8 CWS. ^The^ Curious ^George ^is^ chasing ^the^ bunny^.
• As with the study of Pennington et al. (2012) article omissions and additions were allowed.	^The^ Curious George^ is^ happy^ . ^Man^ is^ happy ^.	_The_ Curious George^ is^ happy^ . _Man^ is^ happy ^.
• Every word added that does not make sense in the sentence must have an error mark before and after it.	_man _~~is~~ _read^the ^book^.	_man _~~is~~ read^the ^book^.
• Words omitted have only one error mark even if two words were omitted.	^The ^ working_ (man) is ^carrying^ the_ (box at) school^.	^The ^ working_ (man)_ is ^carrying^ the_ (box _at) _school^.
When sentences are fairly easy to determine add periods _._ When sentences are not fairly easy to determine, esp if many words seem to be jumbled without thought, then … No Sent. Expected don't add periods!	_ ^The^ Curious George ^is ^sitting ^on ^the^ground_. _Man ^is ^ sitting ^on ^the ^ground^.	garden_pumpkin_picks_ happy _the ^carrot _horse _ Curious George _orange_ plane_ in

APPENDIX I: SESSION SEQUENCE AND MATERIALS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Provide Mouse & Mouse Pad															
Set up 2 Digital Recorders															
Have Extra Batteries- 4 AAA in bag															
Have Clipboard with directions, scripts, and checklists															
Show First then board to															
Read direction cards															
Set up 2 computers & 2 cords															
Picture-to-text Soft.															
Camtasia software															
Picture prompts															
Stop watch & Visual timer															
Parent Survey		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Child Survey		–	–	–	–	–	–	–	–	–	–	–	–	–	–
HSRB forms- 2 copies of Parent & Child versions		–	–	–	–	–	–	–	–	–	–	–	–	–	–

APPENDIX J: FIDELITY CHECKLIST

Observer ______________________________

Note: Mark each step completed or not completed by the researcher. The fidelity of treatment will be calculated by dividing the number of steps completed by the number of steps planned.

Mark the Materials present and steps completed. F T Score = Yes checks /Total number

Writing Prompts

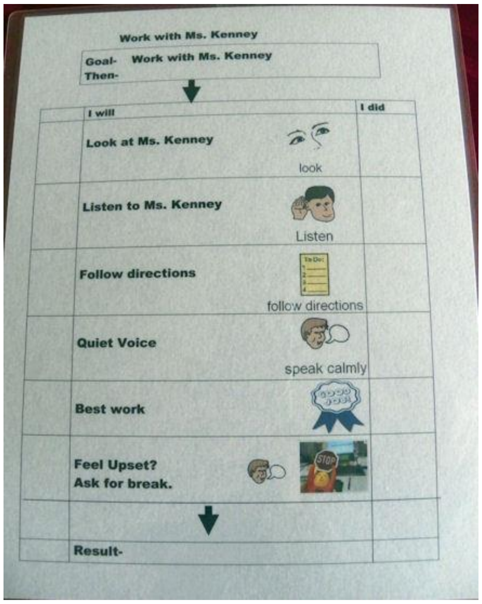
Participant													
Session													
Provided Mouse & Mouse Pad	1												
Opened Picture-to-text document	1												
Sequence													
Set up laptop, mouse, and appropriate document	1												
Provided picture prompt	1												
Began Camtasia & digital recorders	1												
Read prompt script	1												
Started timing	1												
Used vocabulary at students' age/ability level.	1												
Saved document and recording files	1												
During the 1st and last sessions for parent and participant													
IRB forms	2												
Surveys	4												

Do- Put out the computer with a blank document opened. Show picture prompt.
Script- "Look at this picture. Think about it. Write three or more sentences to tell what is in the picture or tell what could be happening. You will have three minutes, but if you need more time, let me know."

APPENDIX K: SESSION MANAGEMENT CARDS

Verbal Prompt Cards

Rule Card



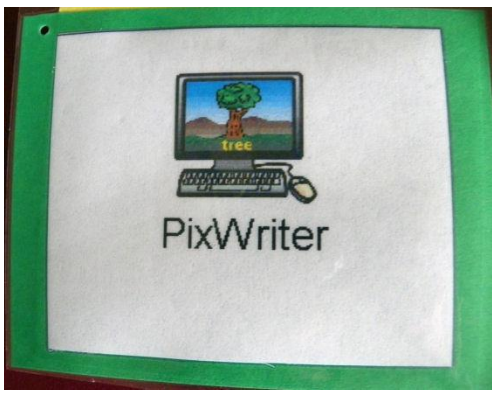
First - Then Board

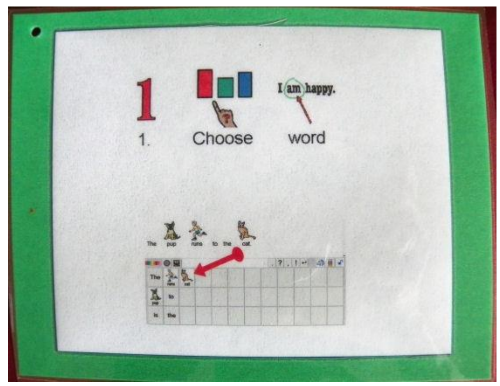
Two Sets of cards

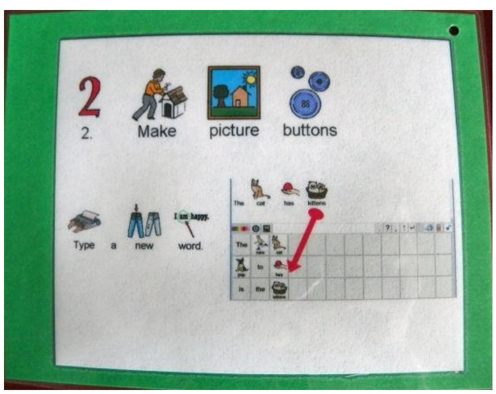
Extra direction cards

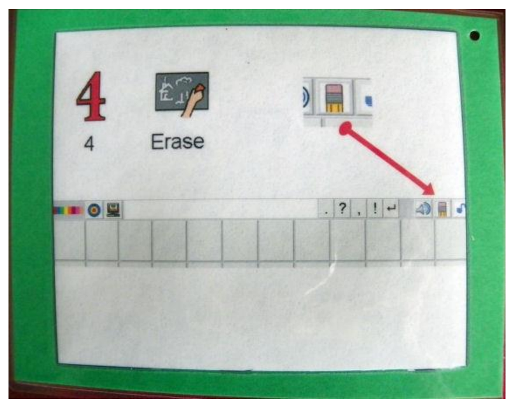
Made with Literacy Support Pictures™ and PixWriter™ software,
www.suncastletech.com

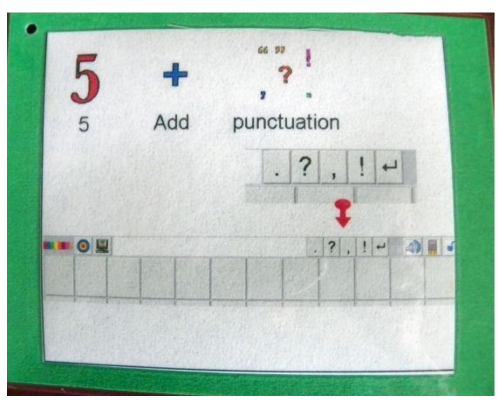
APPENDIX L: PIXWRITER TRAINING CARDS



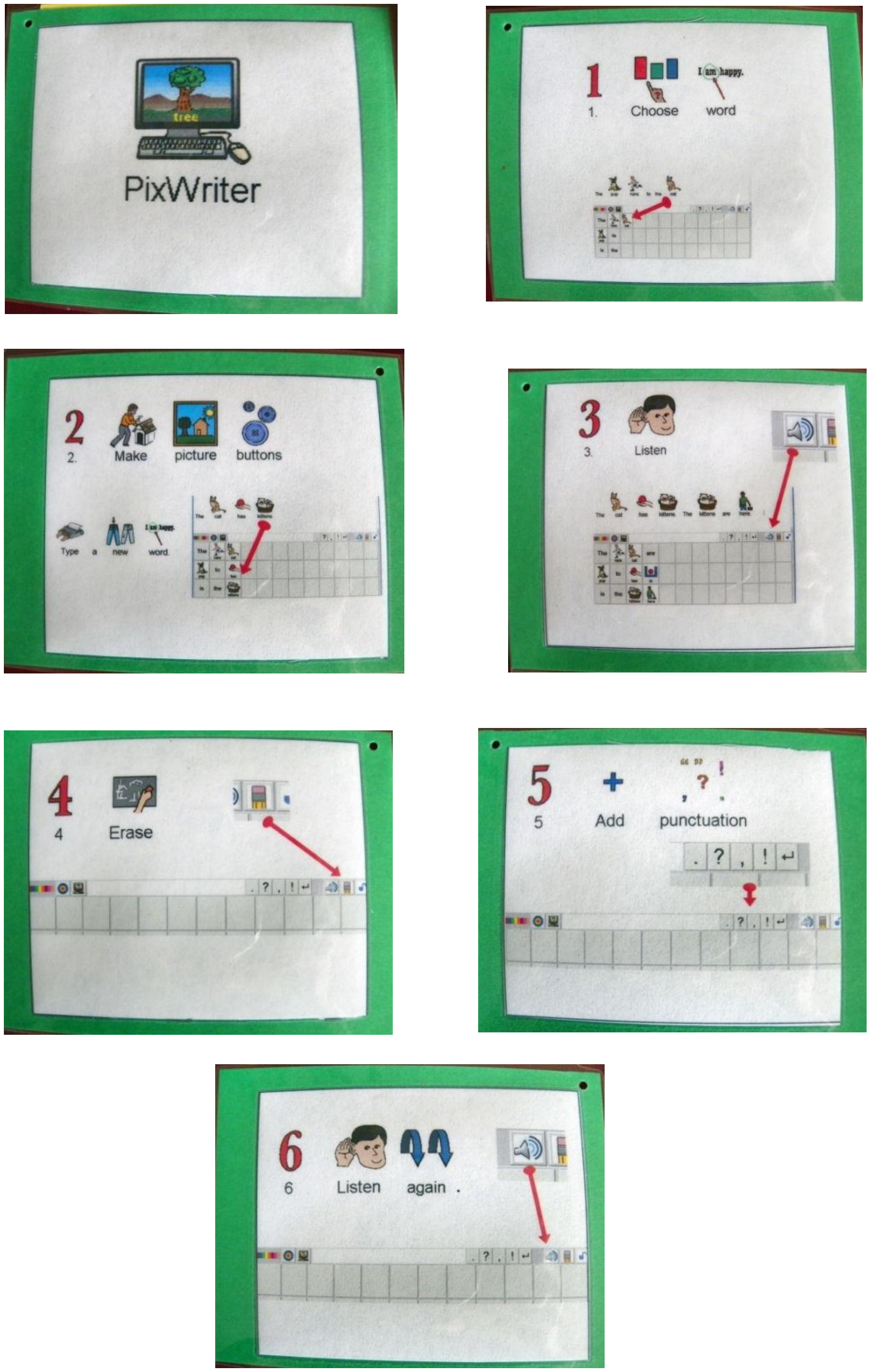








Initial PixWriter Training



Second PixWriter Training

Made with Literacy Support Pictures™ and PixWriter™ software, www.suncastletech.com

APPENDIX M: INSTRUCTIONAL INTERACTIONS CHECKLIST

Observer ______________________________

Writing Prompt Sessions

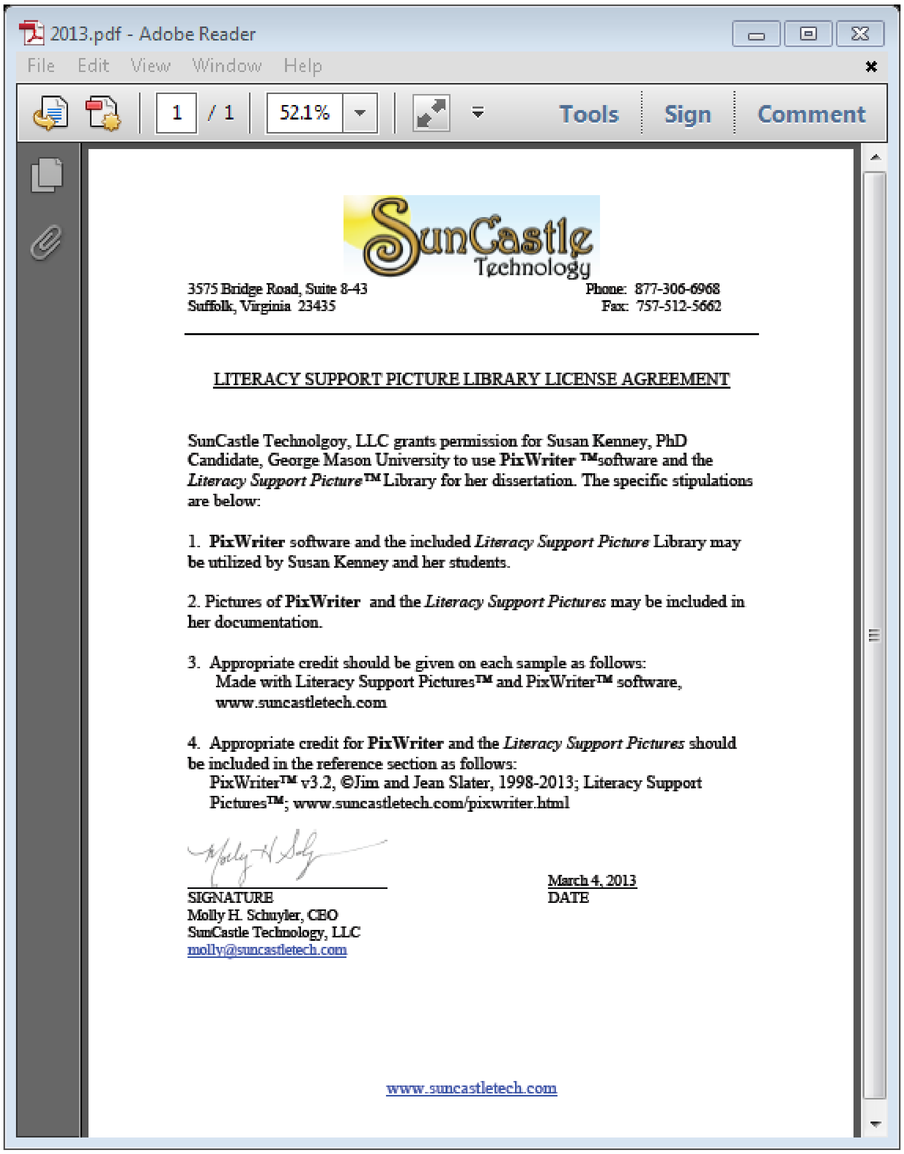
Session earns points according to number of prompts.

3 = Behavior with no prompting
2 = Behavior with minimal prompting (2 or fewer gestural or verbal prompts)
1 = Behavior with moderate prompting (3-4 gestural or verbal prompts)
0 = maximal prompting (5 or more) or refused

Participant													
Session													

Sequence # Points Awarded	#												
Looked at the direction cards	3												
Attempted to echo the rules as they were read	3												
Attempted to echo prompt script while it was read	3												
Participant remained at the computer and on task with no prompting	3												
Participant used the features with no prompting	3												
Participant followed directions	3												
Researcher adjusted procedure because of behavior which resulted in compliance	1												

APPENDIX N: PIXWRITER PERMISSION



SunCastle Technology

3575 Bridge Road, Suite 8-43
Suffolk, Virginia 23435

Phone: 877-306-6968
Fax: 757-512-5662

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3. Appropriate credit should be given on each sample as follows:
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4. Appropriate credit for **PixWriter** and the *Literacy Support Pictures* should be included in the reference section as follows:
   PixWriter™ v3.2, ©Jim and Jean Slater, 1998-2013; Literacy Support Pictures™; www.suncastletech.com/pixwriter.html

SIGNATURE
Molly H. Schuyler, CEO
SunCastle Technology, LLC
molly@suncastletech.com

March 4, 2013
DATE

www.suncastletech.com

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