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Effect of Education Tablet Applications on Beginning Reading Skills of Students with Autism

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Effect of Educational Tablet Applications on Beginning Reading Skills of Students with Autism

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Date of Approval: Dec. 5, 2017
Abstract

The purpose of this study was to explore the relationship between the effect of tablet computer applications and the reading skills of students with autism. Two subjects diagnosed with autism selected by using a convenient sampling method participated in this study. A single subject ABA design was used for collecting data regarding phonemic identification, letter identification, letter discrimination, and sight word identification. Following the collection of baseline data, interventions in the form of different iPad applications were used in individual tutoring sessions and data were collected on the percent of correct responses given per trial. At the completion of a total of 59 sessions of intervention over a period of 8 weeks, data were collected to determine whether skills were maintained. The results showed remarkable change in phoneme identification, classification and sight word identification based on the comparison of baseline and maintenance averages. Limitations of the study include the small sample size and the length of time allotted for interventions. Future study involving the use of tablet technology with a larger sample size is recommended.
Acknowledgements

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Lastly, thank you Mom for always expecting more out of me than I ever thought I was capable of. You always manage to put things in perspective when I am overwhelmed. Without your love and support I would not be where I am today.
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Effect of Educational Tablet Applications on Beginning Reading Skills of Students with Autism

Autism is a developmental disability characterized by deficits in the areas of communication, socialization, and interests (Heflin & Alimo, 2007). Students with autism have difficulty understanding symbols, producing and comprehending language and shifting attention between stimuli. No specific cognitive source has been identified as the cause of the array of symptoms, but based on a general profile researchers believe that deviations in early development cause problems with memory, executive functions, attention and social skills in addition to the language problems discussed (Green, Fein, Joy, & Waterhouse, 1995). These difficulties can range from mild, affecting the student’s ability to maintain conversation, to severe, limiting original speech if there is any at all (Fitzer & Sturmey, 2009). Cognitive deficits are often present in students with autism as well, compounding language difficulties especially in the areas of vocabulary, comprehension and sequencing information (Green, Fein, Joy, & Waterhouse, 1995). Additionally, lack of literacy experiences in the classroom due to communication difficulties can have an unintended effect on a student’s reading skills (Coleman-Martin, Heller, Cihak, & Irvine, 2005).

Relevant Legislation

The Individuals with Disabilities Education Act of 1990 laid the ground work for the educational rights of students with autism. The legislation added autism and traumatic brain injury as recognized disabilities and expanded the definition of related services. Additionally the law reaffirmed the idea of a free and appropriate public education (FAPE) for all students. Through IDEA of 1990 thousands of students are served under the diagnosis of autism every year. The student is assured FAPE based on the necessary accommodations and services outlined
in a student’s Individualized Education Plan (IEP). Failure to provide accommodations such as assistive technology for students who require that service is a violation of FAPE for the student and can result in legal action (Yell, Katsiyannis, Drasgow, & Herbst, 2003).

In 2004 IDEA was revisited and renamed The Individuals with Disabilities Education Improvement Act (IDEIA). IDEIA, mandated that assistive technology be considered as part of the “reasonable accommodations” a student may receive. If assistive technology is deemed necessary, training with the device must also be incorporated into IEP goals.

In 1988 the Technology-Related Assistance for Individuals with Disabilities Act or Tech Act was passed to provide funding to states to then provide technology assistance to students with disabilities. Traditionally assistive technology has been focused on students with physical and sensory disabilities, but more recently assistive technology has been refocused on making learning accessible for students with learning or cognitive disabilities (Bryant & Seay, 1998). The goal of the Tech Act was not only to make technology more accessible to students through funding, but also to train individuals on how the assistive technology can benefit students with disabilities (Bryant & Seay, 1998). Once the student leaves the educational environment the Americans with Disabilities Act of 1990 mandates that employers provide reasonable accommodations to employees with disabilities.

Pre-Reading Skills

Beginning reading skills can be organized into three big ideas: phonological awareness, alphabetic understanding, and automaticity with the code (Coyne, Kame’enui, & Carnine, 2007). Phonological awareness is the idea that our language is made up of corresponding units of sound. In order to become good readers students need to understand the individual units of sound and also be able to use the sounds to change and create words. When teaching phonological
awareness, the emphasis should be on phonemes rather than the corresponding graphemes (Coyne, Kame‘enui, & Carnine, 2007). Specifically, segmenting or breaking apart words into their individual sounds, blending or synthesizing the individual sounds in a word into one unit, and rhyming skills or manipulating specific sounds in a word are key in teaching beginning reading (Henry, 2010). Understanding that individual sounds can be combined, broken apart, and manipulated to create meaningful language is the basis for phonics instruction that follows emergent literacy skills in learning to read (Travers, 2010). Generally, phonological awareness is encouraged initially by providing listening activities along with exposure to a variety of print materials, however because of the specific auditory learning deficits associated with autism students with autism may not benefit from those activities as a typical child would (Henry, 2010; Travers, 2010). Since phonemic awareness skills have been identified as one of the top predictors of reading skill during the first years of instruction it is important to emphasize these skills in different ways to allow students with autism to access the information (National Reading Panel, 2000).

Alphabetic understanding is the principle that sounds are connected to printed graphemes, and the graphemes create specific words in our language (Coyne, Kame‘enui, & Carnine, 2007). Alphabetic understanding facilitates the decoding of unknown words because it gives the student an underlying set of rules that can be applied to any word. If a student reads at the whole word level he has to recognize each word individually rather than decoding the letters in the word. The whole word method is limited by the student’s memory and requires the student to carry a greater cognitive load than if they could use alphabetic understanding to decode words (Coyne, Kame‘enui, & Carnine, 2007). In fact, it is posited that word identification is the most influential skill in determining whether a student is a good reader (Coyne, Kame‘enui, & Carnine, 2007).
Alphabetic understanding, and specifically systematic instruction in phonics has been linked with improved reading achievement in students grades k-6 (Travers, 2010; National Reading Panel, 2000). Specifically, in a synthesis of over 400 studies systematic phonics instruction had an effect size of .60 on student achievement making it a determining factor in academic success (Hattie, 2009).

Automaticity with the code or fluency with reading material is the last determining factor in the reading ability of a student. It is the ability of the student to recognize the word quickly and accurately without having to decode. If a student can read words automatically, with little time spent decoding the material, more time can be spent on the meaning of the words thereby improving a student’s comprehension (Coyne, Kame’enui, & Carnine, 2007). Reading words in context as well as individually will improve the student’s automaticity and ability to recognize the word regardless of context and facilitate the move from learning to read into reading to learn (National Reading Panel, 2000). Becoming more automatic in reading requires a strong base in both phonemic awareness and alphabetic understanding just as strengthened alphabetic and phonic understanding can improve phonemic awareness and automaticity. The three skills are linked together in that without strong skills in all three areas transitioning into reading for comprehension can be difficult (Hook & Jones, 2004).

Due to the triad of deficits characteristic of students with autism, imparting the three big ideas in reading may require specific strategies along with a tightly controlled environment. Existing methods for teaching beginning reading skills are discussed in the following sections.

Language, Beginning Reading, and Students with Autism

Students with autism have specific difficulties in the domain of speech and language as well as social skills (Heflin & Alimo, 2007). Delays in speech and language put students at a
significant disadvantage in beginning reading skills since oral language is considered a prerequisite to beginning reading (Travers, 2010). Specifically, difficulties lie in vocabulary, and pragmatics especially in non-verbal signals that may accompany speech (Heflin and Alimo, 2007). Students with autism may also use language in the form of echolalia in which pieces of speech and/or whole speech are repeated either immediately or at a later time and are not viewed as meaningful communication (Swisher & Demetras, 1985). More recently however, echolalia has been viewed as a delayed form of language development in that some students move from strict repetition to a more flexible form of echolalia known as mitigated echolalia (Schuler & Prizant, 1985). Additionally, it is thought that echolalia provides a platform for students to insert speech into a conversation and thus further their language development (Schuler & Prizant, 1985).

Programs like Picture Exchange Communication System and Functional Communication Training have been effective in providing a communication system for students with autism, followed by reading instruction using sight words rather than a phonic approach (Heflin & Alimo, 2007; Travers, 2010). It has been suggested that a systematic phonics approach can be used to teach students with autism when special care is paid to the individual phase of development (Mirenda, 2003). However, as discussed earlier whole word approaches limit the amount of vocabulary and thus the amount of language a student can utilize. Unfortunately, the research on integrating phonemic awareness, alphabetic understanding and automaticity are lacking possibly due to the prevalence of instruction in functional vocabulary and sight words for students with autism.
Existing Methods

Instructional methods based on the principles of Applied Behavioral Analysis such as Discrete Trial Training, Pivotal Response Training, incidental teaching, and shaping have proved successful in increasing the academic skills of students with autism (Dunlap, Kern & Worcester, 2001; Koegel & Koegel, 1995). These approaches use a process of chaining small steps in a task together to reach an end goal, such as verbally requesting an item. Motivation is at the core of this type of training, with rewards given for each correct response or behavior shown by the child (Volkmar & Weisner, 2009). Interventions are used to shape the behavior of an individual and must show through data collection that the intervention is helping the student to reach a set goal (Heflin & Alaimo, 2007).

Additionally, programs that present information visually, or visually and orally, have been shown to increase joint attention and language comprehension and problem-solving skills in students with autism (Quill, 1997; Bernard-Opitz, Sriram, & Nakhoda-Sapuan, 2001; Mechling, Gast, Langone, 2002; Pennington, 2010). Research has suggested that the presentation of information pictorially, textually, and auditorily increases recognition because the information is stored differently through each representation; the different representations encourage repetitive encoding of information leading to improved recall (Paivio, Rogers, & Smythe, 1968; Dubois & Vial, 2000).

Computer Assisted Instruction (CAI) when used effectively can combine the benefits of applied behavioral analysis and simultaneous visual and oral presentation of information (Bernard-Opitz, Ross & Tuttas, 1990; Williams, Wright, Callaghan, & Coughlan, 2002). CAI can allow for a more visual representation of information versus a traditional approach which makes the material more salient for students (Pennington, 2010). Instruction incorporating
computers has resulted in decreased echolalia and increased communicative initiations (Bernard-Opitz, Ross, & Tuttas, 1990; Hetzroni & Tannous, 2004). In comparison to teacher-led instruction students with autism using CAI not only performed better on tests of specific academic skills, but motivation and attention also increased when interacting with the computer (Bernard-Opitz, Ross, & Tuttas, 1990; Chen & Bernard-Opitz, 1993; Moore & Calvert, 2000).

**Effect of CAI Outside of Academics**

CAI has also shown positive behavioral outcomes for students with autism, which is linked to the acquisition of academic skills in that behavior influences the amount of time on task and involvement in learning (Chen & Bernard-Opitz, 1993). Increased time on task and response rate have been documented in students using CAI and it is posited that the increased attention has a direct link to the development and understanding of language (Quill, 1997; Mundy, Sigman & Kasari, 1990). Some of the stereotypical behaviors that blocked student learning in the past such as echoic responses can work to a student's advantage on a computerized platform because the echoing serves as repetition of information (Reagon, Higbee & Endicott, 2007).

**Effect of CAI on Motivation**

Motivation and willingness to interact are integral in the success of CAI. If the student is unwilling to use the program, even software based on the principles mentioned will not facilitate learning. Simply the medium of the computer is enough to motivate some students; however others may need additional positive reinforcement (Mioduser, Tur-Kapsa, & Leitner, 2000). For example, for those students who enjoy using the computer platform may be motivated at first, but over time as the student becomes accustomed to the computer he needs new reinforcement to keep motivation high. For other students visual or auditory stimuli may be motivational initially but can become unmotivating if the stimuli become monotonous. Therefore, a system of CAI that
provides adaptive motivational stimuli has been linked to the highest attention and enthusiasm for students with autism when compared with programs that are saturated with stimuli or provide little stimuli at all (Song & Keller, 2001).

**Student Centered Programming and Group Work**

Programs that require group work may also contribute to motivation and enthusiasm for some students with autism. Motivation increased specifically for 26 students using applications teaching social skills when the material was personally connected to them in some way or when they were able to problem solve in groups (Hourcade, Bullock-Rest & Hansen, 2011).

Multisensory CAI programs, some involving animations and sound as a form of reward have positive effects on student motivation while still imparting academic information (Heimann, Nelson, Tjus & Gillberg, 1995; Travers, 2010). When compared with teacher led instruction CAI shows increased motivation in students with autism. Specifically, enthusiasm for the material presented increases possible due to increased student control that the computer platform provides (Chen & Bernard-Opitz, 1993). This increased enthusiasm helps to build motivation in students because they are engaged and focused when interacting with the technology. When the program allows the student to feel some autonomy and success motivation and engagement will increase (Higgins & Boone, 1996). Enjoyment, positive feelings and spontaneous communication also show a marked increase after the use of CAI (Heimann, Nelson, Tjus & Gillberg, 1995).

CAI that allows for student control and direction has an effect size of .60 on student achievement, whereas a program that is automatically directed has an effect size of only .20 (Cohen & Dacanay, 1994). The high effect size associated with student control may be linked to
the increased self concept and autonomy students feel when they make decisions independently (Hattie, 2009).

**Effect of CAI in Reading**

The integration of CAI into reading programs shows positive effects in terms of student achievement, especially in phonics skills. When comparing students who receive a reading program including CAI versus those receiving a traditional program effect sizes are as high as .77 in word attack and .76 in segmentation, with all but 2 of 10 reading skills measured below an effect size of .40 (Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2010). A meta-analysis of studies involving CAI and reading instruction yielded more modest results with an overall effect size of $d=.25$ (Kulik & Kulik, 1991). This modest effect size was replicated in another meta-analysis of 50 studies devoted to the effect of CAI on reading skills showing results that were small but positive ($d=.19$) (Blok, Oostdam, Otter, & Overmaat, 2002). The disparity in effect sizes could reflect the difference in scale between a meta-analysis and a single study, because the meta-analysis contained 18 different studies on reading and CAI it gives a clearer estimation of a true effect size between the two variables.

**Effect of CAI in Reading Instruction for Students With Autism**

In reading, the use of a computer program in conjunction with teacher-led activities has shown to increase the phonological awareness skills of students with autism (Heimann, Nelson, Tjus, & Gillberg, 1995). Similarly, Mioduser, Tur-Kaspa, and Leitner found significant improvement in "phonological awareness, word recognition, and letter naming skills" in students who used a CAI instruction program with computer based practice materials (2000). A second program that began with teacher-led instruction and progressively moved towards CAI determined both conditions to be equally effective in teaching students word identification skills.
(Coleman-Martin, Heller, Cihak, & Irvine, 2005). In a recent review of the literature on the effectiveness of CAI for students with autism determined that all 52 students in a total of fifteen studies showed academic gains in pre-reading or reading skills when CAI was used as part of instruction (Pennington, 2010). In a study of vocabulary acquisition, using a language program called Baldi, vocabulary is presented in all three modes through animated tutorial software.

The results indicated that the CAI was an effective method of vocabulary instruction, with 91% of new vocabulary retained 1 month after training ended (Bosseler & Massaro, 2003). A program using auditory and visual stimuli to teach vocabulary skills yielded significant results in retention of vocabulary with 74% recall on vocabulary indicating that the combination visual and auditory clues without textual prompts may be effective in teaching vocabulary skills (Moore & Calvert, 2000). Gains in phonological awareness, word recognition and letter naming skills were shown in students termed “at-risk for reading disabilities” who used CAI versus their peers who received instruction using print materials or no instruction at all (Mioduser, Tur-Kapsa, & Leitner, 2000). CAI that integrates writing and hypertext, or highlighted print that links to further information have been shown effective in preliminary studies with positive effects on beginning reading skills overall (National Reading Panel, 2001). Finally, Lowther, Ross and Morrison showed significant differences in achievement in students who regularly used technology in the classroom versus those who did not with effect sizes ranging from .61 to .78 in overall academic achievement (2003).

CAI contributes in other ways to improved reading skills, by providing a one-on-one learning experience and immediate, consistent feedback which may not always be available through teacher led instruction (Heimann, Nelson, Tjus, & Gillberg, 1995; Moore & Taylor, 2000; Higgins & Boone, 1996). CAI is virtually guaranteed positive reinforcement and
structured prompts that students need provided that the program is well made. The amount of stimuli on the screen or in a specific activity can be controlled for, allowing for less extraneous stimuli that could distract the student and the patterns easily constructed by software allow students to also know what is expected (Boone & Higgins, 2003; Higgins, Boone & Williams, 2000).

Individualization is another key factor that CAI can utilize to improve academic skills for students with autism. One of the criticisms for the use of computers in the classroom is that the software is similar to an electronic workbook rather than a dynamic program offering specific feedback for each student (Bull, Cochran & Snell, 1988). Others pose the questions about the suitability of computer programs for students with autism. The material that is useful to them academically may not fit appropriately with their age and peer group (Moore & Taylor, 2000). However, with the newer innovations in software, computer programs often include assessments that individualize programming to the student. The rapid feedback given through CAI encourages students to be active rather than passive in their learning as is sometimes associated with teacher-led instruction, because the CAI platform requires students to respond. For all of the strategies and useful interventions have been designed for students with autism, little of the research is incorporated into educational computer programs. To direct the creation of new software Higgins and Boone formulated guidelines that should be present in high quality CAI programs for students with autism. These guidelines include: social interaction, age appropriateness, and overlearning to facilitate generalization among others (1996).

Use of the Tablet Interface

Using a tablet computer such as the iPad with students with autism has advantages over a typical computer because of how the user interacts with the tablet. For example, children with
autism often exhibit poor motor skills in the upper body when required to complete a dexterous task (Bhat, Landa, & Galloway, 2011). This makes tasks such as maneuvering a mouse or typing on a keyboard difficult. With a tablet computer no mouse or keyboard is needed. The individual simply uses their finger to manipulate objects on the screen. It has been suggested that differences in brain structure in an individual with autism lead to decreased integration among regions in the brain and contribute to motor difficulties (Bhat, Landa, & Galloway, 2011).

However tablet technology reduces the number of motor tasks a student has to process and complete in order to utilize a program, therefore decreasing the cognitive and physical load on the student. Problems with posture may be a contributing factor in the underdevelopment of motor skills in the upper body and cause difficulty in coordination and hand mobility (Fournier, Hass, Naik, Lodha & Cauraugh, 2010). Differences in muscle tone and difficulty using the hands to grasp items have also been documented in students with autism which may lead to difficulties in typical instruction or CAI (Dawson & Watling, 2000). Fortunately, a tablet requires mainly the use of large muscle groups in sliding and selecting information on the screen, which is more conducive to strong gross motor abilities which may be present in students with autism.

Differences in tone that are present in some individuals with autism can be accommodated through the use of stands and cases that accompany the tablet and prop the machines at different inclines and make the applications more accessible. A typical computer can only be used in an upright position but a tablet computer can be placed flat on a desk or docked in a stand allowing the computer to sit at different angles while remaining steady enough for use.

The use of a tablet computer has also shown measurable gains in joint attention and interaction amongst students with autism using an application that practiced social skills (Hourcade, Bullock-Rest & Hansen, 2011). Joint attention encourages communicative initiation
and response which are important in the development of language and provide a basis for beginning reading skills (Heflin & Alaimo, 2007). The increased portability and flexibility of the tablet encourage student interaction and expand the use of technology beyond the confines of a desktop computer (Hourcade, Bullock-Rest & Hansen, 2011).

Need for Current Research

The need for the current study stems from the widening gap between technology innovation and software innovation specific for students with autism. In the early 1990’s the ratio of computers to students was roughly 1:20, by the year 2000 that ratio had increased to 1:5 with most computers within the classroom rather than confined to the library or computer lab (Wenglinsky, 2005). Now, ten years later, the uses of tablet computers are on the rise in the classroom especially for students with autism. The tablets provide many of the motivational, communicative and structural benefits of computer software in a more flexible format. While the motivational aspect of the tool is utilized as a reward for students little research has been completed on the academic benefits of the tablet applications. If interventions using tablet applications prove successful, the benefits for teacher and students in terms of improvement in reading skills, time on task, and behavior could be significant. Therefore, the purpose of this study was to evaluate the effectiveness of several tablet applications on the beginning reading skills of students with autism spectrum disorders. Specifically the study addressed the following questions:

1. Is there a difference in letter identification skills of students with autism after teaching using applications from the iPad?

2. Is there a difference in phonemic awareness skills of students with autism after teaching using applications from the iPad?
3. Is there a difference in sight word identification skills of students with autism after teaching using applications from the iPad?

4. Is there a difference in letter discrimination skills of students with autism after teaching using applications from the iPad?

5. Is there a difference in sight word identification skills of students with autism after teaching using applications from the iPad?

Method

Design and Subjects

This study used a single subject ABA design. Two male subjects ages 6-7 years (subject A) and 10-3 years (subject B) were selected to participate in this study through a convenience sampling method. Both subjects were diagnosed with Autism Spectrum Disorder based on the DSM-IV. Both subject A and subject B function below grade level in the core areas of reading and math and have varying communicative abilities. The subjects are taught in a self-contained classroom at an elementary school in Southern Virginia using the Treatment and Education of Autistic and Communication related handicapped Children (TEACCH) method out of North Carolina. Neither of the subjects are graded using a typical scale, however the progress of subject B is evaluated through Virginia Alternative Assessment Plan (VAAP) goals. Subject A is evaluated through Curriculum Based Assessment conducted by the teacher.

Description of the Subjects

Subject A has been diagnosed with Obsessive Compulsive Disorder and Attention Deficit Hyperactivity Disorder in addition to the diagnosis of autism. His full scale IQ is 58, with a verbal IQ of 61 and a non-verbal IQ of 60 on the Stanford Binet Intelligence Scale for children given in 2009. The results of the Adaptive Behavior Assessment System also given in 2009.
showed adaptive skills that were significantly below average in the conceptual and social domains. He communicates well verbally and seems to benefit from the highly structured classroom environment.

Subject B participates in a shortened school day in the self-contained classroom on a curriculum comprised mainly of functional skills. The Preschool Language Scale was also administered at that time and placed the student’s total academic development at the equivalent of 34 months of age. His auditory comprehension scored at 1 year and 8 months, expressive communication at 1 year and 5 months and his overall language development at 1 year and 6 months. The student communicates mostly through a visually aided system similar to PECS.

Procedure

Permission was gained from the superintendent, principal, teacher and parents of the subjects involved in the study. The subjects and/or the parents were free to withdraw from the study at any time during the data collection process. Once permission was granted observation to collect baseline data on phonemic awareness, phonics, sight word identification, and categorization skills began. Baseline data were collected over the first week of the study for two hours at a time. Each subject was given one session after the pre-test to explore the technology prior to using the iPad in tutoring. Both subject used specific applications on the Apple iPad 2 during their 59 combined tutoring sessions over the course of two months. Specifically subject A received 23 tutoring sessions and subject B received 36 tutoring sessions. The tutoring occurred on a daily basis with sessions lasting between ten and thirty minutes.

Description of Instrument and Applications Used

iPad 2 and Applications The iPad 2 is part of the second generation of Apple tablets and is a platform for multimedia and applications in addition to web browsing. The user interacts
with the tablet through the touch screen rather than a keyboard and mouse and through an online store as opposed to traditional programs on computer discs. Applications, which function similarly to a program on a desktop computer can be downloaded from the Apple online store, iTunes and will automatically be installed on the tablet through an internet connection. The user need only to select an application through the store either on the iPad or a traditional PC and the application will be installed on the tablet. The user can than access the content by selecting the application using a finger. Each of the applications listed below were obtained through iTunes store at no or low cost in hopes that the interventions presented in the study could be transferred easily to any other classroom.

**Pocket ABC.** Pocket ABC is an application available on the iPad in a full and lite edition. Both editions have the “Flash Card” or “Alphabet Chart” option. Only the “Flash Card” option was used during the tutoring sessions. The lite version of the application was used during the tutoring sessions to decrease the number of letters presented during each session. The lite version contains the letters: a, b, d, e, j, k, m, p, s, and x. Each flash card presented the uppercase and lowercase grapheme for a letter along with an illustration of an animal at the bottom of the card. When the user presses uppercase letter the program says the letter name. This function was used as a prompt for the subject when the letter name was unknown. When the lowercase letter is pressed the phoneme is given. The illustration can also be pressed and will become animated. This function was used as a reward for a correct response during tutoring.
Lakeshore Sound Sorting. This application requires the subject to sort pictures into categories based on the beginning sound of the word that is depicted. It provides a choice of 18 initial phonemes, and the user can choose three phonemes per session. During tutoring the phonemes /b/, /k/, and /s/ were focused on. After initial phonemes are chosen a table is shown with three columns and three rows. At the top of each column is a picture that begins with one of the chosen phonemes. For the phonemes /b/, /k/, and /s/ a picture of a basketball, cat and sun are shown. Then, a list of pictures beginning with those same phonemes is shown on the right for subjects to place in the table.
**Word Match HD:** Word Match HD presents pictures of sight words along with the words themselves. The sight words are presented in groups of four and the student has to match the sight word to the corresponding picture. The application has 48 words overall presented in 12 groups but for the purposes of this study 12 sight words were used.
See Touch Learn. See Touch Learn presents flashcards electronically through the iPad. It contains a library 20 sets of flashcards including “First 100 words” and “Dolch Sight Words”. The libraries used in this study included “Letters” and “Eyes and Mouth”. The lesson can be customized to only include specific letters and control for the number of letters a subject can choose from. For example, in the lesson “Basic: A&B” the student has between one and two choices on each screen and has to select the letter asked for. The student can have up to four choices on a screen and must select the correct answer based on the verbal and visual directions. The lessons “Basic A&B” and “Basic C&D” were used during the tutoring sessions with subject B.

Figure 6: “See Touch Learn” A discrimination page

Figure 7: “See Touch Learn” B discrimination
Clear Things Up. Clear Things Up comes in a full and abbreviated version and asks subjects to sort objects based on a given attribute. Level one, which was used during tutoring, asks the subject to sort red and yellow objects on the screen into two boxes, one with a yellow square and one with a red square. The program shows directions on the screen and also gives them orally for the subject.

Figure 8: "Clear Things Up" Red vs. Yellow

Figure 9: "Clear Things Up" Circle vs. Square

Experimental Conditions

The listed applications were the independent variable used to improve the subject’s beginning reading skills namely phonological awareness and phonic skills. Specifically, subject A used Pocket ABC and Lakeshore Sound Sorting to improve phonological awareness and phonics skills. Each application was introduced individually starting with Pocket ABC and introducing Lakeshore Sound Sorting after the mastery criteria for Pocket ABC was reached.
Subject B used Pocket ABC, Word Match, See, Touch Learn, and Clear Things Up over the course of the data collection. Pocket ABC and Word Match were used concurrently followed by See Touch Learn and Clear Things Up after the initial applications were discontinued.

Subjects also received instruction from their classroom teacher in reading skills over the course of the data collection. Instruction consisted of daily literacy sessions usually lasting twenty to thirty minutes using the Animated Literacy program.

**Baseline Data and Intervention**

According to baseline data taken over three trials of fifteen minutes each before interventions began, subject A was able to identify 10 letters with 37% accuracy when prompted. He was not able to identify any letter sounds even with a prompt during any of the baseline trials. His level of achievement on any given task varied widely depending on his mood. Due to recent violent outbursts, changes in medication and placement are being considered.

Subject B responded to questions through the use of picture cards or by selecting a picture from an array during academic instruction. He had limited spoken vocabulary but could make choices or express basic needs through one word requests. He responded well to instruction when given a choice of answers and can recognize and sort functional words with roughly 70% accuracy when prompted. During baseline trials consisting of three trials for each skill focused on, his average scores were: letter identification, 3% correct unprompted, 10% correct prompted, letter discrimination 43%, sight word identification 39%, and classification of items 77%. However, his maintenance of information was poor and he had trouble retaining new information from day to day. He was very calm and compliant but became frustrated when he was unable to communicate his wants and could become destructive.
Both baseline and intervention data were collected using a daily chart where the day, specific application used; start time and end time were recorded. Any behavioral changes or extenuating circumstances were also recorded that could have affected the data for that session. A mastery goal was set for each application and each subject. Once the subject reached or surpassed the mastery goal three consecutive times, that application was discontinued and a new application was selected. Additionally, scores for each subject and each individual application were charted and graphed.

Analyses of Data

The results of the interventions using different applications were analyzed using descriptive statistics to determine if there was any improvement in the areas of phoneme identification and letter identification for subject A and sight word identification, letter identification, letter discrimination and classification based on one attribute for subject B. Improvement was determined by calculating an average percent correct for each skill during baseline data collection and comparing the mean to the average percent correct during maintenance data collection. The percent of correct responses for each session was recorded on a separate data sheet and then converted into a graph.

Results

The results were graphed for each individual student and application. The data in each graph were separated into a baseline period (A) consisting of three trials, an intervention period (B) and a maintenance period of three trials (A).
Letter Identification Skills

Intervention for subject A focused on letter identification and phoneme identification. During baseline observations subject A identified letters using a computer program designed for English Language Learners. The activity involved matching corresponding letters on the screen or finding a given letter among an array of upper and lowercase letters. After three incorrect attempts the program prompted the student by highlighting the correct letter.

Using the application “Pocket ABC” the student reached the pre-set mastery criteria of 90% correct responses with a prompt within 7 trials. He was able to identify the letters without a prompt with 90% accuracy after 9 trials, which is a 53% increase from the average baseline score. Maintenance data was taken 26 days after the intervention was discontinued using the same application. Over three trials the student maintained 100% accuracy in letter identification when prompted, a 63% increase from the baseline average. Without a prompt the subject remained at the mastery level with an average of 93% accuracy over three trials, a 56% increase from the baseline average.
Figure 10: Subject A percentage of correct letter identifications with and without a verbal prompt before, during, and after "Pocket ABC" intervention.

Figure 11: Subject B percentage of correct letter identifications with and without a verbal prompt before, during, and after "Pocket ABC" intervention.
Intervention with subject B using the “Pocket ABC” application took place over nine trials. A mastery criterion of 90% correct responses over three consecutive trials was set but not obtained during the intervention. The application was discontinued because the data showed a plateau in achievement and the subject became frustrated with the application. With an average of only 43% correct when prompted and 7.5% without a prompt the decision was made to re-evaluate the application and chose a more appropriate intervention. Maintenance data were taken 38 days after the intervention was discontinued.

**Phonemic Awareness Skills**

Baseline observations in phoneme identification took place in the same manner as the observations for letter identification for subject A. Using the same computer program the subject was asked to model letter sounds when prompted and then say the sound that he heard at the beginning or end of a word. The average percent correct over three baseline trials was 0%.

The application “Lakeshore Sound Sorting” was used during the intervention period of data collection. A mastery criterion of 92% or 11 out of 12 correct responses over three consecutive trials was set for the subject but the goal was never obtained during the intervention. The average percent correct over 14 intervention trials was 55% Maintenance data collection began a week after the treatment was discontinued. During the three maintenance trials the subject met the mastery criterion with an average score of 97% over three trials.
Changes in Sight Word Identification

Intervention for subject B focused initially on letter identification and then moved to sight word identification and letter discrimination. A classification application was also used per request of his classroom teacher. Baseline observation in letter identification involved the subject identifying one letter out of four choices with the teacher asking “what letter?” each time a letter was identified.

Baseline observations for sight word identification took place in the classroom while the subject worked with the classroom teacher. He was asked to identify a given sight word by choosing a picture of the word out of two choices and place the picture in a box. The application “Word Match HD” was used to target sight word recognition skills. A mastery criterion of 92% correct over three consecutive trials was set and reached within 9 trials using the application.
Maintenance data were collected 35 days after the conclusion of the "Word Match" intervention. The subject maintained the skill with an average of 92% accuracy over three trials.

Figure 13: Percentage of correct sight word identifications before, during, and after "Word Match HD" intervention.

Changes in Letter Discrimination Skills

Baseline observations in letter discrimination skills were taken in the classroom in the same fashion as the sight word observations. The subject was asked to sort letters from two possible choices by placing a picture of the correct letter into a box.

The application "See, Touch, Learn" was used in the letter discrimination intervention. Two letters were focused on in each lesson. For each pair of letters, a mastery criterion of 90% correct over three consecutive trials was set. For the first set of letters (A&B), the mastery criterion was obtained after 5 trials. The second pair of letters was practiced over 12 trials, but
the mastery criterion was never reached. Over the 12 trials the student had an average of 73% correct.

The maintenance data were collected a week after the intervention was discontinued and 27 days after the first pair of letters was discontinued. The mastery criterion was obtained on the third trial however the average percent correct was 77%. The maintenance data for the second pair of letters yielded an average of 63% correct over three trials which is a 20% increase from the baseline average.

*Figure 14:* Percentage of correct letter discriminations (A&B) before, during, and after "See, Touch, Learn" intervention.
Figure 15: Percentage of correct letter discriminations (C&D) before, during, and after "See, Touch, Learn" intervention.

Classification Skills

The last skill focused on was sorting objects using an iPad application called "Clear Things Up" Baseline data for this skill were taken in the same manner as the data for letter discrimination and letter identification. The subject sorted colors and shapes into two separate piles based on their specific attributes. The average for the baseline data in classification was 77%. A mastery criterion of 90% correct over three consecutive trials was set but not obtained during the intervention period. The average percent correct during the intervention was 65%. However when maintenance data were collected a week after the last intervention trial the subject performed above the mastery level with an average of 100%.
Discussion

Effect of Tablet Applications on Reading Skills

The primary purpose of this study was to determine the effect of tablet applications on the achievement of the subjects in different areas of pre-reading skills. Both subjects showed considerable improvement from baseline data even if the criterion for mastery was not obtained in a specific skill. Subject A increased from 37% correct during baseline letter identification trials to 100% correct in maintenance trials and from 0% to 97% in phoneme identification. Subject B moved from an average of 10% to 43% correct in letter identification, and from 39% correct to 92% correct in sight word identification. Mastery was not met in letter discrimination but baseline to maintenance data showed an increase of 34% for the letters A&B and 20% for the letters C&D. His percent correct when classifying objects based on a single attribute increased from 73% during baseline to 100% in maintenance. Additionally, students were able to maintain
the skill when using the tablet, in some instances several weeks after the intervention was
discontinued. The averages of each of the maintenance trials showed correct responses at a
higher rate than averages for baseline trials and in some cases the averages in the maintenance
period were higher than at the completion of the intervention as in phoneme identification for
subject A and classification based on one attribute for subject B. The applications which allowed
for the most student control (Lakeshore, Word Match, and Clear Things Up) showed some of the
largest percentages in improvement from baseline to intervention consistent with the findings of

The use of the tablet applications also presented unexpected barriers to achievement for
some of the skills being targeted. Subject B initially had difficulty using the “Word Match”
application because it requires the user to drag the word across the screen to a corresponding
picture. In previous interactions with the iPad the student wanted to use multiple fingers to make
a selection. When this method was used for “Word Match” the program automatically restarted
after three failed attempts. By holding the tablet slightly below the desk the subject was able to
rest his arm on the desk and use one finger to drag the word across the screen. The data reflects
this change in positioning starting on the 15th of September.

Subjects' Ease of Use

Both subjects who participated in the study had previous experience utilizing CAI in the
classroom. Prior to working with the subjects, the researcher devoted one session to exploring
the tablet with the students and demonstrating how to make selections within the applications.
The tablet is somewhat more intuitive than traditional CAI because of the direct link between the
user and the interface. However the subjects still encountered difficulty from time to time in
dragging items or using only one finger when selecting an item. It would be interesting to see if a
longer and more direct instructional session in using the tablet would help eliminate some of the physical barriers.

Limitations

The results of the study were affected by different factors that caused inconsistency in student performance and data collection. The classroom schedule and therapy schedule for the subjects varied depending on the day resulting in an inconsistent time frame for tutoring.

Subject behavior was a determining factor in the quality of work particularly for subject A. Subject behavior also led to shortened periods for intervention and data collections and could affect the data collected for that day. Subject A underwent significant schedule changes during the data collection period. Medication changes and setting changes from the self-contained environment to increased exposure in the general education setting may explain the variability of the data.

The length of time allotted for the study and the number of participants were also limitations. Since the researcher completed all of the tutoring individually, the subject pool remained relatively small, limiting the ability of the researcher to generalize the findings to the larger population of students with autism. Given more time to collect data and implement interventions, additional patterns may have arisen regarding motivation and academic achievement.

Recommendations

There are several recommendations for future research that the researcher believes would enhance the reliability and validity of future studies in this area.
1. Future study containing a larger sample size as well as a longer period of time for interventions should be conducted to determine any significant differences across the larger population of students.

2. Additional observers are needed to establish inter-observer reliability and reliability across studies.

3. Subjects from several different schools or districts would enhance the data collected and ensure a variety of students and ability levels to form a more complete picture of the effects of the tablet.

Implications

While the results of this study are limited by the small sample size, larger implications for the use of the iPad as an instructional tool in the classroom can be noted. The conditions in this study were almost identical to conditions in a typical classroom making it easy to replicate the conditions for daily use in the classroom. The tablet in this study was used under direct supervision of the researcher, however if taught to use the tablet, applications utilized in the study could be especially useful for independent practice or enrichment portions of a lesson. The conditions of the current study did not control for the effect of instruction by the classroom teacher, and the results point to positive outcomes for students when teacher-led and tablet instruction are used in conjunction. Combining teacher-led instruction and a tablet computer application gives students the benefits of direct, explicit, modeling and guided practice from the instructor, which can then be augmented by quick, personalized, and consistent feedback by the tablet.

Applications used on tablets such as the iPad are accessible for students and easily downloaded and changed by instructors who can find an application to fit a skill being taught or
the needs of a specific student. The tablet can be used to monitor progress in a specific skill, collect data on student performance and provide consistent and engaging practice for students. When used to enhance traditional instruction tablet technology can improve skill acquisition for students with autism.
References


EFFECT OF EDUCATIONAL TABLET APPLICATIONS


EFFECT OF EDUCATIONAL TABLET APPLICATIONS


EFFECT OF EDUCATIONAL TABLET APPLICATIONS


Appendix A

Letters of Permission
Dear

My name is Jillian Ratliff and I am a graduate student at Longwood University currently working towards my Masters Degree in Special Education. As a part of my degree requirements I am completing research during the fall semester of 2011. My interest is in the effects of incorporating new technology in instruction for students with autism specifically in relation to academic achievement. I am in the process of securing students to participate my research before beginning in the fall.

I am hoping to secure between three and four students with autism spectrum disorders to participate in the research. I plan on completing individual tutoring sessions focusing on reading skills with each student using applications from a tablet computer. No identifying information will be attached to the data collected and the students as well as the school would be free to withdraw participation at any time. Permission will also be obtained from the parents of the students involved in the study once permission is granted by the school.

Thank you for your consideration.

Jillian Ratliff
Masters Candidate
Longwood University

We give permission for our students to participate in the study by Jillian Ratliff. We may withdraw our consent at any time during the study.

X __________________________
Dear Parents and Guardians:

I am a graduate student at Longwood University currently working towards my Masters Degree in Special Education. As a part of my degree requirements I am completing research during the fall semester of 2011. My interest is in the effects of incorporating new technology in instruction for students with autism and how the technology affects their achievement. I am in the process of securing students to participate in my research before beginning in the fall.

I am requesting permission to work with your student this semester in their current classroom setting. I will be entering the classroom several times each week and tutoring individual students on their reading skills using applications from the iPad and tracking their progress throughout the semester. The data collected from students will be treated with every precaution to ensure privacy and will not be attached to any identifying information in the results. Your consent would be greatly appreciated and is entirely voluntary. It may be ended at any time during the semester.

If you are willing to allow your child to participate in the study, please sign and return this form to your student’s classroom teacher. Please feel free to respond with any questions and thank you for your assistance.

Sincerely,

Jillian Ratliff
Masters Candidate
Longwood University

I give permission for my child to participate in the study by Jillian Ratliff. I may withdraw my consent at any time during the study.
Appendix B

Record Sheets
Figure 1

Subject A Data Record

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Subject B Data Record

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