A Comparison of the iPad-Assisted and Traditional Flashcard Instruction for Learners With Autism

Davaa Ulzii

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A Comparison of the iPad-Assisted and Traditional Flashcard Instruction for Learners With Autism

by

Davaa Ulzii

An Applied Dissertation Submitted to the Abraham S. Fischler College of Education in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

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Approval Page

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I declare the following:

I have read the Code of Student Conduct and Academic Responsibility as described in the Student Handbook of Nova Southeastern University. This applied dissertation represents my original work, except where I have acknowledged the ideas, words, or material of other authors.

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Davaa Ulzii

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January 29, 2019

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Abstract

A Comparison of the iPad-Assisted and Traditional Flashcard Instruction for Learners With Autism. Davaa Ulzii, 2019: Applied Dissertation, Nova Southeastern University, Abraham S. Fischler College of Education. Keywords: autism, applied behavior analysis interventions, iPad, app, flashcards, receptive labeling skill

This applied dissertation study compared the effectiveness of the iPad-assisted and traditional flashcard-assisted instruction for teaching receptive labeling skills to learners with autism. A lack of access to certified service providers and insurance coverage and the inability to receive a diagnosis of autism prevent families from accessing applied behavior analysis (ABA) services. The problem addressed in this applied dissertation was a lack of access to ABA services for children with autism. Two school-aged learners with a medical diagnosis of autism served as participants in this study.

The study utilized an adapted alternating treatments design to compare the effectiveness of the iPad app-assisted and flashcard-assisted instructions in the following dimensions: rate of the acquisition of the receptive labeling skills, generalization and maintenance of the receptive labeling skills, frequency of the prompts needed to acquire the skill, and frequency of the challenging behaviors associated with each intervention.

The study included a baseline phase, instructional phase, generalization phase, final probe phase, and a maintenance phase. A visual analysis of the data was used to compare the effectiveness of the interventions. Also, the researcher compared the data between the two interventions using the nonoverlapping data (PND) points. Results indicated iPad-assisted instruction was associated with lower rates of challenging behaviors, lower rates of prompts, and a slightly higher rate of acquisition of the receptive labeling skills when compared to the traditional flashcard-assisted instruction. Furthermore, the results showed iPad-assisted instruction took a shorter time to implement when compared to traditional flashcard instruction. The results of the study have implications on the effectiveness of the instruction, potential time and cost efficiency for the practitioners and caregivers, and an improvement of the quality of life for individuals with autism.
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Chapter 1: Introduction

Statement of the Problem

The problem studied in this applied dissertation addressed improving receptive labeling skills of children with autism effectively using different types of instructional mediums. Previous studies demonstrated the effectiveness of the electronic tablets as an instructional medium to improve skill acquisition in individuals with autism and other developmental disabilities (e.g., Burton, Anderson, Prater, & Dyches, 2013; Chai, Vail, & Ayres, 2015; Copple, Koul, Banda, & Frye, 2015; Dennis, 2016; Du, Speckman, Medina, & Cole-Hatchard, 2017; Eliçin & Tunali, 2016; Fletcher-Watson et al., 2016; Kagohara et al., 2012; Lorah & Karnes, 2016; Murdock, Ganz, & Crittendon, 2013; Xin & Leonard, 2015). Furthermore, studies demonstrated that using electronic tablets as an instructional medium was associated with a lower rate of challenging behaviors and higher rate of academic engagement (Neely, Rispoli, Camargo, Davis, & Boles, 2013) and more likely to be chosen by the students as an instructional medium (Lee et al., 2015) compared to instructions provided via traditional materials.

Educators and parents want to teach skills to children with autism that promotes learning, generalization, and maintenance that can lead to independence and improved quality of life. The purpose of this study was to compare the effectiveness of the traditional flashcard-assisted and iPad-assisted instruction in relation to the rate of acquisition, generalization, maintenance, prompting, and associated challenging behaviors for teaching receptive labeling skills to learners with autism.

Evaluating and comparing the effectiveness, maintenance, and generalization effects of different instructional strategies are comparative studies (Wolery, Gast, & Ledford, 2014). Although not truly permanent, changes in nonreversible behaviors are
likely to maintain when the intervention ends (Gast, 2014). Academic skills such as picture naming and sight-word reading are nonreversible behaviors (Gast, 2014). Adapted Alternating Treatments Design (AATD) was developed to compare instructional strategies for nonreversible behaviors (Sindelar, Rosenberg, & Wilson, 1985). Thus, with respect to nonreversibility of the behavior, the AATD is a suitable research design for examining the efficiency of the traditional flashcard-assisted instruction and iPad-assisted instruction for teaching receptive labeling skills.

The topic. In the fifth edition of the Diagnostic and Statistical Manual (DSM-5), the American Psychiatric Association developed the diagnosis of Autism Spectrum Disorder (ASD) to classify individuals having impairments in social communication and social interaction and having restrictive and repetitive behaviors, activities, or interests (Maye, Kiss, & Carter, 2017). Although the criteria for diagnosis continues to change, impairments in social communication and engagement in restrictive and repetitive behaviors and interests have been the key indicators of this disorder since the 1980s (Maye et al., 2017).

Under the impaired social communication domain, an individual may show abnormal patterns of social-emotional responses or impaired nonverbal communication or delay in the communicative behaviors from a young age (Maye et al., 2017). Multiple studies (Weismer, Lord, & Esler, 2010; Volden et al., 2011) have shown children with ASD have weaker receptive language skills compared to typically developing children.

According to Knight, McKissick, and Saunders (2013), “The use of technology to teach skills to students with ASD is not a new concept” (p. 2629). Technology-based intervention such as computer-assisted interventions (CAI) have been used to teach various skills to learners with ASD (Knight et al., 2013). The use of multimedia tablets
became increasingly popular after 2010 (Allen, Hartley, & Cain, 2015) around the time the iPad, a multimedia tablet, was released to the public in April of 2010 by Apple. Tablet-based interventions bring together the advantages of early intervention for those with ASD and the specific benefits of technology such as close monitoring of learning rates and the personalization of the application (Fletcher-Watson et al., 2016). Careful implementation of applied behavior analysis (ABA) instructional procedures can make iPods, iPads, and iPhones effective instructional aids for individuals with a developmental disability (Kagahora et al., 2012).

**The research problem.** Effective early intervention is essential for the development of children with ASD and other developmental disabilities. Successfully implemented behavior analysis intervention during early childhood can produce notable results in the development of children with autism. Children acquire functional skills; integration with typically developing peers; and for some students, interventions based on behavior analysis resulted in students gaining a typical level of functioning (Grindle, Kovshoff, Hastings, & Remington, 2009).

Families living in rural areas and families that do not have a health insurance policy that covers the services for ASD do not receive the needed therapies. A lack of access to certified service providers and insurance coverage, and the inability to receive a diagnosis of ASD, prevent families from accessing ABA services. The problem addressed in this applied dissertation is a lack of access to ABA services for young children with autism.

**Background and justification.** As of 2014, the Centers for Disease Control and Prevention estimated that approximately one out of 59 eight-year-old children were diagnosed with ASD across multiple areas of the United States (Baio et al., 2018). The
new estimate showed a 15% increase in ASD prevalence nationally between 2012 and 2014 (Autism Speaks, 2018b). ASD is a developmental disorder that can affect one’s social and communication skills and cause behavioral challenges (Centers for Disease Control and Prevention, 2017). Due to the complexity of the disorder and the areas it affects, individuals with ASD require a comprehensive intervention targeting those deficit areas to function successfully in society.

As of December 2018, in the United States, 48 states require a meaningful coverage for ASD to be included in state-regulated health insurance plans (Autism Speaks, 2018c). In the remaining two states, families do not have this coverage legislated. Even if the individual has medical insurance coverage, some policies, such as small employer health insurance plans or self-funded health insurance policies, do not necessarily include coverage for ASD (Autism Speaks, 2018c).

Furthermore, a lack of qualified autism service providers in the United States and worldwide prevents families from accessing quality services. Therapies based on the principles of ABA are the most researched interventions for ASD (Roane, Fisher, & Carr, 2016). The professionals who develop behavior intervention programs and monitor the implementation of the behavior change programs are called Board Certified Behavior Analysts (BCBAs). Therapists certified in implementing ABA services under the direction of the BCBAs are called registered behavior technicians. As of November 2018, there were approximately 30,000 BCBAs in the world, including both the master’s and doctoral level certificants (Behavior Analyst Certification Board, 2018). The number of BCBAs is much lower than the number of other service providers for those with ASD (speech-language pathologists, occupational therapists). For example, American Speech Language and Hearing Association (2018) reported that as of 2017, there were 168,604
certified speech and language pathologists. Also, The American Occupational Therapy Association (2018) reported representing 132,700 occupational therapists and 51,700 occupational therapy assistants.

**Deficiencies in the evidence.** There have been a limited number of studies investigating the effectiveness of tablet-based applications for interventions of ASD (e.g., Chai et al., 2015; Du et al., 2017; Ganz, Hong, Goodwyn, Kite, & Gilliland, 2015; Kemp, Stephenson, Cooper, & Hodge, 2016; Lorah & Karnes, 2016; Spooner, Ahlgrim-Delzell, Kemp-Inman, & Wood, 2014; Stone-MacDonald, 2015; Vandermeer, Beamish, Milford, & Lang, 2015; Withey, 2017). Although many mobile-based applications for teaching skills are available, applications that incorporate behavioral principles are limited.

**Audience.** Findings of this study showed that iPad-assisted intervention is a viable alternative to a traditional flashcard-assisted intervention for improving receptive labeling skills in learners with autism. Most families have portable electronic devices and the affordability of the tablet-based applications will enable families who may or may not have access to ABA services to use the tablet-based applications. Furthermore, policymakers, health insurance companies, schools, teachers, ABA service providers, and researchers in the field will benefit from this study.

**Setting of the Study**

The study was conducted in a home setting where the participants typically received their ABA intervention in a one-on-one setting. The participants received one-on-one ABA intervention three to five times a week in their homes before or after school. The interventions were provided by BCBAs who assessed learners’ skills and develop, implement, train, and monitor the implementation of the ABA programs provided by the therapists.
Researcher’s Role

At the time of this study, the researcher was a BCBA at an agency that provided ABA services to individuals with disabilities. As a behavior analyst, the researcher conducted assessments, developed programs based on the results of the evaluation, and implemented the programs with the assistance of the teachers, therapists, and registered behavior technicians. The researcher recruited participants for the study from the clients of this agency.

Purpose of the Study

The purpose of this study was to compare the effectiveness of an iPad-assisted intervention and a traditional flashcard-assisted intervention using the principles of ABA for teaching receptive labeling skills to learners with autism. The variables investigated in this study were the following: (a) rate of acquisition, (b) rate of generalization, (c) rate of maintenance, (d) frequency of prompts needed, and (e) frequency of the challenging behaviors associated with each intervention.

Definition of Terms

For the purpose of this applied dissertation, the following terms are defined.

Adapted alternating treatments design (AATD). AATD is used to compare instructional practices with nonreversible behaviors (Sindelar et al., 1985). The logic of the design relies on the instructional set of items that are equally difficult to learn assigned to each instructional practice (Sindelar et al., 1985).

Applied behavior analysis (ABA). According to Cooper, Heron, and Heward (2007), “Applied Behavior Analysis is a science devoted to the understanding and improvement of human behavior” (p. 3). ABA strives to improve individuals’ quality of life by targeting and intervening in socially significant behaviors using scientific
principles of behavior change.

**Challenging behavior.** For the purpose of this study, the challenging behaviors included participant looking away from the task or engaging in nontask-related activities verbally or physically.

**Discrete trial instruction (DTI).** A teaching method that uses principles of ABA to increase correct responding in learners. DTI consists of the main components of the operant conditioning model: discriminative stimuli, behavior, and reinforcer (Cooper et al., 2007).

**Generalization.** This term refers to the occurrence of the trained behavior on untrained functionally related examples (Cooper et al., 2007).

**iPad-assisted intervention.** An intervention implemented with the assistance of an iPad.

**Maintenance.** Response maintenance refers to the continued occurrence of the taught behavior when all or part of the intervention has been terminated (Cooper et al., 2007).

**Operant conditioning.** One of the basic principles of ABA, which states the consequence immediately following the behavior determines the future frequency of that behavior. If the frequency of the behavior increases, reinforcement has taken place. If the frequency of the behavior decreases, punishment has taken place (Cooper et al., 2007).

**Prompting.** A response prompt is an additional antecedent stimulus provided by the instructor to occasion the correct response (Cooper et al., 2007). To occasion the correct responses, the instructor provides a response prompt by pointing to the correct stimulus, modeling, and providing physical guidance (Grow & LeBlanc, 2013).

**Receptive labeling.** Listener behavior is determined by whether a speaker’s
verbal behavior evokes a specific nonverbal response from the listener such as performing an action. If the understanding is a nonverbal response, it is considered as listener behavior and termed as receptive language or receptive labeling (Sundberg, 2008).

**Reinforcement.** The stimulus change following a behavior that increases the future frequency of the behavior (Cooper et al., 2007).

**Traditional flashcard-assisted intervention.** An intervention implemented by a therapist in a face-to-face setting using flashcards printed on a paper.
Chapter 2: Literature Review

Theoretical Framework

Teaching academic, social, and adaptive daily living skills to children with ASD and other developmental disabilities using the principles of ABA is grounded on the behavior analytic theory. The behavior analytic theory was primarily based on the work of B. F. Skinner (Schlinger, 1992).

In the 1930s, Skinner founded the experimental branch of behavior analysis (Cooper et al., 2007). Like other psychologists during that time, Skinner thought that behavioral explanations (i.e., Pavlovian respondent behavior, the two-term model) were not sufficient to explain the behaviors that do not have apparent antecedents (Cooper et al., 2007). Respondent behavior is a reflexive behavior that is elicited by its preceding stimuli (e.g., salivating when seeing food). The psychologists at the time explained behaviors without apparent preceding stimuli by mediating variables (i.e., wishes, drive, and free will). Instead, Skinner looked for an explanation for organisms’ behaviors in the environment. By conducting thousands of laboratory experiments from the 1930s through the 1950s with his colleagues and students, Skinner discovered the basic principles of operant behavior (Cooper et al., 2007). Skinner (1974) labeled the basic principles of the behavior the three-term contingency (i.e., stimulus-response-stimulus, S-R-S). The three-term contingency did not replace the two-term contingency for respondent behaviors but provided an explanation for learned behaviors that do not have apparent antecedent stimuli. Schlinger (1992) noted, “behavior-analytic theory includes, but is not limited to, the laws of the respondent (Pavlovian) conditioning as well as the operant laws of reinforcement (and punishment) and stimulus control, and all of their related principles and parameters” (p. 1400).
Skinner’s basic principles of behavior state that consequences shape an organism’s behavior. Skinner called this type of behavior an operant behavior. Cooper et al. (2007) explained, “Operant behaviors are not elicited by preceding stimuli but instead are influenced by stimulus changes that have followed the behavior in the past” (p. 10). In other words, the operant conditioning model holds that consequences determine the future frequency of the organism’s behavior. When stimulus changes immediately following the individual’s action increases the future frequency of that behavior, reinforcement has taken place (Cooper et al., 2007). On the other hand, if a stimulus change immediately following the individual’s action decreases the future frequency of that behavior, punishment has taken place (Cooper et al., 2007). Mayer, Sulzer-Azaroff, and Wallace (2012) noted, “A principle of behavior is a scientifically derived rule of nature that describes the enduring and predictable relationship between a biological organism’s responses and given arrangements of the stimuli” (p. 23).

**Applied Behavior Analysis (ABA)**

ABA is a science devoted to understanding, explaining, and providing strategies to improve human behaviors (Cooper et al., 2007). Behavior is an action. Behavior analysts work with what organisms say and do. Therefore, applied behavior analysts are not concerned with labels, states, and personality characteristics such as happy, sad, and lazy (Mayer et al., 2012). In contrast to mentalistic views concerned with internal states, behavior analytic explanations and research are pragmatic. Behavior analysts strive to answer the question of what one can do to intervene or manipulate the behavior to produce more reinforcing states of affairs (Moore, 2010).

As stated before, the science of ABA was founded by B. F. Skinner, whose works (*The Behavior of Organisms*, [Skinner, 1938]; *Walden Two*, [Skinner, 1948]; *Verbal*
Behavior, [Skinner, 1957]) played a significant role in the establishment of ABA principles. During the 1950s, researchers began to test the behavioral principle derived from the laboratory behavioral experiments with humans and found behavioral principles derived from laboratory experiments with animals were also applicable to human behaviors (Cooper et al., 2007).

Two significant events occurred in 1968 that marked the formal beginning of ABA (Cooper et al., 2007). The first was publication of the Journal of Applied Behavior Analysis, which continues to be the leading journal of the ABA to this day. The second event was publication of the “Some Current Dimensions of Applied Behavior Analysis” by Baer, Wolf, and Risley (1968). ABA strives to improve individuals’ quality of life by targeting and intervening in socially significant behaviors using its scientific principles.

**Discrete Trial Instruction and Children With Autism**

The latest development and advancements in the diagnosis of autism have shown autism can be reliably diagnosed as early as the age of 2, therefore, allowing opportunities for the children to receive an early intensive intervention that helps them to develop and gain functional skills (Autism Speaks, 2018a). American Academy of Pediatrics recommends all children should be screened for ASD during the 18-month and 24-month regular well-child visits (Fettig & Fleury, 2017). Advancement in early diagnosis enables caregivers and children to access early intervention and special education services and to receive ABA intervention through their health insurance.

The No Child Left Behind Act (2001) recommended all children with and without a disability should receive evidence-based and empirically supported education services. ABA is one of the most researched and commonly used behavioral interventions for autism (Autism Speaks, 2018a).
DTI is a teaching method that uses principles of ABA to increase correct responding in learners. The DTI method is commonly used with students with ASD and other developmental disabilities. Since the 1980s, several studies (Dib & Sturmey, 2007; Downs, Downs, Johansen, & Fossum, 2007; Lovaas, 1987) supported the evidence for successfully treating symptoms of autism using DTI. As the number of children diagnosed with ASD increases, the demand for general education and special education teachers with experience and training in DTI is rising. DTI is often included in early intensive behavioral interventions for children with ASD to teach social and academic skills (Cook et al., 2015).

The teaching trials of DTI incorporate the three-term contingency (A-B-C) of ABA. In DTI, the student is presented with discriminative stimuli (e.g., “Point to a circle”; A) which evokes the correct response in the student (B), which then is followed by predetermined reinforcement (e.g., “Nice work!”; C). An instructor addresses occurrences of the incorrect and no responses using prompts (e.g., instructor’s hand partially gesturing toward the “circle”). As the student makes progress, prompts are faded systematically and more advanced skills are taught to improve the student’s academic and social skills.

Although most DTI consists of the main components of the operant conditioning model (discriminative stimuli, behavior, and reinforcer), based on the learner’s level and practitioner’s approach, sessions can vary by the procedural guidelines, duration, task presentation, prompting strategies, and reinforcement schedule. For example, Majdalany, Wilder, Greif, Mathisen, and Saini (2014) compared massed-trial instruction, distributed-trial instruction, and task-interspersed instruction to assess the effectiveness, efficiency, and maintenance for children with ASD. Majdalany et al. found the majority of the
participants reached the mastery criteria most quickly during massed-trial instruction. Regarding efficiency, the massed-trial sessions were shown to be approximately 60% shorter than distributed-trials instruction and task-interspersed instruction (Majdalany et al., 2014). Similarly, Volkert, Lerman, Trosclair, Addison, and Kodak (2008) compared the effectiveness of massed-trial discrete trial instruction and task-interspersed instruction to teach a tacting skill for children with autism. Volkert et al. found massed-trial instructions were more effective in teaching tacting skills than task-interspersed teaching.

Furthermore, several studies (Delprato, 2001; Pellecchia et al., 2015) compared the effectiveness of DTI to other teaching methods based on principles of ABA. Delprato (2001) reviewed eight studies that included a total of 63 participants for comparing the effectiveness of DTI and other normalized behavioral intervention in teaching language skills. Delprato defined the normalized intervention as “loosely structured sessions of indirect teaching with everyday situations, child initiation, natural reinforcers and liberal criteria for presentation of reinforcers” (p. 315). Delprato suggested that, in all eight studies, the normalized behavioral intervention was more effective than DTI in improving language skills in children. Also, Delprato’s findings suggested a normalized behavior intervention approach is more preferred by parents when compared to DTI.

Pellecchia et al. (2015) conducted a study comparing the effectiveness of DTI, Pivotal Response Training (PRT), and teaching in functional routines on outcomes of 191 students in a large public school district. Pellecchia et al. (2001) defined PRT by the following:

Pivotal response training typically consists of loosely structured sessions that are initiated and paced by the child, take place in a variety of locations, and employ a variety of teaching materials. Functional routines are predictable activities with an
expected sequence throughout the day. (p. 2919)

Pellecchia et al. (2001) found that PRT was associated with improved cognitive ability in children compared to DTI and functional routines intervention.

Also, Dib and Sturmey (2007) investigated the effectiveness of improved DTI for reducing stereotypy in three students with autism. This study found that instructions, feedback, rehearsal, and modeling improved teacher implementation of DTI and was accompanied by reduced stereotypy in students.

Several types of error correction procedures can be used during DTI (single-response repetition, remove and represent, represent until independent, and multiple response repetitions). Carroll, Joachim, St. Peter, and Robinson (2015) studied the effectiveness of four commonly used error correction procedures in DTI. The participants were two students with attention deficit hyperactivity disorder and three students with ASD. Carroll et al. found that “re-present until independent” was the most effective in the acquisition of new skills for three of the five participants, “single-response repetition” was most effective for one student, and the “remove and re-present” procedure was most effective for one student (p. 269). Although “re-present until independent” was not the most efficient error correction procedure for two participants, it was the second most efficient error correction procedure for them (Carroll et al., 2015, p. 269).

Cook et al. (2015) investigated the global treatment integrity in implementing DTI and noted, “Global scores provide a ‘big picture’ view of the accuracy with which the intervention was implemented” (p. 38). Cook et al. suggested global treatment integrity scores were not necessarily representative of integrity scores of the DTI. Cook et al. found that therapists frequently implemented the reinforcement procedure with low integrity when conducting DTI.
Receptive Labeling Skill

Both verbal and nonverbal responses can indicate the understanding of the speaker’s words. If the understanding is a nonverbal response, it is considered as listener behavior and termed as receptive language or receptive labeling (Sundberg, 2008). A critical part of assessing a child’s receptive language skill is to ensure the teacher or the therapist does not provide prompts in any way such as visual cueing, eye gaze, and body gestures (Barbera, 2007).

Multiple studies (Weismer et al., 2010; Volden et al., 2011) have shown that children with ASD have weaker receptive language skills compared to typically developing children. On the other hand, Hudry et al.’s (2014) study showed only some of the children with ASD have a relatively lower receptive language skill.

Weismer et al. (2010) compared the early language patterns of children with ASD to early language patterns of children with developmental delay (DD) using a groups-comparison design. The study included 326 participants (257 toddlers with ASD and 69 toddlers with DD). The results of the study showed that children in the DD group scored higher on the receptive language skills compared to the expressive language skills, a similar pattern seen in typically developing children. On the contrary, children with ASD showed reverse results. The children with ASD scored higher on expressive language skills compared to the receptive language skills. Because Weismer et al. conducted the study in 2010, the researchers used the DSM-IV TR diagnostic criteria for autism. The study divided the children with ASD into two groups: (a) children with ASD and (b) children with pervasive developmental disorder-not otherwise specified (PDD-NOS). The PDD-NOS group showed a flat profile across the receptive and expressive language domains.
Weismer et al. (2010) noted that although group difference was evident in this study, participants’ scores demonstrated individual variations among children regardless of the diagnosis. Three percent of the children with ASD, 8% of the children with PDD-NOS, and 12% of the children with DD scored in the normal range of language development.

Kover, McDuffie, Hagerman, and Abbeduto (2013) assessed the characterization of the receptive language skills of boys with ASD using the cross-sectional developmental trajectories approach by Thomas et al. (as cited in Kover et al., 2013). The study included 49 boys with ASD, aged 4- to 11-years old, and 80 boys with typical development, aged 2- to 11-years old. The researchers found that, relative to their chronological age, school-aged boys with ASD showed a delay in their receptive language skills. Also, Kover et al. stated that individual variability was seen in scores among the participants. The differences in scores between the receptive and expressive language skills correlated to nonverbal cognition.

Teaching receptive labeling skills. Grow and LeBlanc (2013) noted, “Most curricula dedicate a proportion of early intervention to developing receptive language skills” (p. 57). In the field of ABA, there are two conventional sequenced methods for teaching receptive language: (a) teaching receptive language before the expressive and (b) teaching receptive and expressive languages simultaneously (Petursdottir & Carr, 2011). The receptive before the expressive model is commonly termed the University of California Los Angeles (UCLA) model. The UCLA model can be traced back to Dr. Ivar Lovaas’s studies at UCLA. In the UCLA model, receptive language is taught before teaching expressive language skills.

On the other hand, the method of teaching receptive and expressive languages
simultaneously is grounded on Skinner’s analysis of verbal behavior. There are many books and publications regarding this method (e.g., Barbera, 2007; Sundberg, 2008; Sunberg & Partington, 1998). According to the verbal behavior approach, expressive manding (requesting) should be prioritized before the other verbal operants (e.g., tact, intraverbal, listener responding, and echoic).

Sundberg (2008) stated three primary skills required for developing listener repertoire are (a) attending to others’ speech and serving as an audience, (b) reinforcing the person speaking by responding in some way, and (c) demonstrating the understanding of what is being said. According to Sundberg, demonstrating comprehension of speech is the most complex skill in the listener repertoire, and it is logical to assume that understanding the other person’s speech is also required for other verbal operants (e.g., mand, tact, and intraverbal). According to Grow and LeBlanc (2013), “Receptive language programming is often targeted to teach learners to pay attention to the instructions of other people” (p. 70).

Grow and LeBlanc (2013) made five general recommendations for teaching receptive language:

- “Require an observing response” (p. 58). The learner must observe the relevant discriminative stimuli being presented before and during the teaching trials.
- “Minimize inadvertent instructor cues” (p. 60). Although instructors follow the programmed behavior sequences during the teaching trials, instructors can inadvertently provide cues for the responses (e.g., eye gaze or body language pointing to the correct response). Therefore, minimizing any unintentional cue is critical and should be avoided with thorough planning.
- “Arrange the antecedent stimuli and required behaviors” (p. 62). Depending on
the learner’s ability, teaching programs vary and should be individualized based on the learner’s skill repertoire and learning goals. Selecting the target behaviors and planning how to introduce the target behaviors and how to present the antecedent stimuli to promote the best learning outcome requires careful planning from the instructor. These steps also include selecting the appropriate auditory stimuli (e.g., “Point to …”), selecting the order of target behaviors introduced and selecting the distractor stimulus. Grow and LeBlanc (2013) explained, “Overall, the simultaneous method is better regarding acquisition, maintenance, and generalization of skills” (p. 63).

- “Prompting and differential reinforcement” (p. 66). Carefully planned prompting strategies that include plans to fade out the prompts is a critical step for helping the learner to acquire the skills faster. Developing an appropriate reinforcement schedule that is not too dense or thin is necessary for acquisition of the skills. A systematically conducted preference assessment will help to identify the reinforcers. The planning for the reinforcement schedule should also include a strategy for thining out the scheduled reinforcement and transfer the reinforcement to the naturally occurring reinforcement. According to Grow and LeBlanc (2013), “If a learner has a strong matching and imitation skills, physical prompts should be avoided despite their inherent effectiveness, as they are unnecessarily intrusive” (p. 67).

- “Troubleshoot existing problems with stimulus control” (p. 68). If problems are interfering with the teaching program and results, instructors should analyze the problems and identify their sources and modify the program to remediate the faulty stimulus. Depending on the interfering issue, prompting, arrangement of
the stimuli, reinforcement schedule, and instructor’s behaviors can be modified to eliminate the existing problems.

**Computer-Based Instruction (CBI)**

Ramdoss et al. (2011) conducted a systematic analysis of studies using CBI to improve communication skills in children with ASD. Ten studies met the inclusion criteria: (a) involving at least one individual with ASD, (b) the use of CBI as the intervention method, and (c) the dependent variable of the study was learners’ communication skill. The findings of the 10 studies showed that CBI was associated with improved communication skills. Ramdoss et al. noted the most important methodological limitation was that many of the studies used research designs that provided a suggestive level of effectiveness for CBI due to the lack of experimental control or use of nonexperimental designs.

Ramdoss et al. (2011) concluded that although CBI should not be considered as a research-based approach for teaching communication skills to children with ASD, it is a promising practice that warrants further research. For future research, Ramdoss et al. recommended the use of CBI with a larger sample of participants with mild to severe ASD and comparing the CBI approach to a traditional person-implemented approach.

Khowaja and Salim (2013) conducted a systematic review of strategies and CBI for reading comprehension in children with ASD. The Khowaja and Salim study utilized the review process recommended by Kitchenham (as cited in Khowaja & Salim, 2013). Eleven studies conducted between 2000 to 2011 met the criteria set by Khowaja and Salim, and five of them had utilized CBI to deliver reading instruction. Findings of the review by Khowaja and Salim were that CBI is more interactive and engaging as compared to the traditional teacher-directed instruction. Furthermore, in some studies,
CBI was found to be promising, and the learners showed significant improvements in their reading comprehension skills. Khowaja and Salim concluded that although a CBI appears to be a promising intervention for improving reading comprehension skills in students with ASD, the empirical evidence to support this claim is somewhat limited. Khowaja and Salim recommended that future studies should include a larger sample of participants and use various research designs.

Mechling, Gast, and Thompson (2009) compared the effectiveness of the smart board technology and traditional flashcards for teaching sight word recognition and observational learning for individuals with disabilities. Mechling et al. used an AATD as the research design and the teaching sessions were implemented in small-group sessions. The results of the study indicated that both SMART board technology and traditional flashcards were effective in teaching functional sight words. However, the participants demonstrated a higher level of observational learning for sight word recognition when using the SMART board technology.

**Teaching Skills Using iPad and Electronic Tablets**

The iPad, a multimedia tablet, was released to the public in April of 2010 by Apple and was followed by several other electronic tablets using various operating systems (Android, Windows). The introduction of the electronic tablets brought many technological advances compared to the previous technology-assisted instructional methods. Before 2010, several multimedia tablets using Windows, Android, OSx, and Maemo Linux operating systems were available to the public. However, the use of multimedia tablets became increasingly popular after 2010 (Allen et al., 2015).

Due to the recent introduction of electronic tablets and their applications, limited research exists on the effectiveness of tablet-based interventions for social and
communication skills in children with autism (Xin & Leonard, 2015). Tablet-based applications built on the principles of ABA are particularly rare. Tablet-based interventions bring together the advantages of early intervention for those with ASD and the specific benefits of technology such as close monitoring of learning rates and the personalization of the application (Fletcher-Watson et al., 2016).

The literature review for the iPad-assisted studies for teaching skills to learners with ASD and other developmental disabilities was conducted using multiple databases (ERIC, ProQuest, and EBSCOHost). The keywords for the search included *autism* and *tablet, autism and iPad, autism and technology, autism and computer, iPad and listener responding, iPad and receptive language, iPad and receptive labeling, tablet and listener responding, tablet and receptive language, tablet and receptive identification.*

The criteria for inclusion in the review included (a) studies conducted between the years 2011 and 2017, (b) studies involved teaching skills to learners with ASD and other developmental disabilities, (c) studies conducted using experimental or quasi-experimental design, and (d) studies published in a peer-reviewed journal.

**Teaching communication skills using the iPad and electronic tablets.**

Kagohara et al. (2012) examined teaching picture naming using a speech-generating device (SGD) that is based on the iPad. Picture naming using the SGD involves the researcher presenting a picture on the iPad and asking, “What is this?” The participants responded to the question by selecting the icon that corresponded to the picture but was not identical to the first picture. Kagohara et al. described the picture naming task using the SGD as similar to the nonidentical matching task.

The study included two adolescents who participated in the study in their classroom setting. The sessions lasted approximately 14 minutes and occurred two to four
times a week. The findings suggested that picture naming using the SGD increased accurate picture naming in both participants. Consequently, Kagohara et al. (2012) suggested students with limited speech may benefit from this type of educational activity and future research should include participants who do not have any other iPad-based training because the history of educational activities using the iPad may create bias in findings.

Murdock et al. (2013) evaluated the effectiveness of an iPad-based play story for increasing the play dialogue in preschool children with ASD. The study included four children with ASD attending an inclusive preschool program. The iPad-based play story was developed using the KeyNote application. The KeyNote application is similar to the PowerPoint program that allows users to create a presentation using pictures and texts. The play story developed for this study was created using toy figures and voice recording for telling the story. During the instruction phase, the participants watched the presentation on the iPad, which is similar to looking at a book with audio. During the data collection phase, the participants were encouraged to participate in a play story with the researcher. The researchers did not provide any prompts or reinforcement during the data collection phase.

Murdock et al. (2013) indicated that an iPad-based play story was effective in increasing a play dialogue with three participants and was not effective for one of the participants. Murdock et al. recommended that future research should replicate the findings of their study and also use the more naturalistic approach to creating and engaging in play dialogue. For example, instead of using the toy figures for instruction and data collection phases, the researchers can use real people acting for the presentation and afterward try out the play dialogue with children while acting as the characters.
Xin and Leonard (2015) studied the effectiveness of the iPad application, SonoFlex, on the expressive communication of children with autism using a single-subject, multiple baseline design. SonoFlex is an application that supports expressive communication in learners, similar to the Proloquo2Go app, but is less expensive than Proloquo2Go. Participants included three 10-year-old students with ASD. The study evaluated the effectiveness of an iPad-based augmentative and alternative communication (AAC) device and the effectiveness of the least-to-most prompting strategies for increasing expressive communication in children with autism.

Xin and Leonard (2015) used highly preferred objects and activities to encourage requesting in students. When the student requested an object or activity, the requested object or activity was given to the student immediately, which reinforced the behavior. When the student independently touched the iPad button to initiate, to comment, or to respond, the teachers provided social praise immediately. Additionally, social interaction with peers functioned as reinforcement for expressive communication in students.

The results of the study by Xin and Leonard (2015) showed the use of SonoFlex increased the expressive communication in all participants. Specifically, responding to questions and commenting in social settings increased more than the requesting skill (Xin & Leonard, 2015). Social communication occurred most frequently on the playground with peers or during less structured activities compared to structured academic settings. Xin and Leonard suggested that the use of an iPad application may be a useful tool for improving communication skills, and it is less expensive to purchase compared to purchasing a designated AAC device. Additionally, families are becoming increasingly familiar with utilization and operation of the iPad. The limitations of the study included limited generalizability of the findings due to the relatively small sample size and a short
duration of the study. Another limitation of the study was that students’ communication (requests, responses, and comments) was recorded in only two environments (classroom and recess). The researchers recommended including additional settings would further validate the findings. Also, the researchers noted the limited features of the SonoFlex application (i.e., fixed icon size and a number of icons presented on the screen) might not be appropriate for all students.

Clark, Austin, and Craike (2015) explored the parents’ and professionals’ attitudes towards using iPad application for ASD. The study included 90 parents and 31 professionals. Their findings indicated that despite the lack of evidence on the effectiveness of the iPad applications for ASD, parents reported significant interest in using the iPad technology. The attitude towards the iPad technology was measured by Clark et al. using the Attitudes Toward Technology subscale of the Computer Technology Use Scale. The findings also indicated that parents and professionals held a positive attitude towards the iPad technology and parents’ attitude towards the iPad technology was related to the degree to which children were encouraged to use the technology. Clark et al. concluded that iPad applications are not being used to a level favored by professionals. Clark et al. urged that the iPad’s increasing popularity and use by individuals with ASD and its potential to deliver time and cost-effective intervention call for progress in research on the effectiveness of the iPad applications.

Fletcher-Watson et al. (2016) studied an iPad intervention targeting social-communication skills in children with autism using a randomized controlled trial. The participants included 54 students under the age of 6 years. Participants were either diagnosed with autism or on the waiting list for assessment of ASD. Twenty-seven participants received the iPad app-based intervention FindMe, and 27 participants were in
a control group.

The participants interacted with the iPad application, FindMe, with the assistance of their parents and caregivers for about 5 minutes per day or 10 minutes every other day. For each correct response, the child earned an electronic token that appeared on the iPad screen. After collecting five tokens, a short animation sequence appeared automatically on the iPad that was intended to function as a reinforcer. The study found the iPad did not improve social communication skills in preschool children with autism. However, the authors suggested it is worth pursuing iPad-based interventions for other domain skills due to its favorable reviews from parents, convenience, and cost-effectiveness for parents and caregivers. The limitation of this study was that students’ skill before and after the intervention was based on parents’ and caregivers’ reports, rather than a formal assessment (Fletcher-Watson et al., 2016).

Dennis (2016) examined the effects of a multicomponent intervention on the expressive vocabulary skills of preschool children. The participants included six preschool children (i.e., 4-year-olds). The interventions included six books selected by the researcher using the inclusion criteria, which was then narrowed by the faculty, early childhood professionals, and practicing preschool teachers. A variation of a repeated acquisition (Gast & Ledford, 2014) design was used to evaluate the intervention. The intervention phases included the following:

- Day 1. Pretest and storybook reading only.
- Days 2 to 4. iPad sessions.
- Day 5. Posttests.

The posttest was assessed by measuring the learner’s expressive vocabulary, definition, and relevant examples of the verb. The iPad app, Book Writer, delivered the
extended instruction (Days 2 to 4).

The results of the study showed all six participants increased their expressive verb vocabulary. Dennis (2016) stated all participants appeared to enjoy the iPad-based instruction and did not show resistance. Also, Dennis noted the postintervention results might not show the actual knowledge of the taught verbs. In other words, a more robust measure of the understanding of the word may help to evaluate in-depth understanding of the verb. Dennis recommended future studies should use strategies to tease out the researcher’s behavior for potential effects as, in this study, the researcher’s role was to extend the use of technology for instruction.

Du et al. (2017) studied the effects of an auditory matching iPad application on echoic and listener response skills in children with autism using a multiple probe design with a time-lagged baseline across participants. Participants included three preschool-aged children: two participants with ASD and one participant with Rubinstein-Taybi syndrome. Du et al. noted that all three participants had used a traditional auditory matching to sample protocol before and failed to make progress. The study was designed to examine the effectiveness of the tablet-based application, “Sounds the Same: An App to Target Listening and Speaking Clearly.” The Sounds the Same application is a newer version of the application designed for iPads, developed in response to the technological challenges of the older version that was used on a computer. This latest version was suitable for younger children, especially individuals who have fine motor deficits. Also, the application collected data on learner’s rate of acquisition and summarized the data for visual analysis automatically. When the student provided a correct response, a firework animation appeared with cheering sounds.

Additionally, the attending teacher provided social reinforcement by giving praise
to the student. If the student provided an incorrect response, the application immediately prompted the student to try again. Du et al. (2017) found the iPad application increased the accuracy of the participants’ articulation and the advanced listener responses.

The limitations of the study included having only one preintervention probe for the advanced listener repertoire (Du et al., 2017). Additional probes for the advanced listener repertoire would have strengthened the findings of the study. Also, a transcription of the participants’ spontaneous speech would provide more information on participants’ echoic skill because progress and complexity of the spontaneous speech affect the clarity and articulation of each word. Du et al. (2017) recommended that future research should consider more flexible measures of functional intelligibility such as the Goldman and Fristoe (2000) test.

**Teaching functional skills using iPads and electronic tablets.** Shane et al. (2012) examined the effectiveness of the technology for visually supporting language and communication skills in individuals with ASD. Shane et al. stated, “currently, we are in the midst of a paradigm shift in AAC for people with ASD” (p. 1228). The researchers explained the shift is occurring due to the growing adoption of mobile devices that are easy to transport, affordable, and socially acceptable. Also, Shane et al. reviewed the Visual Immersion Program and Teaching Language Concepts that were developed by Shane and colleagues at Boston Children’s Hospital to support the communication and language in individuals with ASD visually. The authors concluded that new possibilities exist for the emerging technologies to support the communication and language of individuals with special needs and some of these technologies may be more efficient than their predecessors.

Burton et al. (2013) examined video self-modeling (VSM) presented on an iPad to
teach functional math skills to adolescents with ASD and intellectual disability. The study examined the effectiveness of iPad-assisted teaching using a multiple-baseline across participants design on four participants. The VSM used the learner observing himself or herself performing the target behaviors independently and accurately. Burton et al. created the self-modeling videos by recording the participants performing the steps accurately with prompts and editing and omitting the prompts afterward. During the intervention phase, participants watched themselves completing the functional math problems (i.e., money) and then performed the task independently. During the postintervention phase, the researchers faded out the VSM prompts in multiple steps.

The results of the study showed that learners’ performance improved markedly after the intervention. Findings of Burton et al. (2013) further supported the previous studies on VSM (Bellini & Akullian, 2007; Buggey, 2007; Charlop-Christy & Daneshvar, 2003). The limitations of the study included lack of generalizability of the findings due to a limited number of participants, the researcher performing dual roles for the study (i.e., researcher and teacher), and the school break that occurred during the postintervention phase of the study, which may have affected the results. Also, the similarity of the tasks and items used during the intervention and postintervention phases may have had a facilitative effect on the learner due to the repeated presentations. For future studies, Burton et al. recommended addressing the limitations mentioned above.

Chai et al. (2015) evaluated the effectiveness of the iPad in promoting early phoneme awareness skill in three young children with disabilities. The study consisted of four phases (probe, intervention, generalization, and maintenance). The iPad intervention was evaluated using a multiple-probes-across-participants design. The dependent variable of the study was the percentage of unprompted correct receptive identification responses
of the target phonemes. The independent variable of the study was a constant time delay procedure. The participants’ responses were recorded as an (a) unprompted correct response, (b) unprompted incorrect response, (c) prompted correct response, (d) prompted incorrect response, and (e) no response. The results of the study indicated phoneme awareness skills increased in all three participants.

Chai et al. (2015) suggested the delay period (5 seconds) may have been too long for the participants as some of the participants rushed to get access to the games. Also, according to Chai et al., meeting with the researchers for the first time at the beginning of the study may have caused an unfamiliarity effect on the participants. This was evident in some participants as they responded better when they became familiar with the researchers. Another limitation of the Chai et al. study was that researchers assessed the generalization of the skills by testing phoneme awareness using different positions than during the intervention phase of the study. For example, if the student learned to receptively identify the “k” sound at the beginning of the word, during the generalization phase students were asked to receptively identify the same sound at the end of the word. This task may have been too difficult for the students and is likely to require a separate teaching phase. Chai et al. recommended future research should test the Touch Sound application to evaluate the external validity of the application. Also, future research should use iPad-based learning in a dyad, small group, or peer-tutoring sessions so that social interaction is encouraged during learning.

Siegel and Lien (2015) compared the effectiveness of two different types of iPad-based visual supports in assisting young children transitioning in the school setting. Siegel and Lien used an alternating treatments design to compare the effectiveness of high-context photographs and no-context photographs for supporting children in
transition between activities at school. The study consisted of baseline, alternating treatments, the best treatment, and generalization phases. The results indicated that high-context photographs on an iPad were effective for transitioning between activities for two of the participants. For one participant, the no-context photograph was more effective for transitioning between activities. Siegel and Lien explained the no-context photograph was more effective for this participant due to the participant’s cognitive skill level. This was explained by a notion that compared to the no-context images, visual support based on a high-context image requires a higher level of cognitive processing.

Copple et al. (2015) examined the effectiveness of video modeling (VM) intervention using the SGD on an iPad in preschool children with autism. Copple et al. used a partially nonconcurrent multiple-baseline-across-subject design and evaluated the effectiveness of the VM intervention conjoined with least-to-most prompting strategies. The study included baseline, intervention, generalization, and maintenance phases. Participants were three early learners with autism, and the study took place in the participants’ homes. The VM intervention encompassed filming the person who was engaging in the target behavior and presenting the video to the learner who would imitate the modeled behavior. The VM conjoined with a least-to-most prompting procedure was the independent variable of the study. The generalization phase was conducted in the same manner as the baseline phase, except that data were collected on the nontrained examples. Data to assess maintenance of the skills were collected 30 days after the intervention.

Copple et al. (2015) found that VM was an efficient tool for increasing target behavior in preschool children with autism. The researchers suggested future research should recruit a larger sample of participants and examine the effectiveness of VM across
Eliçin and Tunali (2016) examined the effectiveness of tablet computers for schedule following skills of children with ASD using graduated guidance strategies. The study included three male students with ASD aged 5- to 7-years-old. The dependent variables of the study were the steps for following the schedule (i.e., selecting the program, touching the picture of the activity and receiving instructions, taking the box with the same picture from the shelf, putting the activity on the table, and taking contents out). The independent variable of the study was the instruction provided by the tablet computer using the graduated guidance technique.

Eliçin and Tunali (2016) found that participants acquired the schedule following skills using the tablet computer and the skills were maintained and generalized to other settings. The limitations of the study included using the single-opportunity method for evaluating the participants’ performance and collecting social validity data from teachers only. Eliçin and Tunali recommended that future studies examine the effectiveness of tablet computers and more tablet-computer programs could be developed for teaching skills for children with autism.

**Interventions using iPad and challenging behaviors.** Neely et al. (2013) studied the effects of an iPad on challenging behaviors. The study included two participants who had a prior history of challenging behaviors during instruction. The study utilized an alternating treatments design to compare the effects of the traditional paper/pencil/flashcard instruction versus the iPad-based instruction. The applications used for this study were WritePad, which recognizes handwriting and functions as a worksheet, and Little Matchups, an application that provides matching picture cards on the iPad display. To make the reinforcement consistent between both conditions, a sound
feature of the iPad was disabled. The researcher gave the same type of verbal praise for correct responses during both conditions, and the researchers measured the frequency of the challenging behaviors during sessions. The results showed that for both participants, challenging behaviors decreased, and academic engagement increased during the iPad instruction phase of the study, compared to the instruction phase delivered via traditional materials.

Neely et al. (2013) recommended that future research should evaluate and control for histories of an iPad reinforcement and motivating operation for the participants. Also, Neely et al. recommended that future research could measure and compare the accuracy of responding and a number of trials during each instructional session.

Vandermeer et al. (2015) examined the effectiveness of iPad-based social stories on increasing on-task behavior in young children with autism. The researchers used the application Stories2Learn to create social stories for modeling the on-task behavior for young children with autism. Vandermeer et al. developed social stories according to the criteria recommended by Gray (2010). Each social story considered the child’s attention span and comprehension skills. To illustrate the on-task behavior and to personalize the stories, Vandermeer et al. used the pictures of each child participating in the target on-task behaviors.

Vandermeer et al. (2015) found iPad-based social stories to be an effective strategy for one of the three participants. Limitations of the study included a short period devoted to the intervention phase of the study and reliance on the staff recommendations for selecting participants. For future studies, Vandermeer et al. suggested gathering comprehensive information about the participants when recruiting, considering the child’s learning style (e.g., visual vs. auditory), and emotional state within the classroom.
O’Malley, Lewis, Donehower, and Stone (2014) investigated the effectiveness of the iPad for increasing task-completion behavior in students with ASD using a single-subject (i.e., ABAB) design. The participants included seven students with ASD between the ages of 10 to 13 years. The baseline phase of the study consisted of using traditional materials for math instruction. For the intervention phase of the study, the researchers used the iPad apps for math instruction. The dependent variables of the study were (a) number of independently completed math tasks, (b) the occurrences of noncompliant behavior, and (c) the level of teacher prompting needed for the task completion.

The results of the study showed mixed findings (O’Malley et al., 2014). Although there was moderate evidence of increased task completion, the number of independently completed tasks did not increase during the intervention. Also, even though the students did not engage in active noncompliant behaviors during the study, there were multiple occurrences of passive noncompliant behaviors. Because the study was conducted in a special education classroom with a high staff-to-student ratio, the generalizability of the findings is limited.

Also, O’Malley et al. (2014) cautioned that fidelity of the intervention might have been affected due to the staff requiring additional support to complete tasks and extensive technological support. Lastly, the variability of the data made it challenging to make a precise determination of effects (O’Malley et al., 2014). For future studies, the researchers recommended a more extended baseline and intervention phases; data collected for identifying the factors that may cause the variability; and use of the iPad to support other academic areas, age groups, and settings.

**Teaching receptive labeling skill using an iPad.** Ganz et al. (2015) evaluated the impact of the Picture Exchange Communication System (PECS) application on the
receptive identification skill of a preschool student with ASD. Ganz et al. examined the effectiveness of the electronic tablet-based application using a multiple-baseline design across three target words. Ganz et al. used inclusion criteria for participants, which included a fine motor skill to press a 2 x 2-inch icon or to pick up a photo attached to a book with Velcro and a prior history of mastering receptive identification tasks. The results of the study were mixed. The participant’s ability to receptively identify the object improved for two words and did not show improvement for one of the three target words. Although the results did not show a functional relation between the PECS application-based intervention and the receptive identification skills, the results did show improvement of receptive identification skill for two of the target words.

The limitations of the study included recruiting only one participant and the relatively limited duration of the study (Ganz et al., 2015). Additionally, the researchers clarified that the target behavior (i.e., receptive identification) was different from the purpose of the PECS as the participant had previously used PECS to request items rather than identifying items. Ganz et al. recommended future studies on similar tasks should include participants with various characteristics (i.e., various age groups and with and without expressive language skills). Also, future studies could investigate the collateral effects of the SGDs on participants with more experience in receptive identification tasks.

Lorah and Karnes (2016) evaluated the effectiveness of the Language Builder application for the acquisition of the listener responding skill in children with ASD. The Language Builder application is commercially available and is sold by Apple. The participants for the study included two preschool-aged children, and a multiple-baseline-across-labels design was used for the study. Both participants scored in Level 1 of the listener responding domain in the assessment of the Verbal Behavior Milestones and
Placement Program. The Language Builder application was developed by the same company that created the Language Builder picture cards. According to Lorah and Karnes, teaching protocols of the Language Builder application uses many behavioral principles in its design (e.g., random rotation of the target items, the verbal cue “touch” within stimulus prompting levels contingent on the learner’s response, and built-in social reinforcement).

The experimental sessions were held in the 1:1 instruction room within the university clinic. The dependent measure of the study was the percent of correct responses during training sessions. To ensure results of the study were controlled by the research only, Lorah and Karnes (2016) selected the target nouns based on the likelihood the child would not encounter the object outside of the training sessions. Although it is not clear from Lorah and Karness’ report, it appears paper picture cards were used for the baseline phase to determine participants’ preintervention skill level. During the teaching sessions, the iPad-based pictures were presented in an array of five and with the direction, “Touch.”

If the student responded correctly, the Language Builder application provided social reinforcement such as “You did it!” After three consecutive correct responses, the application produced fireworks and balloon visuals with crowd-cheering audio. The researcher sat next to the learner and did not provide any reinforcement. The research included a generalization phase where the same target picture-identification tasks were presented on paper picture cards. The researchers conducted the generalization probes identical to the training sessions except for the material used (i.e., paper picture cards) (Lorah & Karnes, 2016).

Lorah and Karnes (2016) stated that both participants gained skills to receptively
identify the target items and the identification skills generalized to the paper-based picture cards. According to Lorah and Karnes, one limitation of the study was the overexposure to the nontarget items during the baseline phase. Thus, Lorah and Karnes recommended future research use a multiple-probe design to eliminate the potential overexposure to target and nontarget items. The researchers also suggested replication of this study should be conducted in a more natural setting (i.e., home or classroom) and to determine if the environmental factors influenced the learner’s acquisition.

Chebli, Lanovaz, and Dufour (2017) examined the generalizability of the skills following a tablet-based intervention with children with ASD. The participants were five children between the ages of 4 to 11 years who had a diagnosis of ASD. The researcher used a multiple-probe design across participants and evaluated the effects of teaching one-word concepts using a tablet-based application. Chebli et al. (2017) developed the application using the principles of ABA. The one-word concepts were words from seven categories (i.e., colors, animals, food, clothes, prepositions, letters, and musical instruments). To assess the generalization of the taught examples to new examples, the researchers used real-life objects as well as untaught images of the target concepts. The generalization probes were conducted periodically after five teaching sessions.

The results of the study indicated three of the five children demonstrated generalization for at least two of the concepts. The other two participants did not demonstrate any generalization skills. Chebli et al. (2017) stated the participants who did not show any generalization also needed a more significant number of prompts to sit down and stay on task compared to the other participants. Therefore, Chebli et al. recommended future studies examine whether some level of off-task behavior is an indicator for children not benefitting from a tablet-based instruction and replicate their
findings with a larger sample of participants. Furthermore, Chebli et al. noted there is a lack of studies comparing the effectiveness of CAI and teacher-facilitated instruction, and future research should address this gap in the literature.

Rodríguez and Cumming (2017) investigated the effects of a Language Builder application on the receptive vocabulary, expressive vocabulary, and sentence formation of students with language-based disabilities. The researchers used a group comparison design (20 students in the treatment group and 11 students in the comparison group) to assess the effectiveness of the Language Builder application. The intervention took place four times a week for 8 weeks. The results of the study indicated the treatment group using the iPad-based intervention increased their skill in sentence formation. As for the expressive and receptive vocabulary skills, there were no differences between the treatment group and the comparison group.

The limitations of the study included using the Clinical Evaluations of Language Fundamentals-4 assessment twice within a 6-month period to test and retest the responses to the intervention. Furthermore, the researchers and teachers did not provide scaffolding for the students during the intervention, which may have caused the small effect size of the intervention (Rodríguez & Cumming, 2017).

For future research, Rodríguez and Cumming (2017) suggested including a more extensive sample of participants and participants with other disabilities. Also, future variations of this study should consider the intervention to occur over a more extended period and adding scaffolding into the intervention.

**Systematic reviews and meta-analyses of studies on iPad-assisted instruction.**

Kagohara et al. (2013) conducted a systematic review of studies involving teaching skills to individuals with a developmental disability using iPods and iPads. Their review
included 15 studies that met the inclusion criteria. The studies included in this review taught skills to individuals with autism in five domain areas: academic, communication, employment, leisure, and transitioning at school. Kagohara et al. determined that iPods, iPads, and iPhones were found to be an effective tool for teaching skills to individuals with a developmental disability.

Based on the findings of the review, Kagohara et al. (2013) recommended that future research should target teaching more academic skills (spelling, reading, matching, and arithmetic). The researchers noted, “these devices also seem to be socially accepted and thus perhaps less stigmatizing when used as assistive technological aids” (Kagohara et al., 2013, p. 155). Also, Kagohara et al. indicated studies on individuals with profound and multiple disabilities were rare. The researchers suggested demonstrations of individuals with profound and multiple disabilities benefiting from generic off-the-shelf tools would be a significant practical advance. In conclusion, Kagohara et al. stated, “careful implementation of ABA-based instructional procedures can make iPods, iPads, and iPhones viable technological aids for individuals with a developmental disability” (p. 115).

Knight et al., (2013) reviewed technology-based interventions to teach academic skills to children with ASD. As Knight et al. stated, “The use of technology to teach students with ASD is not a new concept” (p. 2629). Technology-based intervention has been used to teach skills to learners with ASD for decades (Knight et al., 2013). The purpose of this review was to determine the quality of the interventions using the criteria developed by Horner et al. (2005) and Gersten et al. (2005). The inclusion criteria for the review included (a) having at least one participant with ASD, (b) teaching an academic skill, and (c) technology used as part of the intervention. The review included 29 studies
that utilized single-subject designs and group designs. The findings from the review indicated only four single-subject studies were qualified as *acceptable* studies and demonstrated a functional relationship from at least three participants. None of the group-design studies were qualified as *acceptable*. Knight et al. stated some of the studies used reinforcers that were part of the software (i.e., smiley face, social praises); whereas, some of the studies used teacher-delivered reinforcers (i.e., edibles, verbal praises). Knight et al. recommended future studies use sound research designs that are high quality, teach skills in the areas that lack research (e.g., math, science, and social studies), and teach using iPads, iPods, and cell phones.

Moreover, Knight et al. (2013) suggested the decision to use technology to teach skills to learners with ASD should not be taken lightly and should be made on an individual basis. They should also be monitored carefully to ensure students are making progress.

More and Travers (2013) provided guidelines for selecting educational applications for young children with ASD. The guidelines included (a) evaluating the accessibility of the application, (b) identifying the intersect of the developmental appropriateness and the application, (c) ensuring the content is suitable, and (d) determining the relevance to the child’s need. For example, More and Travers suggested using universal design for learning principles to examine the accessibility of the application. Also, More and Travers suggested that merely providing an educational application does not guarantee a positive outcome for learners. The educators should carefully examine the content of the application and its appropriateness for the learner. Moreover, evaluating the application at the beginning of the use will not be enough and educators should continue to monitor the application periodically to ensure it meets the
set educational standards.

Rodríguez, Strnadová, and Cumming (2014) reviewed studies utilizing the iPad for teaching skills to students with disabilities. Rodríguez et al. (2014) suggested that when used appropriately, iPads and iPods are a useful tool for learning. For example, in the study by Demski (2011), English learning students used the iPad with a downloaded dictionary, and students were able to look up the meaning of the new words immediately. Also, students practiced their skills by recording their speech on the iPad. When selecting the application for instruction, Rodríguez et al. recommended using an application evaluation rubric such as the one developed by Walker (2011). Furthermore, Rodríguez et al. suggested that when the appropriate application is selected, purchasing the application in bulk can save costs for educators.

Grynszpan, Weiss, Perez-Diaz, and Gal (2014) conducted a meta-analysis of technology-based interventions for ASD. The analysis included 22 studies that met the inclusion criteria. Grynszpan et al. did not include studies involving teaching procedures and compensatory techniques such as augmentative communication, interventions that used single-case designs, studies assessing improvements without external outcome measures, and interventions that did not involve active interaction with the computerized system (e.g., video modeling). The results of the studies in this review supported the efficacy of the technology-based interventions. This evidence was further supported by analysis of the 14 studies that used control groups by including participants with ASD who did not receive the technology-based interventions. The limitations of the meta-analysis by Grynszpan et al. included a lack of substantial evidence of randomized controlled trials (RCT), and many studies were conducted by researchers who were not blind to the study conditions. Grynszpan et al. recommended that future meta-analyses
should address the differences between studies. For example, some studies assessed technologies that were used in the home without professional guidance; whereas, some studies assessed technologies used in schools with an ABA-based approach. Also, Grynszpan et al. recommended using RCTs for examining the efficacy of technology-based interventions and having researchers who are blind to the study conditions.

Stone-MacDonald (2015) reviewed the commercially available applications for supporting children with disabilities as well as the empirical studies evaluating the effectiveness of the educational applications. Stone-MacDonald reviewed applications for literacy activities (i.e., Pages, Book Creator, and iBooks), applications for reading (i.e., Collins Big Cat Books from Harper Collins Publishers), applications for literacy skill-building (i.e., The Mayer Johnson apps, Grasshopper, and Splingo), applications for reading and writing (i.e., Pictello, Puppet Pals, and Story Creator), and applications for communication (i.e., Tap to Talk, MyTalk Tools, iCommunicate, and Proloquo2Go). Also, the review included a guide for selecting educational applications for use in early childhood education (More & Travers, 2013). Stone-MacDonald suggested the “iPad can be used as a communication device and a computer to access and supplement curricular content” (p. 16). Specifically, the applications can support children’s’ participation in curricular activities by giving them a voice and providing electronic support for creativity. However, Stone-MacDonald warned parents and educators that technology is not the only tool to support literacy development. Also, caregivers and educators should be cautious as many applications are being marketed for children and they should use information from credible sources when selecting an application to support the learner.

Boyd, Barnett, and More (2015) evaluated studies using the iPad technology for improving the communication skills of children with ASD. The results showed the iPad is
less costly and has a less social stigma when compared to other types of AAC devices. Boyd et al. noted the iPad was superior to its previous generation devices (iPod and iPhone) by providing a larger screen, which provides a solution for individuals with fine motor deficits.

Although the iPad is easy to buy and less expensive than the designated AAC devices, purchasing applications can still increase the cost. Therefore, Boyd et al. (2015) recommended parents, caregivers, and professionals should try out the application for free before purchasing. Also, Boyd et al. noted most studies on the effectiveness of the applications for improving communication skills targeted requesting skills in children. Boyd et al. suggested future research should include communicating needs and greetings, as well as comparing two or more applications on the effectiveness of improving the communication skills in children.

Stephenson and Limbrick (2015) reviewed studies that utilized touch-screen devices for teaching skills to individuals with developmental disabilities. The review included 34 studies, of which 25 were within-subject studies, four were case studies, and five were group-comparison studies. The touch screen devices used in these studies included iPod Touch, iPad, iPhone, personal digital assistant, PAQ Pocket PCs, and palmtops. Stephenson and Limbrick noted iPod Touch was used more commonly than the other touchscreen devices and interventions using touchscreen devices should be regarded as effective interventions.

For future research, Stephenson and Limbrick (2015) recommended including younger participants (ages 5 and under) and focusing on teaching spontaneous communication skills in the natural environment. Also, Stephenson and Limbrick recommended examining the effectiveness of the devices in isolation from the
effectiveness of the app, a relative cost of the devices and the applications, and how individuals with developmental disabilities are using the devices outside of the formal teaching settings. Also, for future studies, Stephenson and Limbrick recommended comparing the use of touchscreen devices to more traditional means of instruction.

Eliçin and Kaya (2017) conducted an extensive literature review of studies that used high-tech devices on individuals with ASD. Eliçin and Kaya examined 67 experimental studies that had been conducted between 1995-2015. The researchers found that between 2010 to 2015, there had been a significant increase in research conducted on high-tech device usage in individuals with ASD. Findings included 23 studies conducted on CAI, and 26 studies conducted on instruction using portable electronic devices (e.g., tablets, iPad, and iPod). The applications used in the studies included Proloquo2Go, GoTalkNow, Pick a Word, Pix Talk, Toy Play Symbol, SonoFlex, Key Note, Little Matchups, and My Choice Board.

The results of the review suggested studies conducted on younger children (2- to 7-years-old) used the iPad more frequently; whereas, studies conducted on older children (12- to 18-years-old) used computers more frequently. Eliçin and Kaya (2017) stated that the ease of portable devices makes them simpler for younger children to operate when compared to older children. Also, findings from the review revealed studies using high-tech devices were primarily focused on developing communication skills in learners.

Withey (2017) reviewed studies using applications to develop social skills in children with ASD. Also, Withey described the overall historical milestones of technology integration in a preschool setting. For example, a few years ago teachers used the computer software to create circle time books by using photo images in the story to demonstrate the story. Later, teachers used the software to create social narratives to
teach various themes and subjects. Based on the synthesis of the review, Withey recommended the following steps and considerations for developing applications for teaching socioemotional skills for children with ASD:

1. “Establishing routines and rules for use.”
2. “Selecting developmentally appropriate software.”
3. “Arranging the environment to facilitate the app-based learning.”
4. “Allowing for app exploration and immediate application of the dramatic play” (p. 252).

Also, Withey suggested the target goals of the program should match the goals of the individualized education plan and align with common curriculum standards.

**A Comparison of iPad-Assisted Interventions and Traditional Interventions**

Travers et al. (2011) compared teacher-led instruction (TLI) and CAI for improving the literacy skills of preschool students with ASD. The study included 17 students who were assigned to two groups. Each group received either of the two interventions, followed by a no-intervention phase (i.e., maintenance phase), and received the other intervention, which was also followed by a no-intervention phase. The researchers developed the materials for the CAI (i.e., software) and the TLI (i.e., book). In addition to comparing the results of the two interventions, the researchers also compared the learners’ attention to task and the occurrence of undesired behaviors during the interventions. The students’ ability to recognize the alphabet was measured using the appropriate portion of the Brigance Inventory of Educational Development II.

Travers et al. (2011) found that students made significant gains in their literacy skills during both interventions. The outcomes of both interventions maintained during the no-intervention phase. Furthermore, there were no differences in the students’
outcomes (i.e., attention to task and the occurrence of the undesired behaviors) between the two interventions.

The limitations of the Travers et al. (2011) study included having a heterogeneous and small convenience sample of participants and the setting of the study (i.e., a self-contained classroom for students with ASD). Travers et al. recommended future studies include a baseline phase for the students’ behavioral outcomes and a comparison to the behavioral outcomes following the interventions. Assessing the behavioral outcomes during the baseline phase would provide a better understanding of whether a well-designed literacy intervention impacts students’ behavior. Additionally, Travers et al. recommended future studies examine other digital and traditional instructional technologies for teaching various early learning skills.

Hill and Flores (2014) compared the effectiveness of PECS and the iPad for communication of students with ASD. The study utilized an alternating treatments design and included five participants with ASD and or developmental delay. The iPad-based requesting skill utilized the Proloquo2Go application and, for the PECS-based requesting, the researchers used picture cards that were identical (i.e., same size and same color) to the images on the Proloquo2Go application. The study consisted of probe sessions (i.e., baseline) using both mediums and intervention sessions (i.e., alternating treatments). Probes for the preintervention communication skill and the interventions were evaluated during snack time within the classroom’s natural routine. The participants’ skills were assessed using the event recording of behaviors associated with the PECS. The results indicated that as the interventions progressed, one participant requested more efficiently during the PECS-based sessions; two participants requested more efficiently with iPad-based sessions.
On the other hand, one participant requested efficiently using the iPad consistently, and another participant demonstrated an improving requesting skill during both interventions. Hill and Flores (2014) noted that iPad-based sessions were difficult to control as the student continued clicking on the same image compared to the PECS intervention session. Therefore, during the trial counting, the requesting, reinforcement, and determining the intertrial interval was difficult, which was a limitation of the study. Based on their findings, Hill and Flores recommended that when teaching requesting with the iPad application, teachers and therapists should teach requesting with the PECS first, and when the learner acquires the skills for PECS Levels I to III, then move onto the iPad application-based requesting (Proloquo2Go).

Allen et al. (2015) examined whether children with ASD learned a new word referent better when using an iPad or a traditional picture book and whether instruction using multiple color variations of the pictures promoted generalization compared to instructions using a single example. The participants included 16 children with ASD, aged 4- to 16-years-old. All participants had impaired expressive language skills and received a picture-based intervention for communication. The materials included picture books with colored photographs, iPad-based pictures, and unfamiliar real-life objects. The target items included a unique pairing between a photograph of an unfamiliar target object and a novel word. The sessions using a picture book and iPad were held similarly except during the iPad-based intervention, where participants themselves controlled their transition between pictures.

Allen et al. (2015) found the mediums used for instruction, iPad and book, did not affect the skill to label objects from a picture to a real-life object. Allen et al. concluded that “learning and symbolic understanding do not differ simply because of the medium of
learning” (p. 6). Allen et al. recommended future studies compare students’ engagement and interaction during learning phases for both mediums, examining the social-interaction elements of learning (i.e., interaction with teachers) and their effects on the learning. As for the generalization effects, Allen et al. found that using the multiple variations of the object (e.g., varying in colors) increased the skill and extended to newly learned objects via pictures to referent objects regardless of the mediums used.

The limitations of the study by Allen et al. (2015) included the lack of generalizability of the findings due to the small sample size and participants who had minimal verbal communication being the recipients of the picture-based interventions for communication. Also, the researchers deliberately minimized the differences between the two mediums to control for the experimental variables. Thus, the researchers warned not to rule out the potential advantages of the iPad to support the learning process of students with ASD. Also, Allen et al. recommended future studies identify the barriers to iPad-based learning in students with ASD (e.g., focusing on the other aspects such as pressing buttons). Also, Allen et al. suggested future studies examine the effectiveness of the mediums using between-subjects design and more flexible tasks such as sorting. Finally, Allen et al. recommended examining how the social-communicative context of the two different mediums affects the aspects of the development of the learner.

Bryant et al. (2015) compared the effectiveness of an application-based instruction, teacher-directed instruction, and the combination of instructional approaches on the multiplication performance of fourth-grade students with learning disabilities. The study included six participants who were identified as having a learning disability and were receiving pull-out math instruction in their school. The researchers compared the three instructional approaches in 15 sessions over 3 weeks (five sessions per each
instructional approach). The results of the study were inconclusive as all three participants had overlapping data points between the three interventions. To examine the effectiveness, Bryant et al. used the same tasks for all three instructional approaches. Because carryover effect from one instructional approach to another is possible, Bryant et al. recommended that future research should examine the effectiveness of the approaches to varying tasks. Additionally, Bryant et al. recommended future studies include a concurrent baseline phase.

Lee et al. (2015) compared the therapist-implemented and iPad-assisted interventions for teaching skills to children with ASD using an alternating-treatments design. The study included two participants. For Participant 1, Photos software was used to teach expressive language skills and for Participant 2, the See.Touch.Learn application was used to teach receptive language skills. To demonstrate the effects of the two mediums, the researchers used the same pictures for both therapist-implemented intervention and the iPad-based intervention. The results indicated that for Participant 1, there were no differences in the outcome between the two mediums (i.e., paper picture cards and the pictures presented on the iPad). The results for Participant 2 indicated there were more occurrences of on-task behavior and correct responses and fewer occurrences of the challenging behaviors during the iPad-assisted condition compared to the therapist-implemented intervention. Although the results did not suggest a significant difference between the two conditions for Participant 1, during the final phase of the study when given an option to choose between the two conditions, both participants preferred the iPad-assisted condition. Participant 1 chose the iPad-assisted condition 90% of the time, and Participant 2 chose the iPad-assisted condition 100% of the time.

Lee et al. (2015) recommended future research should take into consideration the
learner’s preference for technology and human interaction, participant’s prior experience of the use of technology, and the appropriateness of the skills taught using technology. According to Lee et al., their study was the first to examine participant’s choice between the iPad-assisted intervention and a traditional therapist intervention. The limitations of the Lee et al. study included having only two participants and the lack of baseline and maintenance phases. Also, participants worked on the same skills during both conditions, which may have resulted in carryover effects from one condition to the other. Lee et al. recommended future research should include different skills for each condition as well as different target goals for each participant. The main weakness of the Lee et al. study was working on the same skills during both conditions. Because expressive and receptive language skills are nonreversible behaviors, the acquired skills from one condition affecting the skill in the other condition are possible.

Dennis, Whalon, Kraut, and Herron (2016) compared the effectiveness of two interventions on the vocabulary of at-risk preschool children. The multicomponent interventions examined were (a) teacher-facilitated intervention and (b) an iPad-facilitated intervention. Dennis et al. used an AATD to compare the effectiveness of the two interventions. The dependent variables were the acquisition of 42 verbs that were equally divided and assigned to the two intervention conditions for 7 weeks. The study included five children between the ages 4- to 5-years-old. The study procedures included the following:

- Day 1. The teacher taught two sets of three verbs using the book. The instructional materials included pictures of the action (i.e., book pictures), teacher’s extended explanation, and the teacher and the learner trying out the action (i.e., jumping over a piece of paper to illustrate the verb, “hop”).
Day 2- 4. The students were assigned to either of the interventions and practiced the verbs taught on Day 1. After practicing the target words in one intervention, the students practiced target words in the other intervention. There was no break between the two intervention sessions. The results of the study indicated that all five students learned the target verbs during two interventions and there were no significant differences in the outcomes of the two interventions.

Although Dennis et al. (2016) utilized the AATD with suitable verb assignments, there were a few methodological flaws in this study. Firstly, the error correction and prompting procedures during the two conditions were not identical. In the teacher-facilitated intervention, when the student responded incorrectly, the teacher blocked the incorrect choice for the next trial, which eliminated one of the incorrect choices. For example, during the first trial, if three pictures were presented and the student selected an incorrect response, two pictures were presented for the second trial. In doing so, the chances of the correct responding became higher for the teacher-facilitated intervention.

On the other hand, in the iPad-facilitated intervention, if the student responded incorrectly, the iPad prompted the student to try again without eliminating the incorrect choice (Dennis et al., 2016). Therefore, repeated presentation of the incorrect choice during the iPad-facilitated intervention requires a more significant effort from the student, resulting in an increased number of trials. The elimination of the incorrect choices during the teacher-facilitated intervention lowers the chances of incorrect responses. In addition, the study procedures lacked the recommended time gap between the interventions to prevent treatment carryover effects when using AATD. The carryover effects from one intervention to the other is higher if the interventions are implemented with no breaks.
between them.

Furthermore, the reinforcers used during two interventions differed (Dennis et al., 2016). An iPad-based reinforcer (i.e., a recorded speech “Great job!”) was provided during the iPad-facilitated intervention. On the other hand, during the teacher-facilitated intervention, teachers provided a real-time verbal reinforcer. Although the teacher provided the same verbal reinforcer as the iPad, the teacher’s facial expression and social attention may have also served as reinforcement. Another critical issue with this design was that teacher-facilitated intervention was used as the primary instruction (Day 1) as well as one of the alternating treatments (Days 2 to 4), which caused more significant exposure to the teacher-facilitated intervention compared to the iPad-facilitated intervention.

Kemp et al. (2016) compared the effectiveness of two types of intervention for engaging preschool students with severe and multiple disabilities using the multiple-treatments-across-participants design. Two interventions for the comparison were storybooks and matching iPad-based stories. The applications for the stories were Paths, Trucks HD, and Peekaboo HD. The stories were chosen based on the child’s interest and skill level. The study included three children with severe and multiple disabilities. All three children had a prior history of using books and iPads at home. The results suggested that iPad-based stories were effective for one participant and suggested effectiveness for another participant, and they were not effective for the third participant. According to Kemp et al., the limitations of the study included that suggested effectiveness seen in one participant indicated that multiple-treatments across participants design may not have been well suited for this study. For future research, Kemp et al. recommended a generalization phase and a more substantial number of participants.
Conclusions

Based on the review of the literature, this researcher concludes there is limited research on using high-tech devices to teach early receptive labeling skills. The findings of the review revealed the majority of the studies using high-tech devices focused on teaching expressive communication skills (e.g., Clark et al., 2015; Dennis, 2016; Fletcher-Watson et al., 2016; Kagohara et al., 2012; Murdock et al., 2013; Xin & Leonard, 2015). Also, a number of studies (e.g., Chai et al., 2015; Travers et al., 2011) focused on teaching academic skills such as literacy and math skills.

Most of the studies on using iPads to teach skills used a multiple-baseline or multiple-probes design to examine the effectiveness of the high-tech devices. To date, there are very few studies (Dennis et al., 2016; Hill & Flores, 2014; Lee et al., 2015; Neely et al., 2013) that compared the effectiveness of high-tech devices to traditional teaching methods using alternating treatments design.

Furthermore, some of the studies that compared the two methods appear to have methodological limitations. In Allen et al.’s (2015) study, the researchers did not use social reinforcers during the iPad-based instruction. However, the researchers stated that when necessary, social reinforcement for paying attention to the task was provided, which suggests social reinforcement was delivered on an intermittent schedule. Also, it is not clear whether Allen et al. provided redirection or reinforcement during the traditional materials-based instruction.

Although Lee et al. (2015) used an alternating treatments design to compare the effectiveness of the two interventions, the researchers used the same targets for the two interventions, which might have caused carryover effects from one intervention to another. It would be beneficial to compare the effectiveness of the two or more
interventions on nonreversible behaviors using the AATD (Gast & Ledford, 2014) and vary the targets for each intervention. In general, studies (Dennis et al., 2016; Grow & Van der Hijde, 2016) using AATD to compare instructional strategies were limited.

Also, there were limited studies (Neely et al., 2012; O’Malley et al., 2014; Vandermeer et al., 2015) on how the use of high-tech devices affects off-task and challenging behaviors and whether there are differences in the level of independence, use of prompts, and directions during the teaching sessions between the high-tech and traditional mediums. Similarly, there was a lack of studies on teaching receptive labeling skills to learners with autism using the iPad or other electronic tablets. Based on the review of the literature, to date, there was only one study (i.e., Lorah & Karnes, 2015) that was published in a peer-reviewed journal comparing the effectiveness of the two mediums for teaching receptive labeling skills.

The review of the literature indicated multimedia tablets are promising teaching tools. However, there were gaps in the literature and research findings that compared the effectiveness of the electronic tablets and traditional ABA interventions. Future research should extend and replicate the past studies and address the gaps in the literature.

**Research Questions**

To compare the effectiveness of an iPad-assisted ABA intervention and a traditional flashcard-assisted ABA intervention on receptive labeling skills of learners with ASD, the following questions were addressed in this study:

1. What are the differences in the rate of acquisition when teaching receptive labeling skills to learners with autism using a traditional flashcard-assisted ABA intervention and an iPad-assisted ABA intervention?
2. Does an iPad-assisted ABA intervention or a traditional flashcard-assisted
ABA intervention result in a more efficient generalization of the receptive labeling skills?

3. Do skills acquired by an iPad-assisted ABA intervention or a traditional flashcard-assisted ABA intervention maintain better over time?

4. What are the differences between an iPad-assisted ABA intervention and a traditional flashcard-assisted ABA intervention in terms of the number of prompts used during teaching trials?

5. Do challenging behaviors occur more frequently during an iPad-assisted ABA intervention or a traditional flashcard-assisted ABA intervention?
Chapter 3: Methodology

Participants

A convenience sampling method was used for recruiting participants for this study. In a convenience sampling method, researchers recruit participants because they are willing to be studied. However, the sample can provide valuable information (Creswell, 2015).

A letter describing the purpose and procedures of the study to all clients of the agency was sent via the BCBAs, who were providing ABA services at the agency, to distribute to all clients (a) who had a diagnosis of ASD, (b) who had ABA treatment goals for improving communication skills, and (c) who met the age range criteria. Once parents expressed their interest in the study, the researcher met with them to further discuss the study and answered their questions. When the parents agreed to their child’s participation in the study, the researcher provided the parents with an informed consent form. The informed consent form described the purpose of the study. Furthermore, the informed consent explained participant’s rights including that participation in the study was entirely voluntary, participants could ask questions or withdraw from the study at any time without penalty, and the researcher would protect the participants’ privacy and confidential information.

The researcher recruited two participants who met the following criteria to participate in the study: (a) had a medical diagnosis of an ASD, (b) had ABA treatment goals for improving communication skills, (c) had adequate motor skills to interact with an electronic tablet and flashcards, and (d) had an ability to understand and follow spoken directions given in English by a therapist.

Although the inclusion criteria for selecting participants in this study was
learners who either had an educational or medical diagnosis of an ASD, both participants had a medical diagnosis of an ASD and were receiving ABA services at home and school.

Emma (a pseudonym) was a 3-year-old girl with a medical diagnosis of ASD and mild hearing loss. Emma wore hearing aids during the day. Emma wore her hearing aids during all research sessions. Emma received in-home ABA therapy 3 to 4 days a week and attended public preschool 5 half-days a week. At school, Emma received speech and language therapy, occupational therapy, physical therapy, and consultation from a teacher of the hearing impaired on a weekly basis.

Sage (a pseudonym) was an 11-year-old girl with a medical diagnosis of ASD. Sage received in-home ABA therapy five times a week. Sage attended public elementary school 5 full days a week. At school, Sage received speech and language therapy, occupational therapy, and physical therapy on a weekly basis.

Both participants’ native language was English, and they spoke English at home. Also, Emma and Sage were familiar with using iPads. Emma interacted with an iPad at school during educational activities. Sage engaged in iPad-based educational activities at school and listened to children’s music on her iPad when at home.

Instruments

Preference assessment. To teach receptive labeling skill successfully, the researcher identified the effective reinforcers for the learners and differentially reinforced the independent correct responses. As recommended by Karsten, Carr, and Lepper (2011), the initial method for identifying reinforcers for learners with ASD, multiple-stimulus presentation without a replacement item (MSWO; DeLeon & Iwata, 1996) was used to identify reinforcers for each participant.
**Target behavioral sets.** The logic of the AATD research relies on the instructional set of items that are equally difficult to learn (Sindelar et al., 1985). Wolery et al. (2014) recommended several ways for creating behavioral sets of the same difficulty. One approach for developing behavioral sets is to conduct a logical analysis of the behaviors. Holcombe, Wolery, and Gast (1994) defined the *logical analysis* as matching the number and nature of the discriminations the learner would need to make to perform the skill. For example, when teaching how to read sight words, logical analysis of the target sight words will include matching the words by the number of syllabi, configuration of the words, initial consonants, and the participant’s ability to say each word (Wolery et al., 2014).

In this study, to develop behavioral sets of equal difficulty, the researcher used a combination of the approaches recommended by Wolery et al. (2014). First, the researcher selected possible target words that have high utility across learner’s environment and consistent with the learner’s ABA treatment goals. Next, as recommended by Wolery et al., the researcher conducted a logical analysis of those words by their practicality, number of letters, initial sounds, syllables, and word configuration. Based on the results of the logical analysis, the researcher selected a pool of 30 words for each participant and divided them into three counterbalanced experimental sets (i.e., a flashcard set, an iPad app set, and a control set).

The control set was used for assessing the learner’s skill at baseline and at the end of the training phase to detect whether history influenced the participants’ responses (Sindelar et al., 1985). There was no instruction provided on the control set. The differences demonstrated between the performances on the two instructional sets and the noninstructional set strengthened the findings in attributing these effects to the
interventions (Sindelar et al., 1985).

In this study, to compare the effectiveness of the flashcard-assisted instruction and iPad-assisted instruction, the instructional materials varied by the intervention and by the participant. For Emma, to compare the effectiveness of the two instructional mediums, Language Builder’s Verbs and Action Word paper flashcards and Language Builder’s Verbs and Action Word pictures were presented on an iPad using the Language Builder’s Pro application (see Appendix A). For Sage, to compare the effectiveness of the two instructional mediums, sight words printed on paper flashcards and sight words presented on an iPad using the Language Builder’s Pro application were used (see Appendix B).

**Data collection sheet.** A data collection sheet was developed by the researcher to record the student’s performance on all 15 teaching trials (i.e., discrete trials) and the frequency of the challenging behaviors during the instructional sessions (see Appendix C).

**Instructional materials.** Instructional materials for this study included pictures and words presented on traditional paper flashcards and pictures and words presented on an iPad using the Language Builder Pro application.

**Traditional flashcards.** For the flashcard-based instruction for teaching receptive labeling of the actions, the researcher used the Language Builder Verbs and Action Word flashcard set produced by Stages Learning (2018). The Language Builder Verbs and Action Word cards use a standard photo of 3 1/2" x 5" size. The Verbs and Action Word card set includes 230 photographic images of people from diverse age, gender, and ethnicities engaging in common activities in many different settings.

For teaching receptive labeling of the functional sight words, the researcher created paper flashcards that presented the sight words. Each sight word was printed on a
3 1/2” x 5” white paper card, which was laminated.

iPad-based cards. For the iPad-assisted instruction, the researcher used the Language Builder Pro application from Stages Learning. The Language Builder Pro application offers the function to upload images based on the learner’s needs. The application allows the therapist to work with multiple students by creating an account for each student and logging in and out for each session.

The researcher uploaded the Language Builder’s Verbs and Action card pictures and sight words that were used during the flashcard-assisted session to the Language Builder Pro application and created an account for each student. The application has the feature to select the prompt types, prompt fading procedure, forms of the reinforcement, and commands to be used during each session. For the purpose of this study, to control for the experimental variables, the additional features of the application (i.e., instructional commands, within-stimulus prompting, and reinforcement) were turned off.

Procedures

Design. While alternating treatments design is used for comparing instructional practices for reversible behaviors, AATD was developed to compare instructional strategies for nonreversible behaviors (Sindelar et al., 1985). The AATD differs from the standard alternating treatments design, in which separate sets of target behaviors of equal difficulty are assigned to the interventions. Also, the AATD can be enhanced by adding a third instructional set (i.e., control set) on which no instruction occurs (Sindelar et al., 1985).

Changes in nonreversible behaviors are likely to maintain when the intervention ends (Gast, 2014). Academic skills such as picture naming and sight-word reading are nonreversible behaviors (Gast, 2014). Thus, with respect to nonreversibility of the target
behaviors (i.e., receptive labeling of the actions and functional sight words), the AATD was used as the research design for examining the efficiency of the iPad-assisted and traditional flashcard-assisted instructions for teaching receptive labeling skills.

The study took place in the setting where the learner typically receives one-on-one, in-home ABA intervention. For Emma, sessions took place in the family living room where she typically received her ABA therapy. For Sage, the study sessions took place in her bedroom where she typically received her ABA therapy.

All phases of the study were conducted in the same manner. The study setting included a child-sized table and a chair suited for the participant’s height. The table was positioned against the wall and within 3” of the seated child. The researcher sat next to the student no more than 6 inches away from the student. The iPad or flashcards were placed immediately in front of the student on the desk within 3 inches of the student. For Emma, a second therapist collected interobserver agreement (IOA) data while sitting on the couch about 3 feet away from the learner. For Sage, the second therapist collected IOA data while standing about 3 feet away from the learner.

For both participants, during the majority of the study sessions, only one parent was present at home, and no distracting noise or stimuli were present in the environment. The participants attended the research sessions three to four times a week. Both interventions were provided on the same days with at least a 1-hour gap between the two instructional sessions. The order of the iPad-assisted instructions and flashcard-assisted instructions were randomly selected; however, if one of the instructions was selected as the first instructional session for the day for 2 days in a row, on the third day, the other instruction was selected as the first instructional session for the day to counterbalance the treatment sequence effects.
During the baseline phase, probe data were collected for each item across instructional mediums. The learner was tested on each medium twice, and a total of 4 baseline data points were collected for each target. The researcher did not test each target three times on each medium (iPad and flashcards) because assessing each target six times in total may have resulted in a facilitative effect and improve the learner’s performance (Gast & Ledford, 2014). Participants were reinforced for attending to the task to ensure they would respond and demonstrate their optimal performance during the instructional phase (Gast, 2014).

During the instructional phase, to control for the sequential effects, no more than two sessions of the same intervention were conducted consecutively. As recommended by Wolery et al. (2014), all aspects of the conditions (i.e., therapist, the number of an array of items presented, prompts, reinforcers, number of trials for each session, and the setting) were the same except for the instructional mediums used.

To ensure better acquisition, maintenance, and generalization of the skill (Grow & LeBlanc, 2013), the researcher presented three target stimuli simultaneously during each trial of the instructional sessions. Following each instructional trial, the position of the pictures and words were changed within the same array. When the participant mastered a word, a new target word was added to the array. Therefore, three target words were presented consistently throughout the instructional phase. A criterion for mastery was 100% independent correct responding for two consecutive sessions.

**Prompting.** Least-to-most prompting strategy was used for both participants. If the participant responded correctly within 5 seconds of the therapist’s auditory instruction, the therapist provided the specified reinforcer. If the participant did not respond within 5 seconds, the therapist delivered the prompt using the following least-to-
most prompting hierarchy: (a) pointing to the correct stimulus within 3 inches of the correct stimulus, (b) pointing to the correct stimulus within 1 inch of the correct stimulus, and (c) gently guiding the student with hand-over-hand prompt to occasion the correct response. The researcher chose least-to-most prompting strategy as both participants demonstrated an aversion to physical prompts in general.

**Reinforcement.** If the participant responded correctly within 5 seconds of the instructional stimuli by touching the correct picture or sight word, the researcher delivered the small amount of a predetermined reinforcer (a preferred snack item) with social praise (e.g., “Nice job!”, “Awesome!”). For each participant, the top three reinforcers identified by the MSWO assessment were used during instructional sessions. Once the participant demonstrated mastery on a target item, the participant’s skill to generalize was tested on multiple untrained examples and across the medium.

In the final probe phase, all sets of the behaviors including the control set were assessed in the same way as the initial baseline phase. The control set allowed for detecting multitreatment interference, history, or maturation effects that influenced the learner’s responding.

The words taught during the instructional phase were tested for maintenance 4 weeks after the intervention ended. The same instructional materials, setting, and arrangement were used to assess the maintenance of the previously learned skills.

**Data collection procedures.** The researcher collected data on participants’ responses during all phases of the study. The data were collected on preprinted data sheets developed by the researcher (see Appendices D and E).

**Response definition.** An independent correct response was defined as touching the correct image without any errors and prompts. A prompted response was defined as
the participant touching the correct image within 5 seconds of the prompt provided by the therapist. An incorrect response was defined as the participant touching the incorrect image within 5 seconds of the therapist’s instruction or within 5 seconds of the prompt provided by the therapist.

**Reliability measures.** To ensure the accuracy of the measurement, IOA and procedural fidelity data were collected for each participant during each intervention and phase of the study (see Appendix D). Observers collected reliability data evenly distributed across the interventions. For data obtained by the event recording method, it is recommended to report the overall IOA on a trial-by-trial basis (Cooper et al., 2007).

The ABA therapist working with the participant observed at least 30% of the sessions during each phase of the study and recorded data simultaneously with the researcher. The therapists were blind to the hypotheses of the study and were trained in the data collection procedures.

Trial-by-trial IOA for participants’ response to instructional stimuli was calculated. The researcher’s and observer’s data were compared to determine agreement. IOA was calculated using the following formula:

\[
\frac{\text{# of agreements}}{\text{# of trials}} \times 100 = \% \text{ agreement}
\]

The mean IOA results for instructional trials across interventions was 97.2% (range: 93.0-100.0).

Trial-by-trial IOA for a number of prompts used during the instructional phase of the study was calculated for each participant. The mean IOA for the number of prompts used across two conditions for both participants was 98.6% (range: 93.0-100.0).

Also, a point-by-point IOA was calculated for occurrences of the challenging
behaviors for each participant during the instructional phase of the study. The mean IOA for the frequency of the challenging behaviors across interventions for both participants was 100%.

Procedural fidelity data were collected for at least 30% of all phases. The steps of the procedural fidelity for the instructional phase included (a) instructional setting is arranged as described in the design, (b) therapist gaining the learner’s attention before delivering the instruction, (c) waiting the appropriate time delay before providing a prompt, (d) providing the appropriate prompt, and (e) providing reinforcement. The procedural fidelity data were calculated by dividing the number of observed behaviors by the number of opportunities, multiplied by 100 (Gast, 2014). The review of the procedural fidelity data indicated the researcher achieved 100% accuracy across all conditions of the study.

**Data analysis procedures.** Visual analysis of the behavioral data is a method proven to be reliable and practical for studies using single-subject research design (Gast & Ledford, 2014). In this study, the visual analysis of the data was conducted to analyze the baseline level and acquisition of the skill during each intervention, the frequency of the challenging behaviors associated with each intervention, and the rate of maintenance and generalization of the skills for each intervention.

**Statistical analysis.** The rate of acquisition of the new target words was calculated by dividing the number of target words the participant had acquired by the number of sessions each participant completed. The average frequency of the prompts associated with each intervention was calculated by dividing the total number of prompts used by the total number of instructional sessions. The average frequency of the challenging behaviors associated with each intervention was calculated by dividing the total number
of challenging behaviors occurred during the instructional sessions by the number of instructional sessions.

Also, nonoverlapping data (PND) point values were calculated during each phase of the interventions. PND is determined by (a) a range of data point values in the first condition; (b) the number of data points in the second condition, (c) counting the number of points from the second condition that falls outside of the range of values of the first condition, and (d) dividing the data points that fall outside of the range of the value of a first condition by the total number of data points in the second condition and multiplying it by 100 (Scruggs & Mastropieri, 1998). Although the nonoverlapping method provides valuable information, it should not replace the visual analysis of the data (Rakap, Snyder, & Pasia, 2014).
Chapter 4: Results

The purpose of this study was to compare the effectiveness of the iPad-assisted ABA intervention and traditional flashcard-assisted ABA intervention in terms of the acquisition, generalization, maintenance, frequency of the prompts needed, and frequency of the challenging behaviors associated with each intervention. This applied dissertation research sought to answer the following questions:

1. What are the differences in the rate of acquisition when teaching receptive labeling skills to learners with autism using a traditional flashcard-assisted ABA intervention and an iPad-assisted ABA intervention?

2. Does an iPad-assisted ABA intervention or a traditional flashcard-assisted ABA intervention result in a more efficient generalization of the receptive labeling skills?

3. Do skills acquired by an iPad-assisted ABA intervention or a traditional flashcard-assisted ABA intervention maintain better over time?

4. What are the differences between an iPad-assisted ABA intervention and a traditional flashcard-assisted ABA intervention in terms of the number of prompts used during teaching trials?

5. Do challenging behaviors occur more frequently during an iPad-assisted ABA intervention or a traditional flashcard-assisted ABA intervention?

Data Analysis

In this study, the visual analysis of the data was conducted to analyze the rate of the acquisition, generalization, maintenance, frequency of prompts needed, and challenging behaviors associated with each intervention. Also, PND point values were calculated during each phase of the interventions. PND was determined by (a) a range of data point values in the first condition, (b) the number of data points in the second
condition, (c) counting the number of points from the second condition that falls outside of the range of values of the first condition, and (d) dividing the data points that fall outside of the range of the value of a first condition by the total number of data points in the second condition and multiplying it by 100 (Scruggs & Mastropieri, 1998).

**Research Question 1. Rate of acquisition.** The first research question looked at the rate of acquisition associated with each intervention. The rate of the acquisition was calculated by dividing the number of target words the participant had acquired by the number of sessions each participant completed.

For acquisition of verbs, Emma started with zero known verbs out of the 20 target verbs for the interventions. At the end of the instructional phase, Emma had mastered receptively identifying 16 out of the 20 verbs (see Figure 1). Emma identified nine verbs on the iPad-based pictures and seven verbs on traditional flashcard-based pictures. The treatment phase included 13 sessions for each instructional medium. For the iPad-based instruction, the rate of acquisition was 0.7. For the traditional flashcard-based instruction, the rate of acquisition was 0.5 (see Figure 2).

![Figure 1. Adapted alternating treatments design comparing iPad and Flashcard-assisted instructions across time for Emma.](image-url)
Visual examination of the data graphs showed no overlapping data between the two instructional mediums. For Emma, PND was 84.6% for both interventions. According to Scruggs and Mastropieri (1998), interventions with PND scores of 70 to 90 are considered as effective interventions. Therefore, teaching receptive labeling skills using iPad-based pictures and traditional flashcards were both effective interventions.

![Graph showing acquisition rates across participants.]

*Figure 2.* Rates of acquisition across participants.

Furthermore, there was limited variability in Emma’s data. In other words, Emma’s data for both interventions continued to rise as the research progressed. Specially, the trend of the data values for iPad-assisted instruction demonstrated a steady increasing trend.

Sage recognized zero of the 20 selected target sight words when the instructional phase began. By the end of the instructional phase, Sage mastered receptively identifying 17 of the 20 target functional sight words (see Figure 3). Sage receptively identified seven sight words on the traditional flashcards and 10 sight words on the iPad. For the iPad-based instruction, the rate of acquisition was 0.6. For the flashcard-based instruction, the rate of acquisition was 0.4 (see Figure 2). Therefore, the iPad-based
instruction resulted in slightly faster acquisition of the functional sight word recognition. Interestingly, during the treatment phase, the researcher observed that Sage’s learning rate was slower for words that had a broad or an abstract meaning (e.g., dairy, food) compared to words that imply concrete concept or meaning (e.g., pickles, push).

Sage’s data values also showed a steady increasing trend for both interventions and had limited variability in performance throughout the study. For Sage, PND was 87.5% for both interventions, which indicated both interventions were effective.

Figure 3. Adapted alternating treatments design comparing iPad and Flashcard-assisted instructions across time for Sage.

Figure 4. Acquisition of the verbs across sets for Emma.
Acquisition and control sets. During the final probe session, Emma demonstrated improved performance on four of the 10 verbs from Set 3 on which no instruction was provided (see Figure 4). For Sage, the data from the final probe revealed Sage had acquired three out of the 10 words from Set 3 on which no instruction was provided (see Figure 5).

Figure 5. Acquisition of the sight words across sets for Sage.

Session duration. To evaluate the rate of acquisition as it relates to the time it took to complete the instructional trials, the researcher measured the duration of all sessions in seconds. There were a few sessions where the researcher failed to start the timer at the beginning of the session. In those instances, the corresponding sessions from the same day were excluded from the calculation to provide a more accurate average duration of sessions.

For Emma, 20 instructional sessions from 10 days were included in the calculation of the average duration. On average, iPad-assisted sessions lasted for 221 seconds, and flashcard-assisted sessions lasted for 291 seconds. For Sage, 30 instructional sessions from 15 days were included in the calculation of the average duration. On average, iPad-assisted sessions lasted for 220 seconds, and flashcard-assisted sessions
lasted for 249 seconds (see Figure 6).

![Figure 6](image)

*Figure 6. Average duration of sessions per medium for participants.*

**Research Question 2. Generalization of skills.** The second research question explored which intervention would result in better generalization of the acquired skills. Generalization assessment evaluated whether participants could generalize the skills across materials and on untrained responses. Once the participant demonstrated mastery by correctly identifying the target item for two consecutive sessions, the participant’s skill to generalize was tested on two untrained exemplars of the target responses and same example presented on the other instructional medium.

Emma was able to receptively identify 100% of the acquired verbs on two additional example pictures showing the same action performed by different people in different settings. Also, Emma demonstrated 100% successful generalization of the verbs across mediums. For example, if Emma learned to receptively identify the verb on the iPad, she was able to identify it on the flashcard, and vice versa (see Figure 7).

Sage was able to receptively identify 100% of the sight words on two additional examples (same words typed in different fonts). Also, Sage demonstrated 100% successful generalization of the words across instructional mediums by identifying it on
both instructional mediums (see Figure 8).

Research Question 3. Maintenance. The third research question looked at the skill maintenance associated with each instructional medium. At the 4-week follow-up maintenance probe, Emma demonstrated an ability to receptively identify 100% of the acquired verbs during the instructional phase (see Figure 9). Also, Emma provided expressive identification responses for some of the acquired verbs independently, although no formal data were collected on this skill.
During the maintenance probe, Sage was able to identify 100% of the acquired functional sight words correctly (see Figure 9). In addition, Sage demonstrated textual response for many of the taught sight words independently, although no formal data were collected on this skill.

![Bar chart showing maintenance of the acquired words across participants]

*Figure 9. Maintenance of the acquired words across participants*

**Research Question 4. Prompts used.** The fourth research question looked at the frequency of prompts associated with each instructional medium. In this study, the least-to-most prompting strategy was used by the following order: (a) pointing to the correct stimulus within 3 inches of the correct stimulus, (b) pointing to the correct stimulus within 1 inch of the correct stimulus, and (c) gently guiding the learner with hand-over-hand prompt to occasion the correct response.

For Emma, an average of 1.0 prompt was used per iPad-based session, and an average of 1.3 prompts was used per flashcard-based session. Furthermore, the number of prompts used during initial flashcard-based teaching session was significantly higher than the initial iPad-based session (see Figure 10). When providing prompts to evoke the correct response, gestural prompts (i.e., pointing within 3 inches or 1 inch of the picture) were sufficient the majority of the time. Hand-over-hand prompts were needed only
during the initial teaching sessions. Beginning with the second teaching sessions, Emma did not need any hand-over-hand prompts during instructional sessions.

For Sage, an average of 0.8 prompts was using per iPad-assisted instructional session, and an average of 1.1 prompts was used during the flashcard-assisted instructional session (see Figure 11). The initial flashcard-assisted instructional session required the highest number of prompts. Moreover, for Sage, gestural prompts (pointing within 3 inches or 1 inch of the presented sight word) were sufficient 100% of the time when providing prompts to evoke the correct response. Hand-over-hand prompts were used zero times during instructional sessions.

Figure 10. Frequency of prompts associated with each instructional medium for Emma.

For Sage, Figure 11. Frequency of prompts associated with each instructional medium for Sage.
Research Question 5. Challenging behaviors. The last research question in this study investigated the frequency of challenging behaviors associated with each instructional medium. The challenging behaviors during instructional sessions included participant looking away from the task or engaging in nontask-related activities verbally or physically. Emma engaged in challenging behaviors six times in total during iPad-assisted instructional sessions and engaged in challenging behaviors 12 times in total during flashcard-assisted instructional sessions (see Figure 12).

For Sage, the rate of the challenging behaviors was low during instructional sessions. During iPad-assisted instructional session, challenging behaviors occurred one time only. During flashcard-assisted instructional sessions, challenging behaviors occurred twice (see Figure 13).
Chapter 5: Discussion

Introduction

The purpose of this study was to compare the effectiveness of the ABA interventions using traditional flashcards and iPad app-based pictures for teaching receptive labeling skills to learners with ASD. The dimensions of the instructional efficiency included rapidity of learning, the extent of maintenance and generalization, breadth of learning and acquiring untrained relations, and influence on future learning (Wolery et al., 2014). The current study addressed the questions related to effectiveness by comparing the rate of skill acquisition, generalization, maintenance, and frequency of prompts required and occurrences of challenging behaviors associated with each instruction.

Summary of Findings

Previous research (Allen et al., 2015; Dennis et al., 2016; Lee et al., 2015) supported that both iPad-assisted and traditional flashcard-assisted instructions are effective for teaching language skills. The findings of the current study showed that both iPad-assisted and flashcard-assisted instruction resulted in the acquisition of receptive labeling skills. However, iPad-assisted instruction showed a slightly higher rate of acquisition compared to the flashcard-assisted instruction.

For instructional efficiency as it relates to the duration of the sessions, iPad-assisted instruction was more efficient for both participants. iPad-assisted instructional sessions took less time to complete than the flashcard-assisted instructional sessions.

Furthermore, both participants’ data indicated fewer challenging behaviors occurred during the iPad-assisted instructional sessions compared to the flashcard-assisted sessions. Also, iPad-assisted instruction required less frequent prompts.
Especially, during the first flashcard-assisted instructional session, both participants needed a significantly higher number of prompts to touch the correct pictures or sight words. The researcher observed that participants were more willing to independently touch the pictures or sight words on the iPad as compared to traditional flashcards. In the previous study by Hill and Flores (2014), participants responded in the same way. Also, Lee et al. (2015) found that when given choices, participants chose iPad as an instructional medium majority of the opportunities.

Although no change in performance on the control set is ideal for demonstrating the functional independence of the interventions (Sindelar et al., 1985), it is possible that including verbs and sight words of high utility may have contributed to improved performance on the control set in this study. The participants were likely to be exposed to the target words outside of the research setting (school and community). However, the researcher decided choosing verbs and sight words that are functional and used frequently in the community would be beneficial for the participants. Furthermore, as More and Travers (2013) and Withey (2017) recommended for utilizing applications, the researcher ensured target words selected for this study were relevant to the learner’s needs and consistent with participants’ ABA treatment goals.

During the maintenance probe, both participants demonstrated an ability to expressively label some of the taught verbs and sight words independently, although no formal data were collected on this skill. The improved performance demonstrated on expressive labeling skills could be due to facilitative effects of the receptive labeling skills training on expressive labeling (Petursdottir & Carr, 2011). Furthermore, similar to the participants of the previous study (Grow & Van Der Hijde, 2016), the participants of the current study were observed as engaging in echoic behaviors by repeating the given
verbal stimulus during instructional sessions.

**Interpretation of Findings**

The findings of the current study indicate that iPad-assisted instruction is as effective as traditional flashcard-based instruction when teaching receptive labeling of the actions and functional sight words. Furthermore, when compared to flashcard-assisted instruction, the findings of this study indicate acquisition rate is slightly higher for iPad-assisted instruction. However, a statistical test of significance is not applicable for ABA studies using single-subject methodology because behavioral data sets do not conform to predetermined criteria (Cooper et al., 2007).

In terms of time required to complete instructional sessions, iPad-assisted instruction was more effective than flashcard-assisted instruction. The previous study by Leet et al. (2015) demonstrated similar results. The researcher observed interspersing the pictures or sight words and presenting the array of stimuli took less time for iPad-assisted instruction. Also, when preparing instructional materials, iPad-based materials took less time to prepare and were more convenient. For example, when preparing pictures or sight words to present on an iPad, increasing or decreasing the color contrast, size, and lighting was easily adjustable when using an iPad.

Results of the study showed that Sage’s rate of challenging behaviors during instructional sessions was relatively low. Previous data indicated Sage engaged in challenging behaviors during teaching sessions at home and school. Sage’s parents reported Sage expressed her desire for learning to read many times. Therefore, receptively labeling functional sight words was chosen as the target skill for Sage. During baseline testing, data showed Sage could recognize less than 10 words with one or two syllables that she frequently encountered in her environment. However, during the
instructional phase, Sage participated in sessions successfully and often expected the activity by placing the “read” icon in her visual activity schedule. It is likely Sage was successful in learning to label sight words and engaged in a relatively low rate of challenging behaviors because of her motivation for learning to read.

Although expressive responding can emerge after training in receptive labeling (Grow & Van Der Hijde, 2016), both participants’ ability to expressively label majority of the taught words during the final probe and 4-weeks maintenance probe were unexpected. Especially, Sage’s textual responding was a significant progress considering her reading ability demonstrated during the baseline phase.

An unanticipated effect observed by the researcher during instructional sessions was Sage’s performance on certain sight words. It was observed that Sage acquired words representing concrete or specific objects or concepts (e.g., push, milk, pickles) faster than words that mean more general or abstract concepts (e.g., dairy, food). When conducting a logical analysis to create sets for two instructional mediums and a control set, the researcher mainly focused on the practicality of the word, number of the syllabus, initial sounds, and sound similarities. Although sorting and receptive labeling are not directly related skills, this finding is similar to findings of the previous studies (Ropar & Peebles, 2007; Shulman, Yirmiya, & Greenbaum, 1995) that showed individuals with ASD sort objects better by concrete features (size, color, shape) compared to using abstract characteristics (i.e., categories). Ropar and Peebles (2007) stated that individuals with ASD may be less inclined to process abstract information if the information is not directly available from the given input.

Because receptive labeling skill is a nonreversible behavior (Wolery et al., 2014), both participants’ improved skill acquisition during the instructional sessions may have
influenced the improved performance on the control set, on which no training was provided. Also, it is possible that carryover effects of the improved performance during one intervention could have influenced the performance during the other intervention, therefore resulting in the overall increasing data trends on both iPad-assisted and flashcard-assisted instructional sets.

Context of Findings

The findings of this study are consistent with findings of Dennis (2016), Lee et al. (2015), and Neely et al. (2013), in that a lower frequency of challenging behaviors were associated with iPad-based instruction. Participants were more willing to independently participate in sessions when the iPad was used as an instructional medium.

Also, the results of the current study are consistent with findings of Grow and Van der Hijde (2016) and Mechling et al. (2009) for teaching sight words to individuals with disabilities. Grow and Van der Hijde demonstrated that teaching sight words using the conditional only model (i.e., presenting three words in an array and simultaneously teaching), which was used in this study, was more effective than teaching sight words using simple-conditional model (i.e., teaching words in isolation before presenting in an array). Furthermore, similar with Grow and Van der Hijde’s results, textual responding emerged when the participant mastered receptively labeling the sight words. Similar to Mechling et al.’s findings, the results of this study showed both high-tech device and traditional flashcards were effective in teaching sight words.

Additionally, in this current study, both participants needed fewer prompts during iPad-assisted instructional sessions, although the first instructional session was iPad-assisted session for both participants. Moreover, hand-over-hand prompts were not used during iPad-assisted sessions. Consistent with findings of Hill and Flores (2014),
participants were willing to click on the pictures or sight words on the iPad more independently than touching the pictures or sight words presented on traditional materials. Furthermore, during the first flashcard-assisted instructional session, participants needed more prompts for touching the flashcards compared to the first iPad-assisted instructional session.

In terms of the generalization of the skills, the findings of this study are consistent with findings of Lorah and Karnes (2016), in that both participants were able to generalize the receptive labeling skills on multiple examples of the target verbs or sight words and identify them across the mediums.

**Implications of Findings**

The implications of the study include that iPad-assisted instruction is as effective as traditional flashcard-assisted instruction when teaching receptive labeling skills to learners with ASD. Although statistical test of significance is not applicable for ABA studies using single-subject research methodology (Cooper et al., 2007), data values on the iPad-assisted instruction demonstrated a slightly higher rate of acquisition compared to flashcard-assisted instruction. Furthermore, the current study shows that creating materials for iPad-assisted instruction and implementing the instruction are relatively time and cost-effective for practitioners.

Moreover, iPad-assisted instruction can be a useful tool for implementing DTI. Technology-based instructions have the potential to decrease those errors that may occur during instruction (Lorah & Karnes, 2016). The timing of the reinforcement and prompts, interspersing of the target stimuli, implementing an accurate number of trials, and data collection procedures are subject to human errors. During DTI, the instructor might inadvertently provide cue, prompts, or incorrect array placement (Grow & LeBlanc,
The iPad can present the array of target stimuli effectively by interspersing the number and position of the stimuli, delivering prompts, and reinforcement. Also, most applications can record the learner’s response, which can save time for collecting and monitoring data.

The findings of this study indicated there is no difference in the level of generalization and maintenance of the skills when using traditional flashcards and iPad-assisted instructions. Once the skill was mastered, participants were able to generalize it on multiple examples of the target stimuli and were able to maintain the skill for both instructional mediums.

Lee et al. (2015) suggested future research should compare the effectiveness of the iPad-assisted and traditional interventions by addressing multiple set of skills and compare whether the differences in effectiveness exist. The current study compared the effectiveness of the iPad-assisted and traditional flashcard-assisted instructions by addressing different instructional target sets and provided information about the effectiveness of the instructional mediums for teaching receptive labeling of actions and functional sight words.

Furthermore, the current study contributes to the literature as it is the only study, to the researcher’s knowledge, to date that compared the rate of prompting associated with iPad-assisted and traditional flashcard-assisted instructions. The findings of this study indicate a lower rate of prompting was associated with iPad-assisted instruction. Moreover, iPad-assisted instruction can facilitate within stimulus prompts that are not used frequently due to time and skills required to develop (Cooper et al., 2007; Grow & LeBlanc, 2013). Also, within stimulus prompts may be appropriate for learners who are aversive to physical touch (Cooper et al., 2007; Grow & LeBlanc, 2013).
The current study adds to the literature by comparing the effectiveness of the two instructional mediums using AATD, which included a control set for comparison, baseline, treatment, generalization, and maintenance phases. The majority of the previous studies utilized a standard alternating treatments design (Hill & Flores, 2014; Lee et al., 2015; Neely et al., 2013; Siegel & Lien, 2015).

Additionally, the current study extends the literature by evaluating the effectiveness of high-tech devices focused on teaching receptive labeling skills. The majority of the previous studies focused on teaching expressive communication skills (Clark et al., 2015; Dennis, 2016; Fletcher-Watson et al., 2016; Kagohara et al., 2012; Murdock et al., 2013; Xin & Leonard, 2015).

The results of this study indicate iPad-assisted instruction is just as effective as the traditional flashcard-assisted instruction. Furthermore, iPad-assisted instruction was associated with slightly faster acquisition and fewer prompts and challenging behaviors for both participants in this study compared to flashcard-assisted instruction. The researcher observed that preparing and organizing instructional materials on an iPad required less time than creating traditional flashcards. Furthermore, similar to previous findings (Lee et al., 2015), the results of the current study showed implementing iPad-assisted instruction took less time than implementing flashcard-based instruction. Time is one of the most valuable resources for practitioners providing services at schools and homes. Time and cost efficient instructional strategies are likely to be preferred by practitioners (Clark et al., 2015), if they lead to same or higher levels of instructional efficiency. Also, if two interventions are shown to be equally effective, it may be beneficial to allow the learner to choose the instructional medium since giving choices to children with ASD has positive effects (Lee et al., 2015). Furthermore, electronic tablets
provide an ability to deliver information using sound and visual effects, and other interactive features that can enrich the learning experience for individuals with autism.

Although some parents report that children with ASD has an easy access to electronic devices and report high level of iPad use (Clark et al., 2015), those concerns were not detected during this study. Because the study had a predictable and consistent structure for all sessions, each instructional session consisting of 15 trials, neither of the participants showed any difficulty for ending the sessions or requested more time on the iPad during sessions. Sage’s rate of challenging behaviors was significantly lower compared to her past rate of challenging behaviors. Emma often showed enthusiasm for engaging in the sessions by leading the researcher to her table when the researcher arrived in her home.

**Limitations of the Study**

Though the common threats to internal validity (i.e., maturation, carryover effects, sequential effects) were controlled by including a control set, randomly assigning the order of the interventions, and implementing the interventions in distant temporal order, there were several limitations associated with the internal validity of the study.

**History.** In order to make it consistent with the participants’ ABA treatment goals, functional words that have high utility across participants’ environment were selected for the target sets (i.e., a flashcard set, an iPad-based set, and a control set). Therefore, the participants were likely to be exposed to the target words outside of the research setting, which may explain the improved performance on the control set during the final probe.

**Multiple treatment interferences.** Multiple treatment inferences refer to the confounding effects of one intervention influencing the effects of the other intervention
administered during the same study within the subject (Cooper et al., 2007) and can be a potential limitation for AATD (Sindelar et al., 1985). Due to receiving multiple interventions, effects of the interventions may have generalized to the other target sets, including the control set, which may explain the participants’ improved performance on all three sets during the final probe.

**External validity.** External validity refers to the degree the findings of the study can be generalized to the relevant populations, settings, and interventions (Creswell, 2015). In this study, having a small sample size, and participants living in the same region of the United States limits the generalizability of the findings to other populations. The study included two learners with ASD who lived in a northeastern part of the United States.

Another limitation of the study was overlooking the concept and meaning of the words when selecting target sight words. By focusing on the functionality of the words, the researcher might have discounted the meaning and concept that may affect the rate of acquisition for the learner. A plausible explanation for Sage’s slower acquisition during the iPad-assisted instructional sessions was using target words that have broad and abstract meaning (e.g., dairy, food). In future studies, the researchers should consider not only the number of syllables, initial sounds, or utility of the words, but also the concept and meaning the word implies. This factor is likely to be relevant because learners with autism are less likely to be inclined to process abstract information that is not directly available in the given input (Ropar & Peebles, 2007).

Also, the materials used for generalization probes were in a similar format as the materials used during the instructional phase. Probing the skill generalization using materials in different formats (actual objects, printed words in a book or the community
signs) may provide further information on skill generalization.

Lastly, to compare the effectiveness of the instructional mediums, all other variables in this study were controlled. Identical teaching strategies, instructors, prompts, reinforcers, and settings were used for both iPad-assisted and traditional flashcard-assisted instructions. In order to do so, some of the available features of the iPad application (i.e., Language Builder) were turned off such as app-based reinforcers (i.e., visual and sound effects), app-based instructions (i.e., verbal instructions delivered by the app), and app-based prompts (i.e., highlighting and fading). Because most electronic tablets and applications already offer these features, which have the potential to help teachers, therapists, and families, especially for those who do not have access to ABA interventions, it would be beneficial to evaluate iPad-assisted instruction with these features allowed.

**Future Research Directions**

To control experimental variables, this study compared the effectiveness of the instructional mediums by teaching receptive labeling skills using different target sets assigned to each instructional medium. The volume and other interactive features of the application were turned off. Except for the medium on which the word or picture was presented, all other variables of the instruction were identical (reinforcers, instructor, prompts, instructional strategy). In future studies, it may be beneficial to compare the effectiveness of instructor-delivered reinforcers, instruction, and prompts to app-delivered reinforcers, instruction, and prompts. Doing so will help further evaluate and compare the effectiveness of the iPad-assisted and flashcard-assisted instructions. Aside from delivering instructional commands, prompts, and reinforcers, most applications have the ability to collect data and generate graphs, which can alleviate challenges related
to limited time and resource for practitioners and families.

Also, future research could compare the effectiveness of the instructional mediums for teaching receptive labeling skills in classrooms. Furthermore, future research should evaluate the skill generalization using real life objects or printed words in the community.

In this study, the researcher used an iPad with screen size 9.7” since it is used most commonly in educational settings. As of 2018, iPads with larger screen size are available on the market (11.0” and 12.9”). Using iPad with larger screen size may produce different results since the size, array, and positioning of the images or words can be different on a larger screen.

A final idea for future research directions is evaluating the feasibility of the iPad-assisted ABA instruction implemented and monitored by caregivers. Because most people are familiar with operating electronic devices, it would be beneficial if iPad-based instruction is implemented and monitored by the caregivers. Previous studies demonstrated DTI can be implemented effectively by parents (Lafasakis & Sturmey, 2007; Subramaniam et al., 2017). If proven to be effective, individuals who do not have access to ABA services can benefit from the instruction facilitated by high-tech devices.
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Appendix A

Emma’s Target Verb List
<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(iPad)</td>
<td>(Flashcard)</td>
<td>(Control)</td>
</tr>
<tr>
<td>Raising hand</td>
<td>Shaking hands</td>
<td>Drying hands</td>
</tr>
<tr>
<td>Dressing</td>
<td>Buttoning</td>
<td>Hanging</td>
</tr>
<tr>
<td>Barking</td>
<td>Yawning</td>
<td>Calling</td>
</tr>
<tr>
<td>Cutting</td>
<td>Folding</td>
<td>Peeling</td>
</tr>
<tr>
<td>Painting</td>
<td>Pointing</td>
<td>Writing</td>
</tr>
<tr>
<td>Breaking</td>
<td>Sweeping</td>
<td>Tearing</td>
</tr>
<tr>
<td>Tickling</td>
<td>Smelling</td>
<td>Skiing</td>
</tr>
<tr>
<td>Standing</td>
<td>Stirring</td>
<td>Blowing</td>
</tr>
<tr>
<td>Throwing</td>
<td>Pulling</td>
<td>Dripping</td>
</tr>
<tr>
<td>Clapping</td>
<td>Riding</td>
<td>Carrying</td>
</tr>
</tbody>
</table>
Appendix B

Sage’s Target Sight Word List
## Sage: Target Sight Words

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(iPad)</td>
<td>(Flashcard)</td>
<td>(Control)</td>
</tr>
<tr>
<td>Boy</td>
<td>Girl</td>
<td>Candy</td>
</tr>
<tr>
<td>Push</td>
<td>Little</td>
<td>Coat</td>
</tr>
<tr>
<td>Off</td>
<td>Deli</td>
<td>Movie</td>
</tr>
<tr>
<td>Food</td>
<td>Hot</td>
<td>Music</td>
</tr>
<tr>
<td>Dairy</td>
<td>Close</td>
<td>Slow</td>
</tr>
<tr>
<td>Men</td>
<td>Drink</td>
<td>Snack</td>
</tr>
<tr>
<td>Soda</td>
<td>Pickles</td>
<td>Caution</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Enter</td>
<td>Soup</td>
</tr>
<tr>
<td>Cold</td>
<td>Volume</td>
<td>Straw</td>
</tr>
<tr>
<td>Danger</td>
<td>Out</td>
<td>Water</td>
</tr>
</tbody>
</table>
Appendix C

Trial-by-Trial Skill Acquisition and Behavior Data Sheet
Date:                      Student:  
Instruction:                Therapist: 
Start Time:       End Time:       Phase: 

Score Key:
Independent Correct Response - +
Incorrect Response - -
No Response - NR

Pointing within 3 in. – P3 (within 5 s)
Pointing within 1 in. - P1 (within 5 s)
Physical Guidance – PG (within 5 s)

<table>
<thead>
<tr>
<th>Item</th>
<th>Trials</th>
<th>% Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Challenging Behaviors:

<table>
<thead>
<tr>
<th>Challenging Behaviors (Tally)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Task Engagement/Attending: Looking at the task or engaging in the task-related activity.

Score Key: Attending (+)                     Non-Attending (-)

<table>
<thead>
<tr>
<th>Trials</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Procedural Fidelity Data Sheet
Procedural Reliability Data

Date:                
Start Time:                
End Time:        

Therapist:                
Instruction:                
Phase:

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Opportunities</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional setting arranged as described.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaining learner’s attention before delivering the instruction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiting the 5s time delay before providing prompt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Providing the appropriate prompt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Providing the appropriate amount of reinforcement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Least-to-Most Prompting

When providing prompts, the auditory stimulus is presented simultaneously:

1. Therapist pointing within 3 in of the target stimuli.

2. Therapist pointing within 1 in of the target stimuli.

3. Physical guidance (The least amount of hand-over-hand guidance to complete the response).
## Preference Assessment Data Sheet
(Multiple Stimulus Without Replacement)

<table>
<thead>
<tr>
<th>Date:</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial #</td>
<td>Item Selected</td>
</tr>
<tr>
<td>1</td>
<td>x x x x x</td>
</tr>
<tr>
<td>2</td>
<td>x x x x x</td>
</tr>
<tr>
<td>3</td>
<td>x x x x x</td>
</tr>
<tr>
<td>4</td>
<td>x x x x x</td>
</tr>
<tr>
<td>5</td>
<td>x x x x x</td>
</tr>
<tr>
<td>6</td>
<td>x x x x x</td>
</tr>
</tbody>
</table>

## Preference Assessment Data Sheet
(Multiple Stimulus Without Replacement)

<table>
<thead>
<tr>
<th>Date:</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial #</td>
<td>Item Selected</td>
</tr>
<tr>
<td>1</td>
<td>x x x x x</td>
</tr>
<tr>
<td>2</td>
<td>x x x x x</td>
</tr>
<tr>
<td>3</td>
<td>x x x x x</td>
</tr>
<tr>
<td>4</td>
<td>x x x x x</td>
</tr>
<tr>
<td>5</td>
<td>x x x x x</td>
</tr>
<tr>
<td>6</td>
<td>x x x x x</td>
</tr>
</tbody>
</table>