A COMPARISON OF IPAD-BASED AND TRADITIONAL INSTRUCTIONAL MATERIALS FOR TEACHING ACADEMIC SKILLS TO CHILDREN WITH AUTISM SPECTRUM DISORDER

by

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Abstract

In recent years, research has emerged on the application of the iPad for teaching academic, communication, vocational, and leisure skills to children with special needs such as ASD (Kagohara et al., 2013). However, only 10 iPad studies to date have sought to teach basic academic skills (e.g., simple reading, math, or printing skills) to students with special educational needs, and only five of these compared iPad-based instruction to the traditional materials. This study aimed to expand the research on the application of the iPad for teaching academic skills by comparing the impact of the mode of instructional delivery (i.e., iPad vs. traditional materials) on the number of sessions required to meet mastery criterion, task engagement, and frequency of problem behaviour. The study employed an adapted alternating treatments design with two young children with autism spectrum disorder. Two tasks were identified for both participants: addition with pictures and word families, with equivalent task sets designed for each condition. All sessions were conducted in participants' homes and lasted 20 to 40 minutes. The results for the number of trials to criterion provide evidence of a functional relation in favour of the TM condition for the word families task but not for the addition task. This is contrary to the hypothesis that a functional relation would be evident for both tasks in favour of the iPad condition. Results for engagement were mixed, with lower engagement in the iPad condition for one participant, and no meaningful difference for the other. No problem behaviour was observed during the study. Implications of the study are discussed as they apply to students with autism spectrum disorder in particular, along with suggestions for future research.

Preface

This thesis is an unpublished, original intellectual product of the author, A. Voroshina. The project's method was approved by the University of British Columbia's Research Ethics Board (certificate H13-03492).

The identification of the research topic and the design of the study were the product of collaboration between the author, A. Voroshina, and her thesis supervisor, Dr. P. Mirenda. The author implemented the intervention throughout the study with supervision from Dr. Mirenda. The data were analyzed by both the author, A. Voroshina, and a research assistant, G. Molina Garcia.

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CHAPTER 1: REVIEW OF THE LITERATURE

> **"**The Apple iPad has been hailed as a savior for assisting children with autism spectrum disorder or other special needs" (Joshi, 2011).

This quote from the *New York Times* is one of many that can be found in popular media, reflecting the belief of many educators and parents that iPod and iPad technologies have revolutionized learning and communication for individuals with autism spectrum disorder (ASD) and other special needs. The iPod Touch, which was first introduced in September 2007, is a portable touch screen video/music player and handheld game console that can be used to host various applications ("apps") that are available for purchase through Apple's iTunes store. The iPad, which was first released in May 2010, is a handheld tablet computer that enables a user to perform a variety of actions that serve a number of functions (e.g., create video, take photos, play music, perform Internet functions, and utilize apps that are also available through iTunes).

Over the past few years, developers have created numerous iPod/iPad applications that are aimed to support individuals with special needs across a variety of domains: academic skills, communication and language, self-care and life skills, self-management, and self-regulation. Many of these apps are designed to be used by individuals with a wide range of disabilities as well as by typically developing children and adolescents. In addition, some developers have focused exclusively on apps for individuals with ASD, to compensate for the learning challenges that are specific to this population. For example, AutismApps (http://touchautism.com/Autism%20Apps.aspx) is a collaborative search engine for applications that are available for individuals with ASD. It provides a list of

over 30 categories, with searchable descriptions of hundreds of apps that can be used for a wide range of teaching and support endeavours.

Tablet computer apps such as those available for the iPod/iPad are a subset of strategies for computer-based instruction (CBI). According to Hardy, Ogden, Newman, and Cooper (2002), CBI technologies have several qualities that are beneficial in assisting students with ASD. Computers can perform a substantial number of functions automatically (e.g., word prediction during typing), allowing users to produce greater output with less effort. CBI also allows learners to be actively engaged in the learning process, through the use of multi-media software programs that contain both sound and 2D-3D visual effects. Such programs are designed to focus learners' attention on relevant stimuli, while ignoring peripheral content. With these properties, students become active participants who are more able to learn meaningful information that is tailored to accommodate individual needs.

Despite these potential advantages, it is important to acknowledge that computers (and the software programs that run on them) are essentially intervention "delivery systems" whose success depends, in large part, on teachers' ability to use them for effective teaching. Thus, practitioners must ensure that software programs address the functional properties of both target skills and individual learners (Ramdoss et al., 2011). In order to do so, it is important to consider the core diagnostic features of ASD, with special attention to those that are most closely related to the use of CBI to teach new skills.

Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a neurological condition that is evident in early childhood and affects a person's development throughout the lifespan. The most recent edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) requires that symptoms be present in early childhood and that they limit and impair everyday functioning. The DSM-5 describes the following diagnostic criteria for ASD:

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by all three of the following:

1. Deficits in social-emotional reciprocity (e.g., abnormal social approach behaviors; failure of normal back-and-forth conversation; reduced sharing of interests, emotions, or affect; lack of initiation or response to social interactions);

2. Deficits in nonverbal communication (e.g., abnormal social use of eye contact, body language, and/or gestures); and

3. Deficits in developing, maintaining, and understanding relationships social awareness and insight, as well as with the broader concept of social relationships (e.g., difficulty adjusting behaviour to suit social contexts; difficulty with imaginative play or making friends; absence of interest in peers).

B. Restricted, repetitive patterns of behaviour, interests, or activities, as manifested by at least two of four symptoms:

1. Stereotyped and/or repetitive speech, motor movements, and use of objects (e.g., simple motor stereotypies, echolalia)

2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behaviour (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns)

3. Highly restricted, fixed interests that are abnormal in intensity or focus; and

4. Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g., preoccupation with textures, visual fascination with lights or movement; apparent indifference to pain or temperature).

ASD and CBI. The ASD symptoms that are most relevant to the use of CBI are those related to communication, speech production, and resistance to change. In a recent review of CBI for social-emotional development of students with ASD, Ramdoss et al. (2012) noted that, of 11 studies that sought to use CBI to address ASD-related social-emotional deficits (e.g., conversational skills, solutions for social conflicts, recognition of facial expressions and emotions), only one provided conclusive evidence that CBI was effective in improving performance of students with ASD on targeted skills and behaviours. The researchers suggested that CBI for social-emotional skills should be used only in conjunction with group instruction or in conjunction with an adult tutor to promote generalization and motivation.

In contrast, Ramdoss et al. (2012) found that CBI appears to be more promising for teaching daily living skills, which were acquired by 93% of 42 participants who engaged in CBI related to this domain. However, the researchers also noted that most of the software programs used in the studies they reviewed are not available outside of the research settings. They also noted that the limited data on generalization from CBI to natural environments restricts the impact of the results that were reported. They

suggested that hardware options such as handheld computers and tablets (e.g., iPads) could be used to provide covert prompts in natural environments and foster generalization of newly-acquired skills.

In a another review focused on the use of CBI to teach communication skills, Ramdoss et al. (2011) concluded that the majority of studies provide a suggestive level of certainty that CBI interventions produce significant outcomes. Researchers across 10 studies with a total of 70 participants with ASD were successful in teaching communication-related skills such as receptive and expressive vocabulary, spontaneous utterances, and vocal imitation skills. Finally, in a review of CBI literature for teaching literacy skills, 4 out of 12 studies yielded conclusive evidence of effectiveness of the intervention (Ramdoss, et al., 2011). In this review, the authors found that participants' knowledge of computers and fine motor skills appeared to be precursors for successful outcomes of CBI. They noted that, because of the wide range of skills and the heterogeneity of the participants, it was not possible to provide a summative conclusion regarding the effectiveness of CBI for teaching literacy skills.

ASD and the iPod/iPad. iPad-based instruction shares many of the characteristics of conventional CBI yet has several distinct features. Many iPad apps are available to support communication, especially for children with ASD who are unable to speak; and many other apps are available to help with transitions, choice-making, and self-management skills. In general, these apps feature clear, interesting graphic images (e.g., photos, videos, pictures) that allow verbal instructions to be combined with visual cues. This is important because visual supports have been shown to be effective for students with ASD and can be used to support transitions (Dettmer, Simpson, Myles, &

Ganz, 2000; Waters, Lerman, & Hovanetz, 2009), reduce challenging behaviours (Jaime & Knowlton, 2007), and compensate for social and/or communication difficulties (Arthur-Kelly, Sigafoos, Green, Mathisen, & Arthur-Kelly, 2009; Ganz & Flores, 2008).

Many individuals with ASD are reluctant to attempt novel tasks that constitute a change in their environment. As such, teaching novel behaviours to this population of students is a labor-intensive process for many educators. To address the resistance to change, educators often use immediate, potent, and explicit reinforcement to foster acquisition of new skills (Cooper, Heron, & Heward, 2007). Many iPad apps provide powerful extrinsic reinforcement upon production of a correct response (e.g., sound or visual effects, a brief game, or a video). Sound and visual effects in these apps appear to be strongly motivating for many individuals with ASD; hence, iPad apps have the potential to be effective for teaching new behaviours.

In the sections that follow, I summarize current research to identify the range of skills that have been successfully taught to individuals with disabilities through iPad or iPod Touch-based instruction. I included only studies in which a specific iPad or iPod Touch app (e.g. Proloquo2Go, iTouch Math, etc.) was used to teach a specific type of skill. Conversely, I did not include studies in which an iPad or iPod Touch was employed to deliver instruction that could have been delivered via another digital platform (e.g., a stationary computer, laptop, or other tablet computer). Specifically, I did not include studies in which the iPad was simply used as delivery system for a social story/social narrative or was used as a platform for video modeling instruction to teach social/play skills (Blood, Johnson, Ridenour, Simmons & Crouch, 2011; Murdock, Ganz & Crittendon, 2013), vocational and leisure skills (Alexander, Ayres, Smith, Shepley &

Mataras, 2013; Bereznak, Ayres, Mechling & Alexander, 2012; Kagohara, 2011; Kellems & Morningstar, 2012; Laarhoven, Johnson, Laarhoven-Myers, Grider & Grider, 2009); or academic skills (Burton, Anderson, Prater & Dyches, 2013; Kagohara, Sigafoos, Achmadi, O'Reilly & Lancioni, 2012; Smith, Spooner & Wood, 2013).

Research on Use of the iPod/iPad to Teach Communication Skills to Participants with ASD or Other Developmental Disabilities

A recent review by Eigsti et al. (2011) found that about 25% of individuals with ASD do not develop functional speech. To address this issue, research on augmentative and alternative communication (AAC) was established in the early 1980s and, since then, has been extensively documented in the research literature (Beukelman & Mirenda, 2013; Ogletree & Harn, 2001). When the iPod Touch appeared in 2007, software developers began to generate a number of apps for communicative purposes (e.g., Proloquo2Go, GoTalkNow, TapToTalk, Pic a Word). Table 1.1 summarizes the studies that have been published up to 2014 to teach children with autism and other developmental disabilities to communicate using Apple® touch-screen devices.

Table 1. 1 Communication studies using the iPod Touch or iPad

Author	Participants (age/diagnosis)	Technology/app	Target behavior	Outcome
Kagohara et al. (2010)	17/ASD, OCD, ADHD	iPod Touch®/ Proloquo2Go	Requesting snacks	Successful activation of iPod Touch
van der Meer et al. (2011)	13/ASD, SID; 14/Klinefelter syndrome, SID; 23/SID, seizure disorder	iPod Touch®/ Proloquo2Go	Requesting toys and snacks	Two participants learned how to use iPod Touch; third participant made no progress after 40 training sessions
Achmadi et al. (2012)	13/ASD, 17/ASD	iPod Touch®/ Proloquo2Go	Unlocking the screen, navigating to the correct screen page, requesting a preferred item	Both participants successfully learned all steps to request preferred items
Flores et al. (2012)	Three elementary school students/ASD; one elementary school/MD; one elementary school student/ID	iPad®/Pic-a-Word	Requesting preferred items on iPad vs picture exchange (PE)	Three participants made more requests on iPad; two participants showed no preference between iPad and PE
Kagohara et al. (2012)	13/ASD, SID; 17/ASD, OCD, ADHD	iPod Touch® and iPad®/ Proloquo2Go	Exp. 1: Selecting icons that correspond to photographs Exp. 2: Same as Exp. 1 but 18 new pictures and a distractor were added on iPad screen	Exp 1: Both participants learned to label pictures and maintained at follow-up Exp. 2: Both participants showed rapid acquisition of new pictures in presence of distractor
van der Meer et al. (2012)	10/ASD; 5/multi-system developmental disorder; 7/DS, ASD; 5/congenital myotonic dystrophy	iPod Touch®/ Proloquo2Go	Requesting snack or preferred item on iPod Touch® vs. manual signs (MS)	All four participants learned to use iPod Touch; three reached criteria for MS. Three participants demonstrated preference for iPod, one participant preferred MS

Author	Participants (age/diagnosis)	Technology	Target behavior	Outcome
van der Meer et al. (2012)	12/ASD; 6/ childhood disintegrative disorder, ID; 10/Angelman syndrome; 13/PDD-NOS	iPod Touch®/ Proloquo2Go	Requesting preferred item on iPod Touch® vs. PE vs. MS	Two participants reached mastery criteria for all modalities and demonstrated preference for iPod Touch; the other two reached criteria for iPod Touch and PE, but not for MS and showed no preference
van der Meer, Sutherland, O'Reilly, Lancioni, & Sigafoos (2012)	4/ASD, global developmental delay; 4/ASD; 10/ASD, epilepsy; 11/ASD, ID	iPod Touch®/ Proloquo2Go	Requesting preferred item on iPod Touch® vs. PE vs. MS	Two participants reached mastery criteria for all modalities; one participant acquired iPod Touch and one participant acquired PE; maintenance was higher when the preferred modality was used
Ganz, Hong, & Goodwyn (2013)	Three participants: 3-4/ASD	iPad®/PECS app	Requesting preferred items on iPad® vs. Picture Exchange Communication Systems (PECS)	All participants learned how to operate iPad; two participants demonstrated clear preference of iPad; one student had preference for PECS
Sigafoos et al. (2013)	5/ASD; 4/ASD	iPad®/ Proloquo2Go	Requesting continuation of interrupted play with a preferred toy	Both participants reached mastery criteria for iPad; problem behavior also decreased
Gevarter et al. (2014)	3/ASD, 3/ASD, 3/ASD	iPad®/GoTalk, Scene and Heard	Compared the efficacy of two apps and configurations within the apps for requesting desired items	Configuration of the display as well as app design might have an influence on acquisition of single mands for preferred objects

Author	Participants (age/diagnosis)	Technology	Target behavior	Outcome
Lorah, Parnell & Speight (2014)	5/ASD, 6/ASD, 4/developmental delay and cerebellar hypoplasia	iPad®/ Proloquo2Go	Tacting (labeling) using the carrier phrases “I see” and “I have”	All three participants acquired independent tacting using carrier phrases in isolation, as well as discriminated tacting when stimuli and targeted carrier phrases were presented in random order
King et al. (2014)	4/ASD, 5/ASD, 3/developmental delay	iPad®/ Proloquo2Go	Requesting skills using an adaptation of PECS to accommodate the device	Requesting repertoire increased for all participants; vocal requests emerged as a side effect for one participant and increased for two others
Waddington et al. (2014)	7/ASD, 8/ASD and developmental delay, 10/ASD	iPad2®/ Proloquo2Go	Multi-step sequences that involved requesting and social communication functions	All three participants demonstrated improvement in performing the communication sequence, which was maintained with a unfamiliar communication partner and during follow-up sessions

ASD = Autism Spectrum Disorder; OCD = Obsessive-Compulsive Disorder; ADHD = Attention Deficit Hyperactivity Disorder; SID = Severe Intellectual Disability; MD = Multiple Disabilities; ID = Intellectual Disability; PDD-NOS = Pervasive Developmental Disorder Not Otherwise Specified

Eight out of 14 studies used the iPad, and the other six used the iPod Touch. In 11 out of 14 studies, the researchers used the Proloquo2Go app (http://www.assistiveware.com/product/proloquo2go). In 12 out of 14 studies, researchers attempted to teach participants to request a preferred toy or a snack item (preference assessment usually occurred prior to baseline). In one of the remaining two studies, researchers taught two participants to label photographs using Proloquo2Go; and in the other study they taught participants to use carrier phrases for labeling items. Four studies compared AAC systems that included the iPod Touch/iPad, manual signs (MS), picture-exchange (PE), or the Picture Exchange Communication System (PECS). All studies demonstrated consistent results in terms of acquisition: most participants reached mastery criteria for all AAC systems that were taught, with the exception of manual signing. Participants did not demonstrate consistent preference of one communication system over another. Overall, the research on communication provides evidence that the iPad- or the iPod Touch-based communication systems can be successfully implemented by individuals with little or no functional speech and ASD. The research, however, does not provide evidence that either the iPad or the iPod Touch is superior over other types of communication systems.

Research on Use of the iPod/iPad to Teach Academic Skills to Students with Special Needs

Individuals with special learning needs, including those with ASD, often exhibit delays in acquiring many cognitive and academic skills. In addition, the learning process varies substantially for students with ASD compared to typically developing students. Due to the characteristics specific to individuals with ASD -- such as resistance to

change, limited interests, preoccupation with objects and topics, and limited functional speech -- teaching academic skills often requires systematic, focused efforts from educators. In addition, students with ASD may engage in problem behaviours to escape or avoid challenging academic tasks. Another concern is the diversity of skills that need to be taught, including those related to language arts, math, and science. In 2010, Pennington reviewed the literature on CBI for teaching academic skills, and concluded that most studies in the review lacked experimental control and were limited to literacy skills only; as such, the conclusions were tenuous. In contrast, the majority of iPad apps for academic instruction deliver instructions with built-in prompts, allow educators to adapt materials to fit the needs of individual students, and provide immediate feedback. The diversity of these apps enables a teacher to choose the most appropriate app for specific students' preferences and needs. Despite these advantages, only 10 studies in which researchers have investigated use of iPad apps to teach academic skills to students with ASD and other special needs have been published to date. These studies are summarized in Table 1.2.

Table 1. 2 Academic studies using the iPod Touch or iPad

Author	Participants (age/diagnosis)	Technology/Apps	Target behavior	Outcome
Haydon, Hawkins, Denune, Kimener, & McCoy (2012)	17/bipolar disorder, PDD-NOS, anxiety disorder; 17/conduct disorder, mood disorder, reactive attachment disorder; 18/ADHD	iPad®/iTouch MATH Grade 5-LITE, V. 2.1, Coin Math, v. 3.0, and enVisionMATH: Understanding Fractions v. 1.1.	Number of correct responses per minute and active engagement on the iPad vs. worksheets	All three students had increases in number of problems completed correctly per minute and levels of engagement under the iPad condition
Miller, Krockover, & Doughty (2013)	18/MID; 18/MID, language impairment; 17/MID, orthopedic impairment; 18/MID, language impairment	iPad®/ Keynote, Inspire Pro, Dictamus	Adapted traditional science notebooks vs. adapted electronic science notebooks for science inquiry	All students had longer engagement time on the iPad; all students showed preference towards the iPad notebooks
Neely, Rispoli, Camargo, Davis, & Boles (2013)	7/Asperger's Disorder; 3/PDD-NOS	iPad®/WritePad, Little Matchups	Levels of problem behaviour and academic engagement on the iPad vs. traditional materials	All students had an increase in academic engagement and decrease in problem behaviour in the iPad condition
Smith, Spooner, & Wood (2013)	12/ASD, ID; 11/ASD, ADHD; 12/ASD	iPad 2®/Keynote	Acquisition of scientific terms with built-in prompts in a slideshow on the iPad	All students met mastery criteria for scientific terms; all students generalized new terms to activity sheets

Author	Participants (age/diagnosis)	Technology/Apps	Target behavior	Outcome
Arthanat, Curtin, & Knotak (2013)	12/ASD, 12/ASD, 13/ASD, 11/ID	iPad ®/Abby Train color, ABC-Letters, Numbers, Shapes and Colors; Kids can spell, Puzzle math; Play words, Jungle Coins	Participation in learning process on the iPad vs computer during academic tasks	Three out of four subjects did not demonstrate preference for the iPad or computer; one subject appeared to have notably higher participation with the iPad
Bouck, Savage, Meyer, Taber-Doughty, & Hunley (2014)	13/ASD, 15/ASD, 15/ASD	iPad2®/Upad lite	iPad-based self-monitoring vs paper/pencil self-monitoring during a food preparation task	All students showed an increase in independent task performance in both conditions, with slight superiority for the iPad. They also completed the task in less time in the iPad condition
Doenyas, Simdi, Ozcan, Cataltepe, & Birkan (2014)	15/ASD, 11/ASD, 4/ASD	iPad®/app developed by the researchers	Putting stories in order (sequencing)	All participants demonstrated improvement from baseline to the final testing sessions
Larabee, Burns, & McComas (2014)	Three 6/ELL students	iPad®/Build A Word – Easy Spelling with Phonics	Standard materials vs iPad for decoding and task engagement	Effect of the iPad app on student decoding performance was mixed and task engagement was high for both conditions

Author	Participants (age/diagnosis)	Technology/Apps	Target behavior	Outcome
Spooner, Ahlgrim-Delzell, Kemp-Inman, & Wood (2014)	12/ASD, 8/ASD, 11/ASD, 8/ASD	iPad2®/GoTalk Now, Building With Stories	Shared story task; answering listening comprehension questions	All students showed an increase in the number of steps performed independently; progress in listening comprehension was slower, with only two students demonstrated a modest change between baseline and intervention
Chai, Vail, & Ayres (2015)	5/SDD, 6/SDD, 8/SDD and reading disabilities	iPad®/Touch Sound	Touching the picture that had the same initial phoneme as a target picture	All students demonstrated an increase in level and an accelerating trend after introduction of intervention
van der Meer et al. (2015)	10/ASD	iPad®/ Proloquo2Go	Picture and word matching	Student demonstrated increased correct matching across all four combinations (picture to picture, word to word, word to picture, and picture to word)

Key: ASD = Autism Spectrum Disorder; ID = Intellectual Disability; ADHD = Attention Deficit Hyperactivity Disorder; MID = Moderate intellectual disability; PDD-NOS = Pervasive Developmental Disorder Not Otherwise Specified; ELL = English Language Learners; SDD = Significant Developmental Delay

Participants in four of the 10 studies had diagnoses of multiple disabilities, emotional disturbance or were at risk for reading failure; one of these students also had ASD. Participants in the other six studies were all diagnosed with ASD. In five of the 10 studies, researchers compared traditional materials (TM) to iPad apps; and in one study, researchers compared iPad-based instruction to computer-based instruction. In the remaining studies, researchers sought to determine whether students could successfully learn novel academic skills with the help of iPad/iPod Touch technology. In two studies, participants learned science concepts; in two studies, students worked on math skills; in two studies, participants were engaged in matching and writing activities; in three studies, participants worked on reading readiness skills; in one study, the participants practiced sequencing skills, and in the remaining study, the participants learned to use a self-monitoring checklist during food preparation. In the majority of the studies that compared TM and iPad apps, results suggested that the participants preferred the iPad and were also more engaged (i.e., spent longer amounts of time on task), produced more output, and exhibited lower levels of problem behaviour with the iPad. However, in one study, there was no significant difference in participants' performance between the two conditions. Similarly, in one study where the iPad was compared to the computer, participants did not show a clear preference toward one mode over the other.

Shortcomings of Previous iPad Research Focused on Academics

Despite the apparently positive outcomes for the use of an iPad to teach academic skills, only five (50%) of the studies conducted to date compared the iPad to traditional paper and pencil or other materials (e.g., books, flashcards). One of these studies (Larabee et al., 2014) showed mixed results regarding the best treatment. In addition, of the five studies that

compared the iPad to traditional materials, three had serious methodological limitations. The report by Miller et al. (2013) was a series of descriptive case studies that did not provide any quantitative data to support the findings. Neely et al. (2013) used a reversal (ABAB) design in which the iPad was introduced and then removed to demonstrate experimental control. The problem with this design lies in the potential learning that may have occurred during the reversal (i.e., carry-over effect) because the same academic task was presented in both the A and B conditions. Finally, Haydon et al. (2012) claimed to use an alternating treatment design (ATD) but they also noted that "The difficulty level of the tasks was the same across conditions" (p. 236). This suggests that they used two different sets of tasks (one for iPad and one for the worksheet condition), which is a hallmark of the adapted alternating treatments design (Sindelar et al., 1985), not the ATD. Furthermore, the design was contaminated by an order effect, because they presented different types of math problems without counterbalancing across conditions or sessions (first coins, then fractions, then patterns, then operations). Because of these limitations, it is not possible determine whether the iPad worked better than, as well as, or worse than other options.

Statement of the Problem and Research Questions

Existing research on the use of iPads and related apps suggests that this combination may be effective for teaching both communication and academic skills to individuals with ASD and other special needs. However, only 10 studies to date have examined this issue with regard to academic skills; and only five of these studies compared TM to iPad apps. Three of the five studies had serious methodological problems, and one (Larabee et al., 2014) showed mixed results regarding the best treatment. Furthermore, no studies have examined this issue as it applies to young children with ASD who are learning basic skills related to academic

and cognitive development. Clearly, there is a need for research that compares the use of iPad and TM to teach basic academic skills to children with ASD, toward the goal of determining whether iPad-based instruction is superior than TM-based instruction and (if it is) which behaviours appear to benefit from instruction in this modality. Toward this end, the research questions are as follows:

1. Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **number of sessions required to meet mastery criterion (**≥90% correct over 3 consecutive sessions) for young children with ASD who are learning basic academic skills?

   Hypothesis: There will be a functional relation, such that fewer sessions will be required to meet mastery criterion in the iPad condition.

2. Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **level of task engagement** for young children with ASD who are learning basic academic skills?

   Hypothesis: There will be a functional relation, such that the level of engagement will be higher during the iPad condition.

3. Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **frequency of problem behaviour** for young children with ASD who are learning basic academic skills?

   Hypothesis: There will be a functional relation, such that the frequency of problem behaviour will be lower during the iPad condition.

4. Will skills acquired via either TM or iPad show evidence of generalization, either to untrained skills or to new materials?

Hypothesis: Skills will generalize to both untrained skills and new materials in both conditions, albeit with some deterioration in percent correct.

5. Will skills acquired via either TM or iPad be maintained at 3-week follow-up?

Hypothesis: Skills will be maintained in both conditions, albeit with some deterioration in percent correct.

CHAPTER 2: METHOD

Participant Recruitment

To recruit participants for this study, I contacted a number of professionals who provide services to families with children with ASD. They distributed a recruitment notice that provided information about the purpose of the study and the participant inclusion criteria (Appendix A). When interested families contacted me, I provided additional information about the study, verified that the child met the study criteria, and visited the family and the child at home to obtain consent for the study (Appendix B). During the visit, I also engaged the child in a few motivating activities that required brief physical prompting from me (e.g., an unfamiliar puzzle), and conducted a brief imitation assessment (see Appendix C).

Participants

Two children with ASD participated in this study. Participants met the following inclusion criteria:

1. A diagnosis of ASD from a multidisciplinary team;
2. Age 3-7;
3. Ability to follow three consecutive requests to come to a table and work, and ability to work on a tabletop task for at least 5 minutes at a time;
4. Ability to tolerate physical prompting and/or ability to imitate simple motor gestures;
5. No instructional iPad experience (previous use of an iPad for recreation/ reinforcement purposes was acceptable); and
6. No history of self-injurious behaviour, severe aggression, or property destruction.

The two participants are described in detail in the sections that follow. All names are pseudonyms.

Lucas

Lucas is the second child in a Middle Eastern family and was 5 years 5 months old when the study began. He was diagnosed with ASD at age 3 years 7 months by a multidisciplinary team. Lucas was born with a heart defect and had to undergo surgery as an infant; this condition was not a concern during the study. Lucas had participated in structured, 1:1 therapy based on the principles of applied behaviour analysis (ABA) for 21 months prior to the study. At the time of the study, he was receiving 10 hours/week of instruction at home and also had a 1:1 support worker at school, where he attended full-time kindergarten.

Lucas had no previous learning experience with an iPad; however, he did have access to an iPad for reinforcement and recreation purposes, as well as for visual scheduling. He was able to tolerate physical prompting and scored 100% on the basic imitation skills assessment during the initial meeting. At the time of the study, Lucas had good language and communication skills. He spoke predominantly in full sentences and was able to answer the majority of wh- questions. He was able to comprehend clear and concise sentences, follow directions, and describe basic events in the past. He did not have a history of significant problem behaviour, nor did he show evidence of such behaviour during the study sessions.

Jonah

Jonah is the second child in a family of Canadian and South African background and was 4 years 6 months old when the study began. He was diagnosed with ASD at age 2 years 4 months by a multidisciplinary team and had participated in ABA therapy at home for 25 to

30 hours/week for the previous 25 months. He also attended preschool twice weekly with 1:1 support from a behaviour interventionist.

Like Lucas, Jonah had no previous learning experience on the iPad but did use one for recreation and reinforcement purposes. He was able to tolerate physical prompting and scored 100% on the basic imitation skills assessment. At the time of the study, Jonah was able to use speech as his primary communication mode; however, his mother reported that speech had emerged only 6 months prior to the beginning of the study. Jonah spoke in 2-3 word phrases and sentences and was able to express his wants and needs clearly, although his speech was predominantly scripted and memorized. Jonah had a history of occasional aggression toward people or objects when frustrated; however, this was not evidenced during the study sessions.

Setting and Materials

The study took place in participants' homes. Materials included an iPad that belonged to the researcher, iPad apps that were appropriate to the tasks selected for instruction, and traditional instructional materials (e.g., pictures, paper-and-pencil tasks) that were developed for the target tasks. Neither the iPad, the apps, nor the traditional materials used in the study were available to the participants outside of study sessions.

To prepare materials for both the iPad and TM conditions, the researcher first identified appropriate target skills for each participant, in collaboration with participants' parents and lead interventionists. For both boys, the ability to complete simple addition problems (e.g., 3+2 = 5) was identified as one of the target skills. The second skill was the ability to sort words by word family (e.g., sorting -an words such as van, tan, and man vs. -ap

words such as tap, map, and nap). The researcher then chose iPad apps that were designed for 4-6 year old children and to teach each of the target skills. For each target skill, the researcher also created traditional (e.g., paper-and-pencil) materials that were identical to the iPad apps in terms of task difficulty, the number of responses required to earn reinforcement, task length and appearance. Three teachers who were not involved in the study but had at least 3-4 years of experience working with students with ASD examined each of the iPad and TM material sets and provided feedback about their equivalence. All three teachers deemed the sets to be equivalent with regard to visual complexity, the motor skills required, the cognitive skills required, and the difficulty level of the tasks themselves.

Addition

Detailed descriptions of the iPad and TM materials for addition are provided in the sections that follow. Generalization was not examined for this target skill set.

iPad. The first task for both children was addition up to 10 with the help of pictures. The iPad app for this task (Addition is Fun, https://itunes.apple.com/ca/app/addition-is-fun/id604844687?mt=8) consists of 10 problems that are presented in the same order every time. Table 2.1 displays the addition questions for the iPad condition and TM.

Table 2. 1 Addition problems for the iPad and TM conditions

iPad problems	Traditional material (TM) problems
1 + 1 = 2	2 + 1 = 3
3 + 2 = 5	2 + 3 = 5
4 + 3 = 7	3 + 4 = 7
3 + 3 = 6	2 + 2 = 4
3 + 1 = 4	1 + 3 = 4
6 + 2 = 8	2 + 6 = 8
3 + 5 = 8	5 + 3 = 8
2 + 4 = 6	4 + 2 = 6
2 + 4 = 6	4 + 2 = 6
4 + 5 = 9	5 + 4 = 9

On the iPad app, the problems were presented in picture form on a colorful background. The child was required to drag numbers corresponding to each set of pictures, count the total number of pictures, and insert the number sum. After a correct response, a picture of the sum appeared, paired with verbal praise from the app: “Well done!” and a star. After an incorrect response, the numbers were cleared from the screen and corrective feedback was provided: “Try again.” Figure 2.1 displays screen shots of an addition problem from the app, before and after completion.

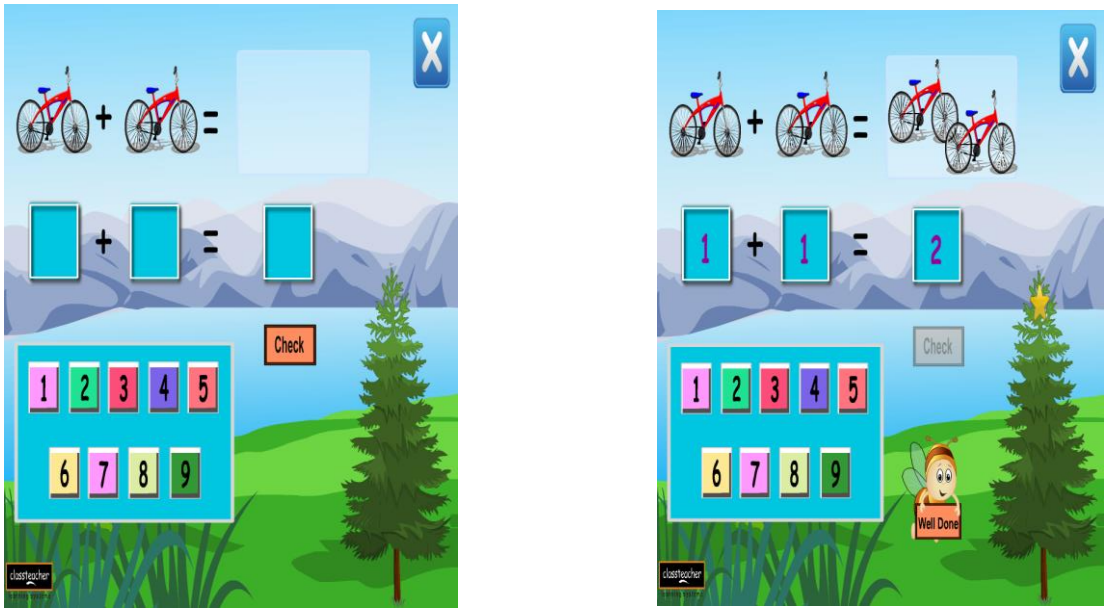

Figure 2. 1 Screen shots from *Addition is Fun* app, before and after problem completion

Traditional materials. The equivalent TM set for addition consisted of 10 paper pages with one question per page. The background of the sheets and the pictures used in the problems (e.g., bicycles, flowers, etc.) were similar to those in the app. The pages were presented to the participant one at a time, always in the same order to ensure equivalence of the problems in terms of both difficulty and response effort compared to the app. The TM problems were identical to the iPad problems, but reversed (e.g., 3 + 2 in the app, and 2 + 3 in TM). As in the iPad, pictures were used to represent the numbers in each problem. However, different pictures were used in the TM set, to reduce the likelihood of a carry-over effect (e.g., if 3 + 2 on the iPad was represented by flowers, 2 + 3 in the TM set was represented by bicycles). The child was required to place the number cards in empty boxes below each picture set, count the total number of pictures, and place the number sum in a box. After a correct response, the researcher provided the picture of the correct number of

objects, paired with verbal praise: “Well done” or equivalent, and a star. After an incorrect response, the numbers were cleared and researcher provided corrective feedback: “Try again.” Figure 2.2 displays screen shots of a TM addition problem before and after completion.

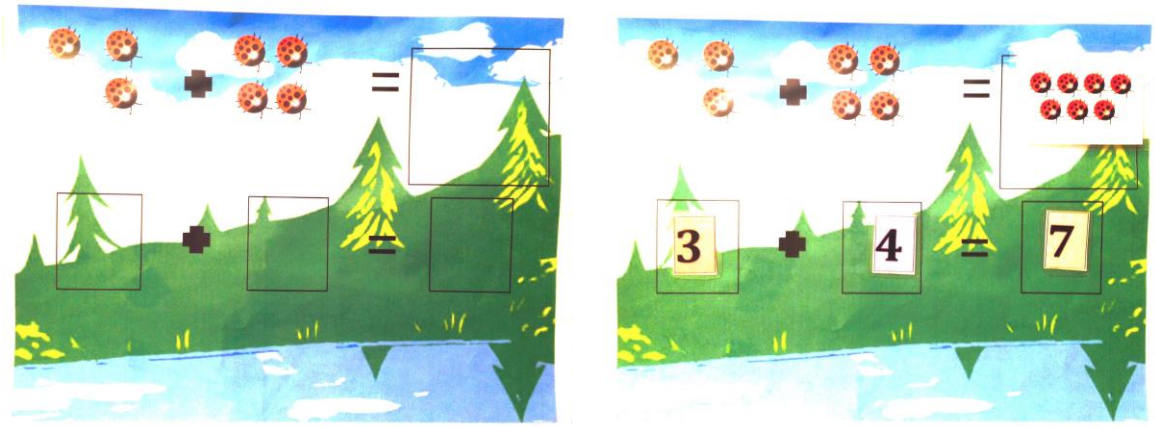

Figure 2. 2 Examples of TM addition problem, before and after problem completion

Word Families

The second task that was chosen for both children was sorting words according to their word families. Detailed descriptions of the iPad, TM, and generalization materials for word families are provided in the sections that follow. Two types of generalization probes were conducted for word families, to examine generalization to untrained target words and to new sets of materials (iPad and TM).

iPad. The iPad app for this task (Phonics Rhyming Bee, https://itunes.apple.com/ca/app/phonics-rhyming-bee-free-short/id492740258?mt=8) consisted of several word families (e.g., -am, -ig), from which two were selected for both participants: -ag and -am. On the app, two flowerpots with one flower in each pot were visible on the screen. A picture of a “seed word” was presented on each pot and the seed

word was also spoken out loud by the app. In learning mode, a bee "flew in" with a word that the participant was to drag onto the correct flower, according to the word family/seed word. For example, if the bee flew in with the word *tag* the participant was to drag the word onto the flower with the seed word, *flag.* Table 2.2 displays the word families, seed words, and target words for all phases of the study.

Table 2. 2 Word families for the iPad and TM conditions

Phase	iPad word family/seed word: target words			TM word family/seed word: target words		
Baseline	All word families and target words below			All word families and target words below		
Intervention	-am/ham: Sam, clam, jam, ram, yam	-ag/flag: wag, drag, bag, rag, tag		-ip/lip: hip, rip, dip, tip, sip	-ig/pig: big, wig, dig, fig, jig	
Generalization 1	-ad/pad: mad, bad, dad, sad, had	-an/can: ran, van, man, pan, fan		-in/chin: bin, fin, pin, win, tin	-it/mitt: sit, fit, lit, kit, pit	
Generalization 2	-id: bid, lid, did, kid, hid, rid	-ig: big, pig, dig, wig, fig, rig	-ip: hip, dip, zip, lip, nip, tip	-ap: cap, lap, nap, tap, rap, yap	-at: cat, bat, fat, hat, sat, rat	-an: tan, man, pan, can, fan, ran
Follow-up	All word families and target words above			All word families and target words above		

For each probe trial, the instructor first activated the app to speak each of the two seed words (*flag* and *ham)*. Then, after the bee flew in with a target word, she instructed the participant "(target word) sounds like?" If the participant placed the target word on the flower with the correct seed word, the word appeared on one of the flower petals, and the app spoke both words in the pair. In addition, the app produced a happy sound and visual effect, and the instructor delivered verbal praise. If the student placed the target word on the incorrect flower, the bee continued to hold the word and the app made an "uh-oh" sound and spoke both words. The researcher then provided feedback took a turn to complete the sorting task correctly, out of participant's view. The game ended when the participant correctly sorted five words in each family. At that point, the app labeled all of the words on each flower and delivered visual and sound effects and praise. Figure 2.3 displays screen shots of a problem before a trial, after completion of one trial, and after completion of the entire task.

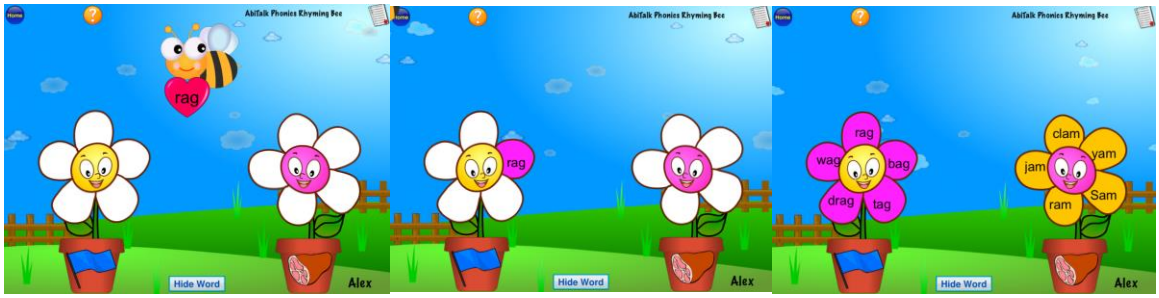

Figure 2. 3 Screen shots from the *Rhyming Bee* app, before and after completion of one target word, and after completion of the entire game

Traditional materials. The equivalent TM set for word families consisted of words ending in –ig and –ip (see Table 2.2 for seed and target words). The main page featured a laminated screen shot of the app as the background, with velcro on each of two flowerpots to attach pictures of the seed words (*pig* and *lip)*. There was also velcro on the bee to attach the

target words, and velcro on the petals to place them once sorted. For each probe trial, the instructor spoke the seed words out loud in the same fashion as with the app. The participant was then expected to put the target word on a flower petal according to the word family. If the participant sorted the word correctly, the instructor spoke both words in the correct word pair, provided verbal praise, and moved on to the next word. If the participant sorted the word incorrectly, the instructor read the pair of words out loud and provided feedback similarly to the Rhyming Bee app. Figure 2.4 displays screen shots of a TM problem before a trial, after completion of one trial, and after completion of the entire task.

Figure 2. 4 Example of TM materials, before and after completion of one target word, and after completion of all words

Generalization. There were two types of generalization probes for this skill set. Generalization 1 probes were conducted using the same app (Rhyming Bee) and corresponding TMs with two new (i.e., untaught) word families (-ad and –an for iPad and –it and –ip for TM; see Table 2.2 for seed and target words). Generalization 2 was conducted using a different app (ABC Phonics Rhyming Words Lite, https://itunes.apple.com/ca/app/abc-phonics-rhyming-words/id437201718?mt=8) with three possible words families: -id, -ig, and –ip for the iPad and –ap, -at, and –an for TM (see Table 2.2). In the ABC Phonics app, for each question, four fruits with words of two word families

(out of three) were presented. The fruits were floating and could be moved. The researcher chose one fruit by touching it, and the participant was required to touch the fruit from the same word family. If the two matched, they disappeared. Screen shots of the app before and after completion of one trial are present in Figure 2.5.

Figure 2. 5 Screen shots from *ABC Phonics app* for Generalization 2, before and after problem completion of one pair of target words

The equivalent set for TM consisted of the light purple laminated background and laminated fruits with words from the target word families on them. For each trial, four fruits from two word families were presented. The researcher then chose one word and placed it on the bottom of the page. The participant was required to choose the fruit with the word from the same word family and place it next to the word chosen by the researcher. Examples of the materials before and after completion of one trial are present in Figure 2.6.

Figure 2. 6 Example of TM materials, before and after completion of one target word

Measurement

Dependent Variables

All sessions were recorded using a Sony, DCR-SX22 video camera mounted on a tripod, and were coded in a research lab at the university following each observation. The video camera was set up in an unobtrusive location in each participant's home to minimize reactivity. The primary dependent variables included (a) number of sessions required to meet mastery criterion, (b) task engagement, and (c) problem behaviour. The secondary dependent variable was generalization across stimuli within a condition.

Number of sessions required to meet mastery criterion. The mastery criterion was set at ≥90% correct, without prompts, over three consecutive sessions. Once the mastery criterion was met for one condition per task, the teaching phase was terminated.

Task engagement. In general, task engagement was defined as a participant (a) responding within 3-5 seconds to a verbal task direction after it was issued once (e.g., "Do the math problems"); (b) visually attending to the task materials without prompting (e.g., by looking at the materials); and (c) physically and independently engaging in the task (e.g., by

manipulating the iPad app or TM appropriately, without prompting). Task engagement was measured using a 10-second whole interval recording procedure (Cooper et al., 2007). If a participant exhibited behaviour defined as engagement for the entire 10-second interval, it was scored as "+." If a participant exhibited any behavior of disengagement at any point during the interval, it was scored as "-." Specifically, non-engagement was coded for Lucas if he exhibited one of the following: (a) stereotypic finger flicking; (b) looking away from the iPad for more than 3 seconds; (c) asking to play a different game; (d) looking at the materials with his eyes closed (a stereotypic mannerism); (e) flopping his body against the researcher; and/or (f) requiring a verbal prompt to continue the task or attend to the materials (e.g., "Keep going," "Look"). Non-engagement was coded for Jonah if he exhibited one of the following: (a) failing to respond within 3-5 seconds to a verbal task direction after it was issued once; (b) playing with the task materials (e.g., sniffing numbers); (c) standing up from the chair; (d) grabbing materials at inappropriate times (e.g., when the researcher was setting them up, when she was delivering an instruction); and/or (e) requiring a verbal prompt to continue the task or attend to the materials (e.g., "Keep going," "Look"). The percentage of engaged intervals per session were calculated and graphed for each session.

Problem behaviour. Potential problem behaviours were identified and defined individually for each participant, by parents' reports of the children's past behavioural history. For Lucas, problem behaviours consisted of (a) verbal refusal to perform a task (e.g., "I don't want to do math") and (b) requests to terminate a task (e.g., "I want to be done"). For Jonah, hitting was identified as potential problem behaviour based on his past history, and was defined as forceful contact with either furniture or an adult using his fist or open hand.

Problem behaviour was measured using a 10-second partial interval recording procedure (Cooper et al., 2007). If a participant engaged in problem behaviour at any time during a 10-second interval, it was scored as "+." If a participant exhibited no problem behaviour at any time during an interval, it was scored as "-." The percentage of intervals with problem behaviour was calculated and graphed for each session.

Treatment Fidelity

To measure treatment fidelity, the researcher created a checklist of the instructional steps used during both baseline, intervention (probes and teaching) and generalization (if applicable) for all iPad and TM tasks (Appendix D). All sessions were videotaped and the researcher scored her own performance for every session, according to the checklists. Table 2.3 shows the results for treatment fidelity. Scores for treatment fidelity were acceptable (i.e. > 80%) for both participants across all phases of the study.

Table 2. 3 Summary of treatment fidelity scores

	Mean % (range)		Mean % (range)	
Condition	Lucas Addition	Lucas Word Families	Jonah Addition	Jonah Word Families
iPad Baseline	97	91	100	100
TM Baseline	100	96	95.8	94
iPad Treatment	100	100	96.5 (93-100)	100
TM Treatment	100	100	100	100
iPad Generalization 1	N/A	100	N/A	100
TM Generalization 1	N/A	100	N/A	100

	Mean % (range)		Mean % (range)	
Condition	Lucas Addition	Lucas Word Families	Jonah Addition	Jonah Word Families
iPad Generalization 2	N/A	100	N/A	100
TM Generalization 2	N/A	100	N/A	100

NOTE: Ranges are not reported for baseline or generalization because there was only one session of each.

Inter-Observer Agreement (IOA)

Inter-observer agreement was measured for all of the dependent variables and for treatment fidelity.

Dependent variables. A research assistant (RA) who was naïve to the purpose of the study was trained to code the video recordings of both baseline, intervention and generalization (if applicable) sessions. The researcher developed a training manual that included operational definitions of all target behaviours, along with examples and non-examples. After the RA read the manual, he coded instructional sessions not included in the study until 90% agreement with researcher codings was achieved across three consecutive sessions. IOA checks were then completed on 33% of both baseline and intervention sessions drawn at random, for each of the instructional conditions. IOA was calculated separately for both conditions, using the following formula: A/(A+D) x 100%, where A is the total number of agreements and D is the total number of disagreements.

IOA for the number of sessions to criterion across all conditions, phases, and tasks (addition and word families) was 100%. IOA for problem behaviour was also 100%. For task

engagement, an agreement was defined as both observers recording the occurrence of task engagement or non-engagement during the same 10-second interval. Mean IOA scores for engagement are summarized in Table 2.4. IOA scores for engagement were acceptable (i.e. > 80%) for both participants across all phases of the study.

Table 2. 4 Summary of IOA scores for engagement

	Mean %		Mean %	
Condition	Lucas Addition	Lucas Word Families	Jonah Addition	Jonah Word Families
iPad Baseline	100%	100%	94.5%	96%
TM Baseline	100%	100%	95%	93.5%
iPad Treatment	97%	98.5%	90%	94%
TM Treatment	98.5%	96%	95%	92%
iPad Generalization 1	N/A	97%	N/A	98%
TM Generalization 1	N/A	100%	N/A	97.5%
iPad Generalization 2	N/A	96.5%	N/A	92%
TM Generalization 2	N/A	100%	N/A	96%
iPad Follow-up	98%	95%	96.5%	97.5%
TM Follow-up	100%	100%	96%	96%

Treatment fidelity. In order to calculate IOA data for treatment fidelity, the RA was trained to code the researcher's behaviours during baseline and intervention, using the checklists described previously (see Treatment Fidelity section). IOA was calculated in a manner identical to that used for the dependent variables. The results for observers'

agreement for treatment fidelity are presented in Table 2.5. IOA scores for treatment fidelity were acceptable (i.e. > 80%) across all phases of the study.

Table 2. 5 Summary of IOA scores for treatment fidelity

	Mean % (Range)		Mean % (Range)	
Condition	Lucas Addition	Lucas Word Families	Jonah Addition	Jonah Word Families
iPad Baseline	98.5	95.5	97	98
TM Baseline	98.5	98	97.9	97
iPad Treatment	100	100	98.25 (96.5-100)	100
TM Treatment	100	100	100	100
iPad Generalization 1	100	100	100	100
TM Generalization 1	100	100	100	100
iPad Generalization 2	N/A	100	N/A	100
TM Generalization 2	N/A	100	N/A	100

Research Design

An adapted alternating treatment design (AATD; Sindelar, Rosenberg, & Wilson, 1985) was used to compare participants' performance on academic tasks in the iPad and TM conditions. The AATD was chosen because it allows direct comparison of two different conditions that have the same learning objectives. According to Gast and Ledford (2009), to employ AATD, target behaviours should be (a) nonreversible, (b) not in the participants' repertoire, (c) independent from one another, (d) functionally equivalent, (e) of equal difficulty. This study meets all five criteria for an AATD design.

A single baseline probe was conducted for tasks in each condition. A single session was chosen in order to prevent learning by exposure alone; this approach is appropriate in an AATD design (Sindelar et al., 1985). Following the baseline probe, the experiment continued with an intervention phase with two conditions: an academic task performed with traditional materials (e.g., paper and pencil) and a similar academic task performed with an appropriate iPad app. Similar to the research design implemented by Haydon et al. (2012), the tasks for both sets of materials were matched on all domains (e.g., content, difficulty, response modes). The presentation order of the conditions was assigned at random and counterbalanced across sessions.

Procedures

Preliminary Assessments

Preference assessment. After consent forms were signed, the researcher interviewed the parents of each participant to identify 5-10 high preference items (toys, foods, drinks, activities, etc.) that might be used as potential reinforcers. For Jonah the following items were identified: dancing, music on the iPad, colouring, trampoline, letters, numbers, colours, and games on the iPad. Lucas's parent identified the following preferred activities/objects: social praise, tickles, physical play, wind-up toys, toys with movements (e.g., spinning toys), and iPad games.

The researcher then conducted a stimulus preference assessment with tangible items from the list for each participant, using the multiple stimulus without replacement (MWSO) procedure (DeLeon & Iwata, 1996). The MWSO procedure was conducted prior to initiating baseline for both the first and the second task. During the MWSO procedure, the items were

presented in an array and the participant was asked to select the one he wanted. For Jonah, the array consisted of music on the iPad, foam letters, a number puzzle, coloured markers, and a clear plastic bag with small toys inside (e.g., cars, wind-up toys, etc.). For Lucas, the array consisted of two wind-up toys, a toy top, a beyblade spinning toy, four pull-back toy vehicles that move, bubbles, and games on the iPad. After a participant chose an item, he got to interact with it for a brief time interval (30-60 seconds) and then returned it to the researcher. The researcher put away the selected item selected and presented the array again without that item; thus, the array decreased by one item each time it was presented. Based on the results, the items were ordered according to each participant's preference. The hierarchy for Lucas was the following (from the highest preference to the lowest): games on the iPad, beyblade, pull-back toy vehicles, wind-up toys, and bubbles. For Jonah, the hierarchy was as follows: markers, toys bag, letters, numbers, and music on the iPad.

Identification of target skills. Following completion of the MWSO procedure, the researcher interviewed the service providers who worked with each participant, to identify three to five cognitive or academic skills that were developmentally appropriate and that were not in the participant's current repertoire. She then conducted one brief (10-20 min) probe session per condition (iPad and traditional materials), to determine whether or not the participant was able to complete tasks related to the identified skills. During these sessions, the relevant materials were presented to the participant, followed by a verbal direction to complete the task (e.g., "Add___", "What is the opposite of ____?"). A task was discontinued immediately upon the occurrence of problem behaviour. To meet criteria for inclusion in the study, one of the following conditions was required:

1. Participant failed to initiate the task in **both** conditions;

2. Participant used the task materials inappropriately in **both** conditions;
3. Participant performed no more than 30% of the task correctly in **both** conditions.

For Jonah, the following tasks were identified as potential target skills: sequencing (i.e., putting a series of pictures in order to make a story), addition (with pictures up to 10), opposites (with pictures), what goes together? (sorting pictures by category), and word families (sorting rhyming words). After completion of probes for each of the tasks, only addition and word families met the inclusion criteria; Jonah completed the other tasks with 50% accuracy or better in both iPad and TM conditions. For Lucas, tasks that were identified as relevant included completing 8-15 piece jigsaw puzzles, sequencing, addition, opposites, what goes together?, and word families. Lucas was able to complete all tasks except for addition and word families with 50% or better accuracy in both iPad and TM conditions.

Probe of word family reading ability. After the target skills were chosen, the researcher probed the participants' ability to read the seed and target words for the word families task, in both the TM and iPad conditions. One cue card was created for each word in Table 2.2 and the participants were asked to read the words on the cue cards. Both participants scored 100% on this assessment.

Baseline

The probe sessions that were used to identify tasks served as single baseline data points in the study for intervention, Generalization 1, and Generalization 2 tasks. During these sessions, the relevant materials were presented to the participant, followed by a verbal direction to complete the task (e.g., "Add the object name)." No prompts or contingent reinforcement was provided. If the participant performed the task correctly, the researcher

said “Nice try. My turn” in a neutral tone of voice and took the iPad/TM away to switch to the next question. The same protocol was followed if the participant performed the task incorrectly. The sound on the iPad was switched off for the entire probe session time in order to prevent unintentional auditory feedback.

Intervention

During the intervention phase, participants were engaged in 30-60 minute one-to-one sessions with the researcher. The sessions employed discrete trial teaching (DTT), most-to-least prompting, and two types of reinforcement: verbal praise following each completed trial of a task (e.g., each math question, each word sorted correctly) and tangible reinforcement with a preferred item following task completion (e.g., upon completion of 10 math questions; upon sorting 10 words into their word families). The following general instructional procedures were implemented during both probe and teaching trials for both iPad and TM tasks:

1. The participant entered the room and was invited to sit at the table.
2. The researcher provided the participant with a choice of all items that were identified during the MSWO assessment. The same items were used in both conditions during a session, to insure that the motivating operations in effect were identical for both sets of materials.
3. After a preferred item was identified, the researcher conducted probe trials for each task, as described in the sections that follow.

Probe trials for addition. Probe trials for addition are described in chronological order below.

1. The researcher presented the task and verbally directed the participant to complete it: "Let's add (objects). What numbers go here?"
2. If the participant responded correctly:
    a. iPad condition: The researcher praised the participant as follows: "Well done (or similar)! My turn," pushed the "check" button on the app, and waited until the next question was presented.
    b. TM: The researcher praised the participant as follows: "Well done (or similar)! My turn," took away the materials, and presented the next page.
3. If the response was incorrect or there was no response within 3-5 seconds,
    a. iPad condition: The researcher provided feedback as follows: "Not quite (or similar). We will try it again; my turn," completed the question out of view of the participant, and returned the iPad to the participant with the next question on the screen.
    b. TM: The researcher provided feedback as follows: "Not quite (or similar). We will try it again; my turn," and presented the next question.
4. Steps 2-3 were repeated as often as necessary until the task was completed.
5. The researcher provided the preferred item selected in Step 2 of the general procedures and allowed the participant to interact with it for 1-2 minutes.

Teaching trials for addition. After probe trials in both conditions were complete, teaching trials for addition commenced. The researcher conducted teaching trials only for those questions/items that the participant answered incorrectly or for which he produced no response during probe trials. In general, instruction was provided as follows for both the iPad and TM conditions:

1. The researcher issued the verbal instruction: “Let’s add (objects). What numbers go here?” and pointed to the empty boxes.
2. The researcher provided verbal prompts and physical or gestural prompts (as necessary) to assist the participant to complete the task successfully.
3. Once the task was completed, the participant was provided with feedback (i.e., praise) in the same fashion as when he produced a correct response during probes.
4. After the teaching was completed, the researcher provided the preferred item that was selected in Step 2 of the general procedures, and allowed the participant to interact with it for 1-2 minutes.

Probe trials for word families. Probe trials for word families are described in chronological order below.

1. The researcher presented the task and verbally directed the participant to complete it: “Let’s sort words. Listen carefully: is it (target word) – (seed word 1) or, it is (target word) – (seed word 2). (Target word) sounds like ____?”
2. If the participant responded correctly:
   a. <u>iPad condition:</u> The iPad spoke the correct pair of words and delivered verbal praise and visual effects. The next word then appeared.
   b. <u>TM condition:</u> The researcher spoke the correct pair of words and delivered verbal praise (“Well done,” or similar). The researcher then presented the next word.
3. If the participant responded incorrectly or there was no response within 3-5 seconds:
   a. <u>iPad condition:</u> The iPad spoke the pair of words and produced an “uh-oh” sound effect. The researcher then delivered feedback, “No, that does NOT sound the same. My turn,” turned off the sound, and took the iPad away from the participant

to place the correct target word on the flow petal. The iPad was then returned to the participant to attempt the next word.

b. TM condition: The researcher spoke the pair of words and delivered feedback "No, that does NOT sound the same. My turn." The researcher then took the page away and placed the target word on the correct petal of the flower, followed by the presentation of the next word to the participant.

4. Steps 2-3 were repeated as often as necessary until the task was completed.
5. The researcher provided the preferred item selected in Step 2 of general procedures and allowed the participant to interact with it for 1-2 minutes.

Teaching trials for word families. After probe trials in both conditions were complete, teaching trials for word families commenced. The researcher conducted teaching trials for all of the words in each word family, regardless of whether or not they were correct in the probe trials. In general, instruction was provided as follows for both the iPad and TM conditions:

1. The researcher issued the general instruction, "Let's sort the words. Read the words," and prompted the participant to read both pairs of seed and target words out loud twice (e.g., flag-drag, flag-drag; and ham-drag, ham-drag) The researcher then physically prompted the participant to put the target word with the correct word family.
2. Once the task was completed, the participant was provided with feedback (i.e., praise) in the same fashion as when he produced a correct response during probes.
3. After the teaching was completed, the researcher provided the preferred item that was selected in Step 2 of the general procedures, and allowed the participant to interact with it for 1-2 minutes.

After the participant reached mastery criterion on a target skill with either set of materials, intervention was terminated for that skill.

Generalization

Probes with the generalization tasks were conducted for the word families task only, after a participant reached mastery criterion. Two generalization tasks were examined. Generalization 1 employed the same app and the same TMs used during the word family intervention, but with two untaught pairs of word families (-ig and –ip; see Table 2.2). The procedures were identical to the procedures during probes in the intervention phase. Generalization 2 employed a different app and a different set of TMs, and required participants to find a word of the same word family as the target word (selected by the researcher) from a field of three (see Table 2.2). Below are the specific procedures for Generalization 2 in the iPad and TM conditions.

iPad Generalization 2. The participant was presented with four words from two word families. The researcher first labeled all four words (e.g., pig, lip, sip, dig). Then she chose a target word (e.g., lip) and read all of the possible pairs, as follows: “Is it (target word)-(word 1), or (target word)-(word 2), or (target word)-(word 3) (e.g., “Is it lip-pig, or lip-sip, or lip-dig”?). She then pushed on the target word to make it blink. The participant was required to push the word from the same word family as the target word (e.g., I the above example, the correct answer was sip). The researcher then provided feedback: “You got it” or similar for a correct response and “No, not right” or similar for an incorrect response. Finally, the researcher said “ My turn” and took away the iPad to match the second pair. Steps 1-3 were then repeated.

TM Generalization 2. The participant was presented with four words. The researcher labeled all of them (e.g., cat, van, sat, pan). She read the pairs of words in the same manner as in the iPad condition. She then placed the target word below on the piece of velcro. The participant was required to choose a rhyming word from the same word family and place it next to the target word on a second velcro piece. The researcher provided feedback identical to the iPad condition. She then stated “My turn,” and took the paper away to reset the field.

Follow-up

Follow-up probes were conducted 3 weeks after completion of the generalization phase for both skills and all tasks in all conditions. Neither participant received practice or instruction in either research task during this time. During these probes, the researcher emulated baseline procedures and collected data on the three dependent variables as per the intervention phase.

CHAPTER 3: RESULTS

The primary research question in this study was: Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **number of sessions required to meet mastery criterion (**≥90% correct over 3 consecutive sessions) for young children with ASD who are learning basic academic skills? I anticipated that a functional relation would be evident, with fewer instructional sessions required to meet mastery criterion in the iPad condition. In an AATD, a functional relation occurs if the following three questions can be answered in the affirmative (Gast & Ledford, 2009):

- Are differences in data for the compared strategies consistent across measures (e.g., trials to criterion)?
- Are differences consistent across participants? and
- Is there a meaningful, clear separation between the data paths?

In this study, the results for the number of trials to criterion provide evidence of a functional relation in favour of the TM condition for the word families task but not for the addition task. This is contrary to the hypothesis that a functional relation would be evident for both tasks in favour of the iPad condition. Overall, results do not provide strong evidence of a functional relation for the primary research question.

There were also four secondary research questions. The first two addressed behaviours that were expected to be associated with learning: (1) Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **level of task engagement** for young children with ASD who are learning basic academic skills? and (2) Is there a functional relation between the mode of instructional delivery (TM vs. iPad apps) and the **frequency of problem behaviour** for young children with ASD who are learning basic

academic skills? I anticipated that engagement would be higher in the iPad condition and problem behaviour would be higher in the TM condition. However, a functional relation was not evident because only one data path for Lucas (word families) and neither of the data paths for Jonah showed clear separation for engagement, for either of the experimental tasks. In addition, no problem behaviour occurred during the study for either participant, so the second question could not be addressed.

The third and fourth secondary questions addressed generalization and follow-up: (3) Will skills acquired via either TM or iPad show evidence of generalization, either to untrained skills or to new materials? and (4) Will skills acquired via either TM or iPad be maintained at 3-week follow-up? I anticipated evidence of both generalization and maintenance during follow-up, but with some deterioration in accuracy (i.e., percent correct) compared to the intervention phases. Generalization data were available for the word families task only, and provided evidence of generalization for the TM but not the iPad condition for both participants. Follow-up data also favoured the TM condition across both tasks and participants. In the remainder of this chapter, I will summarize the results of the study for each participant for each skill in terms of the number of trials to criterion and task engagement.

Lucas

Addition, Number of Trials to Criterion. Figure 3.1 displays the results for trials to criterion for Lucas.

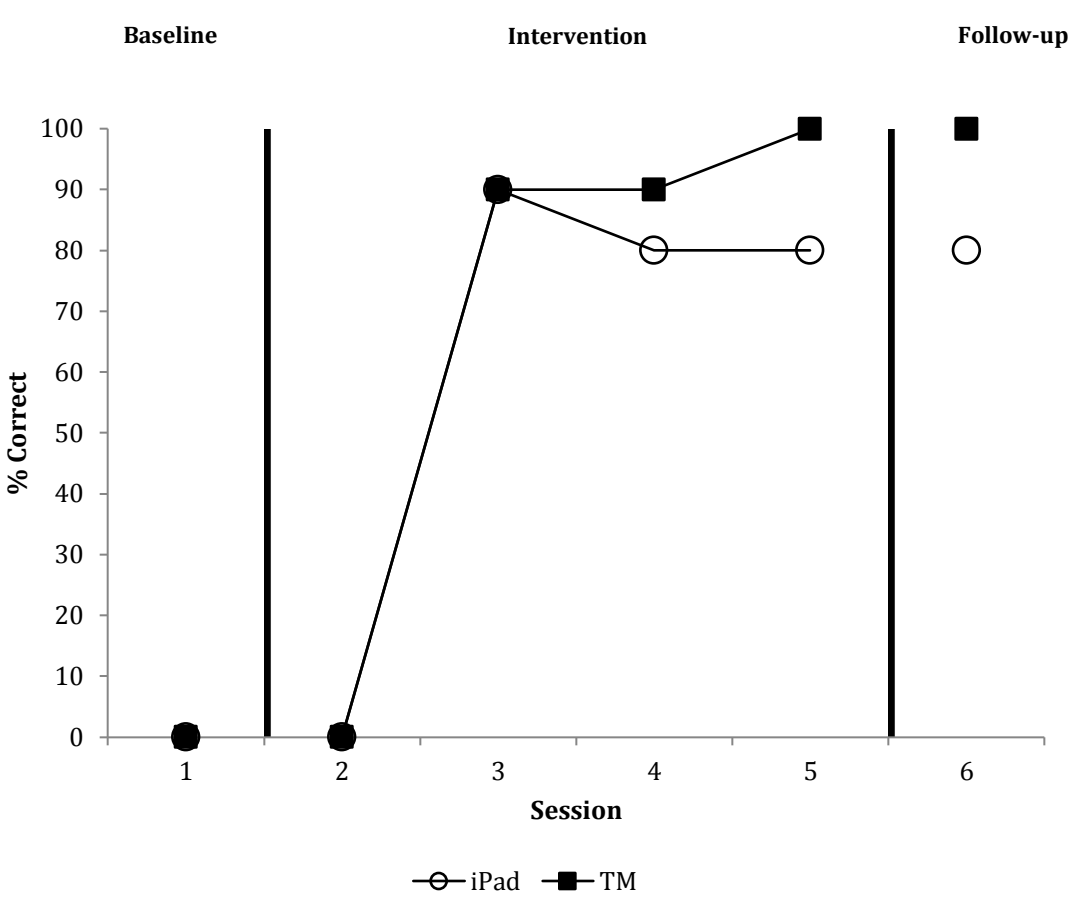

Figure 3. 1 Percentage of correct addition problems across baseline, intervention, and follow-up phases for Lucas

Lucas reached mastery criterion for addition with TM after four sessions of teaching. He demonstrated 0% correct responses during baseline for TM and on the first day of intervention, followed by an upward trend that averaged 93% over three sessions (range: 90%-100%). For iPad, he never reached mastery criterion; he demonstrated 0% correct during baseline and during the first intervention session, and then averaged 83% correct (range: 80%-90%) over the next three sessions. During follow-up, Lucas continued to achieve 100% for TM, compared to 80% for iPad. Overall, there was evidence of clear separation of the data paths.

Addition, Percent of Engagement. Figure 3.2 displays the results for engagement for Lucas.

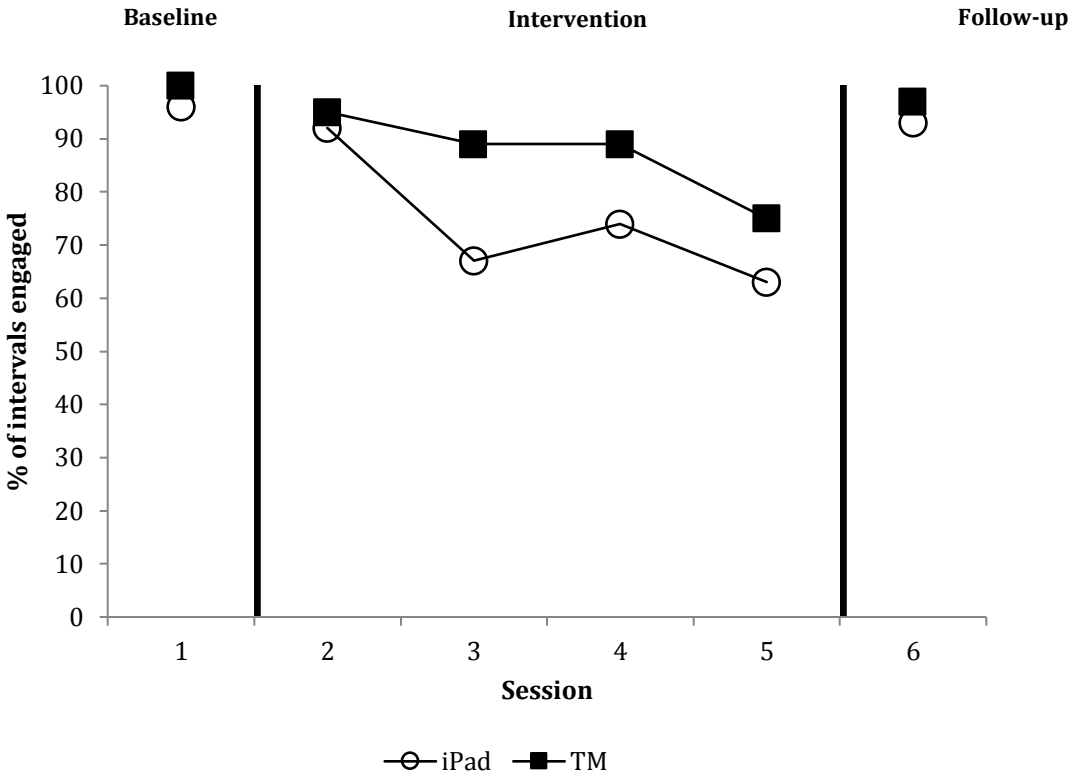

Figure 3. 2 Percentage of intervals engaged during the addition task across baseline, intervention, and follow-up phases for Lucas

During baseline, Lucas demonstrated high levels of engagement in both conditions (96% for iPad and 100% for TM). However, during intervention, a downward trend was observed in both conditions, with iPad having lower mean levels of engagement (average = 74%, range: 63%-92%) compared to TM (average = 87%, range: 75%-95%). During follow-up, Lucas again had high levels of engagement that were equivalent in both conditions (iPad = 93% and TM = 97%). Considering both intervention and follow-up data combined, engagement did not show evidence of data path separation for Lucas.

Word Families, Number of Trials to Criterion. Figure 3.3 displays the results for trials to criterion for word families for Lucas.

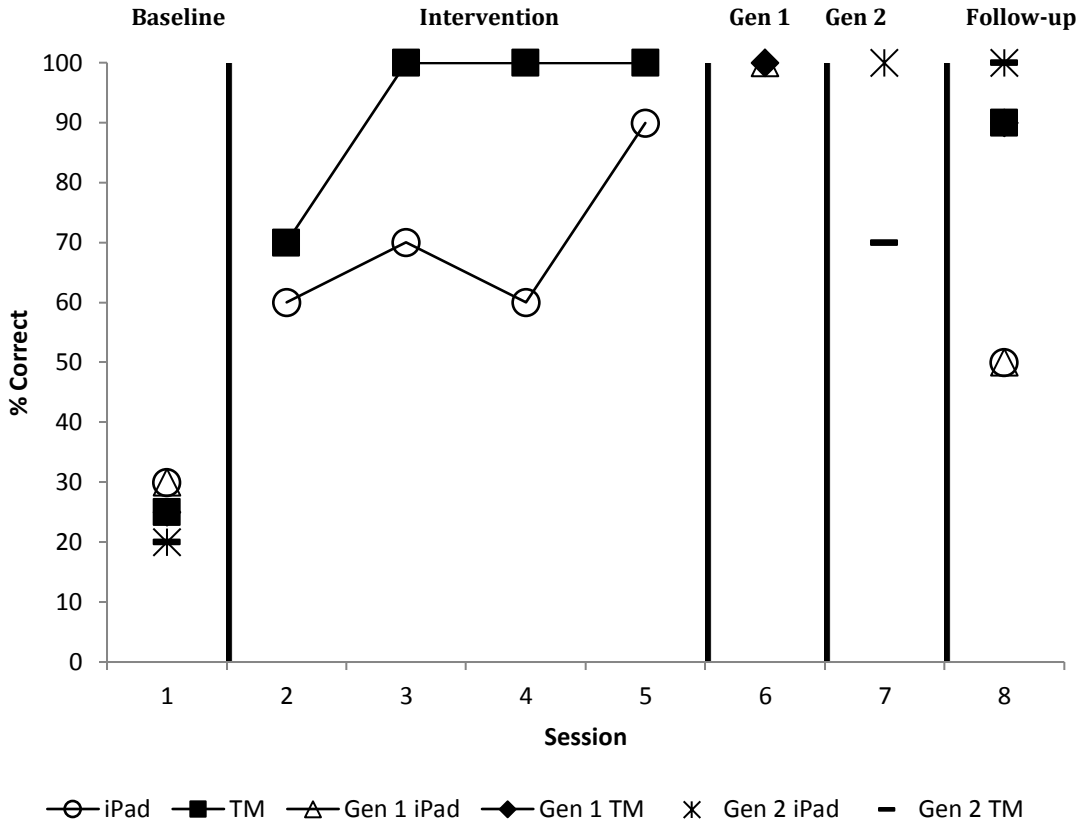

Figure 3. 3 Percentage of correct responses for word families across baseline, intervention, generalization 1, generalization 2, and follow-up phases for Lucas

Lucas reached mastery criterion for word families with TM within four sessions of teaching. He demonstrated an average of 23% (range: 20%-25%) of correct responses during baseline for TM across both target and generalization stimulus sets. On the first day of intervention, he scored 70% correct, followed by three sessions at 100% correct. For iPad, he never reached mastery criterion. He demonstrated an average of 26% (range: 20%-30%) of correct responses during baseline. During the first intervention session, he scored 60% correct, and then averaged 73% correct (range: 60%-90%) over the next three sessions, with

an upward trend evident in the final session. For generalization 1, Lucas achieved 100% in both conditions; however, for generalization 2, he got 100% correct in the iPad condition and only 70% correct in the TM condition. During follow-up, Lucas achieved an average of 93% (range: 90%-100%) for TM, compared to an average of 67% (range: 50%-100%) for iPad. Overall, considering both intervention and follow-up data, there was clear separation of the data paths in favour of the TM condition.

Word Families, Percent of engagement. Figure 3.4 displays the results for engagement for Lucas.

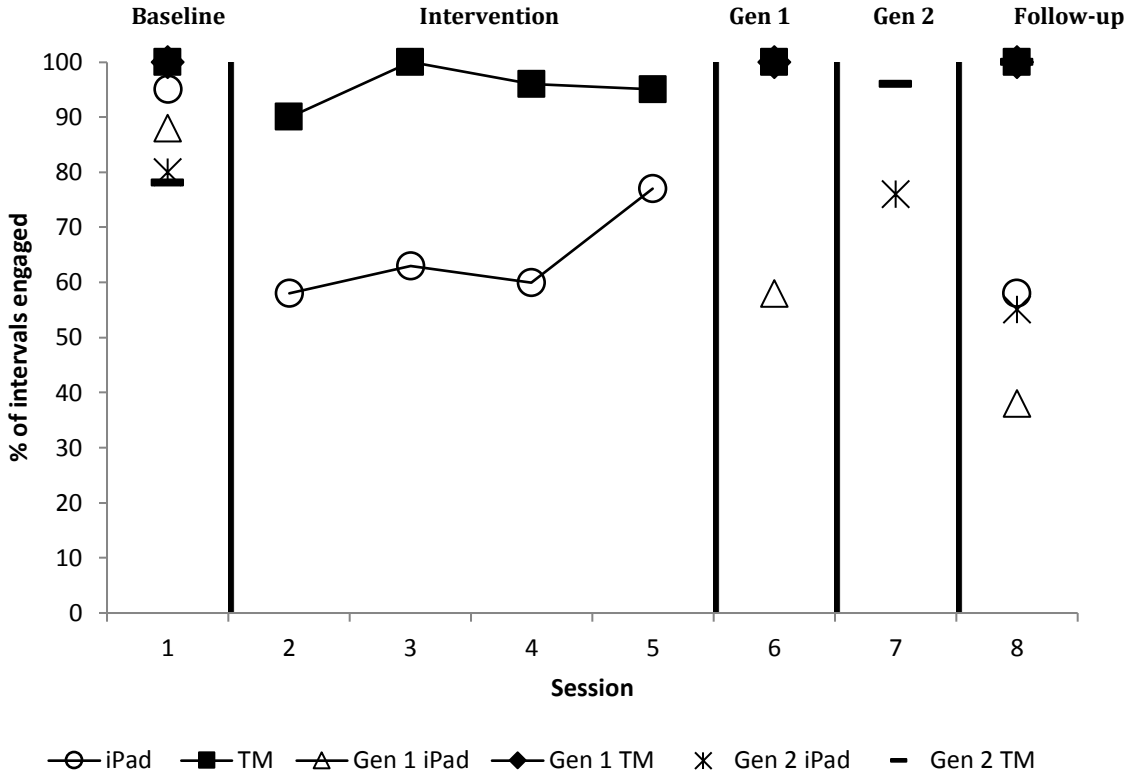

Figure 3. 4 Percentage of intervals engaged during word families across baseline, intervention, generalization 1, generalization 2, and follow-up phases for Lucas

During baseline, Lucas demonstrated high levels of engagement in both conditions: an average of 93% (range: 78%-100%) for TM and an average of 88% (range: 80%-95%) for iPad. However, during intervention, he continued to display a high stable level of engagement in the TM condition (average = 95%, range: 90%-100%), whereas engagement was stable at the medium level (average = 64.5%, range: 58%-77%) in the iPad condition. Consistently, during generalization 1 and 2, Lucas had higher levels of engagement in TM (average = 98%, range: 96%-100%), compared to iPad (average = 67%, range: 58%-76%). During follow-up, Lucas again had high levels of engagement in TM (average = 100%) compared to iPad (average = 50%, range: 38%-58%). Overall, there was clear separation of the data paths and engagement was substantially higher in the TM condition.

Jonah

Addition, Number of Trials to Criterion. Figure 3.5 displays the results for trials to criterion for Jonah.

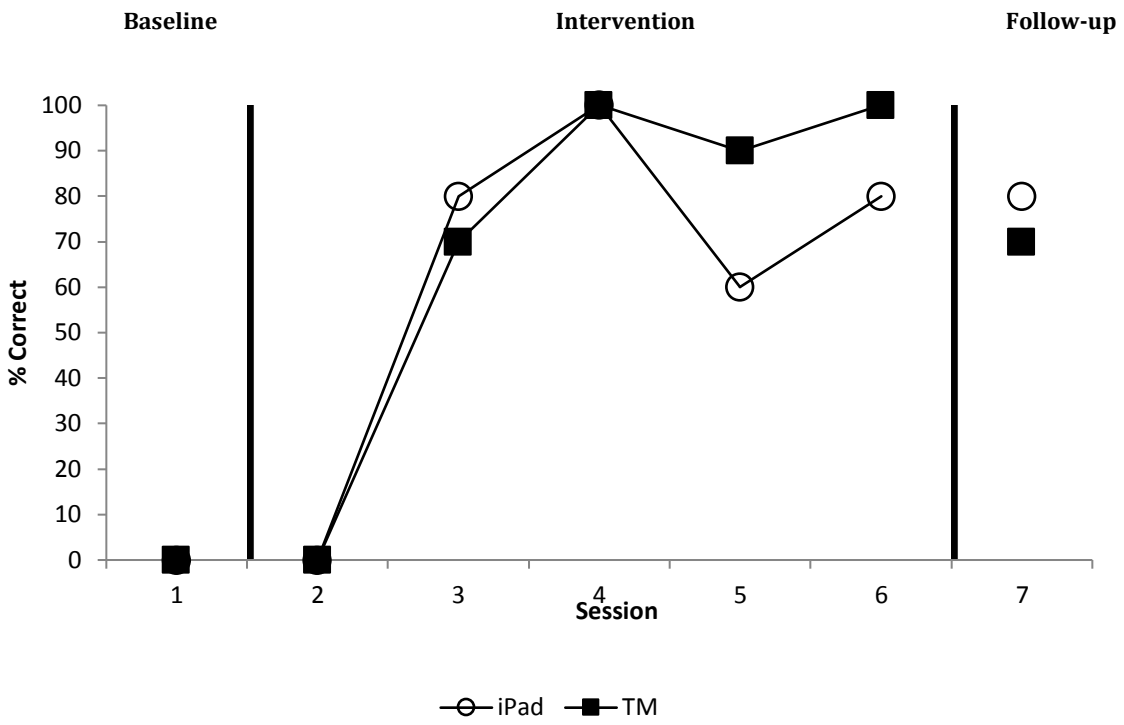

Figure 3. 5 Percentage of correct responses during addition across baseline, intervention, and follow-up phases for Jonah

Jonah reached mastery criterion for addition with TM after five sessions of teaching. He demonstrated 0% of correct responses during baseline for TM and on the first day of intervention, followed by an upward trend that averaged 90% over four sessions (range: 70%-100%). For iPad, he failed to reach criterion, demonstrating 0% correct during baseline and during the first intervention session, and then averaging 80% correct (range: 60%-100%) over the next four sessions. During follow-up, the data were reversed: Jonah achieved 70% for TM, compared to 80% for iPad. Considering both the intervention and follow-up phases together, there was no clear separation of the data paths.

Addition, Percent of Intervals Engaged. Figure 3.6 displays the results for engagement level for Jonah.

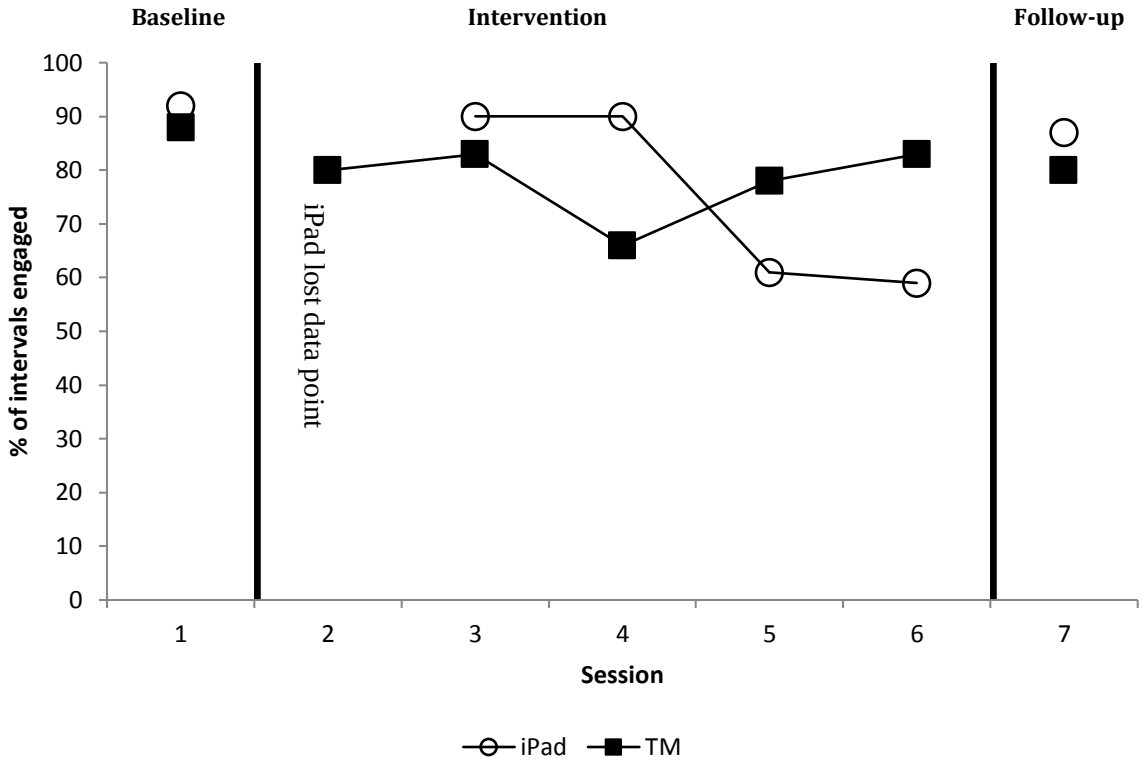

Figure 3. 6 Percentage of intervals engaged during addition across baseline, intervention, and follow-up phases for Jonah

During baseline, Jonah demonstrated high levels of engagement in both conditions (92% for iPad and 88% for TM). During intervention, the levels of engagement remained stable for the TM condition (average = 78%, range: 66%-83%); however, a slight downward trend was observed in the iPad condition (average = 75%, range: 59%-90%). During follow-up, Jonah had similar levels of engagement in both conditions (iPad = 87% and TM = 80%). Overall, engagement was similar in both conditions, with no clear data path separation.

Word Families, Number of Trials to Criterion. Figure 3.7 displays the results for trials to criterion for Jonah.

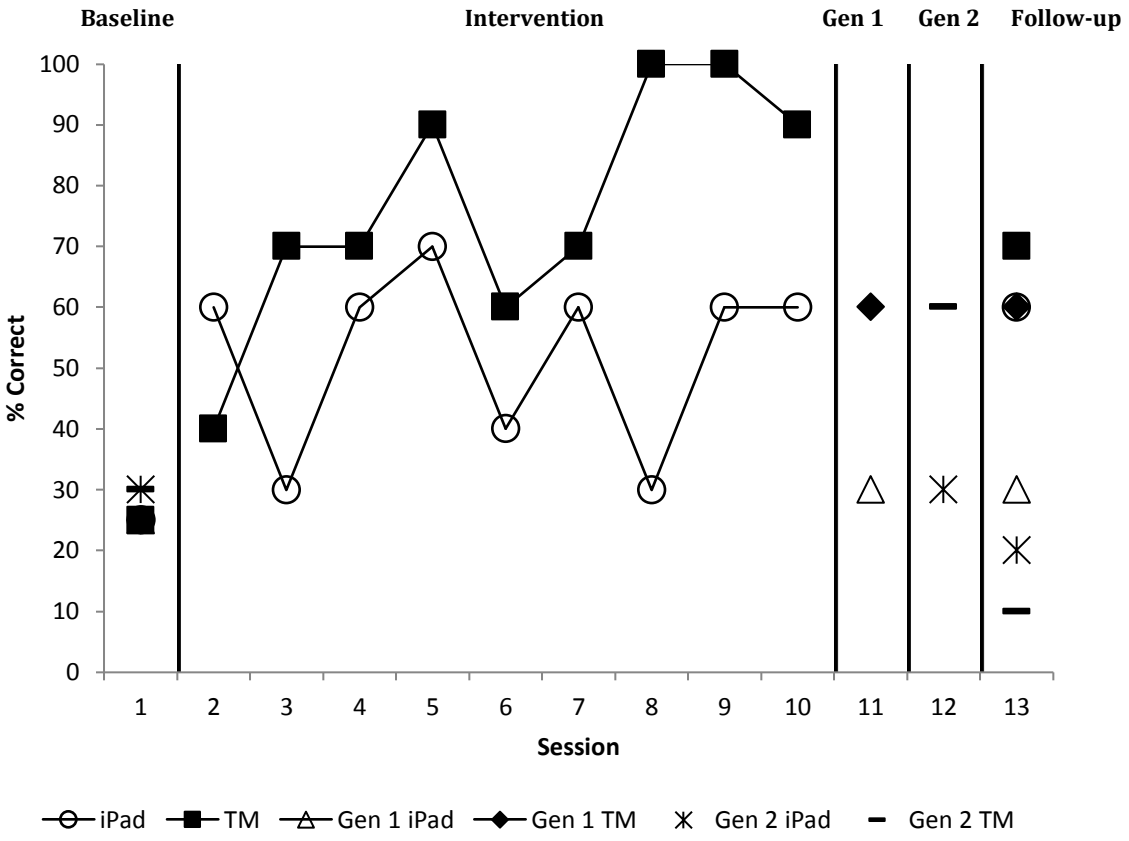

Figure 3. 7 Percentage of correct responses during word families across baseline, intervention, generalization 1, generalization 2, and follow-up phases for Jonah

Jonah reached mastery criterion for word families with TM within nine sessions of teaching. He demonstrated an average of 26% (range: 25%-30%) of correct responses during baseline for TM, across both the target and generalization stimulus sets. On the first day of intervention, he scored 40% correct, followed by an upward trend for the next three sessions that averaged 76% (range: 70%-90%). On the fifth session, Jonah scored 60% correct, which was followed by an upward trend during next four sessions that averaged 90% (range: 70%-100%). For iPad, Jonah did not reach criterion, and demonstrated a variable trend that averaged 52% correct (range: 30%-70%). For both generalization 1 and 2, Jonah achieved 60% correct in TM, compared to only 30% correct in iPad. During follow-up, he achieved an

average of 46% (range: 10%-70%) for TM, compared to an average of 36% (range: 20%-60%) for iPad. Overall, there was clear separation of the data paths and Jonah's performance was considerably better in the TM condition for this task.

Word Families, Percent of Intervals Engaged. Figure 3.8 displays the results for engagement level for Jonah.

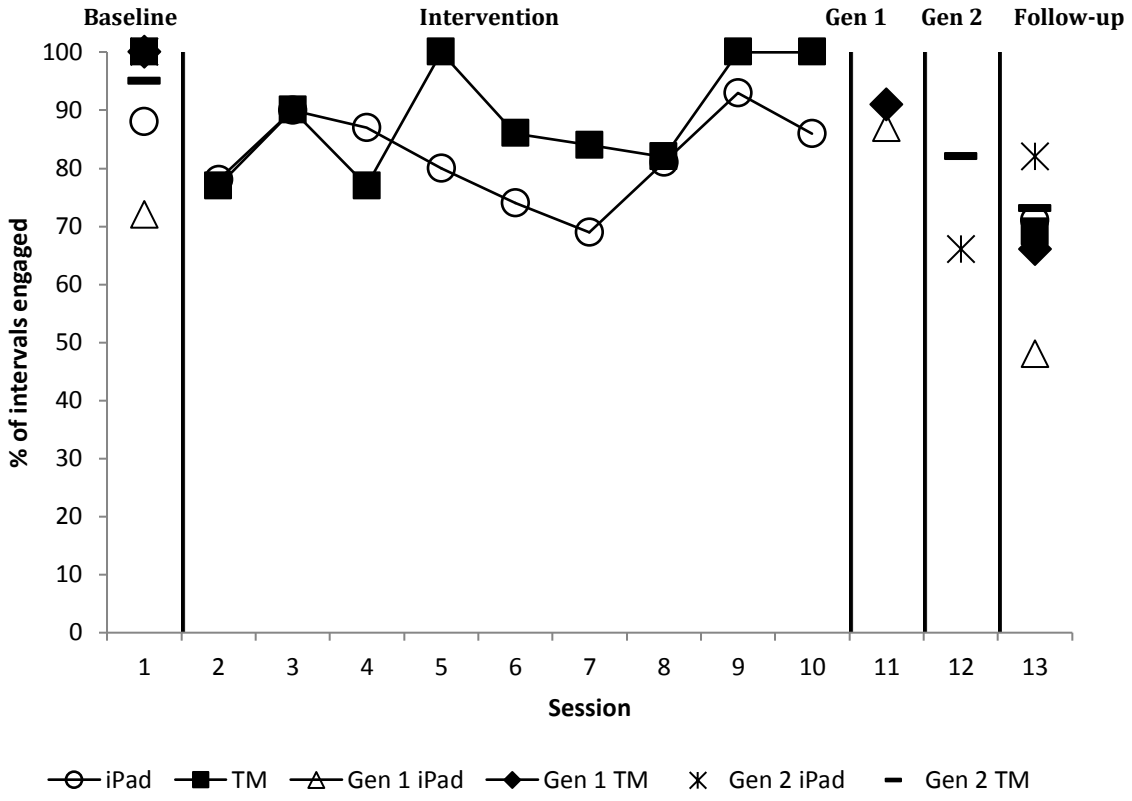

Figure 3. 8 Percentage of intervals engaged during word families across baseline, intervention, generalization 1, generalization 2, and follow-up phases for Jonah

During baseline, Jonah demonstrated high levels of engagement in both conditions: an average of 98% (range: 95%-100%) for TM and an average of 86% (range: 72%-100%) for iPad. During intervention, engagement in both conditions remained high, with TM slightly higher at an average of 88% (range: 77%-100%) compared to 82% (range: 69%-

93%) for Pad. Consistently, during generalization 1 and 2, Jonah had slightly higher levels of engagement in TM (average = 86.5%, range: 82%-91%), compared to iPad (average = 76.5%, range: 66%-87%). During follow-up, Jonah demonstrated similar levels of engagement in both TM (average = 70%, range: 66%-73%) and iPad (average = 67%, range: 48%-82%). Overall, engagement levels were similar in both conditions, with no data path separation.

Summary

Contrary to the hypothesis, the results do not provide evidence of a functional relation between the number of sessions to criterion and either the TM or iPad conditions, using the criteria proposed by Gast and Ledford (2009). Data path separation between the TM and iPad conditions for the number of trials required to reach criterion were not consistent across either tasks or participants. In addition, there was no evidence of a functional relation for engagement, and no problem behaviour occurred during the study. However, there was suggestive evidence in support of generalization in the TM condition, and the 3-week follow-up data were also stronger for this condition.

CHAPTER 4: DISCUSSION

The purpose of the study was to compare the effectiveness of the iPad and traditional materials (TM) for teaching academic skills to children with ASD. Based on the limited previous research, I hypothesized that the iPad condition would result in fewer trials to criterion and higher levels of engagement than the TM condition. However, this was not the case: results demonstrated that the iPad condition was not superior to the TM condition. Both participants acquired target skills slightly faster in the TM condition, but the magnitude of the differences were not consistent across tasks. The level of accuracy remained stable during follow-up and (for the word families task) generalization probes. Some differences were noted between participants for task engagement. In the section that follows, I will first discuss the procedures that were employed to control for alternative explanations of the results. I will then discuss the results themselves, the limitations of the study, and future research.

Overcoming the Shortcomings of Previous Research

I hypothesized that participants with ASD would learn new academic skills faster, show higher levels of engagement, and engage in fewer problem behaviours in the iPad condition. This hypothesis was based, in part, on previous research that provided some evidence that iPad-based instruction is superior to TM-based instruction in one of more of these ways (Bouck et al., 2014; Neely et al., 2013; Haydon et al., 2012). However, there were a number of methodological limitations in previous comparative studies (see Chapter 1) that called this conclusion into question. Therefore, I attempted to eliminate many of the confounding variables and methodological problems that were present in the previous research. Three procedural strategies were employed to accomplish this: use of an AATD

design with equivalent stimulus sets, randomizing and counterbalancing the order of conditions, and controlling for external motivational factors.

Adapted alternating treatment design (AATD). An AATD was employed in order to compare the two conditions with mastery criterion. When employing an AATD, it is critical to demonstrate equivalence between the sets of stimulus materials prior to the study, through objective and/or factual means (Gast, 2010; Schlosser, Sigafoos, & Belfiore, 2009). To confirm equivalence, I ensured that the materials used in both the iPad and TM conditions were similar in the following ways: (a) the background graphics were identical with regard to content, colour, and complexity; (b) the number of questions that participants were required to answer in order to gain access to reinforcement or terminate the task were identical; (c) the difficulty of the tasks was the same (e.g., for addition, the problems in TM were the reverse of the problems on the iPad app, as per Sindelar et al., 1985; for word families, the target word families in both conditions consisted of simple 3-4 letter words with vowel-consonant endings such as –ig and -ap); (d) the prerequisite skills (e.g., fine motor skills, cognitive skills, attention span) required for both tasks were the same; and (e) the instructional procedures that were implemented by the researcher were identical (i.e., probe and intervention scripts, verbal praise, etc.). In addition, I asked three professionals who work in the field of ASD and who were blind to the purpose of the study to examine both the iPad and TM materials and procedures and provide their opinion about the extent to which they were equivalent in terms of task difficulty, effort required for completion, and prerequisite skills. All three agreed that both conditions met the criteria for equivalency.

Randomization and counterbalancing. To guard against carry-over effects, the iPad and TM conditions for both tasks (addition and word families) were presented in a “semi-

random" order (Barlow et al., 2009, p. 247), such that no condition was the first one in a session more than twice in sequence. This was especially important because it was impossible to insert long breaks between the two experimental conditions during each session. Both participants were enrolled in school during the study; therefore, experimental sessions were conducted after school hours. Additionally, both boys were engaged in intensive home-based ABA therapy sessions that also took place after school. Due to their busy schedules, experimental sessions were scheduled either between school and ABA therapy sessions (a one-hour window) or after ABA therapy sessions were completed (during a one-hour window before the evening routine). The time required for probe trials for each task in each condition was 15 to 20 minutes and the time for the intervention phases was an additional 20-30 minutes. Therefore, due to scheduling constraints, the researcher had to allow participants only 5-minute breaks between the iPad and the TM conditions. This made randomization and counterbalancing of the two conditions even more important than in a typical AATD study.

Motivation. Based on previous research, I expected that the animated graphics and video/sound effects provided by the iPad would be more motivating than the reinforcers (social praise and preferred items) provided for correct responses in both conditions, and that this increased motivation would result in faster skill acquisition. Thus, it was essential to control for the quality and amount of external tangible and social reinforcement that was available for correct responses in both conditions. Prior to initiating the study, I conducted interviews with parents to identify potential reinforcers. Each parent identified between five to seven preferred items, including toys, music, and various games. I then conducted a MWSO preference assessment during the initial assessment session with both participants.

Based on the results, I offered each participant an array of preferred items identified during the MWSO assessment before each set of probe trials, and insured that the reinforcers available were identical in both conditions throughout the entire study. In addition, participants gained access to the reinforcer of their choice on the same reinforcement schedule in both conditions within a task (e.g., fixed ratio of 10 for addition and word families for both conditions). Since the iPad apps provided verbal feedback for both incorrect and correct responses (e.g., “Try again,” “Well done,” etc.), I also ensured that procedures for the TM condition included the same kinds of verbal feedback that were delivered with similar levels of enthusiasm as in the iPad condition. Together, these safeguards were aimed at insuring the equivalence of non-iPad-based reinforcers across the experimental conditions.

Relationship Between Trials to Mastery Criterion and Engagement

The results for the number of trials required to reach the mastery criterion of ≥90% correct over three consecutive sessions were consistent across both participants and skills. Both boys reached the criterion for addition within 4-5 sessions in the TM condition; Lucas and Jonah never reached this criterion for the iPad. For word families, both boys reached the criterion in 4-9 sessions in the TM condition but never demonstrated mastery in the iPad condition. This result was surprising, in light of the hypothesis that iPad would result in faster acquisition.

An examination of the engagement data suggests two different explanations for the results. Lucas demonstrated a clear difference in engagement between the two conditions when learning both tasks. Jonah, on the other hand, was engaged at similar levels in both the iPad and TM conditions during both tasks.

Lucas. Lucas was more disengaged in the iPad condition for both tasks, primarily because of an increase in finger-flickering, body tensing, and other apparently self-stimulatory behaviours that were triggered by auditory feedback from the iPad. For the addition task, Lucas had high engagement levels (96%-100% of intervals) during the baseline probe, when the iPad sound was turned off. During the first intervention session, when Lucas was less attuned to both the nature of the task and the built-in auditory reinforcement provided by the iPad app, engagement in both conditions remained high (92%-95%). However, this changed considerably for the remaining sessions, in which engagement ranged from 63%-74% for the iPad and 75%-89% for TM. Although there was a downward trend in both conditions, it was more marked for the iPad than for TM. It appeared that, once Lucas understood the task expectations and could anticipate differential auditory feedback on the iPad, he became increasingly anxious about the feedback provided when he made a mistake and increasingly over-excited about the feedback provided when he was correct. This, in turn, resulted in an increase in self-stimulatory behaviour. A similar pattern was seen for word families; engagement was high in both conditions (95%-100%) during baseline probes, when the sound on the iPad was turned off. However, there was an immediate decrease in engagement for iPad during intervention, with scores ranging from 58%-77%, compared to 90%-100% for TM. Engagement also remained low in the iPad condition during generalization and follow-up (38%-76%), compared to 95% -100% for the TM. Again, Lucas's decreased engagement was related to self-stimulatory behaviour that appeared to be triggered by the iPad auditory feedback for both mistakes and correct responses.

Jonah. In contrast to Lucas, Jonah's engagement data did not differ markedly between the iPad and TM conditions. During the addition baseline probe, when the iPad sound was

turned off, engagement was 88% for the TM and 92% for the iPad. During intervention and follow-up, engagement ranged between 66%-83% for the TM and between 59%-90% for the iPad, with many overlapping data points across the two conditions. Similarly, engagement was high during word families baseline in both conditions (88%-100%) and remained similar during intervention (TM: 77%-100% and iPad: 69%-93%). The lack of trend was also observed for generalization and follow-up. During follow-up, engagement data were mixed, with a range of 66%-80% for TM and 48%-87% for the iPad condition in both tasks. During both generalization probes, Jonah was slightly more engaged in the TM condition (82%-91%) compared to the iPad (66%-87%); however, the difference was not dramatic.

Because the engagement data were similar in both conditions, there is no apparent explanation for why Jonah reached mastery criterion in the TM condition and never reached it in the iPad condition. At least two possible explanations can be provided on a speculative basis. First, the discrepancy in Jonah's performance might reflect his past learning history with the iPad: prior to this study, he used the iPad solely for recreational activities such as listening to music, watching videos, and playing games in which correct responses were not necessarily differentially reinforced. In contrast, during his home-based ABA sessions, therapists always used traditional materials (e.g., flash cards, paper and pencil tasks) as the mode of instructional delivery, with correct responding always differentially reinforced. As a result of this history, traditional materials may have come to exert greater stimulus control over correct responding than the iPad apps. In other words, it is possible that Jonah perceived the iPad apps to be games rather than learning tasks, and was thus less focused on providing correct responses even when appeared to be otherwise engaged.

Second, it is possible that the observable behaviours that were selected to reflect engagement were not sufficient indicators of this construct for Jonah. To review, engagement during an interval was scored as occurring unless Jonah (a) failed to respond within 3-5 seconds to a verbal task direction after it was issued once; (b) played with the task materials (e.g., sniffed numbers); (c) stood up from the chair; (d) grabbed materials at inappropriate times (e.g., when the researcher was setting them up, or when she was delivering an instruction); and/or (e) required a verbal prompt to continue the task or attend to the materials (e.g., "Keep going," "Look"). These behaviours are similar to those used to indicate non-engagement by researchers in previous studies that compared the iPad with traditional materials (e.g., failing to look at/listen to the task or teacher; failure to follow directions; failure to use instructional tools appropriately; etc.). However, there may have been additional, subtle behaviours indicative of non-engagement, such as lack of eye contact to the task that were overlooked in this study and resulted in higher engagement scores for Jonah than were appropriate.

Educational Implications

The results of this study have several implications for educators. First, educators should not assume by default that the iPad will be a more effective educational tool. Before delivering an instructional intervention, one must assess the profile of individual learners, in order to find the best possible mode of delivery (see Walker, 2011, for a rubric that was developed for this purpose). For example, Lucas, who was prone to engage in self-stimulatory behaviour, did not perform as well with the iPad as he did with traditional materials. It appeared that Lucas found the auditory feedback provided by the iPad to be over-stimulating and engaged in self-stimulatory behaviour in response to these antecedents.

In addition, when choosing an iPad app for instruction, educators need to be aware that the number of trials provided by the app prior to reinforcement might not correspond to the attention span of the student. It is possible that students with short attention spans will be more successful with traditional materials that can be arranged to accommodate individual attending capabilities.

It is also important to remember that the vast majority of iPad apps are designed by non-behaviour analysts who are unaware of the importance of incorporating basic behavioural learning principles into app design. For example, many apps do not provide prompts to signal correct responses, and/or fail to differentiate clearly between the visual and auditory feedback that is provided for incorrect versus correct responses. Thus, behavioural principles will need to be employed by educators when using the iPad as an instructional delivery mode. For example, all of the procedures used in this study were adapted to fit the apps through the addition of differential reinforcement for correct responses and most-to-least procedures for prompting and prompt fading. Without the addition of procedures based on the basic principles of behaviour, it is unlikely that the participants in this study would have been able to acquire new skills.

The afore-mentioned cautions notwithstanding, it is also important to consider the potential advantages of the iPad versus traditional materials, particularly with regard to cost and time. Assuming that a student already has access to an iPad, the cost of buying many (if not most) instructional apps is likely to be substantially lower than the cost of creating comparable traditional materials. For example, the Addition is Fun app that was used in this study was available for the iPad at no cost. However, the cost of producing comparable traditional materials for addition was $24.50 ($6.50 for colour printing and $18.00 for

lamination). In addition, the researcher spent 4.5 hours developing and producing the addition materials, compared to zero time that was required to prepare the iPad addition app. For the word families task, the lite version of the Bee app that features four word families was available for free, and the full version (with more than 20 word families) costs $3.49. No preparation time was required to set up the app once it was downloaded; in contrast, preparation of traditional materials for four word families tasks cost around $5.25 and required approximately 2 hours of the researcher's time. Finally, the ABC Phonics Rhyming Words lite app used for generalization was free, and the full version would have cost $3.99. To develop traditional materials that were comparable cost approximately $9.00 and approximately 1.5 hours of the researcher's time. From these comparisons, it is clear that there are significant time savings and at least modest cost savings for educators who use conventional iPad apps for instruction. This may account, at least in part, for their popularity.

To summarize, it is important to emphasize that the iPad should be viewed as an educational tool that has certain benefits (such as time efficiency and cost savings). It also has the potential to be used successfully for academic learning; however, thoughtful decisions must be made based on the individual learner profiles and task requirements. Educators should not automatically assume that the iPad will be a better mode of instructional delivery for all learners.

Limitations

This study has several limitations that must be acknowledged. First, only two children with ASD of primary school age participated, and they had a number of characteristics in common. They were both verbal and spoke English as their first language, had existing

repertoires of receptive language and beginning literacy skills, and had a history of participation in early intensive behavioural intervention. Neither child was prone to problem behaviour and neither engaged in any problem behaviour during the study. Both participants had previous recreational experience with the iPad but neither had instructional experience with it. The study sessions were conducted in quiet, non-distracting settings at home that were also used for ABA instruction and thus exerted stimulus control over participants' behaviour. Finally, the researcher was trained in and had several years of experience in ABA and was thus able to establish instructional control with both children within a single study session. These unique participant, setting, and instructor profiles limit the generalizability of the results to those with similar profiles.

In addition, only two academic skills, which were identical for both children, were taught. The apps that were used were not customizable; rather, they were designed to be used in specific ways and could not be adapted to suit individual learners. It is possible that the inclusion of different target skills, or the use of different apps to teach the target skills, would have resulted in different outcomes.

There are also three methodological limitations to the study. One is that only one probe session was implemented at baseline. Gast and Ledford (2009) recommended that baseline data be collected in an AATD for at least three sessions or until data are stable for each condition. In this study, only one baseline probe was conducted because the researcher wanted to prevent learning skills by mere exposure to the materials, thus jeopardizing intervention phase. The second limitation is that there was only a brief time gap (approximately 5 minutes) between the iPad and TM conditions, rather than the 60 minutes recommended by Wolery, Gast, and Hammond (2010). As noted in the Method section, the

insertion of longer time gaps was not possible because of the limited amount of time available for the children to participate in the study, given their other daily commitments (school, ABA sessions, etc.). Finally, although not required in an AATD design, the addition of a phase in which the "superior" treatment (TM?) was applied to target behaviours in the other condition might have provided additional, useful information.

Future Research

Clearly, more research is needed to replicate the results of this study with participants of different ages, instructional backgrounds, previous iPad experiences, and functioning levels. Furthermore, a variety of settings should be included, with specific emphasis on school and center-based interventions where instruction is most likely to take place. It would also be useful to examine the relative outcomes achieved when iPad apps and traditional materials are implemented by less experienced instructors, including special education assistants and parents. Studies are also needed to examine the effectiveness of iPad interventions with differential feedback alone versus in combination with instruction.

Both participants had previous experience with the iPad for leisure purposes and reinforcement, while their exposure to traditional materials was for learning tasks only. Perhaps, a history of extended and continuous use of the iPad for learning purposes would have altered the results, as such exposure might have resulted in stimulus control by the iPad over behaviours related to learning, rather than playing. Future research should explore this possibility, either by involving participants with no iPad experience at all or by recruiting those with previous learning experience with an iPad. Finally, future research should endeavour to resolve the minor methodological limitations of the present study.

Conclusion

The present study is the first study to compare the use of iPad apps and traditional materials to teach two basic academic skills to two young children with ASD. Contrary to expectations, both participants acquired both skills faster with traditional materials, although the difference was meaningful only for the word families task. The results suggest that educators, parents, and others should be cautious in assuming that the iPad is a beneficial and (perhaps even a preferred) learning tool for all students with special needs. This perception is largely based on the user-friendly design and widespread popularity of the iPad in general, combined with the active public relations campaign was developed by Apple in 2011 (see https://www.youtube.com/watch?v=GEqV_8ahr90). These factors resulted in school boards purchasing iPads to use for students with ASD and other special needs prior to the emergence of a body of well-designed research aimed at clarifying the circumstances under which this technology is most appropriate. It seems clear from the unexpected results of this study that additional research is needed in this regard.

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Appendix A

Recruitment Flyer

The University of British Columbia

Department of Educational and Counseling Psychology and Special Education

OPPORTUNITY TO PARTICIPATE IN A RESEARCH PROJECT AIMED AT TEACHING ACADEMIC SKILLS ON THE iPAD TO CHILDREN WITH ASD!

My name is Alexandra Voroshina and I am a graduate student at the University of British Columbia. I have been working as behaviour interventionist with children with autism spectrum disorder (ASD) since 2009 in various settings: home-based early intervention teams, preschools, and schools. Teaching basic concepts and early academic skills is part of most preschool and elementary school curricula. Although many children with ASD use iPad apps for play and as reinforcers; I would like to explore whether iPad apps are also useful to teach these basic skills. For my masters thesis, I will conduct a study that compares the use of traditional instructional materials (for example, paper-and pencil tasks) and iPad apps to teach basic skills to children with ASD. I will compare the levels of task engagement and problem behaviour, as well as how quickly children learn the tasks using both methods.

I am hoping to recruit three children for my study. To qualify for the study, a child must:

- have received a diagnosis of ASD from a multidisciplinary team;
- be between 3-7 years old;
- agree to come to a table when asked to do so and sit at the table to work on tasks for at least 5 minutes at a time;
- be able to either tolerate physical prompting or imitate basic motor movements;
- not have previous teaching experience with the iPad (previous use of the iPad for play or reinforcement purposes is okay). Preferably not have previous communication experience;
- not engage in self-injurious behaviour, severe aggression, or property destruction.

All sessions will occur in the children's homes or early learning centers. The times and days will be determined based on family and/or center preferences. Each session will be 20-30 minutes long and will take place 2-3 times per week. I will provide all materials needed for study sessions, including the iPad, iPad apps, and other materials, so parents will not need to purchase anything. You must be willing to allow your child's sessions to be videotaped for data collection purposes. The potential benefit is that your child may learn new academic skills that are relevant to his or her preschool or school program. In addition, your child's participation will help us to understand how the iPad can be helpful to teach new skills to children with ASD.

If you are interested in finding out more or having your child participate in this study, please contact me directly at (778) XXX-XXX or xxxxxxxxxx@gmail.com.

Alternatively, you may contact my supervisor, Dr. Pat Mirenda, at (604) XXX-XXXX or xxxxxxxxxxx@ubc.ca. Thank you for your consideration!

Appendix B

Consent Form

The University of British Columbia

Department of Educational & Counselling Psychology, and Special Education

Informed Consent Form

A Comparison of iPad-Based and Traditional Instructional Materials for Teaching Academic Skills to Children with Autism Spectrum Disorder

Principal Investigator
Pat Mirenda, Ph.D., BCBA-D, Professor (Faculty Advisor)
Department of Educational Psychology and Counseling Psychology, and Special Education (ECPS)
Faculty of Education, University of British Columbia
(604) XXX-XXXX

Co-investigator
Alexandra Voroshina, Graduate Student (Masters)
Department of Educational Psychology and Counseling Psychology, and Special Education (ECPS)
Faculty of Education, University of British Columbia
(778) XXX-XXXX
Research for the fulfillment of degree requirements for the Master of Arts degree (public document).

Purpose of the Study

The purpose of this study is to compare traditional instructional materials (e.g., pencil-and-paper tasks, puzzles) and iPad apps for teaching basic academic skills to children with autism spectrum disorder (ASD). Your child is invited to participate because he or she is diagnosed ASD, is between 3-7 years old, and was identified by your behaviour consultant as a child who is learning basic skills.

Study Procedures and Time Commitment

In consultation with you and your behaviour consultant, we will identify three academic tasks that are appropriate for your child's developmental age and grade level. Two versions of each task will be created: one using an iPad application and one using tradition\al instructional materials. The two versions will be similar with regard to the content, difficulty level, and skills required. For example, to teach puzzle construction, we might use a 6-piece jigsaw puzzle depicting your child's favorite cartoon character and a 6-piece iPad-based jigsaw puzzle of the same character. We will measure how fast your child learns to perform the task

with each set of materials, how long he or she attends to each task, and how often he or she engages in minor problem behaviours during each task. After your child reaches mastery criterion for one version of each task, we will test for generalization by providing a new task at the same level of difficulty with different content; for example, this might be a 6-piece jigsaw puzzle depicting an animal instead of a cartoon character. All sessions throughout the study will be videotaped, and the researcher will use these videos to record data on both instructor and child behaviour.

The iPad, iPad apps, and traditional instructional materials will be provided during the study by the research team, at no cost to you. All teaching sessions will take place either in your home or at your child's early learning centre/preschool, depending on your preference. Each session will be 20-30 minutes long, and your child will work on a 1:1 basis with the co-investigator. We anticipate that 12-17 sessions will be required for your child to master all three tasks. We would like to schedule two sessions per week over a 6-9 week period, at your convenience. Altogether, the teaching sessions will require between 4.5-8.5 hrs (20-30 minutes x 12-17 sessions). One additional hour will be required for a home visit to get to know you and your child and find out about what foods, drinks, or toys he or she prefers. Thus, the total time commitment for you will be one hour and the total commitment for your child will be 5.5-9.5 hrs over a 6-9 week period.

Study Results

The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. Your child will not be identified by name or location in any reports or publications.

Potential Risks

There are no risks to your child if he or she participates in the study. If, either during or before a session, your child indicates, either verbally or by his/her behavior, that he or she does not want to participate, he will not have to do so.

Potential Benefits

Your child may learn new skills related to the academic tasks selected for the study. In addition, you may use what we learn from this study to inform your child's educational team about the potential of using an iPad to support his or her learning.

Confidentiality

All information from this research will be kept strictly confidential. Your child will not be identified by name in any reports of the completed study. All data records and videotapes will be identified by a code number and kept on a password-protected computer in Dr. Pat Mirenda's research lab at UBC, and will be destroyed 5 years after the study is published. Only the principal investigator, the co-investigator, and a research assistant will have direct access to the data. Your service provider and you will receive a final report of the study, but your child will not be identified by name in that report.

Payment

No financial compensation is available for this study.

Contact

If you have any questions or would like more information about this study, you may contact either Alexandra Voroshina at (778) XXX-XXXX or Dr. Pat Mirenda at (604) XXX-XXXX. If you have any concerns about your child's treatment or rights as a research participant, you may contact the Research Subject Information Line in the UBC Office of Research Services at (604) 822-8598, or if long distance e-maito RSIL@ors.ubc.ca or call toll free at 1-877-822-8598.

Consent

Taking part in this study is entirely up to you. You have the right to refuse to have your child participate in this study. If you decide to take part, you may choose to pull out of the study at any time without giving a reason and without any negative impact on your relationship with UBC or your service provider.

Your signature below indicates that you have received a copy of this consent form for your own records.

Your signature indicates that you consent to have your child participate in this study.

Please print your name and sign the appropriate section below.

_____

Parent/Guardian's name (please print)

_____

Parent/Guardian's signature Date

_____

Child's name (please print) Date

Appendix C

Imitation Skills Assessment

iPad related:

Swiping motion	Y/N
Dragging motion	Y/N
Tracing motion	Y/N

Traditional materials related:

Picking up 3D object	Y/N
Picking up card	Y/N
Holding pencil	Y/N
Drawing basic lines	Y/N

Appendix D

Fidelity Checklists

Addition – Baseline

Baseline Addition **Date:**_____

1. Tx turns off sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's practice addition" (or similar) ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
4. Therapist presents iPad problem or first/next page of tradmats.										
5. Tx: "Add (objs). What numbers go here?" + point to empty boxes										
6. **Correct iPad (two steps) :** • Tx "Nice try (or similar)! My turn!"										
• Tx pushes "check" button out of participant's view and waits until the next question is presented										
• **Correct Tradmats (two steps)**: • Tx "Nice try (or similar)! My turn!"										
• Tx takes away the materials and presents the next page										
7. Incorrect or no response in 3-5 seconds iPad (two steps): • Tx "Nice try (or similar)! My turn!"										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
• Tx does the question out of participant's view and waits until the next question is presented										
• **Incorrect or no response in 3-5 seconds Tradmats (two steps):** • Tx "Nice try (or similar)! My turn!"										
• Tx takes away the materials and presents the next page										
• Repeat steps 4-6 for all 10 questions										

Addition – Probes

Probes Addition **Date:_____**

1. Tx turns on sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's practice addition" (or similar) ☐
4. Tx gives participant a choice of 4-5 preferred items ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
5. Therapist presents iPad problem or first/next page of tradmats.										
6. Tx: "Add (objs). What numbers go here?" + point to empty boxes										
7. **Correct iPad (two steps) :** • Tx: "Let's check"; CHILD reads the question; Tx: "You got it!" (or similar)										
• Tx pushes "check" button in participant's view; Tx: "You got a star"										
• **Correct Tradmats (two steps)**: • Tx:" Let's check" CHILD reads the question; Tx: "That's right!" (or similar)										
• Tx puts a sticker on the empty page: "You got a star"										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
8. Incorrect or no response in 3-5 seconds iPad (two steps): • "Let's check" (or similar) CHILD reads the question										
• Tx pushes "check" button in participant's view; Tx: "No" (or similar)										
• **Incorrect or no response in 3-5 seconds Tradmats (two steps):** • "Let's check" (or similar) CHILD reads the question;										
• Tx: "No" (or similar); Tx takes away the materials and presents the next page										
• Repeat steps 5-8 for all 10 questions										
• Tx delivers chosen item for 1-2 minutes										

Addition – Teaching

<u>Teaching Addition (only incorrect responses)</u> **Date:_____**

1. Tx turns on sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's practice addition" (or similar) ☐
4. Tx gives participant a choice of 4-5 preferred items ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
5. Therapist presents iPad problem or first/next page of tradmats.										
6. Tx: "Add (objs). What numbers go here?" + point to empty boxes										
7. **iPad or tradmats (six steps)** • Tx and child count the first group of objects. Tx: "Find the number" (point prompt if necessary)										
• Tx point at "+" and says "Plus means "and"										
• Tx and child count the second group of objects. Tx: "Find the number" (point prompt if necessary)										
• Tx points at "=" and says "Equals means make together"										
• Tx: "Let's count all". Child counts all objects (point prompt if necessary). Tx: "Find the number"										
• Tx: "Let's check". CHILD reads the sum sentence while pointing										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
to the corresponding pictures and numbers.										
• **Tradmats:** • Tx: "You got it! You get a star!" (or similar)										
8. iPad: • Participant pushes "Check" button. iPad gives him a star. Tx: "You got a star!"										
• Repeat steps 5-8 for all questions that were incorrect at probe										
• Deliver chosen item for 1-2 minutes										

Word families – Baseline

Baseline WF **Date:_____**

1. Tx turns OFF sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's sort the words" (or similar) ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
4. Therapist presents iPad problem or first/next page of tradmats.										
5. Tx: "Listen carefully. Is it (target) – (seed 1) or (target) – (seed 2)? (Target) sounds like?"										
6. **Correct iPad (two steps) :** • Tx "Nice try (or similar)! My turn!" + takes iPad away before the visual effects start										
• Tx (out of participant's view) waits until the next question is presented										
• **Correct Tradmats (two steps)**: • Tx "Nice try (or similar)! My turn!" + takes TM away										
• Tx re-presents TM with the next target word										
7. Incorrect or no response in 3-5 seconds iPad (two steps): • Tx "Nice try (or similar)! My turn!" + takes iPad away before the										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
visual effects start • Tx does the question out of participant's view and waits until the next question is presented										
• **Incorrect or no response in 3-5 seconds Tradmats (two steps):** • Tx "Nice try (or similar)! My turn!" + take TM away										
• Tx waits for a few seconds and re-presents with the next target word										
• Repeat steps 4-7 for all 10 questions										

Word Families – Probes

Probes WF **Date:**_____

1. Tx turns ON sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's sort the words" (or similar) ☐
4. Tx gives participant a choice of 4-5 preferred items ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
5. Therapist presents iPad problem or first/next page of tradmats.										
6. Tx: "Listen carefully. Is it (target) – (seed 1) or (target) – (seed 2)? (Target) sounds like?"										
7. **Correct iPad:** • The iPad (in participant's view) names the correct pair and makes sound and visual effect; Tx: "You got it!" (or similar)										
• **Correct Tradmats** • Tx: Names the correct pair + "You got it!"										
8. Incorrect or no response in 3-5 seconds iPad (two steps): • The iPad makes sound effect and names the pair. Tx: "No, (pair) does NOT sound the same. My turn"										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
• Tx takes away the iPad, turns OFF the sound, and places the word on the correct flower out of participant's view										
• **Incorrect or no response in 3-5 seconds Tradmats (two steps):** • Tx: "No, (pair) does NOT sound the same. My turn".										
• Tx takes away the materials and places the word on the correct flower out of participant's view										
• Repeat steps 5-8 for all 10 questions										
• Tx delivers chosen item for 1-2 minutes										

Word Families – Teaching

<u>Teaching WF (ALL TARGETS)</u> **Date:_____**

1. Tx turns ON sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's sort the words" (or similar) ☐
4. Tx gives participant a choice of 4-5 preferred items ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
5. Tx presents iPad problem or first/next page of tradmats.										
6. **iPad or tradmats (three steps)** • Tx: "Read the words".										
• Child reads the pairs twice, while Tx points: "(seed 1) – (target) or (seed 2) – (target)"										
• Tx: "(target) sounds like?" + point prompt to the correct flower										
• Participant places the word onto the correct flower										
7. Reinforce • **Tradmats:** Tx: "You got it! (target) – (correct seed)!"										
• **iPad:** The iPad says the words and makes the sound effect. Tx: "You got it!"										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
• Repeat steps 5-7 for ALL questions										
• Deliver chosen item for 1-2 minutes										

Word Families – Generalization 2

Generalization WF **Date:_____**

1. Tx turns ON sound on iPad. ☐
2. Tx invites child to sit at the table ☐
3. Tx: "Let's do the words" (or similar) ☐
4. Tx gives participant a choice of 4-5 preferred items ☐

	Trial #									
	1	2	3	4	5	6	7	8	9	10
5. Tx presents iPad problem or first/next page of tradmats.										
6. iPad or tradmats (three steps) • Tx reads four words										
• Tx choses one word to be a target word										
7. Tradmats: • Tx puts the target word below array on the velcro										
iPad: • Tx pushes on selected target word and it starts to blink										
8. Tx reads all pairs: "Is it (target)-(word 1), (target)-(word 2) or (target)-(word 3). (Target) sounds like?"										
9. Participant chooses the word of the same word family by pressing on it in the iPad or placing on the velcro next to target in TM										

	Trial #									
	1	2	3	4	5	6	7	8	9	10
10. Tx provides feedback: • **Tradmats correct:** "You got it!" + takes off the words to re-present the next set of words • **Tradmats incorrect:** "No" + takes off the words and re-presents the next set of words										
• **iPad correct:** "You got it!" + the words blink and disappear with visual effect. Tx takes away iPad and does finishes the question out of participant's view and presents him with new set of words • **iPad incorrect:** "No" + takes away the iPad and does the words out of participant's view. Presents participant with new set of words										
11. Repeat steps 5-10 for all targets										
12. Chosen item is delivered for 1-2 minutes										