USING TWO IPAD® APPS THAT PROVIDE GRAPHIC ORGANIZERS AND EXPLICIT CURRICULAR VOCABULARY INSTRUCTION FOR STUDENTS WITH AUTISM SPECTRUM DISORDER: A SINGLE SUBJECT MULTIPLE PROBE STUDY

by

Mary Fay Briggs

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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ABSTRACT

This study represents a quantitative approach to research, which was focused on information retrieval in children with autism spectrum disorder (ASD), who attended inquiry-based classes in British international primary schools in Hong Kong. A single-subject multiple probe across behaviors**,** with concurrent replication across five participants, was the research design, which was used to study the effects of both the Popplet app and Futaba Classroom Games for Kids app on the ability of 7-11 year old children with ASD to learn vocabulary words for an International Baccalaureate Primary Years Programme (PYP) Unit of Inquiry. The study also examined the effects of the use of these two apps on the ability of each participant to use those vocabulary words during speaking activities in the inclusive classroom and on the end-of-unit reflection sheet. In order to collect data, the researcher used: (a) probe sessions, (b) systematic observations during lessons**,** and (c) analysis of written or verbal responses for the end-of-unit reflection sheet. Graphic analysis was conducted through visual inspection of graphs as well as by calculation of: (a) data trends, (b) absolute level change, (c) relative level change, (d) level stability, and (e) the percentage of non-overlapping data (PND). The results indicated a functional relationship between the intervention and the ability of each participant to learn and use targeted vocabulary words.

Keywords: autism spectrum disorder, memory, vocabulary, inquiry-based learning, apps

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List of Abbreviations

Application (app)

Applied Behavior Analysis (ABA)

Autism Spectrum Disorder (ASD)

California Verbal Learning Test (CVLT)

Comprehensive Test of Phonological Processing (CTOPP)

Comprehensive Treatment Models (CTMs)

Computer-Assisted Instruction (CAI)

Electroencephalogram (EEG)

Individuals with Disabilities Education Act (IDEA)

Individual Education Plan (IEP)

International Baccalaureate ® (IB)

International Baccalaureate Organization (IBO)

International Classification of Diseases (ICD)

Institutional Review Board (IRB)

Magnetic Resonance Imaging (MRI)

Medical Research Council (MRC)

National Research Council (NRC)

Office of Special Education Programs (OSEP)

Percentage of nonoverlapping data (PND)

Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS)

Primary Years Programme (PYP)

Randomized controlled trial (RCT)

Research Assistant (RA)

Rey Auditory Verbal Learning Test (RAVLT)

Rey Osterrieth Complex Figure (ROCF)

Restricted and Repetitive Behaviors (RRB)

Special Educational Needs (SEN)

Special Educational Needs and Disability (SEND)

CHAPTER ONE: INTRODUCTION

Background

Autism spectrum disorder (ASD) is a neurological disability characterized by social-communicative impairments and restricted and repetitive behaviors (RRB) (Grzadzinski**,** Huerta, & Lord, 2013). Once, ASD was thought to be untreatable; thus**,** there was a paucity of research until recently (Thompson, 2013). However, the recognition of autism as a treatable condition**,** coupled with recent technological advances such as neuro-imaging**,** have resulted in an increasing interest in the topic of autism and the corresponding exponential growth in autism research over the last 25 years (Thompson, 2013). Additionally, this paradigm shift in thinking about individuals with autism, and the effectiveness of many early invention programs, means that students with ASD are now being educated in inclusive school settings alongside their typically developing peers (Koegel, Kuriakose, Singh, & Koegel, 2012; Leach, 2010; Owen-DeSchryver, Carr, Cale, & Blakeley-Smith, 2008).

Many students with ASD are being placed in inclusive schools (Parsons, et al., 2013) where an inquiry-based curriculum is being used. Inquiry-based learning experiences are based on the idea that much of what children learn about the world around them is through dialogue with others (Cooperstein & Kocevar-Weidinger, 2004). When children make statements, a teacher or classmate may respond and affirm, tweak, or challenge the statements. Children process this interaction and then may choose to refine their views, opinions, or factual base. However, the use of this process to acquire knowledge through dialogue is seriously hindered when it is difficult for children to retrieve information from their memories (Boudreau & Costanza-Smith, 2011). Consequently, the determination and implementation of effective

information retrieval strategies will enhance the academic, social, and emotional growth of all children, especially children with ASD (Phelan, Filliter, & Johnson, 2011).

Because, often, students with ASD find it difficult to retain and retrieve information, multiple researchers have focused on the memory skills of these individuals (Beversdorf, Narayanan, Hillier, & Hughes, 2007; Bowler, Limoges, & Mottron, 2009; Mayes & Calhoun, 2008; Phelan et al., 2011; Poirier, Martin, Gaigg, & Bowler, 2011; Rhee, 2009; Smith, Gardiner, & Bowler, 2007; Sze, 2009). These researchers have examined the difficulty that students with ASD display during free recall tasks, which require them to recall: (a) lists of numbers, (b) lists of words, and/or (c) stories and personal experiences. To address difficulties with free recall, a few researchers have begun investigations into the effectiveness of the use of: (a) concept mapping (Roberts & Joiner, 2007); (b) enactment (Zalla et al., 2010); (c) rehearsal (Bebko & Ricciuti, 2000; Rhee, 2009); and (d) provision of visual and/or semantic cues (Bowler, Gaigg, & Gardiner, 2010; Corwin, 2011; Phelan et al., 2011; Sze, 2009) as strategies to increase retention as well as improve retrieval of information.

Based on the literature currently available, researchers have emphasized that there is a need for more detailed studies of the relationship between learning strategies and later recall**,** particularly among subgroups of students with ASD (Brunner & Seung, 2009; Mesibov & Shea, 2011; Phelan et al., 2011; Poirier et al., 2011; Rhee, 2009). Several researchers have suggested that the use computer-assisted instruction (CAI) is well-suited for students with ASD (Blischak & Schlosser, 2003; Bosseler & Mossaro, 2003; Pennington, 2010). Additionally, systematic instruction in the context of a structured environment has been identified as the most suitable learning environment for students with ASD (Iovannone, Dunlap, Huber, & Kincaid, 2003).

As researchers have promoted the use of systematic instruction and a structured classroom for students with ASD, educators in most of the international schools in Hong Kong have changed to inquiry-based teaching (Lee, Hallinger, & Walker, 2011). Two British international primary schools in Hong Kong provided the setting for this study. These two schools have chosen to use the Primary Years Programme (PYP), an inquiry-based curriculum, which is firmly rooted in the educational philosophies of Bruner (1974), Dewey (1916), Piaget (1923), and Vygotsky (1976, all cited in Cooperstein & Kocevar-Weidinger, 2004; Thompson, 2013). Throughout each Unit of Inquiry, children are expected to "integrate a great deal of information and apply this accumulation of knowledge in a cohesive and effective way" (International Baccalaureate Organization, 2002, p. 5). Accordingly, students with ASD require the use of learning strategies, which will allow them to retain and retrieve information for use in dialectic, collaborative, and inquiry-based classrooms.

Recent researchers (Knight, Smith, Spooner, & Browder, 2012; Knight, Spooner, Browder, Smith, & Wood, 2013; Schenning, Knight, & Spooner, 2013; Smith, 2012) have been building toward a synthesis of strategies, which are designed to assist students with ASD, who attend schools where an inquiry-based curriculum is used. Knight et al. (2012) studied the use of explicit instruction to teach science descriptors to students with ASD. The generalization probe took place in a science inquiry lesson. Recommendations for future research included the possibility of teaching conceptual vocabulary in other content areas to students with ASD. In a later study, Knight et al. (2013) studied the use of explicit instruction combined with graphic organizers to teach science concepts to students with ASD and intellectual disabilities. Based on the outcomes of this study, the researchers noted that "it would be interesting to see whether this study could be replicated using a device such as a Smartboard™ for group use, or an iPad® for

personal use" (p. 124). Schenning et al. (2013) extended the research of Knight et al. (2012) and Knight et al. (2013) when they explored the effectiveness of the use of explicit instruction combined with graphic organizers within the context of structured inquiry lessons to assist students with ASD to comprehend social studies vocabulary, concepts**,** and information. Schenning et al. (2013) recommended that future researchers should attempt to embed the intervention into the inclusive classroom. Embedded instruction refers to explicit, systematic instruction**,** which occurs several times throughout a class period within the context of the regular activities of the inclusive classroom (McDonnell, Johnson, & McQuivey, 2008). However, according to Smith (2012), there is little quality research on the use of embedded instruction to teach core content to students with ASD.

In 2009, Wilczynski, the Executive Director of the National Autism Center, published the National Standards Project Report. By categorizing interventions as Established, Emerging**,** Unestablished, or Ineffective/Harmful, Wilczynski sought to assist parents, educators, and policymakers in the selection of evidence based ASD interventions. Technology based treatments fell into the category of Emerging interventions. "Additional high quality studies that consistently show these treatments to be effective with individuals with ASD are needed before we can be fully confident that the treatments are effective" (Howard, Ladew**,** & Pollack, 2009, p. 57).

There is a wealth of research (Chen, Wu, Lin, Tasi, & Chen, 2009; Dillon & Underwood, 2012; Oakley, Howitt, Garwood, & Durack, 2013; Whitcomb, Bass, & Luiselli, 2011; Yaw, et al., 2011) on the use of technology to teach literacy to students with ASD and, as reported by Smith (2012), there is some research on the use of technology to teach mathematics, first aid**,** and safety skills to students with ASD. However, there is actually little quality research available on

the use of computers to teach core content to students with ASD (Pennington, 2010). Pennington recommended that future researchers should study the effectiveness of affordable, commercially available computer programs. Consequently, researchers (Smith, 2012; Schenning et al., 2013) have begun to explore the possibility of the use of technology to provide embedded instruction in order to teach core content to students with varying levels of disabilities including those with ASD.

Smith (2012) studied the effectiveness of the use of PowerPoint slides on an iPad® (i.e., a tablet computer) to provide embedded science vocabulary instruction for students with ASD. The next step in this line of research would be to explore the effectiveness of the use of inexpensive apps to provide embedded curricular vocabulary instruction and practice for students with ASD. The term, *app,* is an abbreviation for application**,** and it refers to software, which has been designed for iOS devices such as iPods® and iPads® (Gliksman, 2012). There are currently some apps with user friendly capabilities for the design of graphic organizers and games. Use of the Popplet iPad®app allows teachers to create graphic organizers, and the Futaba Classroom Games for Kids iPad® app can be used by teachers to create a multiple choice game. These two iPad® apps could be used by educators to embed direct instruction into inquiry-based classrooms and**,** thus**,** enhance the ability of students with ASD to encode and retrieve vocabulary.

Theoretical Framework

This study was based on the information processing model, a model in which the emphasis is on the encoding and retrieval of information (Boucher & Bowler, 2008). Weak central coherence and neural underconnectivity were the two theories of autism, which formed the theoretical framework for this study of memory in students with ASD. Theorists and researchers (Boucher & Bowler, 2008; Coben & Myers, 2008; Levy, 2007; Thompson,

Thompson, & Reid, 2010) have attempted to integrate various theories of memory in individuals with autism. For example, Coben, Myers and Levy, who study neural connections, may be able to provide scientific validity for the theory of weak central coherence, which describes the difficulty people with ASD experience when they are required to take pieces of information and integrate them into a cohesive whole (Happé & Booth, 2008). Consequently, the theory of weak central coherence appears to explain why students with ASD often struggle to effectively and efficiently retrieve pertinent information for participation in group discussions and completion of assessments (Happé & Frith, 2006; Levy, 2007; Rajendra & Mitchel, 2007; Roberts & Joiner, 2007; Waterhouse, 2008).

It has been found that the use of graphic organizers are effective in addressing the difficulties with encoding information which results from weak central coherence and neural underconnectivity (Knight et al., 2013; Roberts & Joiner, 2007; Schenning et al., 2013). Consequently, I employed the Popplet iPad®app to create graphic organizers which may help students with ASD to more successfully encode vocabulary into their long term memory and later retrieve those words for use in classroom discussions as well as end-of-unit reflection sheets. Additionally, rehearsal strategies have been used to help students with ASD to encode information in their long term memory and later retrieve it for functional use as needed (Bebko & Ricciuti, 2000; Phelan et al., 2011; Rhee, 2009). Consequently, also, I employed the use of the Futaba Classroom Games for Kids iPad® app to provide participants with an opportunity to practice the vocabulary words numerous times. In summary, these two apps were chosen as a means to enhance the ability of students with ASD to encode and later retrieve academic vocabulary for use in a variety of school related activities.

Problem Statement

As described in the National Autism Center's National Standard Report (Howard et al. 2009), there are a number of teaching strategies that are still classified as emerging treatments for students with ASD. Currently, there are a limited number of high quality research studies on the use of affordable, commercially available technology (Knight et al., 2013; Pennington, 2010) and on the use of embedded instruction (Smith, 2012; Schenning et al., 2013) to teach academic vocabulary to students with ASD. In particular, researchers have not yet investigated the effects of the use of the Popplet iPad® app and Futaba Classroom Games for Kids iPad® app to teach academic vocabulary to students with ASD.

Purpose Statement

The purpose of this single subject multiple probe across behaviors with concurrent replication across participants design study (Gast, 2010; Horner & Baer, 1978; Tawney & Gast, 1984) was to examine the effect of the use of two iPad® apps on the ability of 7-11 year old students with ASD to learn and use vocabulary words. One independent variable was the use of the Popplet iPad® app, and a second independent variable was the use of the Futaba Classroom Games for Kids iPad® app. The dependent variables were: (a) the number of vocabulary words the participants learned, (b) the number of vocabulary words the participants functionally used during Unit of Inquiry lessons in the inclusive classroom, and (c) the number of vocabulary words the participants functionally used on the end-of-unit reflection sheets.

Significance of the Study

The results of this study may strengthen the base of research on teaching strategies that are still classified as emerging treatments for students with ASD. Current research appears to have been building toward a culmination of the use of technology as a means to provide

embedded instruction to teach academic vocabulary and concepts to students with ASD (Knight et al., 2012; Knight et al., 2013; Schenning et al., 2013; Smith, 2012). In this study, I examined the effectiveness of using an inexpensive app to provide embedded curricular vocabulary instruction to students with ASD. I also examined the effectiveness of using another inexpensive app to provide curricular vocabulary practice to students with ASD. Although two specific iPad® apps were used in this study, the reality is that technology is rapidly changing (Ayres, Mechling, & Sansosti, 2013), and future technological innovations may prove to be even more effective than these two iPad® apps. Consequently, the findings from this study may contribute to the field, in that, they provide a model of the use of current technology as a means to provide direct instruction to the student with ASD, who has been placed in an inquiry-based general education classroom. In fact, the provision of technology based direct instruction within the inclusive classroom setting could be the bridge that is needed for students, with ASD and other communication and memory related impairments, to function more effectively in any school where an inquiry-based curriculum is used.

Research Questions

The purpose of this study was to explore information retrieval in students with ASD in the context of the Primary Years Programme (PYP), the primary version of the International Baccalaureate® (IB). The following research questions were addressed:

1. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to learn Unit of Inquiry vocabulary in the inclusive classroom?

2. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary during speaking activities in an inclusive classroom setting?
3. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary when completing end-of-unit reflection sheets?

Identification of Variables

One of the independent variables in this study was the use of the Popplet iPad® app developed by Notion, Incorporated (Miller, 2012). The Popplet iPad® app was designed to provide children, teenagers, and adults with a simple platform for the display of thoughts and information in the form of a concept map. For the purposes of this study, the five most useful features of the Popplet iPad® app were: (a) the ability to create concept maps, (b) the ability to import pictures, (c) the ability to combine pictures and words on the concept map, (d) the ability to make simple drawings, and (e) the ability to zoom in to see the details and zoom out to see the big picture. Features (a) through (d) (see Figure 1) were used to design lessons that were used to teach Unit of Inquiry vocabulary to the participants in this study.

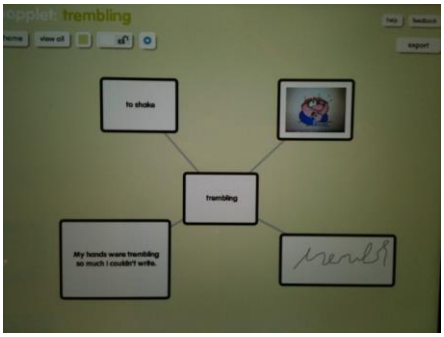


Figure 1. Popplet app.

The other independent variable in this study was the Futaba Classroom Games for Kids iPad® app produced by INKids (Clare & Rachel, 2012). The designer of this app wanted to provide students aged 4 to 11 with a fun way to learn and review key foundational information and concepts. The Futaba Classroom Games for Kids iPad® app allows educators to choose from a selection of prepared learning sets or to create their own learning sets. For this study, I created a learning set for each Unit of Inquiry. I entered questions and associated answers, and then the Futaba app embedded these questions and answers into a game format. The Futaba Classroom Games for Kids iPad® app was used to provide the participants in this study with repetitive practice of the Unit of Inquiry vocabulary (see Figure 2).

Figure 2. Futaba Classroom Games for Kids app.

The first dependent variable in this study was the number of Unit of Inquiry vocabulary words each student learned. The second dependent variable in this study was the number of

times each student used these words during speaking activities in the general education classroom. The third dependent variable was the number of times each student used these words for the end-of-unit reflection sheets.

Learning Vocabulary

I collaborated with the general education classroom teacher and learning support class teacher (i.e., the special education teacher) to generate a list of vocabulary words and short informational sentences associated with the new Unit of Inquiry. These vocabulary words and sentences were displayed in the form of concept maps on Popplet.

Use of Vocabulary in Speech During Lessons

At least one time during each Unit of Inquiry, the research assistant and I digitally video and audio recorded each participant during speaking activities in the inclusive classroom. We sought to capture each participant's interactions during speaking activities in order to later tally the number of Unit of Inquiry vocabulary functionally used by each participant during the speaking activities in the inclusive classroom. For this measurement, the functional use of vocabulary refers to the participant's ability to use the words correctly in phrases and sentences during a conversation (Camarata & Nelson, 2002).

Use of Vocabulary for the Reflection Sheet

During the last week of the Unit of Inquiry, students completed an open-ended reflection sheet on which they were instructed to record the breadth and depth of their understanding of the information, concepts**,** and skills related to the Unit of Inquiry. After the participants completed the reflection sheet, the research assistant and I separately made a tally of the number of vocabulary words that each participant functionally used in completion of the reflection sheet. For this measurement, the functional use of vocabulary refers to the participant's ability to use

the words correctly in phrases and sentences when recording what they have learned (Camarata & Nelson, 2002). Also, inter-rater reliability measures were recorded and reported for this data collection procedure (Gast, 2010).

Definition of Terms

1. *Autism spectrum disorder* - Autism spectrum disorder (ASD) is a neurological disability with varying degrees of impairment. In the *Diagnostic and Statistical Manual for Mental Disorders* (4th ed. revised; *DSM-IV-TR*; American Psychiatric Association, 2000), ASD was categorized by a triad of impairments in social interaction, communication, and restricted, repetitive behaviors (RRB) and interests. However, in the *Diagnostic and Statistical Manual for Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association, 2013), social and communicative impairments have been combined into one impairment, thus, the criterion are narrowed to two categories: social-communicative impairments and RRB (Grzadzinski et al., 2013). Some people have expressed concerns that certain individuals, who would have qualified for services under the *DSM-IV-TR* criteria for ASD, will no longer qualify under the *DSM-5* criteria (Kite, Gullifer, & Tyson, 2013). It should be noted that the participants in this study were diagnosed according to the criterion described in the *DSM-IV-TR*.
2. *Embedded instruction* - Embedded instruction refers to explicit, systematic instruction that occurs multiple times throughout a class period within the context of the regular activities of the general education classroom (McDonnell et al., 2008).

3. *Explicit instruction* - Explicit instruction refers to a teaching method whereby the teacher: (a) tells the student the reason for learning a new skill, (b) gives clear, direct explanations, (c) demonstrates the new skill, (d) provides opportunities for guided practice, and (e) gives feedback on progress. Typically, this process is followed until the student demonstrates mastery of the skill (Archer & Hughes, 2011). Also, explicit instruction has been described as an errorless teaching strategy, whereby teachers model how to obtain the correct answer and lead students to the correct answer. Thus, the opportunities for the student to make a mistake or learn incorrect information are minimized (Knight et al., 2012).
4. *Functional relationship* - The term, functional relationship, is used in single subject research to show that there is a link between the independent variable and the dependent variable (Lodico, Spaulding, & Voegtle, 2010). Single subject research, which culminates in the observation of a functional relationship, provides evidence of a potentially effective intervention (Gast, 2010).
5. *Inquiry learning* - Inquiry learning is an approach to teaching and learning that encourages students to explore open-ended topics. The focus is more on the process of learning than on finding the right answer to a question. Although students may sometimes follow a topic of personal interest, inquiry-based learning often takes place in the context of a community of learners. The ultimate goal of inquiry learning is to equip students with the skills necessary to be lifelong learners (Kuhlthau, Maniotes, & Caspari, 2007).

CHAPTER TWO: LITERATURE REVIEW

Introduction

In 2009, Wilcyznski, the Executive Director of the National Autism Center and Chair of the National Standards Project, published the National Standards Project Report (Howard, Ladew**,** & Pollack, 2009). The purpose of this report was to provide parents and educators with comprehensive information regarding the scientific evidence for various treatments for students with ASD, as well as the recommended age at which an established treatment will be most effective. Based on an analysis of 775 studies, panelists classified treatments for students with ASD as Established, Emerging, Unestablished or Ineffective/Harmful. These panel members classified technology as an emerging treatment. Pennington (2010) and Knight, Spooner, Browder, Smith & Wood (2013) also noted that there was limited high quality research on the use of affordable, commercially available technology. Additionally, Smith (2012) and Schenning, Knight, and Spooner (2013) pointed out the lack of research on the use of embedded instruction to teach core content to students with ASD. Consequently, the purpose of this study was to examine the effectiveness of using commercially available technology to embed direct instruction into inquiry-based lessons in the general education classroom.

In the next part of this Chapter, I describe the initial procedures used to identify relevant articles, dissertations**,** and books. In addition, further refinement of selection criteria for final inclusion is explained for future researchers. Subsequently, I provide: (a) the theoretical framework for the study, (b) a review of the literature, and (c) the gap in the literature which formed the basis for this study.

Literature Review Procedures

I began the literature review with an electronic search of the Liberty University Research Portal. Recent, relevant dissertations were located as a means to: (a) assess the current state of the research, (b) identify the gaps in the literature, and (c) provide potential additional sources through an examination of the bibliographies. Descriptors such as: (a) autism, (b) autism spectrum disorder (ASD), (c) Asperger's, (d) information retrieval, (e) memory, (f) memory strategies, and (g) learning strategies were used in isolation and in combination in order to search such databases as Academic Search Complete, Cambridge Journals, ERIC, and ProQuest Central for relevant articles. Descriptors such as (a) embedded learning, (b) inquiry-based, (c) vocabulary, (d) computer, (e) computer assisted, (f) iPad® and (g) technology were used to locate additional articles. Also, the titles of articles listed in the table of contents of journals, such as *Focus on Autism and Other Developmental Disorders*, were examined as another means to locate relevant articles. The reference lists for most articles were reviewed in order to identify additional pertinent studies. I focused mainly on those studies, which were published from 2007 forward, in which the authors described students with ASD who, with varying levels of support, were able to attend inclusive schools. Studies, which were focused mainly on students with ASD, who were extremely low-functioning and required extensive support in special schools, were not included in this literature review. The decision to exclude these studies was based on the fact that the participants in these studies would not meet the criteria for participation in this study. Specifically, the participants in the excluded studies would not qualify for placement in Learning Support Classes in Hong Kong.

Theoretical Framework

The theoretical framework for this study of memory in students with ASD is the information processing model (Broucher & Bowler, 2008). In the information processing framework, a process theory which first appeared in the 1960s (Brown & Craik, 2000), the authors compared the processes of the human brain to that of a computer. Similar to a computer, the brain receives, stores, and later outputs information. The terms,**"**encoding" and "retrieval,**"** are used to describe the input/output process. Encoding refers to the placement of information in memory, and retrieval refers to the location of that information for use at a later date. The concepts of encoding information, retrieving information**,** and memory systems are described as "the most fundamental hypothetical constructs in theory of memory" (Broucher & Bowler, Chapter 1, para. 3).

For much of the first half of the 20th Century, experimental psychologists supported the view that individuals possessed only one memory system (McGeoch & Irion, 1952, as cited in Nilsson, 2014). However, during the 1940s and 1950s, researchers supported a dual memory system involving both short term and long term memory (Brown, 1958; Hebb, 1949, as cited in Thorn & Page, 2009; Peterson & Peterson, 1959). Atkinson and Shiffrin (1968) added a third component, sensory memory. Their memory model was referred to as the modal model. According to the modal model, if information reached the short term memory, it would automatically pass on to the long term memory.

Next, researchers (Baddeley & Warrington, 1970; Shallice & Warrington, 1970) conducted studies involving patients with damage to specific parts of the brain. The results from these studies suggested that there was neuropsychological support for a differentiation between short term and long term memory. A few years later, researchers (Bjork & Whitten, 1974; Craik

& Watkins, 1973) tested the modal memory model and discovered that other factors were involved in the transfer of information from short term memory to long term memory. Consequently, Baddeley and Hitch (1974) began to study the relationship between short term and long term memory. As a result of their studies, they proposed one of the most well-known information processing models, the Working Memory Model.

In the Working Memory Model, Baddeley and Hitch (1974) subdivided short-term memory into three components: (a) the central executive, (b) the phonological loop, and (c) the visuospatial sketchpad. According to this model, the central executive refers to the ability to control attention to the task at hand. The visuospatial sketchpad serves to store visual and spatial information in the short term memory. The phonological loop consists of a phonological store and an articulatory rehearsal process. Baddeley and other researchers (Baddeley, Papagno, & Vallar, 1988, Gathercole & Baddeley, 1989; Papagno, Valentine, & Baddeley, 1991; Vallar & Baddeley, 1987) went on to study the functional significance of the phonological loop. Their studies indicated that impairments in the phonological loop impact directly on the acquisition of both native and foreign language vocabulary words.

A fourth component, the episodic buffer was later added to the Working Memory Model (Baddeley, 2000). Baddeley provided the following explanation for the role of the episodic buffer:

> It comprises a limited capacity system that provides temporary storage of information held in a multimodal code, which is capable of binding information from the subsidiary systems, and from long term memory, into a unitary episodic representation. (p. 417)

In other words, the episodic buffer serves as an interface between the phonological loop, the visuospatial sketchpad and long term memory (Baddeley, 2007).

In the 1980s, advances in the development of neuro-imaging equipment meant that researchers could begin to link various activities with different sections of the brain. For example, Paulesu, Frith, and Frackowiak (1993 as cited in Buchsbaum & D'Esposito, 2008) used positron emission tomography (PET) to search for the location of the phonological loop in the brain. Based on their results, these researchers proposed that the phonological loop is located in the section of the brain known as the supramarginal gyrus. However, exact neural locations for various components of Baddeley's Working Memory Model remain controversial (Buchsbaum & D'Esposito, 2008). Researchers (Frith, 1989; Just, Cherkassky, Keller, & Minshew, 2004; Takare, Minshew, Luna, & Sweeney, 2007) have proposed two main theories of autism. Weak central coherence and poor neural connectivity may be the possible explanations for the difficulties, which individuals with ASD demonstrate in their retrieval of information (Coben & Meyers, 2008).

Weak Central Coherence

One of the central theories**,** which underpins much of the research on ASD, is weak central coherence (Happé & Booth, 2008; Happé & Frith, 2006). The theory of weak central coherence emerged from the Gestalt movement, in which it was proposed that the whole is considered to be more than the sum of the parts. Frith (1989), the primary theorist of weak central coherence, noted that neurotypical individuals display a natural tendency to take pieces of information and weave them together. However, although research conducted with individuals with ASD demonstrated their ability to notice details, there was a corresponding deficit in the ability to pull the details together to create a whole picture (Happé & Booth, 2008; Levy, 2007; Rajendra & Mitchel, 2007). Based on these observations, Frith advanced the theory of weak central coherence. She maintained that more could be learned through an examination of

strengths than a focus on areas of failure and, consequently**,** a good theory would be able to explain strengths and weaknesses.

Neural Connectivity

With recent advances in medical technology, neuroscientists have begun to use magnetic resonance imaging (MRI) to examine the brains of individuals with ASD. The findings suggest an underconnectivity between frontal and posterior regions of the brain (Just et al., 2004; Takare et al., 2007). In a review of connectivity studies, Coben and Myers (2008) noted that there may be as many as seven abnormal connectivity patterns in the brains of individuals with ASD. Since some researchers have successfully used neurofeedback to retrain the brains of individuals with epilepsy (Walker & Kozlowski, 2005) and head injuries (Walker, Norman, & Weber, 2002), other researchers (Coben, 2006; Coben & Myers, 2008; Coben & Padolsky, 2007) have proposed the use of neurofeedback to improve connectivity in the brains of individuals with ASD. Although theorists, such as Frith (1989), believe this deficit in neural connectivity provides support for the theory of weak central coherence (Coben & Myers, 2008), Takare et al. never referred to the theory. In addition, Just et al. claimed their findings did not support the theory of weak central coherence and that no exact brain mechanisms have been found to support the theory of weak central coherence.

Waterhouse (2008) stated that, "despite the overwhelming flood of causal theories of autism, the field has not made progress in creating a synthesized, standard predictive causal theory of autism" (p. 273). Consequently, researchers need to base their studies on the theories of autism that are currently available and, in the case of this study, neural connectivity and weak central coherence are two theories of ASD that seem to fit well within the framework of the information processing model. Accordingly, the intervention used in this study was designed to

enhance the ability of students with ASD to encode information in their long term memory and later retrieve this information for use in a variety of situations.

An Overview of Autism Spectrum Disorder

In 1912, Bleuler (as cited in Blanc & Volkers, 2008) described autism as a form of withdrawal from social interaction with others. Thirty years later, Kanner (1943) published his studies of 11 children with comparable profiles: (a) social skills deficits, (b) echolalia, (c) language delay, (d) a strong reaction to changes in routines, (e) obsessions, and (f) a lack of interest in the world around them. These distinguishing characteristics formed the initial definition of autism (Matson & Minshawi, 2006). Unaware of Kanner's work, Asperger (1944) published his studies of four children who had features similar to the children with autism described by Kanner. The noticeable difference was that the children in Kanner's study demonstrated language delay**,** whereas the children in Asperger's study demonstrated average to above average language ability.

In an effort to narrow the definition of autism, Kanner and Eisenberg (1956) chose to focus on the extreme aloneness of these children, as well as their insistence on sameness. Additionally, in order to provide a diagnostic distinction between autism and schizophrenia, Kanner and Eisner established the onset of autism as before the age of 2, with the onset of schizophrenia occurring at a later date. Since the early 1960s, efforts to redefine autism have often been politically motivated, that is, they have reflected the wishes of particular interest groups.

The concept of autism as a spectrum disorder first appeared in the 1990s. Efforts to provide specific criteria for autism, Asperger's Syndrome**,** and Pervasive Developmental Disorder have met with considerable disagreement (Matson & Minshawi, 2006). Nevertheless,

the *Diagnostic and Statistical Manual for Mental Disorders* (*DSM*) has been the universal standard for the diagnosis of ASD. The criteria specified in the *DSM* are also used for the diagnosis of ASD in Hong Kong (Peters & Forlin, 2011).

Criteria for Autism Spectrum Disorder

Autism spectrum disorder is classified as a neurological disability, which ranges from mild to severe in impairment (American Psychiatric Association, 2013). In the *DSM-IV-TR* (American Psychiatric Association, 2000)**,** ASD was subdivided into the following categories: (a) Autism, (b) Asperger's Syndrome, (c) Pervasive Development Disorder, (d) Rhett's Disorder, and (e) Childhood Disintegrative Disorder. In the *DSM-IV-TR*, the authors described a triad of impairments and provided the following criteria for a diagnosis of autism:

> a) qualitative impairments in social interaction, qualitative impairments in communication, restricted repetitive and stereotyped patterns of behavior, interests and activities, b) delays or abnormal functioning in at least one of the following areas, with onset prior to the age of 3: social interaction, language as used in social communication, symbolic or imaginative play, and c) the disturbance is not better accounted for by Rhett's Disorder or Childhood Disintegrative Disorder (American Psychiatric Association, 2000, pp. 69-70).

However, over the last several years**,** more than 400 experts have worked to revise the *DSM-IV-TR* (American Psychiatric Association, 2000)**,** which resulted in changes to the categories of ASD as well as the criteria for a diagnosis of ASD (Reiger, Kuhl, & Kupfer, 2013). In the *DSM-5* (American Psychiatric Association, 2013), social and communicative impairments were combined into one impairment; thus, the criteria of social-communicative impairments and restricted and repetitive behaviors (RRB) were narrowed (Grzadzinski**,** Huerta, & Lord, 2013).

Other changes include the removal of the requirement for a delay in expressive language and the addition of sensory responses and stereotyped language under the RRB criterion (Grzadzinski et al., 2013). Many educators and health professionals have reported their concern that individuals who, previously, would been diagnosed with Asperger's Syndrome, will not meet the *DSM-5* criteria for ASD and, thus will be ineligible for the receipt of the services previously provided to individuals with Asperger's Syndrome (Kite, Gullifer, & Tyson, 2013). It should be noted that the participants in this study received a diagnosis of ASD based on the criteria in the *DSM-IV-TR*.

The *International Classification of Diseases (ICD*) (World Health Organization, 1992) is similar to the *DSM*. Both the *DSM* and *ICD* are used to provide clinicians, researchers, and educators with standardized criteria for diagnosis (Mezzich, 2002). Researchers prefer to use the *DSM* for recruitment of participants, since meeting *DSM* criteria is often required for publication in research journals (Dalal & Sivakumar, 2009). While the *DSM* and *ICD* provide common criteria for diagnoses, other publications influence and determine educational policy and practice (Fogt, Miller, & Zirkel, 2003).

In England, the focus of the Special Educational Needs (SEN) Code of Practice (Department of Education, 2001) is less on a specific diagnosis and more on the specific learning difficulties faced by the student (Wilkinson, 2010). The newly published Special Educational Needs and Disability (SEND) Code of Practice (Department for Education, 2014) continues to focus on the specific learning disabilities of children rather than a particular diagnosis. In the United States, the Individuals with Disabilities Education Act (IDEA, 2004) uses 13 disability categories to determine special educational services for students. According to IDEA, the definition for autism is:

> (c)(1)(i) Autism means a developmental disability significantly affecting verbal and nonverbal communication and social interactions, generally evident before age 3, that adversely affects a child's educational performance. Other characteristics often associated with autism are engagement in repetitive activities and stereotyped movements, resistance to environmental change or changes in daily routines, and unusual responses to sensory experiences.
>
> (ii)The term does not apply if a child's educational performance is adversely affected primarily because the child has an emotional disturbance, as defined in this section.
>
> (iii) A child who manifests the characteristics of 'autism' after age 3 could be diagnosed as having autism if the criteria in paragraph (c)(1)(i) of this section are satisfied. (IDEA, 2004, Section 300.8)

Although neither Asperger's nor Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) is specifically mentioned in the IDEA (2004), staff of the National Research Council (2001) recommended that every student, who is diagnosed with ASD, be provided with special education services (Wilkinson, 2010). This recommendation was based on the understanding that the vast majority of students with ASD display characteristics, which affect their academic performance. Nevertheless, it is important for practitioners to understand this difference between criteria for a clinical diagnosis and criteria for an educational placement particularly in regard to students, who have previously been diagnosed with Asperger's Syndrome.

Additionally, in this author's review of the literature on autism, an on-going disagreement was found as to whether Asperger's Syndrome is the same as High-Functioning Autism or if they are two separate diagnoses (Kozlowski, Matson, & Sipes, 2012; Macintosh & Dissanayake,

2004; McLaughlin-Cheng,1998; Sanders, 2009). The presence or absence of language delay has often been used as a determining factor between a diagnosis of High-Functioning Autism and a diagnosis of Asperger's Syndrome (Sciutto & Cantwell, 2005). Accordingly, individuals**,** who exhibit autistic features but no language delay, have generally been given a diagnosis of Asperger's Syndrome, and individuals, who exhibit autistic features accompanied by language delay, have been diagnosed with autism. Whereas some people have used the presence or absence of language as a way to distinguish between High Functioning Autism and Asperger's Syndrome, others point to the interest in relationships as possible criteria for differentiation between the two diagnoses.

Grandin (Grandin & Barron, 2005) describes herself as a woman with High-Functioning Autism**,** who has no interest in developing relationships with other people. Like a light switch, her emotions are either on or off, and when they are on, they are almost impossible to control. Conversely, according to Grandin, individuals with Asperger's Syndrome, often have a variety of sensory issues and, despite their inadequate social skills, they are interested in relationships with other people. Lack of research to support multiple categories of ASD**,** as well as the continuing disagreements over precise criteria and diagnoses**,** prompted the *DSM-5* Task Force to make several revisions to the section of the manual on ASD. Consequently, the separate categories of autism previously listed in the *DSM-IV-TR* are no longer listed in the *DSM*-5. Those categories have been replaced with a single diagnosis of ASD (Grzadzinski et al., 2013).

The growing number of students**,** who have been diagnosed with High Functioning Autism or Asperger's Syndrome in recent years**,** has caused people to raise questions as to whether individuals on the higher end of the autism spectrum should be classified as disabled or merely considered different. Students with High Functioning Autism or Asperger's Syndrome

are object oriented and focused on details**,** whereas their classmates are more relationally oriented. In a university setting, a student with Asperger's Syndrome may choose to study engineering**,** whereas one of his former classmates may choose to become a social worker. Society benefits from the detail oriented engineer and the relationally oriented social worker (Baron-Cohen, 2002).

Challenges for Students with ASD

Students with ASD may encounter a wide range of challenges when they attempt to access the academic curriculum in an inclusive setting. Sensory issues, immature social skills, language delays, and memory functioning are some of the challenges that are explored in this section. However, the focus of this section is on memory functioning for students with ASD.

Many students with ASD have sensory processing difficulties (Brake, 2008; Weedn, 2010). Some students with ASD are hypersensitive. As a result, when they are bothered by certain sounds, sights, smells, textures**,** and tastes, they may find their school environment overwhelming or even unbearable. Noisy playgrounds, crowded hallways, overly decorated classrooms, chemical odors, and unfamiliar food items have the potential to trigger anxiety and distress in many student with autistic characteristics. Conversely, other students with ASD are hyposensitive and demonstrate a craving for visual, auditory, and vestibular stimulation (Brake, 2008; Weedn, 2010). Additionally, some students with ASD lack sensory integration and, initially, may be able to only use one sensory channel at a time. Consequently, if they are forced to establish appropriate eye contact, then they are no longer able to listen to what is being said to them or think of words to answer a question (Grandin & Barron, 2005).

In order for children to have meaningful social interactions with others, they must develop the ability to observe, interpret, and respond appropriately to the verbal communication, facial expressions, and body language of others. However, often, children with ASD are unable to naturally recognize or interpret the facial expressions or body language of those around them (Weedn, 2010). Students with ASD require explicit instructions in how to: (a) join a group activity, (b) take turns, (c) allow others the opportunity to go first, and (d) transition to the next activity (Grandin & Barron, 2005). Also, the natural process of acquiring age appropriate social skills may be hindered by delays in language development.

Often, students with ASD have difficulty with expressive language and receptive language. Expressive language refers to the ability to speak fluently and meaningfully to others, and receptive language refers to the ability to gain intended meanings from the words spoken by others (Batson, 2010). Delays in processing auditory information can cause receptive language difficulties and, thus, hamper the development of conversational skills (Brake, 2008). Some individuals with ASD hear the consonant sounds**,** but not the vowel sounds when someone speaks to them, which requires the provision of concentrated speech and language therapy (Grandin & Barron, 2005). These challenges emphasize the need for teaching and learning strategies designed to facilitate the efficient encoding and retrieval of vocabulary for use in a variety of situations. The purpose of this study was to explore the use of technology as a means to embed direct vocabulary instruction into inquiry-based lessons in order to enhance the ability of students with ASD to encode and retrieve academic vocabulary.

Memory

Early researchers (Boucher & Warrington, 1976; DeLong, 1978; Hauser, DeLong, & Rosman, 1975; Rimland, 1964) suggested that developmental amnesia contributed to the

memory impairments displayed by individuals with ASD. Further research (Bowler, Matthews, & Gardiner, 1997; Minshew & Goldstein, 1993; Rumsey & Hamburger, 1988) during the 1980s and 1990s shifted to exploring executive functioning, theory of mind, and weak central coherence in individuals with high functioning ASD. These researchers concluded that developmental amnesia was probably not the underlying cause of autism. Instead, individuals with ASD learned and remembered new information in different ways than their typically developing peers.

As reported by Poirier et al. (2011), the research, which explored the various aspects of memory functioning yielded a complex profile for individuals with ASD. This profile includes a strong rote memory, visual acuity, and attention to detail coupled with difficulties with free recall of words, stories, and personal experiences. These difficulties in various aspects of free recall are attributed to the deficient organizational strategies, which are needed to support free recall. Impairments in the skill of organizing information into a meaningful structure impact the ability of students with ASD to comprehend longer reading passages and more abstract reading material (Randi, Newman, & Grigorenko, 2010). Often, these impairments are referred to in the theoretical literature as weak central coherence (Frith, 1989).

The concept of weak central coherence describes the tendency of individuals with ASD to focus on details rather than synthesize the details in order to comprehend the bigger picture. In the late 1990s, Minshew, Goldstein, and Siegel (1997) conducted research with 33 individuals with high functioning autism and 33 typically developing individuals. These researchers noted that the individuals with ASD were able to process simple information in the same manner as their typically developing peers. However, individuals with ASD demonstrated impairments for processing complex information across all cognitive domains.

Based on these findings, Minshew and Goldstein (1998) proposed the complex information processing model. Williams, Goldstein, and Minshew (2006) used a wide variety of assessment tools to test their proposed complex information processing model with children to determine whether the results corresponded with similar testing, which Minshew had conducted with adults. The participants in the study included 56 children with ASD, as well as a control group of 56 children who were developing typically. The students ranged in age from 8-15 years old and had an IQ of 80 or higher. The scores showed that the neuropsychological profile of children with ASD was similar to that of adults with ASD. However, one marked difference was that the children showed greater sensory impairments than the adults. Williams et al. stated,

> Autism is a selective impairment in the neural processing of complex information across domains and sensory modalities, with intact or enhanced simple abilities in the same domains as impairments. In this model, complexity is a proxy for the level of demand placed on the brain's processing capacity by task or situations. Cognitive or neurologic function is compromised when the processing demands placed on the brain's systems exceed their capacity. (p. 280)

Au-Yeung, Benson, Castelhano, and Rayner (2011) planned a study to test the Minshew and Goldstein (1998) complex information processing theory. These researchers used ScanMatch to study the eye movements of 14 adolescents and adults with ASD and 13 neurotypical adolescents and adults. These results indicated the presence of similar eye movements for processing simple information. However, the individuals with ASD demonstrated different eye movements during the task, which involved the processing of complex information. Analysis of the eye scans indicated that individuals with ASD did not recognize the incongruous feature as quickly as the typical peers in the control group. The

researchers concluded that their findings provided further support for the Minshew and Goldstein complex information processing theory. It would be useful to replicate this study with primary age children, as the results may indicate an even greater discrepancy in the time required to process complex information.

Additionally, the findings obtained by Tsatsanis et al. (2011) supported those from the Williams et al. (2006) study. These researchers used the Rey Osterrieth Complex Figure (ROCF**) (**Osterrieth, 1944) test to explore the effect of a part-oriented vs. configurational processing style on the ability of adolescents and adults with ASD to replicate a complex drawing from memory. The results indicated that, despite a different approach, the participants with ASD were able to recall as many details as those in the control group. Tsatsanis et al. concluded that "individuals with ASD who process information in a part-oriented but organized manner may be vulnerable to becoming overloaded in open-ended situations and need time to find structure in the constituent parts" (p. 145). Because the provision of open-ended situations to students is foundational to inquiry-based learning, this conclusion has implications for students with ASD, who study in schools where the Primary Years Programme (PYP) is used.

Recognition, free recall, and cued recall. The neuropsychological profile of individuals with ASD includes: (a) strengths in recognition, (b) difficulty with free recall, and (c) an enhanced demonstration of memory on tests involving cued recall. On tests of recognition, children with ASD demonstrated intact memory for: (a) pictures of shapes (Boucher & Bowler, 2008); (b) pictures of common objects (Joseph, Steele, Meyer, & Tager-Flusberg, 2005; Renner, Klinger, & Klinger, 2000; Salmond et al., 2005); (c) pictures of meaningless shapes (Bigham, Boucher, Mayes, & Anns, 2010); as well as (c) words and word pairs (Salmond et al., 2005). However, on tests of free recall, Iwanaga, Kawasaki, and Tsuchida (2000) noted impairments in

immediate sentence repetition in preschool children with ASD, and Botting and Conti-Ramsden (2003) noted similar impairments in immediate sentence repetition in upper primary school children with ASD. Additionally, Verté, Geurts, Roeyers, Oosterlaan, and Sergeant (2006) noted impairments in delayed free recall of meaningless patterns in children with ASD.

Beversdorf, Narayanan, Hillier, and Hughes (2007) used data from a previous study conducted by O'Connor and Hermelin (1967) to compare node activation in typically developing individuals and high-functioning individuals with ASD. They concluded that, students, who were typically developing, would have an 80% chance of retrieving words during free recall, whereas students with ASD would only have a 50% chance of retrieving those same words during free recall. Beversdort et al. proposed "that impaired search strategies due to executive dysfunction may relate to the discordant findings on recall and recognition on the 'false memory' task" (p. 1047). One limitation of this study was that secondary data were utilized, which were collected during the O'Connor and Hermelin study. Current replication of this node activation study with participants would further enhance the reliability of the findings.

In subsequent studies of free recall, Bowler et al. (2009) examined serial recall as well as the use of category cues as a means to enhance recall. These researchers conducted a quantitative study, in which they used repeated measures to examine patterns of recall related to serial positions. They predicted that people with ASD would "show similar patterns of serial position effects on the Rey Auditory Verbal Learning Test™ (RAVLT) as were found for frontal lobe patients" (p. 911). The sample included 21 teenage youth and young adults with ASD, who were considered to have average intelligence, as well as 21 participants who had demonstrated typical development and did not have close relatives**,** who had been diagnosed with ASD or a psychological disorder. The results from the French version of the RAVLT confirmed previous

findings (Bowler, Gaigg, & Gardiner, 2008), in which it was suggested that individuals with ASD and individuals with frontal lobe damage demonstrated similar results on item recall tests. Additionally, individuals in the autism spectrum appeared to process information in a different manner.

Whereas Bowler et al. (2009) studied only free recall, Phelan, Filliter, and Johnson (2011) studied: (a) free recall, (b) cued recall, and (c) recognition. Phelan et al. predicted that students with ASD would demonstrate better scores for cued recall vs. free recall, and they would score lower than the comparison group across free recall trials. The participants in the Phelan et al. study included 30 children and adolescents. The experimental group consisted of 15 students who had been diagnosed with either Asperger's Syndrome or Autistic Disorder. The control group consisted of 15 children and adolescents who were typically developing and had been matched for gender and IQ.

With use of the children's version of the California Verbal Learning Test® (CVLT**)** **(**Delis, Kramer, Kaplan, & Ober, 2000)*,* the researchers found that, when the students with ASD were provided with category cues, there was a noticeable improvement in their scores. The researchers concluded that "the central finding in this study is that free recall in youths with ASD, but not comparison participants, improved with semantic cueing" (p. 521).

Short term memory. Poirier, Martin, Gaigg, and Bowler (2011) conducted a quantitative study with use of a repeated measures quasi-experiment to explore verbal short term memory in adults with: (a) ASD, (b) intelligence in the average range, and (c) typical language development. For the first experiment, because there were no significant effects, and this finding did not support previous research in the field, the researchers recommended that the experiment be replicated. The researchers concluded the discussion of their results with the recommendation

that both children and adults with ASD be provided with rehearsal training and vocabulary development support.

Personal experiences. In addition to free recall, recognition**,** and short term memory, researchers have examined the ability of students with ASD to recall personal experiences. In 2007, McCrory, Henry, and Happé used the observation of a live event as the basis for the interviews of 27 students between the ages of 11-14, who were typically developing and attended an inclusive secondary school, and 24 individuals between the ages of 11-14 diagnosed with Asperger's Syndrome, who attended a special school designed for students with ASD. These researchers predicted that participants with ASD would demonstrate poor free recall in relation to not only the number of details recalled, but also the relationship of those details to the bigger picture of the event. Secondly, these researchers predicted that participants with ASD would recall fewer socially relevant details in comparison to those in the control group. Finally, these researchers predicted that participants with ASD would demonstrate a positive correlation between executive functioning and the ability to recall the details of an event.

McCrory et al. (2007) found that there was poorer gist recall for students with ASD (U = 205, $p < .05$). The researchers concluded that free recall appears to be an underestimate of memory, and further questioning can elicit near to normal levels of recall from students with ASD. Furthermore, they suggested that future research should be conducted to investigate the possibility that children with ASD are more compliant than their peers, as well as to determine whether deficits in free recall are due solely to difficulties in the retrieval of information or whether contextualization of information plays an added role.

Like McCrory et al. (2007), Lind and Bowler (2009) wondered if it was difficult for students with ASD to recall the details of events due to an inability to understand the greater

context of the situation. Lind and Bowler conducted a quantitative study to explore: (a) recognition memory, (b) source memory, and (c) false belief. The sample consisted of 53 students with ASD and a comparison group comprised of 50 students who were either typically developing or evidenced intellectual disabilities of unknown origin. Lind and Bowler wanted to measure self-other source memory in a large population of students with ASD because, in previous studies (Farrant, Blades, & Boucher, 1998; Hill & Russell, 2002; Williams & Happé, 2009), the researchers used small samples. Additionally, they wanted to determine whether students with ASD displayed the enactment effect in a similar manner to students in the comparison group. Finally, they wanted to test the possibility that theory of mind impairments might be the cause of poor episodic memory in students with ASD.

Using the Expressive One Word Vocabulary Scale (Brownell, 2000), Lind and Bowler (2009) found similar performances for the two groups for the recognition test. However, students with ASD demonstrated diminished source memory. Consequently, the researchers concluded that "whilst semantic memory appears to be relatively undiminished, episodic memory appears to be significantly impaired" (p. 1231). Impairments in episodic memory were attributed to impaired relational coding (Bowler, Gaigg, & Lind, 2011; Gaigg, Gardiner, & Bowler, 2008). For the false belief test, 67.3% of students in the comparison group passed the test**,** whereas only 50.7% of students with ASD passed the test. Furthermore, the researchers proposed the possibility that students with ASD use semantic memory to compensate for deficits in episodic memory. Shalom (2009) also suggested that individuals with high functioning ASD were capable of using semantic memory to compensate for atypicalities in episodic memory. Shalom attributed these difficulties with episodic memory to altered neural connectivity.

Students with ASD display memory difficulties not only in academic subjects, but also in relation to autobiographical memories. Researchers (Goddard, Howlin, Dritschel, & Patel, 2007; Losh & Capps, 2003) have found that individuals with autism have diminished memories of past experiences, and this affects their ability to project future experiences. A lack of self-awareness contributes to this diminished memory of past experiences (Lind, 2010).

Story recall. As well as being asked to recall personal experiences, such as the annual writing assignment "What I Did on My Summer Vacation," often, students are asked to provide story recounts in order to demonstrate their comprehension of a short reading passage, a chapter, or an entire book. However, Diehl, Bennetto, and Young (2006) reported that "several studies suggest qualitatively that the narratives of individuals with ASDs are marked by deficiencies in organization and coherence" (p. 87). Diehl et al. conducted a quantitative study designed to examine: (a) narrative length, (b) syntactic complexity, (c) causal connections, and (d) memory for story events in high-functioning students with ASD. The researchers included 17 children who were typically developing and 17 children with ASD. These participants were students between the ages of 6-14.

Based on their findings, Diehl et al. (2006) concluded that the narratives of students with ASD may appear the same as narratives of typically developing students. However, a detailed analysis did reveal group differences, in that, the narratives of students with ASDs tended to be more like the report of a grocery list of separate items rather than a recounting of interconnected events. In the data analysis, a significant main effect was found for the number of causal connections (F (3,96) = 44.75, $p < .001$), an indication that the students with ASD used fewer causal connectors when they retold a story. Additionally, children with ASD displayed more instances of unusual or inappropriate storytelling.

Diehl et al. (2006) discussed the theoretical implications of narrative in autism and concluded that further research is needed to explore a possible relationship between theory of mind and the organization of narratives. Also, the deficit in central coherence theory was discussed in relationship to retelling story. For future research, the researchers recommended the inclusion of control group students, who have developmental difficulties other than autism, as well as an examination of subgroups to determine any differences between students diagnosed with autism and students diagnosed with Asperger's syndrome.

In another study of story recall in students with ASD, Gabig (2008) explored the relationship between working memory and story recall. Gabig's sample consisted of 15 children with autism and 10 children who were typically developing. The children ranged in age from 5-7 years old. It was required that the children with ASD had to be able to speak at the phrase or sentence level and possess a nonverbal IQ of 70 or higher. Gabig used three instruments: (a) the nonword repetition (NWR) and memory for digits span (MD) subtests of the Comprehensive Test of Phonological Processing (CTOPP) (Wagner, Torgensen, & Rashotte, 1999); (b) the sentence imitation (SI) subtest of the Test of Language Development-Primary, Third Edition (TOLD-P:3) (Newcomer & Hammill, 1997); and (c) The Renfrew Bus Story (Cowley & Glasgow, 1994), a test of story recall and continuous speech. The results of Gabig's tests examining the relationship between story recall and working memory are displayed in Table 1.

Table 1

Working Memory and Story Recall

Variable	Children with ASD	Children Who Are Typically Developing
Non-word Repetition	7.20	9.60
Memory of Digits Span	5.50	9.50
Sentence Imitation	3.00	10.60
Index of Propositions Recalled	0.26	0.68
Longest Utterance Length	5.10	13.50

Gabig (2008) calculated Pearson product-moment correlations for: (a) receptive vocabulary, (b) word articulation, (c) verbal working memory, and (d) story recall. She found that there was a strong relationship between receptive vocabulary and the index of propositions recalled (IPR) ($r = .64$, $p < .05$) as well as the longest utterance length (LUL; $r = .67$, $p < .01$) for children with ASD. This would suggest that a student's ability to process and recall story propositions, as well as speak in longer phrases or sentences**,** was related to stored vocabulary knowledge. Students with ASD demonstrated "escalating memory deficits with increasing task complexity" (p. 505).

Teaching and Learning Strategies for Students with ASD

With the increase in the number of students, who are diagnosed with ASD, increasing numbers of researchers have conducted studies designed to identify effective teaching and learning strategies to use with students with ASD (Brake, 2008; Iovannone, Dunlap, Huber, & Kincaid, 2003; Pennington, 2010; Rhee, 2009; Roberts & Joiner, 2007; Smith, 2012; Sze, 2009;

Zalla et al., 2010). According to Wong et al. (2014), research on interventions for students with ASD can be described as either comprehensive treatment models (CTMs) or focused intervention approaches. Odom, Boyd, Hall, and Hume (2010) examined 30 CTMs. Several examples of CTMs are: (a) The Denver model (Rogers, Hall, Osaki, Reaven, & Herbison, 2000); (b) the LEAP model (Strain & Bovey, 2011; Strain & Hoyson, 2000); (c) the TEACCH program (Marcus, Schopler, & Lord, 2000); (d) the UCLA Young Autism Program (Lovaas, Koegel, Simmons, & Long, 1973; Smith, Groen, & Winn, 2000); and (e) the Autism Spectrum Disorder Program (Brake, 2008).

Whereas CTMs are designed to address a broad range of needs, focused interventions tend to target a single skill (Odom et al., 2010). For example, a number of researchers (Bebko & Ricciuti, 2000; Bowler, Gaigg, & Gardiner, 2010; Corwin, 2011; Phelan et al., 2011; Rhee, 2009; Roberts & Joiner, 2007; Sze, 2009; Zalla et al., 2010) have examined the effectiveness of teaching memory strategies to students with ASD. These types of focused interventions are considered the foundation of any educational program for students with ASD (Odom, et al., 2010).

Although Wong et al. (2014) categorized the research into either CTMs or focused interventions, the research could be categorized according to the manner in which the intervention is delivered. For example, several researchers (Blischak & Schlosser, 2003; Bosseler & Massaro, 2003; Pennington, 2010; Ploog, Scharf, Nelson, & Brooks, 2013) have examined the use of computer assisted instruction (CAI) for students with ASD. In terms of these three categories of research, the rest of this literature review will describe one CTM, examine the advantages of computer assisted instruction, and then conclude with an examination of focused interventions related to memory in students with ASD.

Autism spectrum disorder program. Brake (2008) reported that the Autism Spectrum Disorder Program was implemented in five high schools in Ontario, Canada, in 2007. In this program, Applied Behaviour Analysis (ABA) was used, a teaching approach that is focused on: (a) direct teaching, (b) repetition, and (c) rewards to teach new skills to students with various disabilities. Students, who participated in this 5 year program could choose to attend small classes for up to 50% of each school day. The student-teacher ratio for these classes is 6:1. Also, students had access to a resource room where they could go to calm down when they were upset. Brake conducted an ethnographic study to describe the experiences of 14 high school students diagnosed with Asperger's Syndrome, who participated in this Autism Spectrum Disorder Program. During the interview process, teachers reported to Brake that the use of group work was a teaching and learning strategy, which was not effective with most students with ASD, due to social skills deficits. Consequently, most of these students had an accommodation in their IEP, which exempted them from group work, and teachers could give them alternative assignments.

Computer assisted instruction. Numerous researchers have recommended the use of CAI for students on the autism spectrum (Blischak & Schlosser, 2003; Bosseler & Massaro, 2003; Pennington, 2010; Ploog et al., 2013). Although the research findings about the effectiveness of CAI for students with ASD date back to the 1970s, Pennington chose to examine the research literature between 1998 and 2008. Because of the recent emphasis on reading, all of the 15 studies he reviewed were focused on the use of CAI for the improvement of literacy skills. In addition to the improvement in literacy skills, when CAI is used, there is less emphasis on the social skills normally required of students to function successfully in the inclusive classroom. Because, typically, students with ASD demonstrate social skills deficits, Pennington anticipated

that these students would make better academic progress if they used computer based learning programs.

Also, many students with ASD exhibit difficulties with receptive language, a skill needed in the inclusive classroom where much of the instruction is verbal, and opportunities to learn required verbal interactions with others (International Baccalaureate Organization, 2002). However, in computerized learning, often, there are animated graphic features, which help students with ASD to more fully understand information. Additionally, a student with ASD may know a specific piece of information, but struggle to retrieve it from his or her mind and express it clearly. Consequently, Mayes and Calhoun (2008) recommended the provision of multiple choice questions for students with ASD. Given that, in computer software programs, students can be provided with a multiple choice format, this assessment feature further increases the value of CAI for students in the autism spectrum (Pennington, 2010).

Memory strategies. Researchers, educators, and parents have tried a variety of strategies to help students with ASD to improve their memory. These strategies include but are not limited to: (a) concept mapping (Roberts & Joiner, 2007); (b) enactment (Zalla et al., 2010); (c) rehearsal (Bebko & Ricciuti, 2000; Phelan et al., 2011; Rhee, 2009); and (d) visual as well as semantic cues (Bowler et al., 2010; Corwin, 2011; Phelan et al., 2011; Sze, 2009).

***Concept mapping*.** The use of concept mapping is a strategy, which allows students to visually connect new information to pre-existing knowledge. Past researchers (Anderson-Inman, Ditson, & Ditson, 1998; Griffin, Malone, & Kameenui, 1995; Ritchie & Volkl, 2000) have explored the effectiveness of the use of concept maps to enhance the learning of students with and without disabilities. However, Roberts and Joiner (2007) were the first researchers to examine the benefits of the use of this learning strategy for students with ASD. By teaching

concept mapping, the strong visual processing skills of students with ASD could be used to address their difficulties with weak central coherence.

Whereas students with ASD tend to focus on the details, other people are able to see the big picture. Concept mapping can be used as an effective way for students with ASD to link all the details together to form a visual big picture. This, in turn, enables students to recognize relationships and improve the organization of their information. Using a within-participants crossover experimental design, Roberts and Joiner examined the amount of information students with ASD were able to retain and recall as a result of using concept mapping vs. traditional teaching methods. The researchers documented a fourfold increase in the amount of information retained by students with ASD as a result of their use of concept mapping.

Enactment. Enactment is a memory strategy that requires individuals to perform an action or participate in an activity as a means to enhance recall of information. Zalla et al. (2010) conducted a quasi-experimental quantitative study to assess whether adults with Asperger's Syndrome "would benefit from the enactment effect when recalling a list of previously enacted items versus items that were only visually and verbally experienced" (p. 2). The participants included 18 adults with a diagnosis of Asperger's Syndrome and 18 adults who were typically developed. The two groups were matched for age, IQ, and gender. The participants with Asperger's Syndrome recalled fewer self-enacted events than comparison participants. Zalla et al. concluded that acting out items did not enhance free recall in participants with Asperger's Syndrome.

Evidence of an action monitoring deficit, however, was inconclusive, as recall failure may be related instead to difficulties with information retrieval. Zalla et al. (2010) recommended that future researchers should examine the possibility of impaired action monitoring systems that

"systematically vary visual, motor and efferent signals during action execution tasks" (p. 6). The results from the study conducted by Zalla et al. supported the conclusions drawn by Shalom (2003) in his review of the literature on memory in autism. Also, Shalom concluded that individuals with ASD demonstrate impairments in memory tasks involving episodic memory.

Rehearsal. Rehearsal is a memory strategy that involves multiple repetitions of a word, process**,** or action in order for information and skills to be retained and retrieved at a later date (Bebko & Ricciuti, 2000). Researchers have studied the use of rehearsal as a memory strategy for: (a) students with learning disabilities, (b) students with cognitive disabilities, and (c) students who were deaf (Bebko & Ricciuti, 2000; Phelan et al., 2011; Rhee, 2009). Bebko and Ricciuti (2000) sought to add to the research literature in their conduct of two experiments designed to examine the potential of rehearsal as an effective memory strategy for students with autism. The participants for the first experiment included: (a) boys with high-functioning autism, (b) boys with low-functioning autism; and (c) boys who were typically developing. The researchers assumed that, if executive functioning was a deficit commonly found in children with ASD, then they would observe either no rehearsal strategies or ineffective rehearsal strategies. The results of their experiment demonstrated that over one-half of the boys with high-functioning autism were already spontaneous rehearsers. However, in the group of boys with moderate-functioning autism, only one boy was a spontaneous rehearser. The researchers concluded that for high-functioning students with ASD**,** although the development of rehearsal as a memory strategy may be delayed, once the skill has been learned, it is used and maintained.

For the second experiment, Bebko and Ricciuti (2000) used the same high-functioning and moderate-functioning participants, but chose a new group of boys who were typically developing. The boys were taught rehearsal strategies before participating in the task described

in the first experiment. The researchers correctly assumed that rehearsal strategy users would demonstrate higher recall during serial recall tasks. The results indicated that the moderate-functioning boys benefited the most from being taught rehearsal strategies as evidenced by the increase (e.g., from one to eight) in the number of moderate-functioning boys who used the rehearsal strategies**.** Bebko and Ricciuti concluded that "there is a need to teach specific cognitive strategies directly to children with autism, and not simply to emphasize the content to be remembered" (p. 318).

For his doctoral dissertation at York University in Canada**,** Rhee (2009) studied the effects of teaching cumulative rehearsal and extended the research by an examination of metacognition in students with ASD. The participants in Rhee's first two studies included: (a) 20 moderate to high-functioning children with ASD, (b) 20 moderately developmentally delayed children, and (c) 20 typically developing children. For his first study, the participants were taught cumulative rehearsal strategies during a single training session. Rhee accurately predicted that a single training session was insufficient and that students with ASD would not show retention of the cumulative rehearsal strategies when retested several weeks later.

Rhee (2009) followed the first study with one in which the cumulative rehearsal training sessions were taught as many as five sessions. In this second study, the participants, who had previously been non-rehearsers, had learned to use the cumulative rehearsal strategy quite effectively as a result of several training sessions. In his third study, Rhee doubled the number of participants and tested them on four areas of meta-memory. He concluded that "meta-memory also holds true as the strongest predictor of rehearsal when entered into the model simultaneously with *both* verbal IQ *and* language proficiency" (p. 90).

Semantic cues. Cued recall or semantic cueing simply refers to the use of key words to enhance memory and may occur when individuals learn information or when they are required to retrieve information (Bowler et al., 2010). Semantic cues can include: (a) words, (b) phrases, and (c) category labels. Bowler et al. stated that

> Memory in autism spectrum disorder (ASD) is characterized by a particular pattern of performance across tasks. Better performance tends to be seen on tasks, such as recognition and cued recall, which provide some support at test; poorer performance is more likely on tasks, such as free recall, which do not provide such support. (p. 179)

For his doctoral dissertation at the Chinese University of Hong Kong, Sze (2009) examined the effects, when semantic cues were provided as a means to facilitate memory retrieval in children with ASD. One unique feature of his study was the use of electroencephalogram (EEG) technology to examine which neural connections were being activated in the brains of students with ASD, when they participated in memory tasks. Sze conducted three experiments. In the first experiment, memory profiles of children with ASD were evaluated in the context of the information processing model. The participants for this experiment included 22 children with ASD and 36 children who were typically developing. Participants' verbal memory was assessed with the Hong Kong Learning List Test (HKLLT) (Kwok, 1999, as cited in Sze, 2009), in which they were required to learn 16 Chinese words. During the non-cued learning session, the children with ASD remembered an average of 23% fewer words than the children in the comparison group. However, when external cues in the form of forced recognition choices were provided, the children with ASD remembered an average of 15% fewer words than the children in the comparison group.

Sze (2009) conducted a second experiment to explore whether memory impairment was the result of the qualitative or quantitative complexity of the new learning materials. In addition, he sought to determine whether students would show the same response to implicit cues as they had to explicit cues. The participants in this second experiment included 23 children with ASD and 39 typically developing children. The Rey Osterrieth Complex Figure (ROCF) (Osterrieth, 1944) was administered to measure memory for complex abstract figures. Results indicated that individuals with ASD demonstrated memory impairment based on qualitative, rather than quantitative complexity of learning materials. Additionally, the participants displayed difficulties in clustering semantic information, but they demonstrated greater success in clustering abstract geometric shapes.

For the third experiment, Sze (2009) repeated the second experiment and included the same participants. However, this time each participant's neural connections were monitored while they were involved in the memory exercises. After completion of the three experiments, Sze suggested that it is difficult for students with ASD to organize information in a meaningful way; therefore, it is difficult for them to retrieve information. Provision of cues was shown to enhance processing and retrieval of information. Additionally, the findings from the neural imaging demonstrated that, often, students with ASD expend huge amounts of mental energy in order to sustain their attention on a task. Consequently, there is little available mental energy to process and store new information. The researcher recommended replication of the first experiment with a larger sample size; also, the object replication task should be conducted with use of explicit rather than implicit cues.

Bowler et al. (2010) conducted a study to examine the effects of semantic cueing on pattern recall in individuals with ASD. Whereas Sze (2009) examined children, Bowler et al.

evaluated 16 adults with ASD and 16 adults who were typically developed. The Bowler et al. participants were tested in four ways: (a) no-cues condition, (b) encoding-cues condition, (c) retrieval-cues condition**,** and (d) full-cues condition. During the encoding-cues condition, category labels were made available**,** and participants were required to state which category would be appropriate for each word in the word list. During the retrieval-cues condition, category labels were made available as participants attempted to recall words from the word list. Finally, during the full-cues condition, category labels were made available throughout the testing process.

Both Bowler et al. (2010) and Sze (2009) found that individuals with ASD consistently recalled fewer words on delayed trials than students in the comparison group. The Bowler et al. results indicated that the use of encoding-cues is helpful on the first trial, but they do not facilitate learning over trials. Conversely, the use of category cues at retrieval did facilitate learning for the second trial, but not the first trial. Additionally, Bowler et al. noted that participants with ASD tended to cluster items less frequently than participants in the comparison group. This last conclusion was supported by the findings of Roberts and Joiner (2007), who reported that it was efficacious to use concept mapping to increase retention and recall of information for students with ASD.

Phelan et al. (2011) furthered the research on the use of semantic cuing for students with ASD. Similar to Sze (2009), they worked with children and used a standardized word list. However, their students spoke English in contrast to Sze's participants who spoke Cantonese. In this new study, these researchers predicted that students with ASD would demonstrate better scores for cued recall vs. free recall and, also, would score lower than the comparison group across free recall trials. The participants in their study included 30 children and adolescents.

The experimental group consisted of 15 students, who had been diagnosed with either Asperger's Syndrome or Autistic Disorder. The comparison group consisted of 15 typically developing children and adolescents who were matched for gender and IQ.

Whereas Bowler et al. (2010) devised their own word lists, Phelan et al. (2011) used the children's version of the CVLT (Delis et al., 1987) and found that the students with ASD improved significantly when category cues were provided (t (14) = -3.22, p = .006; partial *eta2* = 0.42). This was not true for the comparison group. The researchers stated that "The central finding in this study is that free recall in youths with ASD, but not comparison participants, improved with semantic cueing" (p. 521). In addition, they recommended that further studies be conducted to determine the effectiveness of external cues for subgroups of students with ASD divided according to IQ levels.

Visual cues. Visual supports refer to "pictorial and graphic stimuli that enhance comprehension and learning in individuals who may otherwise struggle with communication" (Arthur-Kelly, Sigafoos, Green, Mathisen, & Arthur-Kelly, 2009, p. 1475). Most people with ASD are visual learners (Earles-Vollrath, Cook, & Ganz, 2006). Therefore, Ganz (2007) recommended that visually based interventions should be used with individuals with ASD.

Mnemonics. Also, educators have used mnemonics to enhance memory in students with learning disabilities (Wolgemuth, Cobb, & Alwell, 2008). However, the focus of very few studies were on the use of mnemonics with students with ASD. Asaro and Sadler (2009) studied the use of mnemonics to help a 10 year old student with ASD develop independent narrative writing skills. Although the mnemonics helped the student to independently include all the elements of a story, the researchers noted that the boy's stories continued to be quite short.

Recommendations for future research included the use of mnemonics with a larger number of participants and to extend the intervention to include other genres of writing.

In summary, concept mapping, enactment, rehearsal, semantic cues, visual cues, and mnemonics are several of the memory strategies that researchers and educators have attempted to use to help students with ASD improve their memories. The use of concept mapping to enhance memory was highly successful, and students demonstrated a fourfold increase in information (Roberts & Joiner, 2007). The use of enactment, on the other hand, did not enhance free recall in individuals with ASD (Zalla et al., 2010). Students in the high-functioning and moderate-functioning ranges of autism benefited from the explicit teaching of rehearsal strategies, and there was an improvement in their metacognitive awareness (Bebko & Ricciuti, 2000; Rhee, 2009). Lastly, the use of semantic cues effectively assisted students with ASD to process and retrieve information (Bowler et al., 2010; Phelan et al., 2011; Sze, 2009).

According to Howard et al. (2009), there is now empirical evidence, which supports the use of a variety of teaching and learning strategies. The fact that researchers cannot agree on one best strategy may explain why educational policy makers have been rather slow to integrate these strategies into current curricular programmes and policies (Iovannone et al., 2003). Currently, **t**here are few programs in place to meet the needs of children with high functioning autism, who have been placed in general education classrooms (Camilleri, 2009).

Vocabulary

More recently, researchers have focused on helping students with ASD to encode and retrieve vocabulary and, thus, increase their comprehension of academic content. Knight, Smith, Spooner, and Browder (2012) examined the use of explicit instruction to teach science vocabulary to students with ASD. These researchers used a multiple probe across behaviors with

concurrent replication across participant design with three primary age students with ASD. The intervention phase consisted of a model-lead-test format to teach 15 science descriptors. They found that a functional relationship existed between the intervention and the acquisition of vocabulary. Additionally, participants were able to generalize to objects and, to a lesser extent, to a science experiment. The researchers recommended that future researchers should examine the use of explicit instruction in other content areas as well.

Smith (2012) extended the research of Knight et al. (2012) by the use of an iPad to deliver instruction to students with ASD. She used a multiple probe across participant research design to study the effectiveness of the use of PowerPoint slides on an iPad® to provide explicit teaching of science vocabulary to students with ASD. The results indicated a functional relationship between the intervention and the ability of participants to reach the criterion level performance of correct identification of at least 14 of 18 science terms. Smith noted that this intervention may not prove as effective with students with ASD, who demonstrate high levels of anxiety in the inclusive classroom or have difficulty when they transition from a preferred activity to another activity.

Both Knight et al. (2012) and Smith (2012) noted a functional relationship between explicit teaching and vocabulary acquisition for students with ASD. Consequently, Knight, Spooner, Browder, Smith, and Wood (2013) chose to add to the limited research on the teaching of science vocabulary to students with ASD by the additional use of a graphic organizer. Knight et al. (2013) used a multiple probe design to explore the effects of combining explicit instruction with graphic organizers to teach science vocabulary to three middle school students with ASD. They found a functional relationship between the chosen intervention and the participants' completion of a task which demonstrated their understanding of the concept of convection. The

researchers noted that it would be interesting to replicate their research with the use of a Smartboard™ or iPad®.

Whereas the studies by Knight et al. (2012), Knight et al. (2013), and Smith (2012) were focused on teaching science vocabulary and concepts to students with ASD, Schenning et al. (2013) chose to explore teaching social studies vocabulary and concepts to students with ASD. Schenning et al. examined the use of explicit instruction combined with graphic organizers during guided inquiry lessons to assist students with ASD to learn social studies vocabulary and concepts. The researchers recommended that this intervention be embedded into inclusive classroom lessons. However, Smith noted that, currently, there is little research on the use of embedded instruction to teach academic content to students with ASD.

Primary Years Programme

The International Baccalaureate® (IB) Diploma Programme was designed by a group of teachers from the International School of Geneva in consultation with other international school teachers (International Baccalaureate Organization [IBO], 2013). Subsequently, the IBO became a non-profit organization. In 1997, the faculty of many primary schools began to use the IB Primary Years Programme (PYP), and as of 2014, the PYP was being used in 1,174 preschool and primary schools around the world. The PYP is an inquiry-based curriculum firmly rooted in the educational philosophies of Piaget (1923), Vygotsky (1978), Bruner (1974)**,** and Gardner (1983). During the course of the school year, each grade level participates in six units of inquiry, which last approximately 6 weeks. Natural breaks in the school calendar may impact on the length of each Unit of Inquiry. Each year the students explore the following themes: (a) Who We Are, (b) Where We Are in Place and Time, (c) How the World Works, (d) How We Express Ourselves, (e) How We Organize Ourselves, and (f) Sharing the Planet (IBO, 2000).

At the beginning of each Unit of Inquiry, the PYP teacher seeks to determine each child's current understanding of a topic (IBO, 2000). Based on these findings, the teacher then assists students to link new information to their prior knowledge by the provision of opportunities for discussion as well as collaboration. Students are expected to choose and pursue a personal line of inquiry**,** which should culminate in taking some form of action based on what they have learned.

To fully participate in the PYP curriculum, students need to: (a) have good social and communication skills, (b) understand abstract words and concepts, and (c) be able to integrate the bits and pieces into the whole. However, social and communication skills are the two great weaknesses for students with ASD. In addition, students with ASD may lack the vocabulary, including conceptual vocabulary, to speak or write about their observations. In the conduct of their study, Knight et al. (2012) found that "the challenge in using inquiry in an activities-based approach for students with ASD, is finding a way to concurrently teach the conceptual vocabulary needed to describe the phenomena observed" (p. 379). Furthermore, often, these students demonstrate weak central coherence, which makes it difficult for them to synthesize the information they learn in class.

Summary

The ability to retain and later retrieve information is vital to children's social, emotional**,** and academic development (Phelan et al., 2011). However, it is difficult for some children with ASD to retain and retrieve information. Consequently, researchers (Bowler, Limoges, & Mottron, 2009; Gabig, 2008; Lind & Bowler, 2009; McCrory et al., 2007; Phelan et al., 2011; Poirier et al., 2011) have examined the difficulties that students with ASD exhibit during free recall tasks that involve the recall of: (a) numbers, (b) lists of words, (d) stories, and (e) personal

experiences. To address these difficulties with free recall, researchers have studied the effectiveness of: (a) concept mapping (Roberts & Joiner, 2007); (b) rehearsal ((Bebko & Ricciuti, 2000; Rhee, 2009); (c) enactment (Zalla et al., 2010); and (d) provision of visual and/or semantic cues (Bowler et al., 2010; Phelan et al., 2011; Sze, 2009) as strategies to use to increase retention as well as retrieval of information. Researchers have noted the need for more detailed studies of the relationship between learning strategies and later recall, particularly among subgroups of students with ASD (Brunner & Seung, 2009; Mesibov & Shea, 2011; Phelan et al., 2011; Poirier et al., 2011; Rhee, 2009).

Moreover, researchers have noted that the utilization of CAI is compatible with the learning characteristics of students with ASD (Blischak & Schlosser, 2003; Bosseler & Mossaro, 2003; Pennington, 2010). However, the committee members of the National Standards Project Report (2009) classified technology as an emerging intervention, that is, there is a need for the conduct of more high quality studies. Pennington (2010) recommended that future researchers study the effectiveness of inexpensive, commercially available computer programs. Additionally, Knight et al. (2012) emphasized the need to find ways to involve students with ASD in inquiry-based inclusive classrooms. In response to this need, Smith (2012) examined the use of PowerPoint slides on the iPad® to provide embedded vocabulary instruction to students with ASD. In an attempt to extend Smith's research, the purpose of this current study was to examine the use of affordable iPad® apps to provide embedded curricular vocabulary instruction to students with ASD. Also, I examined the effectiveness of these apps on the ability of students with ASD to retain and retrieve Unit of Inquiry vocabulary for use in classroom speaking activities and in order to complete end-of-unit reflection sheets.

CHAPTER THREE: METHODS

The purpose of this single subject multiple probe across behaviors, with concurrent replication across participants, design study was to examine the effect of the combination of the use of two iPad® apps on the ability of five students with autism spectrum disorder (ASD) to learn and use vocabulary words. These students with ASD used a combination of the Popplet iPad® app and Futaba Classroom Games for Kids iPad® app to learn and practice vocabulary from their Primary Years Programme (PYP) Units of Inquiry. I recorded the number of vocabulary words the participants: (a) learned, (b) used during Unit of Inquiry lessons in their inclusive classroom, and (c) used on the end-of-unit reflection sheets.

In this chapter, I have provided an explanation of the research design, research questions, instruments, and procedures. Also, I have included a detailed description of the participants and settings for the study. Lastly, I have concluded with a discussion of the choice of data analysis which was employed in this study.

Design

For this study, a single-subject multiple probe across behaviors with concurrent replication across participants design (Gast, 2010; Horner & Baer, 1978, Tawney & Gast, 1984) was chosen. I chose this design as a means to investigate the effectiveness of an intervention for five individuals with ASD attending international primary schools in Hong Kong.

Sidman (1960), a behavioral scientist, was the first researcher to describe single-subject research methodology. Single-subject research is quantitative research (Gast, 2010). Single-subject research is characterized by: (a) the introduction of an intervention, (b) baseline logic, (c) experimental control, (d) repeated measurement of specific behaviors, (e) the individual as the unit of analysis, and (f) the lack of randomization of participants (Gast, 2010; Horner et al.,

2005). Baer, Wolf, and Risley (1968) followed with a more detailed explanation in regard to the usefulness of this research methodology for evaluation of one-on-one intervention strategies. In particular, these researchers introduced single-subject multiple baseline designs. Later, Horner and Baer (1978) introduced the multiple probe research design.

The multiple probe research design begins with the collection of pre-intervention data. Once a stable baseline has been established, the researcher introduces the intervention for the first behavior, condition, or participant. When criterion level performance is achieved, the researcher introduces the intervention for the second behavior, condition**,** or participant. When criterion level performance is achieved for the second tier of intervention, the researcher introduces the intervention for the third behavior, condition**,** or participant. Throughout each of the three tiers of intervention, the researcher collects data on an intermittent basis in order to record any change in the dependent variable as a result of the introduction of the independent variable.

Today, single-subject research design studies appear in more than 45 journals (Gast & Ledford, 2014), which is an indication of their growing acceptance in the field of research. Additionally, because individuals with ASD display such a wide variety of characteristics, single subject research designs are considered more practical and less expensive to conduct than the large randomized controlled trial experiments, which are usually used by researchers to demonstrate the effectiveness of an intervention with students without disabilities (Barlow, Nock, & Hersen, 2009; Mesibov & Shea, 2011).

Once research questions are formulated, the questions serve as a guide toward the choice of the most appropriate research design (Gast, 2010). The research questions in this study are focused on participants diagnosed with ASD, a population that lacks the large numbers needed

for typical randomized control group design studies. Therefore, I employed a single subject research design. Although there are a number of single subject research designs to choose from, the multiple probe design provides the flexibility, rigor, and practicality required for research in an applied setting.

In an analysis of single subject research studies conducted from 1983-2007, Hammond and Gast (2010) noted an increase in the use of combination designs. For example, when two multiple probe designs are conducted, the researcher can address limitations and improve experimental control. Consequently, the multiple probe across behaviors with concurrent replication across participants design, a design used by other researchers (Flores & Ganz, 2007; Flores & Ganz, 2009; Knight, Smith, Spooner, & Browder, 2012; Ledford, Gast, Luscre, & Ayres, 2008; Mechling & Hunnicutt, 2011; Oppenheim-Leaf, Leaf, & Call, 2012; Smith, 2012; Spooner, Jimenez, & Browder, 2011) in the field of autism, was chosen for this study.

I sought to meet the highest level, Rating 5, of the National Autism Center Scientific Merit Rating Scale (Howard, Ladew**,** & Pollack, 2009) to determine whether the methods used in a study were rigorous enough to determine the effectiveness of an intervention designed for students with ASD. To achieve a Rating 5, the researcher must include at least three participants, who have received a diagnosis of ASD from a qualified professional. The diagnosis must be based on the *DSM* (*DSM-IV-TR, 2000; DSM-5, 2013*) criteria or *International Classification of Diseases (ICD-10*; World Health Organization, 1992) criteria. Additionally, the researcher must collect reliability data for at least 25% of the sessions, and the inter-observer agreement for these data must be at least 90%. Furthermore, the researcher must collect procedural fidelity data for at least 25% of the intervention sessions, that is, the intervention must be implemented accurately at least 80% of the time, and the inter-observer agreement for these

data must be at least 80%. Finally, the researcher must collect both maintenance and generalization data.

Research Questions

The purpose of this study was to explore information retrieval in students with ASD in the context of the Primary Years Programme (PYP), the primary version of the International Baccalaureate ® (IB). The following research questions were addressed.

1. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to learn Unit of Inquiry vocabulary in the inclusive classroom?
2. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary during Unit of Inquiry lessons in an inclusive classroom setting?
3. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary when completing end-of-unit reflection sheets?

Setting

Two British international primary schools in Hong Kong were chosen as the sites for this study. Most of the British international schools in Hong Kong are part of a larger system, comparable to a school district in the United States. This British school system was originally established by the Hong Kong government to provide the children of English speaking expatriates with an English education. The school system has grown, and now it consists of four

preschools, nine primary schools, five secondary schools, a school for children with severe special needs, and two private independent schools. In anticipation of the English handover of Hong Kong to mainland China in 1997, many expatriates moved away from Hong Kong. Consequently, the faculty and staff of these British schools began to enroll children of other nationalities. Today, children from more than 50 nationalities are enrolled in these schools. The school system has transitioned from the British National Curriculum to the Primary Years Programme (PYP), which is the primary version of the International Baccalaureate® (IB).

Only recently have students with special needs been enrolled at other international schools in Hong Kong; however, at the school system in this study, such students have been enrolled for many years. During the 2013-2014 school year, Learning Support Class (LSC) placements were available to 112 primary students and 96 secondary students. An additional 64 placements were available at the special school for students with severe disabilities. Furthermore, this school system is the only large international school system in Hong Kong with a comprehensive system for the: (a) assessment, (b) placement, and (c) continual monitoring of students with special needs. Consequently, the schools in this school system provide the ideal setting for research with English speaking students with ASD**,** who currently live in Hong Kong.

Two participants in this study were students enrolled in the LSC at International Primary School A with a total population of 540 students. Also, all students, who were enrolled in the LSC, were members of an inclusive classroom, which contains 30 students. Each participant had a full-time LSC teacher or LSC educational assistant, who provided in-class support as well as withdrawal lessons when necessary.

At International Primary School A, each grade level consisted of three self-contained classes with 30 students in each class. Classroom furniture consisted of: (a) an interactive white

board attached to the wall, (b) built-in storage spaces along two walls, (c) a desk for the teacher, (d) a desk for the educational assistant, (e) 30 desks and matching chairs for students, and (f) a recharging unit for laptops.

The other three participants in this study were students enrolled in the LSC at International Primary School B with a total population of 900 students. I worked with the participants at this school. Also, these students were members of an inclusive classroom of 30 students and had a full-time LSC teacher or LSC educational assistant, who provided in-class support, differentiated assignments and, when necessary, withdrawal lessons for literacy, numeracy, and Units of Inquiry.

At International Primary School B, each grade level consisted of five classrooms with 30 students in each class. Each of the five classrooms were closed in on three sides, and the fourth side opened onto a large, rectangular common shared area. Classroom furniture consisted of: (a) two large square tables, (b) a raised table with accompanying backless bar height seats, (c) two narrow rectangular tables, (d) two semi-circular tables, and (e) a boomerang shaped table.

Students at International Primary School B were encouraged to consider the entire school grounds as their classroom. Consequently, the students might chose to work: (a) in the common shared area for their grade level, (b) the common shared area outside the music rooms, (c) the Access Centre, (d) another teacher's classroom, or (e) the library. As a result, the intervention and the recordings did not always take place in the participant's assigned classroom. Instead, I supervised the intervention and recordings wherever the participants were around school. Due to time constraints, some probe sessions took place in these various work settings around school. However, the majority of probe sessions took place in the Access Centre.

The Learning Support Classroom was renamed the Access Centre. The Access Centre was an entire suite which included: (a) a foyer; (b) two bathrooms designed to accommodate students with physical handicaps; (c) a small teaching room; (d) a small calming room; (e) a storage and prep room; (f) two medium sized teaching rooms; and (g) a room which served as an office, meeting room, and teaching space. The office space had floor to ceiling glass on three sides, which allowed oversight of movement throughout the Access Centre.

Participants

The participants for this study were five English speaking students, ages 8 to 11, with a diagnosis of ASD and classification as LSC students. These participants attended international primary schools in Hong Kong. A narrative description of each participant is presented below. The actual names of participants have been replaced with pseudonyms.

Edward

At the beginning of this study, Edward, an Asian male, was 11 years 9 months old, diagnosed with: (a) ASD, (b) attention deficit disorder (ADD), and (c) intellectual disability. When he was younger, his Full Scale IQ was reported to be 73 and more recently to be 52. However, the educational psychologist stated that the more recent IQ scores should be interpreted with caution, due to his distractible behaviors during the days of testing. Edward was fluent in both Cantonese and English. At home, Edward spoke Cantonese, the Chinese dialect spoken in Hong Kong. He attended an international school, where English was used as the medium of instruction. At school, Edward participated in a daily 45 minute lesson in Mandarin, the Chinese dialect spoken in mainland China.

Edward received one-on-one instruction in the Access Centre for mathematics and literacy, and he required adult support to be included in the general education classroom for Unit

of Inquiry lessons as well as music, physical education (PE), and Mandarin lessons. Edward had good rote mathematical skills and was beginning to develop conceptual understandings in mathematics. Edward's word reading skills were 3 years below his chronological age, and his comprehension skills were more than 5 years below his chronological age. Edward had a pleasant personality and enjoyed coming to school each day.

Emmanuel

When this study began, Emmanuel, an Asian male, was 11 years 1 month old, diagnosed with: (a) ASD, (b) attention deficit hyperactivity disorder (ADHD), (c) obsessive-compulsive disorder, (d) sensory integration disorder, and (e) social anxiety. His Full Scale IQ was not computed, due to a 45 point difference between verbal and performance IQ. Emmanuel was fluent in four languages. He spoke Cantonese and another Asian language at home. Emmanuel attended an international school, where English was used as the medium of instruction. At school, Emmanuel participated in a daily 45 minute lesson in Mandarin, the Chinese dialect spoken in mainland China.

Emmanuel was included in the general education classroom for instruction in mathematics, Unit of Inquiry, music, PE, and Mandarin. Although Emmanuel's word reading skills were 1 year above his chronological age, his comprehension skills were more than 2 years below his chronological age. Consequently, he came to the Access Centre for lessons in reading and writing as well as social skills. For more than 4 years, Emmanuel had been prescribed medication to control his impulsiveness and increase his attention. Additionally, Emmanuel was sensitive to loud noises. Emmanuel was beginning to develop self-starting skills in subjects, which would be considered his strengths.

Jesse

At the beginning of this study, Jesse, an Asian male, was 11 years 2 months old, diagnosed with ASD. He had a Full Scale IQ of 123. Jesse was fluent in Cantonese, English, and Mandarin. At home, Jesse spoke Cantonese, the Chinese dialect spoken in Hong Kong. He attended an international school, where English was used as the medium of instruction. At school, Jesse participated in a daily 45 minute lesson in Mandarin, the Chinese dialect spoken in mainland China.

Jesse was included in the general education classroom for instruction in mathematics, Unit of Inquiry, music, PE, and Mandarin. Although Jesse's word reading skills were appropriate for his chronological age, his comprehension skills were more than 2 years below his chronological age. Consequently, he came to the Access Centre for lessons in reading and writing as well as social skills. When he was younger, he was diagnosed with speech delay. At the time of this study, Jesse had progressed to speaking in sentences, although with little variation in his tone, and his topics of conversation were limited to a few narrow topics. Jesse was beginning to be able to follow and contribute to classroom discussions.

Seth

When this study commenced, Seth, an Asian male, was 8 years 11 months old, diagnosed with ASD. He had a Full Scale IQ of 99. Seth was fluent in both Cantonese and English. At home, Seth spoke Cantonese, the Chinese dialect spoken in Hong Kong. He attended an international school, where English was used as the medium of instruction. At school, Seth participated in a daily 45 minute lesson in Mandarin, the Chinese dialect spoken in mainland China.

Seth was included in the general education classroom for all lessons. His word reading skills were considered to be average for his age. However, Seth's reading comprehension and reasoning skills were 2 years below his chronological age, and his ability to make inferences was limited. He was a perfectionist, who frequently erased and rewrote words as well as entire sentences. Seth had a cheerful personality and enjoyed coming to school.

Theo

At the start of this study, Theo, an Asian male, was 10 years 1 month old, diagnosed with ASD and ADHD. He had a Full Scale IQ of 94. Theo was fluent in both Cantonese and English. At home, Theo spoke Cantonese, the Chinese dialect spoken in Hong Kong. He attended an international school, where English was used as the medium of instruction. At school, Theo participated in a daily 45 minute lesson in Mandarin, the Chinese dialect spoken in mainland China.

Theo was included in the general education classroom for all lessons. His word reading skills were average for his age. However, his reading comprehension was more than 2 years below his chronological age. Although Theo was actually more than a year older than his classmates, he did not stand out in terms of size or maturity. Theo did not like unexpected changes in routine, demonstrated repetitive behaviors, and was prescribed Ritalin to help control his hyperactivity. Theo was able to match vocabulary words and definitions fairly quickly. However, his ability to formulate his own definitions and answers to questions was limited.

A summary of the demographic information for these participants are displayed in Table 2. While the family's income level has not been reported, it should be noted that the international schools involved in this study charge a refundable capital levy of US $3,571, a deposit of US $1,282, and an annual tuition fee of US $8,974 per child.

Table 2

Demographic Information for Participants

	Age	Gender	Year in School	Diagnosis	Verbal Comprehension	Full Scale IQ	Receptive Vocabulary PPVT
Edward	11.9	M	Year 6*	Autism Spectrum Disorder (CARS) Attention Deficit Disorder Intellectual disability	68 WISC-IV	73/52 WISC-IV	5 years 7 months -3 SD
Emmanuel	11.1	M	Year 6*	Autism Spectrum Disorder Attention Deficit Hyperactivity Disorder Obsessive-Compulsive Disorder Sensory Integration Disorder Social Anxiety	65 WISC-IV	not computed	6 years 9 months -2 SD
Jesse	11.2	M	Year 6*	Autism Spectrum Disorder (ADOS-3)	114 WISC-IV	123 WISC-IV	8 years 0 months -1.5 SD
Seth	8.11	M	Year 4**	Autism Spectrum Disorder (CARS)	91 WISC-IV	99 WISC-IV	6 years 9 months -1 SD
Theo	10.1	M	Year 4**	Autism Spectrum Disorder (CARS) Attention Deficit Hyperactivity Disorder	83 WISC-IV	94 WISC-IV	13 years 11 months +1 SD

Note. *Year 6 in Hong Kong is equivalent to Grade 5 in the United States. **Year 4 in Hong Kong is equivalent to Grade 3 in the United States.

Number of Participants

International Primary School A had three grade levels with a total number of seven LSC students between 7 and 11 years old, who were diagnosed with ASD. International Primary School B had three grade levels with a total number of six LSC students between 7 and 11 years old, who were diagnosed with ASD. Therefore, the sampling pool contained 13 potential participants. From this sampling pool, one grade level from each school was chosen for inclusion in this study. Consequently, five participants were chosen for this study. Researchers who use single subject research designs usually try to involve three or more participants in their study as replication of results with several participants increases the external validity of any study (Gast, 2010).

Autism Spectrum Disorder

After receiving permission from the members of the Liberty University Institutional Review Board (IRB), the principals of both schools, and the parents of the participants, I reviewed the school copy of each participant's report from the educational psychologist. The purpose of this review was to ensure that the description of the child's characteristics matched criteria for ASD as provided in *The Diagnostic and Statistical Manual for Mental Disorders* (4th ed. revised; *DSM-IV-TR*; American Psychiatric Association, 2000). The diagnostic criteria from this manual were used to identify the qualitative impairments in social interaction and speech as well as accompanying repetitive behaviors. The criteria listed in the *DSM-IV-TR* are also used in Hong Kong to diagnose ASD (Peters & Forlin, 2011). Although new diagnostic criteria have recently been published in the *Diagnostic and Statistical Manual for Mental Disorders* (5th ed.; *DSM – 5*; American Psychiatric Association, 2013), all participants in this study were diagnosed at an earlier date based on the criteria from the *DSM-IV-TR*.

Learning Support Classes

In Hong Kong, many expatriate and local English speaking children who are diagnosed with ASD begin their schooling in an LSC in one of the primary schools of a large international school system. There is a trend toward renaming the LSCs and calling them Access Centres. However, because the term, Learning Support Class, is still commonly used among educators and parents in Hong Kong, this term is used throughout this dissertation. Parents who are interested in an LSC placement for their child must first provide a comprehensive report from an educational psychologist. After the school system has received the report, two LSC teachers will: (a) read it, (b) observe the child in a school setting, and (c) speak with the parents and the classroom teacher. The two LSC teachers then present the information at a Moderation Panel meeting, and the panel members make the decision as to whether the child should be recommended for: (a) a general education classroom placement, (b) an LSC placement, or (c) a special school placement.

For many years, the faculty and staff of this school system have provided a matrix to describe provisions at each level, as well as descriptors in order to assess a student's levels of adjustment in the following areas: (a) curriculum differentiation, (b) understanding and use of language, (c) social competency, (d) self-regulation, (e) facilitation of communication, and (g) health care. During 2012, this matrix was under revision. In January of 2013, the Moderation Panel members began to use the new matrix to assess a student's levels of adjustment in the areas of: (a) thinking and learning, (b) speech and language, (c) emotional and social well-being, (d) social communication, (e) motor coordination, (f) sensory processing, and (g) medical needs. Children, who score in the 1 and 2 range on the matrix, are considered mainstream children who require extra support. Children, who score in the 3 and 4 range, are assigned to an LSC, which is

subsidized by the Hong Kong government. These children may receive some instruction in the Learning Support classroom. However, they are also integrated into inclusive classroom activities as much as possible. Children**,** who score in the 5 and 6 range, are recommended to attend a special school for children with more severe needs.

During the school year in which the data were collected for this study, there were nine primary schools with established LSCs to provide educational placement for 112 students in Grades K-5. Students with a wide range of special education needs are enrolled in the LSCs. Consequently, due to their age or the nature of their disabilities, not all students in LSCs were potential candidates for participation in this study.

Sampling

According to a survey conducted in 2006 and 2007, the number of individuals with ASD who lived in Hong Kong was estimated to be 3,800; 2,500 of those individuals were under the age of 15 (Hong Kong Census and Statistics Department, 2008). Although those numbers would seem to suggest a large population for research, the majority of those children and teenage youth speak Cantonese, the Chinese dialect spoken in Hong Kong, and attend Cantonese speaking schools. However, the focus of this study was on English speaking students with ASD, who live in Hong Kong; so the availability of participants was much more limited than might otherwise be the case in other areas of the world. Also, it should be noted that in Hong Kong, when preschool students are diagnosed with ASD, usually, their parents are encouraged to focus on one language at home. Consequently, a LSC in this school system may include: (a) Caucasian students whose parents speak English fluently, (b) ethnically Chinese children whose parents speak English and Cantonese fluently, or (c) ethnically Indian children whose parents speak English and an Indian dialect fluently.

The Department Head at International School A provided me with a list of all of the LSC students with ASD who attended that school. Additionally, I compiled a list of the LSC students with ASD who attended International School B. These lists are referred to as sampling frames (Gall, Gall, & Borg, 2007). At International School A, two Year 3 LSC students, three Year 4 LSC students, and two Year 6 LSC students had been diagnosed with ASD. At International School B, one Year 3 LSC student, two Year 4 LSC students, and three Year 6 LSC students had been diagnosed with ASD. A single stage design was used, since I had access to the lists of the LSC students with ASD who attended both schools.

The participants for this study were selected by the use of purposive sampling of students at two primary schools, which are in close proximity to each other. Logistically, it would be quite difficult to work with students across several grade levels at two separate sites. Consequently, I provided recruitment letters to the general education teacher at each site who had the greatest number of students with ASD. Five sets of parents were willing to have their child participate in the study. Consequently, no more recruitment letters were sent home as five participants exceeded the National Autism Center Scientific Merit Rating Scale (Howard et al., 2009) criteria for the minimum number of participants needed for a single subject study. Individual meetings were arranged with the parents of potential participants in order to explain the study and receive permission for their students to participate in the study.

Research Assistant

A female research assistant (RA) recorded the participants during speaking activities in the inclusive classroom and transcribed the recordings. Also, the RA was the inter-rater, who tallied the number of targeted Unit of Inquiry vocabulary spoken or written by the participants. The RA first earned a Bachelor of Science degree from a Canadian university with a major in

psychology and a minor in biology and physiology. Upon returning to Hong Kong, the RA earned a master's degree in special education from a university in Hong Kong. The RA has: (a) taught life skills to non-verbal teenagers diagnosed with ASD, (b) worked as an RA for a professor at a university in Hong Kong**,** and (c) worked as an educational assistant for students with mild and moderate learning difficulties. At the time this study was conducted, the RA was enrolled part-time in a teacher education degree program. The RA was not employed by either of the schools where the research was conducted for this study.

Instrumentation

The students at many international schools in Hong Kong demonstrate varying levels of English acquisition. Consequently, I chose to assess each participant's level of English vocabulary. I used the Peabody Picture Vocabulary Test (PPVT-4**) (**Dunn & Dunn, 2007) to assess each participant's level of receptive vocabulary. This information will be useful for practitioners as well as future educators. In this section, I describe a social validity instrument as well as the app, which was used to assess acquisition of Unit of Inquiry vocabulary.

Peabody Picture Vocabulary Test-4

The PPVT-4 (Dunn & Dunn, 2007) was used to measure each participant's level of English. The PPVT-4 is an individually administered, standardized test of receptive vocabulary. It was designed to assess content area vocabulary and parts of speech for individuals, who range in age from 2.6-90 years old. Both Form A and Form B contain 228 items, which have been divided into 19 sets. The testing materials consist of a booklet, which can be displayed in easel format so that the examinee can view four colorful pictures at one time. The examiner says a word, and the examinee points at the picture that corresponds to the spoken word. The test is not timed but, generally, it takes from 10-15 minutes to complete one Form.

The reliability of the PPVT-4 (Dunn & Dunn, 2007) is: (a) 0.94 for Form A and Form B, (b) 0.89 for alternate form reliability, and (c) 0.93 for test-retest reliability. Both forms are reported to have an internal consistency coefficient of 0.97 (Lau, 2013). Each participant completed the PPVT-4, and the scores were reported so that comparisons can be made by practitioners as well as future researchers.

Intervention Rating Profile 15

The Intervention Rating Profile 15 (IRP-15) (Witt & Elliot, 1985) was used to measure the social validity of the use of both the Futaba Classroom Games for Kids iPad® app and the Popplet iPad® app as perceived by the teachers and teachers' aides, who worked with the participants on a regular basis. Although a number of instruments are available for the measurement of social validity, Finn and Sladeczek (2001) evaluated nine instruments for the measurement of social validity and were unable to recommend one instrument as being more comprehensive than the others. Originally, the IRP-15 was termed, the Intervention Rating Profile (IRP) (Witt & Martens, 1983), and it was designed to extend the concept of social validity into the field of education, in order to allow researchers to record which interventions were perceived by teachers to be effective in an educational setting (Carter, 2009). The IRP consisted of 20 items**,** which were rated with a 6 point Likert scale; 1 represents Strongly disagree, and 6 represents Strongly agree. The internal consistency of this first version was 0.89 (Tarnowski & Simonian, 1992).

The IRP (Witt & Martens, 1983) was later modified in order to shorten the assessment and "increase item loading on a single factor" (Carter, 2009, p. 52). Thirteen previous items were removed, and 8 new items were included in the revised assessment, which results in 15 items. The new IRP-15 (Witt & Elliot, 1985) has an internal consistency of 0.98 and requires a

score of 52.5 out of 90 for the intervention to be considered at a moderate level of acceptability (Carter, 2009). Additionally, the IRP-15 has a readability level of 7.9 (i.e., 7th grade 9th month) (Harris & Jacobson, 1982).

Measurement of Dependent Variables

The Futaba Classroom Games for Kids app was produced by INKids in order to provide an entertaining way for students to master key foundational information and concepts (Clare & Rachel, 2012). The Futaba Classroom Games for Kids app allows educators to choose from a selection of prepared learning sets or to create their own learning sets. To create their own learning sets, teachers can enter: (a) pictures and associated words, (b) questions and answers, or (c) vocabulary words and definitions. These learning sets are then embedded into the Futaba game format for single or multi-player use. Also, the Futaba app provides Cloud service, which allows teachers to create learning games on one iPad® and then easily transfer those games to other iPads. In addition to being used as part of the intervention, this game app was used in probe trial sessions to gather baseline data and intermittent probe sessions throughout the intervention to collect data on the first dependent variable, the acquisition of Unit of Inquiry vocabulary.

The second dependent variable, the functional use of Unit of Inquiry vocabulary during speaking activities in the inclusive classroom setting, was measured by video and audio recording of the participants. At least one time during each of the Units of Inquiry, either the research assistant or I digitally video and audio recorded each of the participants during speaking activities in his inclusive classroom. The research assistant or I digitally recorded each participant's interactions, and then used the recordings to tally the number of Unit of Inquiry vocabulary spoken by the participants during these speaking activities in the inclusive classroom.

The third independent variable was the end-of-unit reflection sheet. At the beginning of each Unit of Inquiry, the general education classroom teacher gave each student a reflection sheet with three questions or headings. The questions or headings were related to the central idea of the Unit of Inquiry. Next, the teacher instructed the students to answer the questions or write down everything they already knew about the Unit of Inquiry, which they were about to study. At the end of each Unit of Inquiry, the general education classroom teacher gave each student another copy of the same reflection sheet. Once again, the teacher told the students to answer the questions or write down everything they knew about the topics of the Unit of Inquiry. I also gave a verbal prompt: "Write down everything you learned from the iPad." After each participant completed the end-of-unit reflection sheet, I tallied the number of Unit of Inquiry vocabulary words each participant had used on the end-of-unit reflection sheet. Although I cannot report measures of reliability for the end-of-unit reflection sheet, for purposes of social validity, I found that learning was demonstrated through the number of Unit of Inquiry words written on the end-of-unit reflection sheet.

Procedures

In this section, I have described the steps required to gain permission for research and the preliminary activities, which were completed prior to beginning the intervention. Next the intervention has been described in detail so that future researchers can replicate and extend this study. Information on reliability and procedural fidelity procedures are also included in this section.

Permission

Permission to conduct this research study was granted by the principals of the two primary international schools in Hong Kong (see Appendix A). Next, permission to conduct the study was granted by the members of the Liberty University Institutional Review Board (IRB). Recruitment letters were given to the general education teacher at each school who had the largest number of students with ASD. Permission for research was requested from those parents, who indicated an interest in having their child participate in the study (see Appendices C and D). Once parental written permission was obtained, I scheduled an initial 30 minute session with each of the students in their natural school setting. During each session, I: (a) sought to establish a comfortable working relationship with the participant, (b) introduced the study via an iPad Activities Explanation sheet (see Appendix E), and (c) obtained written assent from the participant (see Appendix F). Also, I introduced the research assistant and explained her role so the participants were not surprised to see the research assistant at school.

During the reading of the iPad® Activities Explanation sheet, I introduced the Popplet and Futaba Classroom Games for Kids iPad® apps to the participants. Also, the iPad® Activities Explanation sheet was designed to be used to explain a potential reward system. Motivation is considered to be a key factor, which contributes to academic success. This is particularly true of students with ASD who often respond positively to the provision of token economies (Allyon & Azrin, 1968; Cooper, Heron, & Heward, 2007; Matson, 2009; Tarbox, Ghezzi, & Wilson, 2006).

Therefore, in order to encourage cooperation, I planned to give participants green stickers for their demonstration of cooperation throughout each session. Participants would have the option of using 15 stickers to choose a prize from the small Treasure Box or using 30 stickers to choose a prize from the big Treasure Box. The small Treasure Box would contain stickers,

pencils, pens, erasers, small plastic animals, and the like. The large Treasure Box would contain paperback books, origami paper, hand puppets, small Lego kits, slime, and the like. The items in both boxes would be based on the students' interests.

However, the LSC teacher at International Primary School A indicated that the participants at her school were cooperative and did not need a reward system. Additionally, the participants at International Primary School B had outgrown the sticker and Treasure Box system. Therefore, I did not show the participants the third page of Appendix E, and I did not use the sticker and Treasure Box system with the participants. Nevertheless, other researchers might find this system useful with participants who may lack motivation or perseverance.

Prior to a student's initial entry into the international schools involved in this study, parents sign a form, which gives consent for the digital and audio recordings of their children. Nevertheless, an informational letter, to explain this current research study, as well as a consent form were given to the parents of non-participants who might be digitally or audio recorded during the course of the research (see Appendix G).

Preliminaries

Choice of vocabulary words. It is important to note that a dynamic curriculum is used in the PYP. Within a framework of six pre-determined broad themes, the PYP Coordinator plans the scope and sequence for the six Units of Inquiry at each grade level of the school. Before a new Unit of Inquiry is initiated, all of the general education teachers for a particular grade level meet with the PYP Coordinator and collaboratively plan the next Unit of Inquiry. Sometimes, the Unit of Inquiry remains fairly similar to the previous year; however, other times, there are drastic changes to the Unit of Inquiry.

Because the curriculum is planned by the teachers at each school, there is no set of recommended grade appropriate vocabulary words in the PYP curriculum. As a result, the general education teacher, the LSC teacher, and I collaborated to produce a list of vocabulary and short informational sentences for Unit of Inquiry A, B, and C. I then used these words and sentences to prepare a Popplet lesson and associated Futaba Game for each Unit of Inquiry.

Social validity questionnaire. Teachers and teachers' aides, who worked directly with the participants, completed a predictive social validity questionnaire (Witt & Elliot, 1985). The purpose of this questionnaire (see Appendix I) was to allow educators to comment on the perceived usefulness of the proposed intervention. When the student participants had completed the intervention, teachers and teachers' aides completed the same social validity questionnaire.

Standardized test. I scheduled a second session with each participant in order to administer a vocabulary test. I administered the PPVT-4 (Dunn & Dunn, 2007), a standardized test for receptive vocabulary. Each participant's scores have been reported in Table 2 in order to provide educators with a basis for the comparison of their own students' vocabulary levels with the vocabulary levels of the participants.

Baseline data. I gathered baseline data for the first research question by the conduct of a probe trial. During the probe trial, I collected data for Unit of Inquiry A. Participants answered the vocabulary questions on the Futaba Classroom Games for Kids iPad® app. I did not comment on whether the participant's answer was right or wrong. I recorded a plus sign (+) for correct responses and a minus sign (-) for incorrect responses. I continued to collect probe data for Unit of Inquiry A for three more sessions. Participants completed these probe trial activities during the regular instructional time in a quiet room away from the inclusive classroom. I collected baseline data for the second research question through a Functional Speech

Questionnaire (see Appendix O). Also, I gathered baseline data for the third research question by a review of the participant's most recent end-of-unit reflection sheet and tally of the number of: (a) topic related sentences, (b) topic related phrases, and (c) topic related words.

Participant training. The students who participated in this study did not need training in how to use an iPad® as they had used iPads® on a regular basis for 2.5 years. However, it is difficult for many LSC students to maintain attention to task. When given an iPad®, many students will flick from one app to another app. Therefore, apps, which were already on the school's iPads®, were placed in folders in order to minimize potential distractions. During regular instructional time, I trained each participant to follow a script (see Appendix J) to help ensure procedural fidelity. The directive in step six was designed to provide explicit teaching of a rehearsal strategy to students with ASD as recommended by Bebko and Ricciuti (2000).

Intervention

Whereas the preliminary activities took place in a room away from the inclusive classroom, I planned that the actual intervention would take place in the inclusive classroom. I planned to embed direct instruction of Unit of Inquiry vocabulary into the regular activities in the inclusive classroom. However, many times the students were allowed to work in other areas of the school such as: (a) the common area shared by all the classes in the grade level, (b) the common area outside the music rooms, (c) another teacher's classroom, (d) the learning support classrooms, or (e) the library. Therefore, I embedded direct instruction of Unit of Inquiry vocabulary into the regular activities wherever the participants were working throughout the school.

Intervention for Unit of Inquiry A. Unit of Inquiry sessions can vary in length ranging from 45-90 minutes. Often, the teacher begins the session with the whole class. During the rest of the Unit of Inquiry session, frequently, students collaborate with a classmate or small group of three to six classmates. Each student fulfills a role within the group and completes a task which contributes to the fulfillment of the goal of the group. Therefore, each participant in this study had flexibility in this setting to transition back and forth between the intervention and his inquiry task.

For each Unit of Inquiry session, I collaborated with the general education teacher to determine the most convenient times for the intervention to take place within the Unit of Inquiry session. I prompted the participant to complete the Popplet lesson and the Futaba Game for Unit of Inquiry A during a Unit of Inquiry lesson in the inclusive classroom. Each participant followed a script (see Appendix J) which asked him to: (a) open the Popplet Unit of Inquiry A lesson on the iPad®, (b) read and listen to the lesson one time, (c) open the Futaba app to the game corresponding to that lesson, and (d) play the game one time.

I had planned that, at the next convenient time in the Unit of Inquiry session, the participant would complete the intervention a second time, and at the third convenient time in the session, the participant would complete the intervention a third time. However, when I used this method on the first day of the intervention, none of the participants were able to quickly shift their concentration from the iPad® activities back to the Unit of Inquiry session. By the time they were just beginning to get some work done, it was time to return to the iPad® intervention. I concluded that this method was disrupting their learning. Consequently, on the second day of the intervention and, thereafter, I requested that the participant complete all three phases of the intervention in one sitting. As a result, the participants concentrated on the iPad activities until

the intervention was completed for that day, and then the participants concentrated on the Unit of Inquiry session for the remainder of the time.

Each participant completed the app intervention 3-4 days per week until: (a) criterion level performance was attained, (b) level stability was established, or (c) the Unit of Inquiry came to an end. Criterion level performance was the demonstration of mastery at 80% on the Unit of Inquiry vocabulary words during three probe data collection sessions. I was present at each intervention session. A procedural fidelity checklist (see Appendix J) was completed for 55% of the intervention sessions.

Collection of probe data for Unit of Inquiry A. During the intervention phase, I used the Futaba Game for Unit of Inquiry A for intervention and the collection of probe data. In order to collect probe data, I recorded the number of correct responses provided by the participant during the playing of the Futaba Game. Criterion level performance was set at the demonstration of mastery of 80% of the Unit of Inquiry vocabulary words during three probe data collection sessions. Once a participant had attained criterion level performance or reached stability level, I waited 1 week and then collected maintenance data for Unit of Inquiry A.

Unit of Inquiry B and C. Once a participant had attained criterion level performance or reached stability level for Unit of Inquiry A, I then repeated the same intervention, probe data collection**,** and maintenance procedures for Unit of Inquiry B. When a participant had reached criterion level performance or stability level for Unit of Inquiry B, I then repeated: (a) the intervention, (b) probe data collection, and (c) maintenance procedures for Unit of Inquiry C.

Video and audio recording. At least one time during each of the Units of Inquiry, the research assistant or I digitally video and audio recorded each participant during speaking activities in the inclusive classroom or the inclusive settings found throughout the school. We

used a Makayama Movie Mount with a .45x wide angle lens and a single shot microphone to record the speaking activities. For recording purposes, an iPad®, mini-iPad, and iPhone are some of the electronic devices, which can be attached to the Makayama Movie Mount. We sought to digitally record each participant's interactions during these times with a view toward later tallying the number of targeted Unit of Inquiry vocabulary spoken by each participant during the speaking activities in the inclusive classroom.

End-of-unit reflection sheet. At the beginning of each Unit of Inquiry, the general education classroom teacher gave each student a reflection sheet with three questions or topical headings. Next, the teacher instructed the students to answer the questions or write down everything they knew about the Unit of Inquiry they were about to study. Later, at the end of the Unit of Inquiry, the general education teacher gave the students another copy of the reflection sheet. The teacher asked the students to answer the same questions or write down everything they knew related to the Unit of Inquiry. When it was time for the participants in this study to complete the end-of-unit reflection sheet, I added the following verbal prompt "Write down everything you learned from the iPad®." The research assistant and I supervised the participants while they completed the end-of-unit reflection sheets. After the participants completed their end-of-unit reflection sheets, I tallied the number of Unit of Inquiry vocabulary words each of the participants had written on the end-of-unit reflection sheets.

Reliability and procedural fidelity. The National Autism Center Scientific Merit Rating Scale (Howard et al., 2009) is used to evaluate the rigor of the methods employed when implementing an intervention designed for students with ASD. To achieve the highest rating, a Rating 5, the researcher must collect reliability data for at least 25% of the sessions (Howard et al., 2009). In this study, inter-observer data were collected for 50% of the video and audio

recordings of speaking activities in the inclusive classroom, and inter-rater data were collected for 33% of the end-of-unit reflection sheets. Additionally, to achieve a Rating 5, the researcher must collect procedural fidelity data for at least 25% of the intervention sessions. In this study, the collection of procedural fidelity data (see Appendix J) occurred for 55% of the intervention sessions.

Social validity questionnaire. At the culmination of the third intervention phase, teachers and teachers' aides who worked directly with the participants were asked to complete a culminating social validity questionnaire. Although, often, the findings from measures of social validity are considered subjective, Wolf (1978) stated that "if our objective was. . . to do something of social importance, then we needed to develop better systems and measures for asking society whether we were accomplishing this objective**"** (p. 207). Consequently, the results from the social validity questionnaire provided an indication of the educators' perceptions of the social importance of this intervention.

Thank you letters. Finally, thank you letters were given to the principals, general education classroom teachers, LSC teachers, and teachers' aides. In addition, thank you letters were sent to the participants and their parents.

Data Analysis

Intervention Data

Graphic analysis was conducted by means of visual inspection and calculation of the percentage of non-overlapping (PND) data. Graphic displays are the most common form of data analysis for single-subject design studies as they allow for continuous visual analysis of data throughout the study (Cooper et al., 2007; Parsonson & Baer, 1978; Parsonson & Baer, 1992).

Visual analysis is based in the behavior-analysis research literature. Skinner (1963) preferred visual analysis of graphs to statistical methods and commented that:

> The simpler (direction observation) procedure is possible because rate of responding and changes in rate can be directly observed. . . . Statistical methods are unnecessary. When a variable is changed and the effect on performance is observed, it is for most purposes idle to prove statistically that a change has indeed occurred. (p. 508)

In visual inspection, there is an emphasis on clinical significance in order to determine whether the intervention had any practical value for the participant (Perdices & Tate, 2009). Considering the practical and cost effective nature of the Popplet app and the Futaba Classroom Games for Kids app, results, which indicate clinical significance, could lend credence to the social validity of the intervention (Gast, 2010).

I prepared a single subject research design graph for each of the participants for all three Units of Inquiry. Each participant's graph depicted the number of correct responses during the probe trial sessions, followed by the number of correct responses during the probe intervention sessions, and culminated in the number of correct responses during the probe maintenance session. Data points were analyzed for: (a) data trends, (b) level changes, and (c) level stability (Gast, 2010). The split-middle method (White & Haring, 1980) was used to describe a data trend of: (a) acceleration, (b) zero-celeration, and/or (c) deceleration. I calculated absolute level change and relative level change. Absolute level change was calculated by noting the first and last data points within a condition and subtracting the smaller number from the larger number. Relative level change was determined by: (a) calculation of the median value of the first half of the data points, (b) calculation of the median value of the second half of the data points, and (c) subtraction of the smallest median value from the largest median value. Additionally, I used the

80% - 25% criterion to analyze the last three to five data points in a condition, as recommended by Gast (2010) in order to determine level stability. The 80% - 25% criterion is a method that refers to the determination of whether 80% of the data points fall within the *stability envelope*, a term that refers to the space within 25% on either side of the median level of the data points being analyzed. When level stability is demonstrated, I can then be confident that it is the appropriate time to move on to the next condition.

Also, I calculated the percentage of non-overlapping data (PND). To obtain the PND, it is necessary to "divide the number of intervention data points that exceed the highest baseline data point by the total number of intervention phase data points, multiplied by 100" (Ganz & Flores, 2009, p. 79). Overlapping data would indicate that the intervention has had minimal impact on the dependent variables. In contrast, a higher percentage of non-overlapping data would suggest that a functional relationship exists between the independent and dependent variables. Although initial visual analysis may appear to obviously support the effectiveness of the intervention, for a treatment to be considered supported empirically and well established, in general, it must be replicated several times, and each successive study must produce results which support prior studies (Kratochwill & Stoiber, 2002).

Reliability Data

Inter-observer agreement was calculated by: (a) dividing the number of pre-determined points of agreement by the number of pre-determined points of agreement plus any points of disagreement, and (b) multiplying that number by 100. In a similar fashion, for procedural fidelity, the number of correct actions performed were divided by the number of actions planned and then divided that number by 100.

Social Validity Data

Prior to the study, the teachers and teachers' aides, who worked with the participants, completed a predictive social validity questionnaire, which contained 15 statements assessed by means of a 6 point Likert scale. Upon completion of the intervention, the same teachers and teachers' aides completed the same social validity questionnaire. I then reported, compared**,** and discussed the results of the two social validity questionnaires.

Summary

This study was based on the information processing model, a model in which the emphasis is on the encoding and retrieval of information (Broucher & Bowler, 2008). Weak central coherence and neural underconnectivity were the two theories of autism which provided the theoretical framework for this study. Weak central coherence and neural underconnectivity are two theories of autism, which attempt to explain the difficulties that individuals with ASD demonstrate, when they need to integrate information into a cohesive whole (Happé & Booth, 2008) and later retrieve that information (Coben & Meyers, 2008). Researchers have found that the use of graphic organizers are effective in order to address the difficulties with encoding information, which result from weak central coherence and neural underconnectivity (Knight, Spooner, Browder, Smith, and Wood, 2013; Roberts & Joiner, 2007; Schenning et al., 2013). Consequently, I used the Popplet iPad® app to design a graphic organizer to assist students with ASD to encode and retrieve vocabulary for use in the inclusive classroom. The participants used the concept maps on the Popplet iPad® app to learn new vocabulary and the Futaba Classroom Games for Kids iPad® app to practice the new vocabulary.

I collected data by: (a) the conduct of probe sessions, (b) the use of systematic observations during lessons, and (c) the analysis of written or recorded verbal responses for the

end-of-unit reflection sheet. Graphic analysis of the data was conducted through visual inspection of graphs as well as by the calculation of: (a) level stability, (b) absolute level change, (c) relative level change, (d) data trends, and (e) the percentage of non-overlapping data (PND). I reported the results in Chapter Four and discussed the findings in Chapter Five.

CHAPTER FOUR: FINDINGS

The purpose of this study was to explore vocabulary retrieval in five primary students diagnosed with autism spectrum disorder (ASD), who were enrolled in schools where the Primary Years Programme (PYP) was used, the primary version of the International Baccalaureate® (IB). Two international schools in Hong Kong provided the setting for this study. The information processing model provided the overarching framework for this study, and the theory of weak central coherence (Happé & Booth, 2008; Levy, 2007; Rajendra & Mitchel, 2007) was used to explain the results of applying the information processing model to individuals with ASD. The theory of weak central coherence refers to the manner in which students with ASD focus on details and demonstrate difficulty when they are expected to connect the details into a cohesive whole. To address this difficulty, concept maps have been used successfully to facilitate learning in students with ASD. Roberts and Joiner (2007) demonstrated a fourfold increase in learning for students with ASD as a result of the use of concept maps.

Observations, made during this study, supported the theory of weak central coherence. All of the participants were students with a confirmed diagnosis of ASD. Consequently, concept maps were included as part of this intervention to assist the participants to connect the details to a main idea. However, each participant did exactly the same thing. They would use two fingers to enlarge the words on the iPad®, and in this manner, they would proceed to read each piece of information in isolation. I needed to tell each participant to not change the screen size nor read each piece of information in isolation in order to see the entire concept map.

The results for Research Question #1 are depicted in graphic form, and the results for Research Questions #2 and #3 are depicted in table form. The analysis of the data is described in narrative form. Anecdotal observations follow many of the graphs and tables.

Effectiveness Data for Research Question #1

1. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to learn Unit of Inquiry vocabulary in the inclusive classroom?

The results, which depict the effectiveness of the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app on the ability of the participants to learn Unit of Inquiry vocabulary, are displayed in Figures 3-7. Each graph consists of baseline, intervention and maintenance data points across three sets of Unit of Inquiry vocabulary words. First, I collected baseline data to provide information on the number of vocabulary words each participant knew prior to the beginning of the intervention. Next, I continued to collect data throughout the intervention. Finally, I collected maintenance data, which indicated the number of vocabulary words each participant still retained 1 week after the end of the intervention. Long-term maintenance data collection was not conducted due to the summer holidays and the fact that three of the five participants had transitioned from primary school to secondary school. Educators can quickly ascertain the effectiveness of a proposed intervention through visual inspection of the graphs. In the case of this research study, visual inspection of the graphs displayed in Figures 3 through 7 indicate a functional relationship between the intervention and the ability of the participants to learn Unit of Inquiry vocabulary.

In single subject research, "functional relationship" is a term used to indicate that there is a connection between the independent variable and the dependent variable (Lodico, Spaulding, & Voegtle, 2010). The greater the number of intervention data points that do not overlap with the baseline data points, the greater the functional relationship. An intervention is deemed promising when a functional relationship is observed between the independent variable and the

dependent variable (Gast, 2010). A promising intervention may be considered best practice when the results of the original research are independently replicated in further studies (Gast, 2010). I have also provided a more detailed analysis of the data in the paragraphs below.

Edward

At the time of this study, Edward was 11 years old. He had previously been diagnosed with ASD, ADHD, and intellectual disability. Edward's reading comprehension was more than 5 years below his chronological age, and his vocabulary was more than 6 years below his chronological age. The effectiveness of the two apps on Edward's ability to learn Unit of Inquiry vocabulary is described in the following section.

Unit of Inquiry A. During the baseline probe session, Edward correctly responded to a mean of 2.25 out of 15 vocabulary words (i.e., range 2-3). During the intervention probe session, Edward correctly responded to a mean of 6.88 out of 15 vocabulary words (i.e., range 4-10). During the maintenance probe session, Edward correctly responded to 7 vocabulary words. Edward's probe data demonstrated an absolute level change of +1 within the baseline condition and +6 within the intervention condition. Edward's intervention data were variable; only 37% of the data fell within 25% of the median level for the condition. His scores dipped in the middle of the intervention probe sessions as demonstrated by a relative level change of -0.5. Using the split middle method to calculate the trend, Edward's intervention data demonstrated a trend of deceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Edward's ability to learn the vocabulary words for this Unit of Inquiry.

Unit of Inquiry B. During the baseline probe session, Edward correctly responded to a mean of 2 out of 15 vocabulary words (i.e., range 2-2). During the intervention probe session,

Edward correctly responded to a mean of 5 out of 15 vocabulary words (i.e., range 3-7). During the maintenance probe session, Edward correctly responded to 6 out of 15 of the vocabulary words. Edward's baseline data were stable and showed zero celeration due to an absolute and relative level change of 0. In contrast, Edward's intervention data were variable; only 20% of the data fell within 25% of the median level for the condition. Nevertheless, his intervention probe data scores demonstrated a trend of acceleration. Additionally, Edward never reached criterion level as he was never able to demonstrate mastery of 80% of the vocabulary words. The percentage of non-overlapping data was 100%. This percentage indicated that there was a functional relationship between the intervention and Edward's ability to learn the vocabulary words for the Unit of Inquiry B.

Unit of Inquiry C. During the baseline probe session, Edward correctly responded to a mean of 2 out of 13 vocabulary words (i.e., range 2-2). During the intervention probe session, Edward correctly responded to a mean of 8 out of 13 vocabulary words (i.e., range 6-10). During the maintenance probe session, Edward correctly responded to 7 out of 13 of the vocabulary words. Edward's baseline data were stable and showed zero celeration due to an absolute and relative level change of 0. Edward's intervention data were variable; only 50% of the data fell within 25% of the median level for the condition. Although Edward's intervention data demonstrated an absolute level change of -2, the overall trend showed zero celeration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Edward's ability to learn the vocabulary of this Unit of Inquiry. The results for Edward's vocabulary acquisition are displayed in Figure 3.

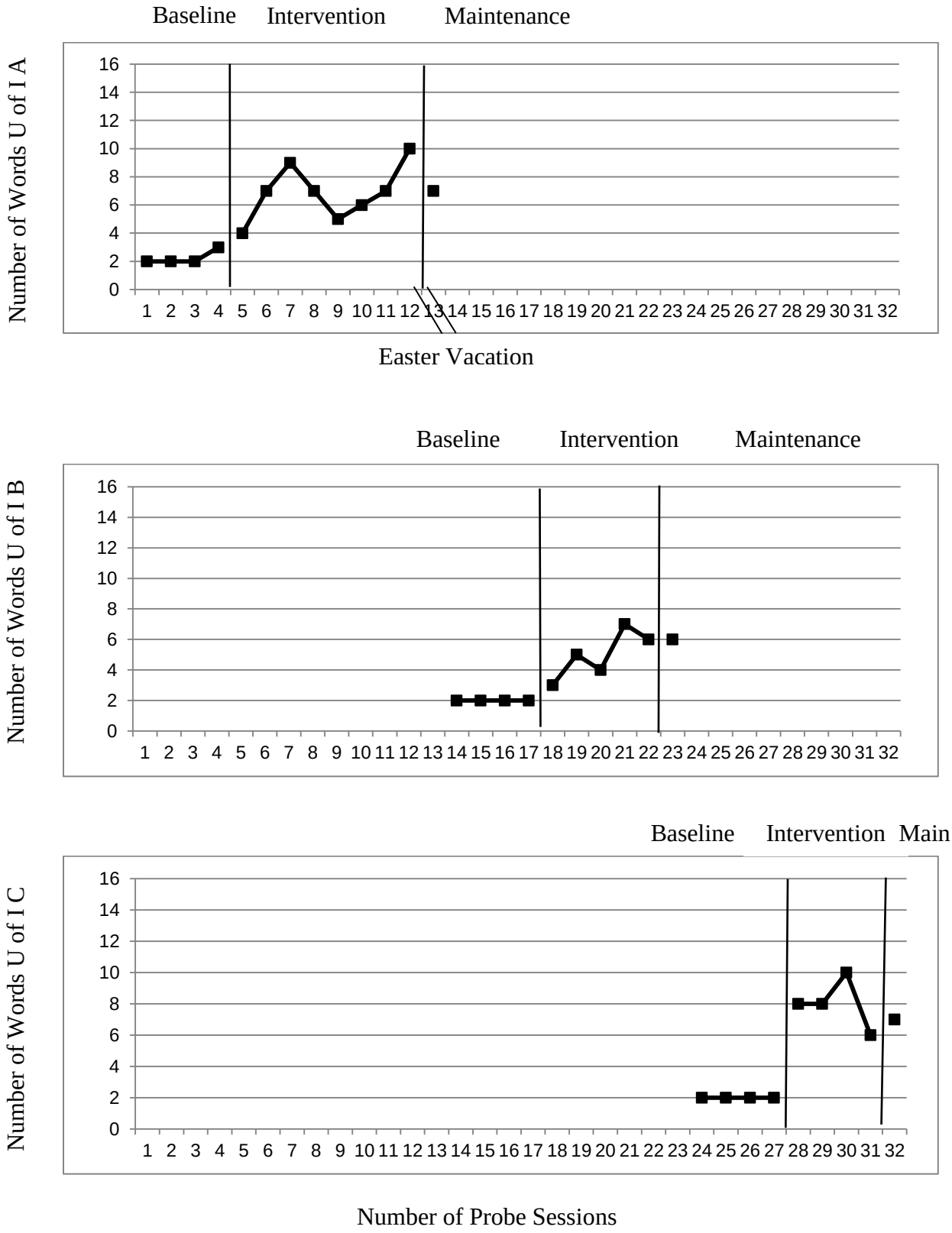


Figure 3. Edward's Futaba vocabulary scores.

Observations of Edward. Edward was easily able to independently follow the script for the intervention. However, when he first starting playing the Futaba Game, he would not take the time to listen to the definition or read the definition and the four vocabulary choices. He would just impulsively press one of the four choices. When this method did not prove successful, he then tried other methods. One day he alternated between using his left thumb to press the answer furthest to the left and then his right thumb to press the answer furthest to the right. Each time, when he found his method did not work, he would say, "Help me." I continually reminded Edward that he needed to listen to and read the definition as well as read all four choices before he pressed a choice. By Unit of Inquiry C, Edward was finally listening to and reading the definition and the four choices. Although Edward never demonstrated 80% mastery of the vocabulary words, he learned a study skill, which will be useful for him throughout his schooling.

Emmanuel

At the time of this study, Emmanuel was 11 years old. He had previously been diagnosed with ASD, ADHD, obsessive-compulsive disorder, sensory integration disorder, and anxiety disorder. Emmanuel's reading comprehension was more than 2 years below his chronological age, and his vocabulary was more than 4 years below his chronological age. The effectiveness of the two apps on Emmanuel's ability to learn Unit of Inquiry vocabulary is described in the following section.

Unit of Inquiry A. During the baseline probe session, Emmanuel correctly responded to a mean of 4 out of 15 vocabulary words (i.e., range 4-4). During the intervention probe session, Emmanuel correctly responded to a mean of 13.3 out of 15 vocabulary words (i.e., range 13-14). During the maintenance probe sessions, Emmanuel correctly responded to all 15 vocabulary

words for Unit of Inquiry A; thus, he demonstrated an increase of 1.7 correct responses above his mean of 13.3 during the intervention probe sessions. Emmanuel's baseline and intervention data were stable; 100% of the data fell within a 25% range of the median level for each condition. Emmanuel's baseline demonstrated zero celeration due to an absolute and relative level change of 0. However, with an absolute level change of -1, his intervention data indicated a slight within condition deterioration. Also, the intervention probe data demonstrated a trend of slight deceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Emmanuel's ability to learn the vocabulary words for this Unit of Inquiry.

Unit of Inquiry B. During the baseline probe session, Emmanuel correctly responded to a mean of 6.25 out of 15 vocabulary words (i.e., range 6-7). During the intervention probe session, Emmanuel correctly responded to a mean of 13.67 out of 15 vocabulary words (i.e., range 13-14). During the maintenance probe session, Emmanuel correctly responded to 14 out of 15 vocabulary words. Emmanuel's baseline and intervention data were stable; 100% of the data fell within a 25% range of the median level for each condition. Emmanuel's baseline data showed a slight deterioration with an absolute level change of -1. However, his intervention data showed some improvement with an absolute level change of +1 and a trend of slight acceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Emmanuel's ability to learn the vocabulary words for Unit of Inquiry B.

Unit of Inquiry C. During the baseline probe session, Emmanuel correctly responded to a mean of 3 out of 14 vocabulary words (i.e., range 3-3). During the intervention probe session, Emmanuel correctly responded to a mean of 12.75 out of 14 vocabulary words (i.e., range 11-

14). During the maintenance probe session, Emmanuel correctly responded to 12 out of 14 of the vocabulary words. Emmanuel's baseline data showed zero celeration due to an absolute and relative level change of 0, and his intervention data showed improvement with an absolute level change of +3. Emmanuel's baseline data were stable. Emmanuel's intervention data were variable. However, the last three intervention data points were stable; 100% of the last three data points fell within a 25% range of the median level for the condition. Additionally, his intervention probe data scores indicated a trend of acceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Emmanuel's ability to learn the vocabulary words for the Unit of Inquiry C. The results of Emmanuel's vocabulary acquisition are displayed in Figure 4.

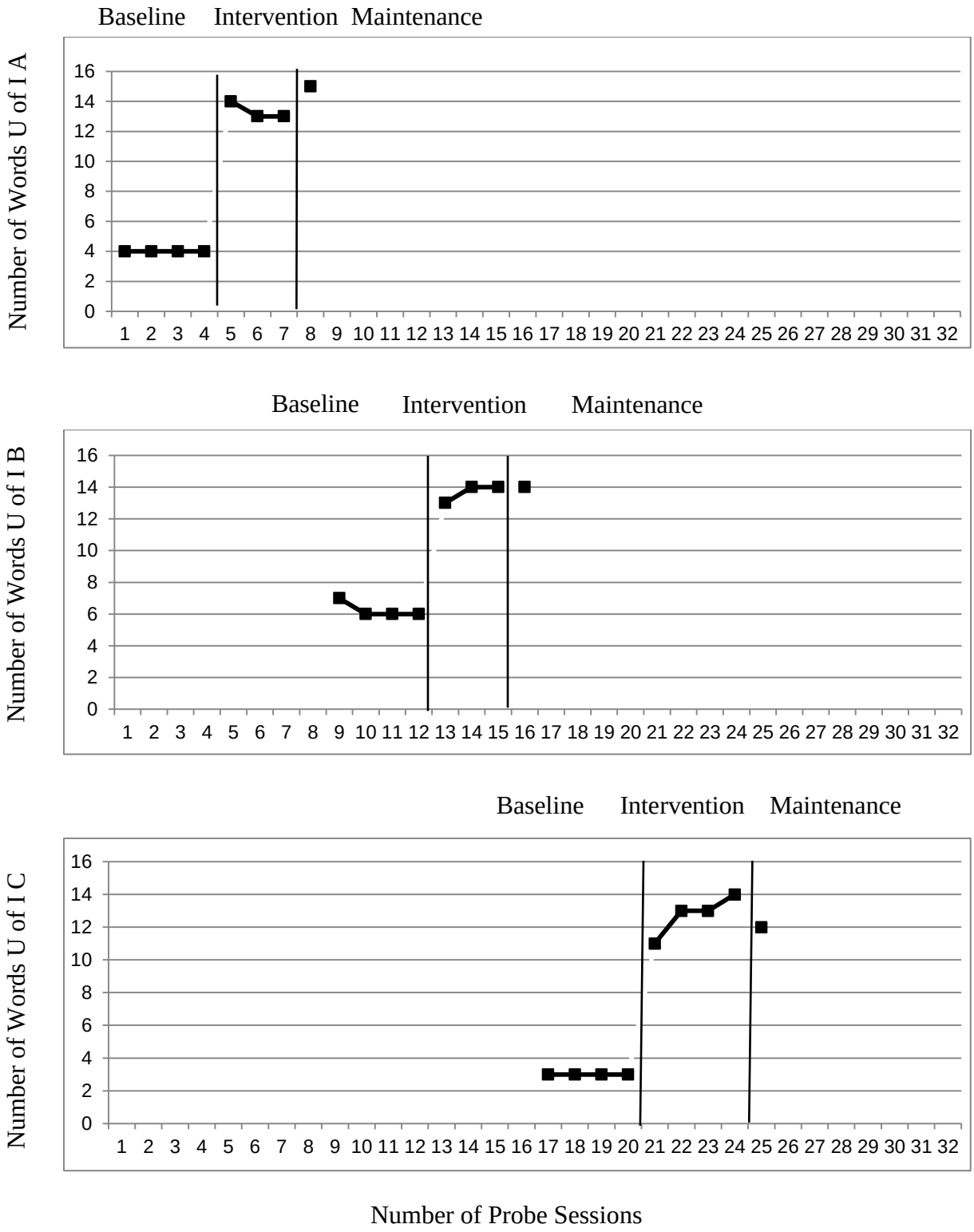


Figure 4. Emmanuel's Futaba vocabulary scores.

Jesse

At the time of this study, Jesse was 11 years old. He had previously been diagnosed with ASD. Jesse's reading comprehension was more than 2 years below his chronological age, and his vocabulary was 3 years below his chronological age. The effectiveness of the two apps on Jesse's ability to learn Unit of Inquiry vocabulary is described in the following section.

Unit of Inquiry A. During the baseline probe session, Jesse correctly responded to a mean of 3.75 out of 15 vocabulary words (i.e., range 3-4). During the intervention probe session, Jesse correctly responded to a mean of 13 out of 15 vocabulary words (i.e., range 13-13). During the maintenance probe sessions, Jesse correctly responded to 12 out of 15 vocabulary words for Unit of Inquiry A; thus, he demonstrated a decrease of 1 correct response below his mean of 13 during the intervention probe sessions. Jesse's baseline and intervention data demonstrated zero celeration within conditions, due to an absolute and relative level change of 0. Jesse's intervention data were stable; 100% of the data fell within a 25% range of the median level. The percentage of non-overlapping data was 100%. This percentage indicated a strong functional relationship between the intervention and Jesse's ability to learn the vocabulary words for this Unit of Inquiry.

Unit of Inquiry B. During the baseline probe session, Jesse correctly responded to a mean of 10.5 out of 15 vocabulary words (i.e., range 10-11). During the intervention probe session, Jesse correctly responded to a mean of 14.3 out of 15 vocabulary words (i.e., range 14-15). During the maintenance probe session, Jesse correctly responded to 14 out of 15 of the vocabulary words. Jesse's baseline and intervention data were stable, 100% of the data fell within the 25% range of the median level of each condition. His baseline data demonstrated an absolute level change of zero. However, his intervention data showed a trend of slight

deceleration and an absolute level change of -1. The percentage of non-overlapping data was 100%. This percentage indicated that there was a functional relationship between this intervention and Jesse's ability to learn the vocabulary words for Unit of Inquiry B.

Unit of Inquiry C. During the baseline probe session, Jesse correctly responded to a mean of 3.75 out of 15 vocabulary words (i.e., range 3-4). During the intervention probe session, Jesse correctly responded to a mean of 13.3 out of 15 vocabulary words (i.e., range 13-14). During the maintenance probe session, Jesse correctly responded to 12 out of 15 vocabulary words. As with Unit of Inquiry A and B, Jesse's intervention data were stable, 100% of the data fell within a 25% range of the median level of the condition. Similar to Unit of Inquiry B, Jesse's intervention data demonstrated a trend of slight deceleration and an absolute level change of -1. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Jesse's ability to learn the vocabulary words for Unit of Inquiry C. The results for Jesse's vocabulary acquisition are displayed in Figure 5.

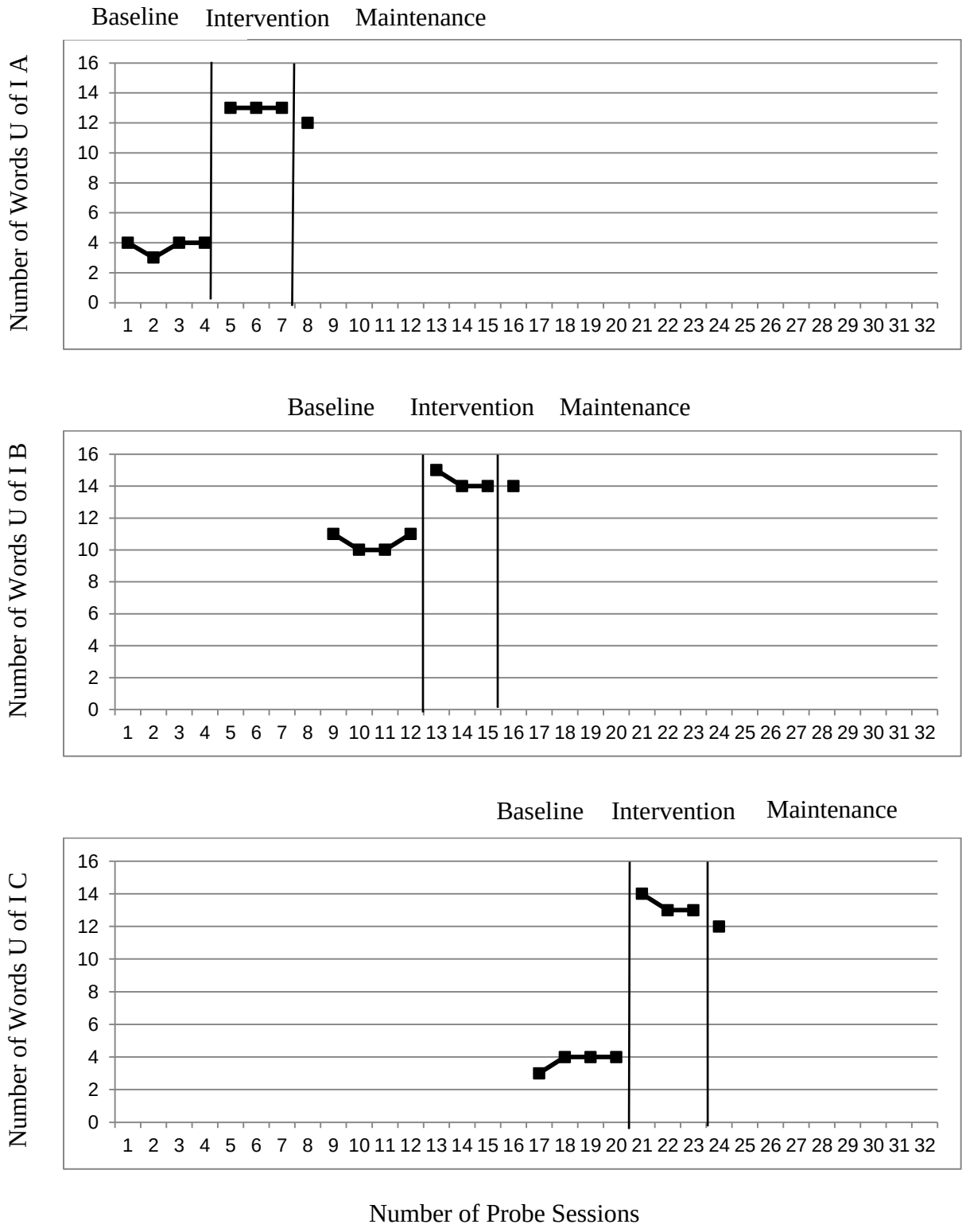


Figure 5. Jesse's Futaba vocabulary scores.

Observations of Jesse. Some days, in the middle of completing the intervention, Jesse would look away from the iPad and then start talking about something unrelated to the intervention. For example, Jesse would say something about his therapist or blurt out a complicated math problem. I would tap on the iPad®, and Jesse would say, "I need to stay focused." This type of behavior was also observed during the recording sessions.

Seth

At the time of this study, Seth was 8 years old. He had previously been diagnosed with ASD. Seth's reading comprehension was 2 years below his chronological age, and his vocabulary was more than 1 year below his chronological age. The effectiveness of the two apps on Seth's ability to learn Unit of Inquiry vocabulary is described in the following section.

Unit of Inquiry A. During the baseline probe session, Seth correctly responded to a mean of 2.75 out of 16 vocabulary words (i.e., range 2-3). During the intervention probe session, Seth correctly responded to a mean of 12.5 out of 16 vocabulary words (i.e., range 9-14). During the maintenance probe session, Seth correctly responded to 14 out of 16 vocabulary words. Seth's baseline data demonstrated zero celeration due to an absolute level change of 0. Seth's intervention data demonstrated a trend of acceleration and an absolute level change of +5. Seth's intervention data were variable. However, the last three intervention data points were stable; 100% of the last three intervention data points fell within 25% of the median level. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Seth's ability to learn the vocabulary words for Unit of Inquiry A.

Unit of Inquiry B. During the baseline probe session, Seth correctly responded to a mean of 6.25 out of 16 vocabulary words (i.e., range 6-7). During the intervention probe session,

Seth correctly responded to a mean of 15.3 out of 16 vocabulary words (i.e., range 15-16). During the maintenance probe session, Seth correctly responded to 13 out of 16 vocabulary words. Seth's baseline and intervention data were stable, and 100% of the data fell within a 25% range of the median level for each condition. The absolute level change was -1 for the baseline condition and +1 for the intervention condition. The intervention data indicated a slight acceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Seth's ability to learn the vocabulary words for Unit of Inquiry B.

Unit of Inquiry C. During the baseline probe session, Seth correctly responded to a mean of 4.75 out of 15 vocabulary words (i.e. range 4-5). During the intervention probe session, Seth correctly responded to a mean of 14.3 out of 15 vocabulary words (i.e., range 14-15). During the maintenance probe session, Seth correctly responded to 12 out of the 15 vocabulary words. Seth's baseline and intervention data demonstrated a trend of zero celeration due to an absolute and relative level change of 0 for both conditions. Seth's baseline and maintenance data were both stable, and 100% of the data points fell within 25% of the median level. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Seth's ability to learn the vocabulary words for Unit of Inquiry C. The results for Seth's vocabulary acquisition are displayed in Figure 6.

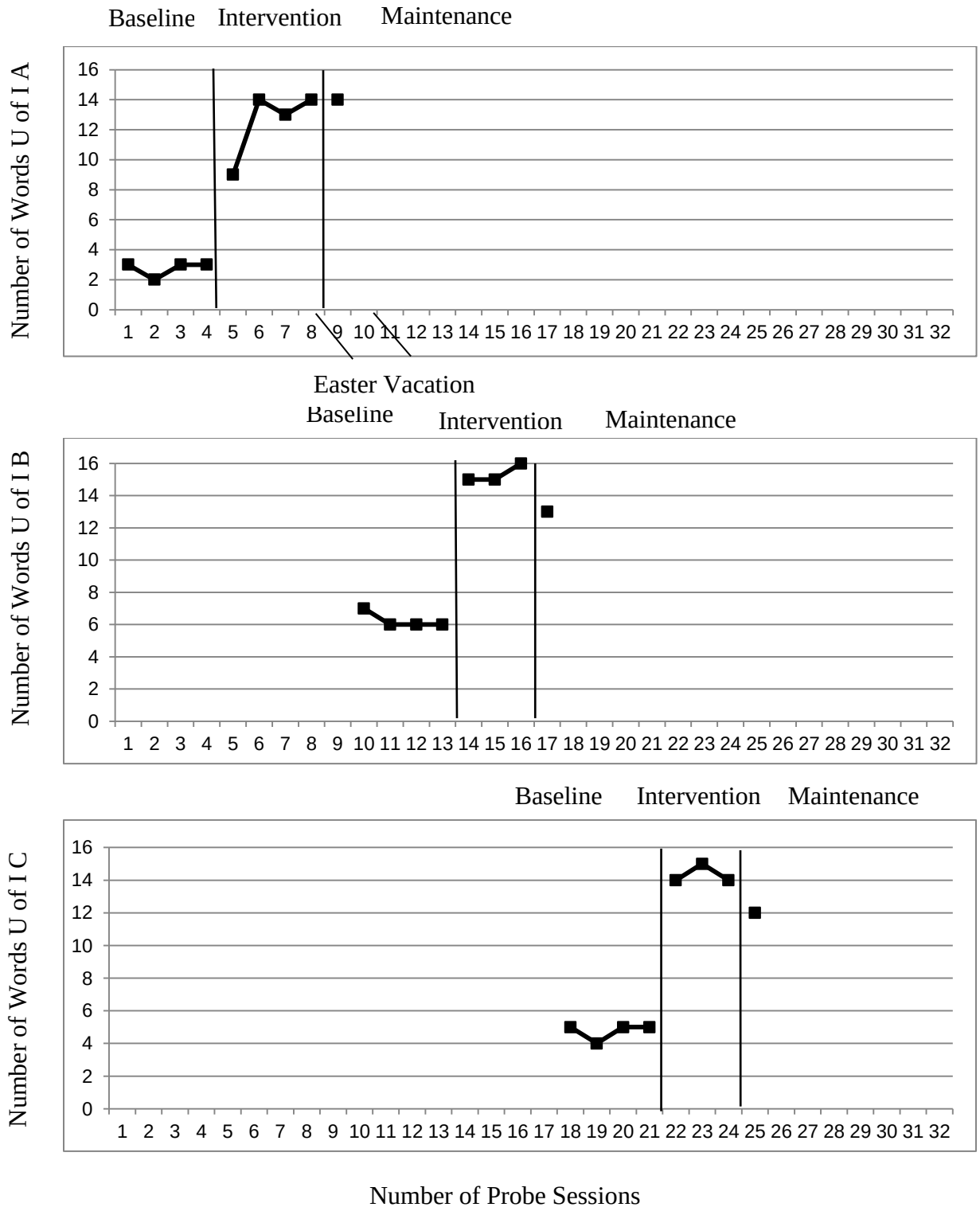


Figure 6. Seth's Futaba vocabulary scores.

Theo

At the time of this study, Theo was 10 years old. He had previously been diagnosed with ASD and ADHD. Theo's reading comprehension was more than 2 years below his chronological age. However, he scored almost 4 years above his chronological age on a receptive vocabulary test, which required only picture identification and did not require speech. The effectiveness of the two apps on Theo's ability to learn Unit of Inquiry vocabulary is described in the following section.

Unit of Inquiry A. During the baseline probe session, Theo correctly responded to a mean of 9.25 out of 16 vocabulary words (i.e., range 8-10). During the intervention probe session, Theo correctly responded to a mean of 12.5 out of 16 vocabulary words (i.e., range 11-16). During the maintenance probe sessions, Theo correctly responded to all 16 vocabulary words. Theo's baseline data were stable. Theo's intervention data were variable. However, the last three intervention data points were stable; 100% of the last three intervention data points fell within 25% of the median level of that condition. The intervention condition showed a trend of acceleration and an absolute level change of +4. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between the intervention and Theo's ability to learn the vocabulary words for Unit of Inquiry A.

Unit of Inquiry B. During the baseline probe sessions, Theo correctly responded to a mean of 11 out of 16 vocabulary words (i.e., range 11-11). During the intervention probe sessions, Theo correctly responded to all 16 vocabulary words each time. During the maintenance probe session, once again, Theo responded correctly to all 16 vocabulary words. Theo's baseline data and intervention data were stable and showed a trend of zero celeration due to an absolute and relative level change of 0 within each condition. The percentage of non-

overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Theo's ability to learn the vocabulary words for Unit of Inquiry B.

Unit of Inquiry C. During the baseline probe session, Theo correctly responded to a mean of 3.75 out of 15 vocabulary words (i.e., range 3-4). During the intervention probe session, Theo correctly responded to a mean of 14.3 out of 15 vocabulary words (i.e., range 14-15). During the maintenance probe session, Theo correctly responded to all 15 vocabulary words. Theo's baseline and intervention data were both stable; 100% of the data points within each condition fell within 25% of the median level for that condition. Theo's baseline data showed an absolute level change of +1. However, his intervention data revealed an absolute level change of -1 and a trend of slight deceleration. The percentage of non-overlapping data was 100%. This percentage indicated a functional relationship between this intervention and Theo's ability to learn the vocabulary words for Unit of Inquiry C. The results for Theo's vocabulary acquisition are displayed in Figure 7.

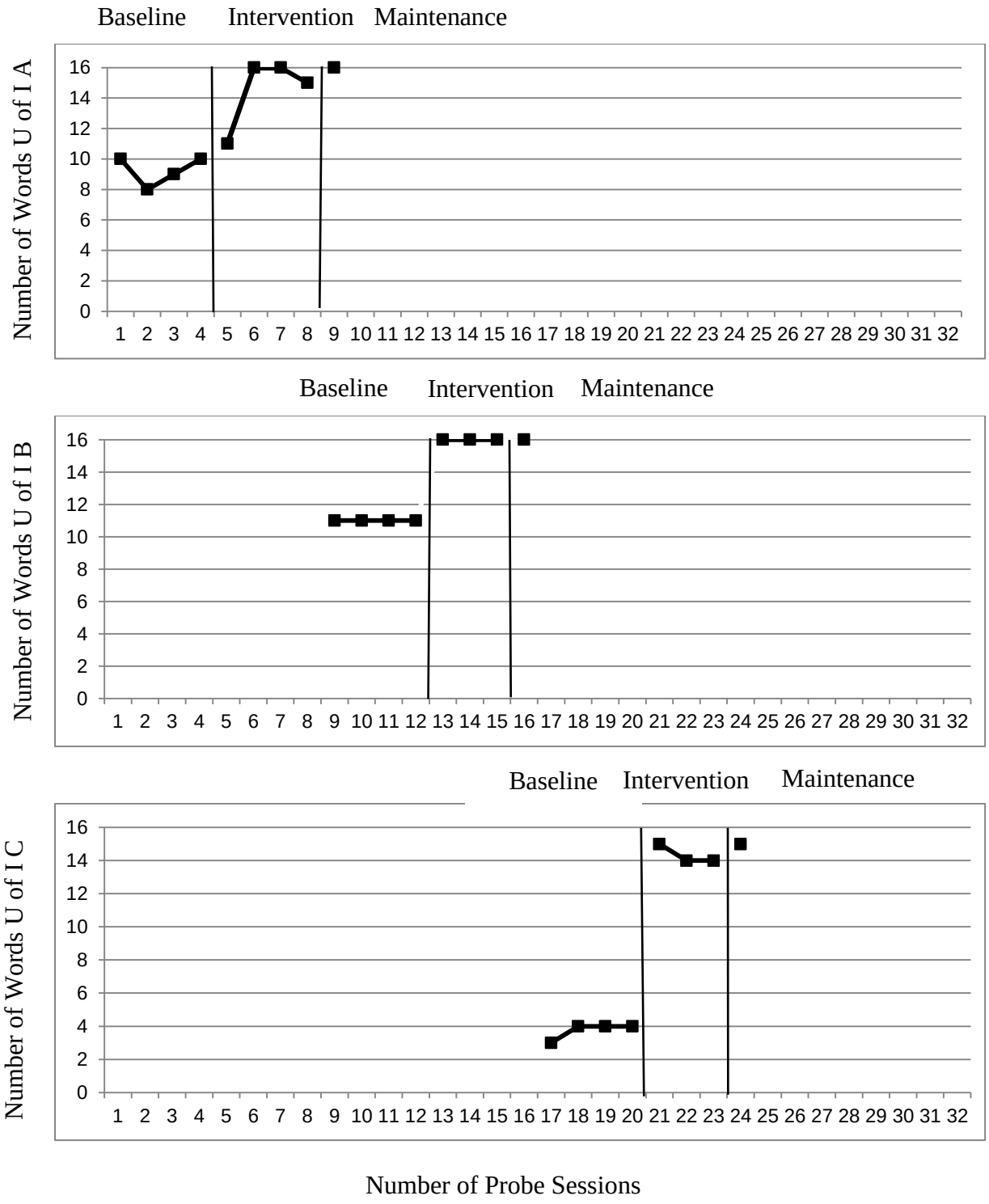


Figure 7. Theo's Futaba vocabulary scores

Observations of Theo. Visual inspection of Theo's graphs would indicate that Theo was already familiar with a number of the vocabulary words. In this case, some readers may question the necessity of the intervention for Theo. However, although during baseline data collection, Theo could match vocabulary words and definitions, he was not able to write definitions for these words. Consequently, the intervention was still useful since it equipped Theo with the ability to provide an oral and written definition of the vocabulary words. These observations are supported by the mismatch between: (a) Theo's inability to provide oral definitions of vocabulary words during reading assessments as reported by his LSC teacher, and (b) Theo's above average scores on the Peabody Picture Vocabulary Test (PPVT) (Dunn & Dunn, 2007), an assessment which allows the participant to point to a picture that matches the spoken vocabulary word.

Additionally, Theo tended to display more tics when he played the Futaba Game. He would flick back his head in response to the automatically generated sound, which followed a correct response on the game. One time, I tested this observation by turning off the sound. With the sound turned off, Theo could not hear the definitions being read aloud, but he no longer flicked back his head.

Rehearsal Strategies

Researchers (Bebko & Ricciuti, 2000; Phelan et al., 2011; Rhee, 2009) have focused on teaching rehearsal strategies to students with ASD. Rehearsal refers to multiple repetitions of words or actions in order to facilitate retention of information for use at a later date (Bebko & Ricciuti, 2000). Emmanuel and Jesse, two of the older participants, spontaneously practiced rehearsal strategies during the intervention. Both boys would read the information on the concept map, cover up the information with one hand and then try to repeat the information

aloud without looking at the concept map. On the other hand, Seth and Theo, who were the youngest of the participants, would rush through the intervention lesson in order to get to the Futaba Game. Neither Seth nor Theo ever evidenced any overt use of rehearsal strategies. Similar observations were noted by Bebko and Ricciuti (2000) in their conduct of two experiments designed to examine the effectiveness of teaching rehearsal strategies to students with ASD. These researchers noted that the development of rehearsal strategies may be delayed in students with ASD, but once these students have learned the skill, they will continue to use it.

Effectiveness Data for Research Question #2

2. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary during speaking activities in an inclusive classroom setting?

The results, which depict the effectiveness of the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app on the ability of the participants to functionally use Unit of Inquiry vocabulary in an inclusive classroom setting, are shown in Tables 3-7. The headings in the table include: (a) Functional Speech Questionnaire, (b) Unit of Inquiry A, (c) Unit of Inquiry B, (d) Unit of Inquiry C, and (e) Year 6 Exhibition. The Functional Speech Questionnaire refers to a questionnaire which teachers and teachers' aides completed prior to the beginning of the intervention. The purpose of the Functional Speech Questionnaire was to provide some insight into the nature and frequency of each participant's involvement in speaking activities in the general education classroom. The Year 6 Exhibition refers to an opportunity given to the Year 6 students to showcase: (a) the attributes of the IBO learner profile, (b) key concepts, (c) transdisciplinary themes, and (d) transdisciplinary skills which they have learned

throughout primary school (International Baccalaureate Organization, 2008). Year 6 students work in groups to conduct an open-ended inquiry to explore a real life issue.

Initially, the main focus of this research was on the results from Units of Inquiry A, B, and C. However, after potential participants from Year 6 agreed to participate in the research, I decided to include the results from the Year 6 Exhibition for two reasons. First, social validity is a key feature of single subject research (Gast, 2010). Social validity refers to the value that stakeholders place on an intervention. In a school where the PYP curriculum is used, administrators and teachers view the Year 6 Exhibition as the culminating event of the PYP curriculum. Therefore, if an intervention helps a student with the Year 6 Exhibition, then the intervention may be deemed of great value. Second, the Year 6 mainstream teachers purposely planned Unit of Inquiry A and Unit of Inquiry B to prepare students for the Year 6 Exhibition. The students then needed to use what they had learned in Unit of Inquiry A and Unit of Inquiry B to be successful in the Year 6 Exhibition. Therefore, results from the Year 6 Exhibition may provide some insight into the ability of the Year 6 participants to retain and apply what they had learned in Unit of Inquiry A and Unit of Inquiry B.

Edward

The results for Edward's participation in the inclusive classroom are displayed in Table 3. Data are presented for several different factors. Narrative information regarding Edward's participation in the inclusive classroom is provided below Table 3.

Table 3

Edward's Participation in the Inclusive Classroom

	Functional Speech Questionnaire	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C	Year 6 Exhibition
Type of speaking activity	all	group	group	partner	individual
Number of topic related sentences	0	NA	5	11	6
Number of topic related phrases	0	NA	1	2	3
Number of topic related words	0	NA	1	1	4
Vocabulary words	0	NA	2	5	0

Edward's participation. Throughout the school day, it was difficult for Edward to provide responses that matched the questions which were asked of him. Edward continued to demonstrate these difficulties during the recording sessions conducted for this study. During the recording session for Unit of Inquiry A, Edward began to recite the intervention verbatim. Although he had memorized this information, he was not able to take segments of the information and use those segments to answer questions or contribute to the discussion. During the recording session for Unit of Inquiry B, Edward was more involved in the group dialogue. When asked where he was going to secondary school next year, Edward gave the correct answer, and then he started asking each member of his group where they were going to secondary school. It was then pointed out that if all of the group members were over at secondary school, none of them would be at the primary school to take care of their project. When asked who would take

care of their project, Edward smiled and gave the names of two secondary teachers who had come to visit the primary school the day before. Edward then started laughing, and I assumed he was purposely giving the wrong answer and trying to be funny.

Emmanuel

The results for Emmanuel's participation in the inclusive classroom are displayed in Table 4. Data are presented for several different factors. Narrative information regarding Emmanuel's participation in the inclusive classroom is provided below Table 4**.**

Table 4

Emmanuel's Participation in the Inclusive Classroom

	Speech Questionnaire	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C	Year 6 Exhibition
Type of speaking activity	all	group	group	partner	individual
Number of topic related sentences	0	0	0	10	5
Number of topic related phrases	0	0	0	3	1
Number of topic related words	0	0	0	2	1
Vocabulary words	0	6	1	0	1

Emmanuel's participation. As presented in Table 4, prior to the intervention, Emmanuel rarely spoke in group settings in the mainstream classroom. In fact, there were times when Emmanuel did not respond verbally to the general education teachers or follow their instructions. During Unit of Inquiry B, when the general education teacher was leading a

discussion with Emmanuel's group, his answers consisted of: (a) umm; (b) no, he didn't know the answer; (c) yes, he needed more time to think; (d) shake his head to indicate no; and (e) smile while he gave the wrong answer.

As mentioned previously, the Year 6 Exhibition is an opportunity for students to synthesize all the information, skills, and concepts they have learned throughout primary school. Many visitors come to the school on the day and evening of the Year 6 Exhibition, and the Year 6 students need to be able to answer the visitor's questions. At first, Emmanuel displayed great difficulty in answering questions. He would just respond with "umm. . ." However, toward the end, Emmanuel successfully answered several questions. All of these questions related to what he had done during each of the stages of the inquiry cycle, and each of his answers were correct. As part of the intervention for Unit of Inquiry A, Emmanuel had learned the stages of the inquiry cycle, and now he was able to use those stages to describe each step of his group's learning journey. In this case, the inquiry cycle served as a concept map for Emmanuel. With this concept map in mind, Emmanuel was able to describe his group's Year 6 Exhibition from beginning to end. This observation supports the results of Roberts and Joiner (2007) who noted a fourfold increase in learning when students with ASD used concept maps.

During Unit of Inquiry C, Emmanuel did not work in a group. Instead, he worked with a classmate he had known for 3 years. During the video and audio recording session for Unit of Inquiry C, Emmanuel answered all but one of the questions. A closer examination of Table 4 indicates that Emmanuel was unwilling to answer questions in a group setting, but he was willing to answer questions when he was with a trusted partner or when he was on his own. This observation may indicate that a student's level of social anxiety may have a direct impact on the observed strength of the functional relationship between intervention and participation.

Generalization. As part of the intervention for Unit of Inquiry A, Edward, Emmanuel, and Jesse studied a diagram (see Figure 8) of an inquiry cycle (Murdoch & Hornby, 1997). They also learned what students should be doing during each stage of the inquiry cycle. One day the general education teacher showed the class a diagram of a different inquiry cycle. The designer had switched the last two stages of the inquiry cycle and given them different names. The next day Emmanuel told me that I had the wrong inquiry cycle on the iPad because the last two stages had been switched, and the names should be different. Researchers have expressed concern that students with ASD are capable of rote learning, but they do not often demonstrate generalization of what they have learned (Charlop, Schreibman, & Thibodeau, 1985; Chiang & Carter, 2008; Koegel, 2000; Spencer & Higbee, 2012). In this case, Emmanuel had learned the six steps of the PYP Inquiry Cycle (see Figure 9). He had learned the meaning of each step of the PYP Inquiry Cycle. Furthermore, he was able to explain that the two steps were switched, even though the two inquiry cycles used different labels to name a particular step. Thus, in this particular setting, Emmanuel demonstrated generalization of what he had learned.

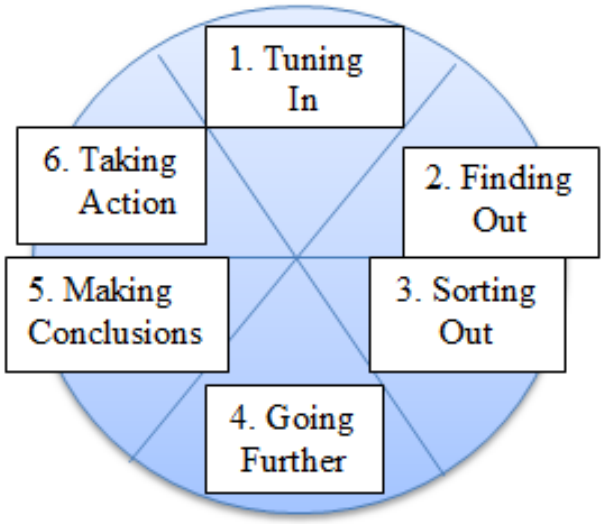


Figure 8. Diagram of an Inquiry Cycle.

Figure 9. Part B of Emmanuel's end-of-unit reflection sheet for Unit of Inquiry A.

Jesse

The results for Jesse's participation in the inclusive classroom are displayed in Table 5. Data are presented for several different factors. Narrative information regarding Jesse's participation in the inclusive classroom is provided below Table 5.

Table 5

Jesse's Participation in the Inclusive Classroom

	Speech Questionnaire	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C	Year 6 Exhibition
Type of speaking activity	all	group	group	partner	individual
Number of topic related sentences	0	2	5	8	14
Number of topic related phrases	0	3	0	5	4
Number of topic related words	1	4	0	3	0
Vocabulary words	0	4	5	3	3

Jesse's participation. As mentioned previously, it was often difficult for Jesse to control his internal thoughts and regulate his attention. During the video and audio recording session for Unit of Inquiry B, Jesse's group members were taking turns describing their role in helping their group complete the work for the upcoming Year 6 Exhibition. These roles included being a leader, researcher, recorder, presenter, and errand monitor. When asked if one role was harder than another, Jesse responded that taking action was the most difficult role. However, taking action is not a group role. Taking action is a phrase that refers to a step in the PYP Inquiry

Cycle. Jesse's answer demonstrated that he had not been following the group's dialogue. However, later when he was asked how his group was gathering evidence, Jesse was able to answer that they were collecting data by doing a survey. Additionally, when he was asked how his group was going to make sure that their action was sustainable, Jesse was able to reply that they had asked some Year 5 students to carry on their action next year.

During the video and audio recording session for Unit of Inquiry C, Jesse was preoccupied with thoughts about his therapist**.** When discussing the various roles of characters in a drama, Jesse used his therapist as an example of an antagonist. A few minutes later, Jesse was laughing inappropriately. Consequently, he did not hear the question. When I asked why he was laughing, Jesse replied that he was thinking about his therapist. At the end of the recording session, I asked Jesse what he would like to study besides drama. Jesse replied that he would like to make sculptures, and that his therapist made marshmallow sculptures. The ability to control internal thoughts and regulate attention has a direct impact on the ability of students with ASD to retain information in their long term memory as well as to join in speaking activities with their classmates.

Although Jesse displayed difficulties with his attention regulation, he wanted to do well during the day and evening of the Year 6 Exhibition. Jesse was able to give some correct answers even including some percentages from the surveys conducted by his group. However, when asked what action his group had taken, Jesse stated that they had found a room and set some things out. This was a very literal answer. He should have replied that his group had started a club. Additionally, when asked what day of the week his group conducted their club, Jesse did not know. After thinking about the question, he gave an answer related to the data his group had collected from their surveys. Furthermore, when an answer did not come easily, Jesse

said, “I want this one. . . I should know. . . let me think quickly.” These statements led me to assume that Jesse wanted to do his best.

When reading through the transcripts of Jesse’s recording, I discovered that Jesse had developed a way to compensate for his difficulties. When someone asked him a question, Jesse would repeat part or all of the person’s words and use those words as part of the answer to the question. For example, the teacher asked, “How is your group going to make sure that your action is sustainable?” Jesse replied, “How to make sure the action is sustainable. . . is by. . . we asked the Year 5 girls to run the club for us next year.” Other times, Jesse would just repeat part of the teacher’s question in echolalic fashion, but he would not continue to answer the question. Additionally, he did not display any signs of awareness that he had not answered the question.

Seth

The results for Seth’s participation in the inclusive classroom are displayed in Table 6. Data are presented for several different factors. Narrative information regarding Seth’s participation in the inclusive classroom is provided below Table 6. Since Seth was in Year 4, Table 6 does not include results from the Year 6 Exhibition.

Table 6

Seth's Participation in the Inclusive Classroom

	Speech Questionnaire	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Type of speaking activity	all	group	group	group
Number of topic related sentences	1	1	5	10
Number of topic related phrases	0	1	1	1
Number of topic related words	0	0	0	1
Vocabulary words	0	0	5	2

Seth's participation. During one recorded speaking activity, Seth and Theo were working at a circular table with a group of three female classmates. These three girls sat close to each other to work on a laptop. Meanwhile, Seth sat on the left hand side of the group of girls, and Theo sat on the right hand side of the group of girls. The girls rarely spoke to Seth or Theo, and neither Seth nor Theo could easily see the laptop. Since it was a circular table**,** the boys were across from each other and began to tease each other. "You are a girl." "Am I a girl?"

In contrast, the recorded speaking activity during the next Unit of Inquiry was quite different. Seth worked with three classmates, and they were different classmates from the ones he had worked with during the previous Unit of Inquiry. Seth was an active participant in this group. He told the group that they should include erosion as one of the topics in their report, and he provided the group with a definition of erosion. These children had a positive attitude toward

Seth, included him in their decision-making processes**,** and valued his ideas. It appears that the willingness of other group members to include a student with ASD may have an effect on the number of vocabulary words, topic related words, phrases, and sentences spoken by the participant.

Theo

The results for Theo's participation in the inclusive classroom are displayed in Table 7. Data are presented for several different factors. Narrative information regarding Theo's participation in the inclusive classroom is provided below Table 7. Since Theo was in Year 4, Table 7 does not include results from the Year 6 Exhibition.

Table 7

Theo's Participation in the Inclusive Classroom

	Speech Questionnaire	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Type of speaking activity	all	group	group	N/A
Number of topic related sentences	0	0	4	0
Number of topic related phrases	1	1	3	0
Number of topic related words	1	1	3	0
Vocabulary words	0	0	5	0

Theo's participation. During the recording session for Unit of Inquiry C, Theo did not want to work with any of his classmates. From across the classroom, I could see Theo seated by himself absorbed in typing on a laptop. Closer inspection revealed that Theo had independently typed the name of a natural disaster as well as the exact definition provided on the Futaba Game used in the intervention. Nevertheless, zeroes had to be placed in the column for Unit of Inquiry C as a result of Theo's insistence on working by himself.

While the data presented in Tables 3-7 did indicate an increase in functional speech throughout a variety of speaking activities, there were factors, which influenced naturally occurring speech. One of the most obvious factors was whether the participants were placed with general education classmates who knew how to work well in a group setting and knew how to include students with ASD. Another factor was whether the student with ASD wanted to work with other students on any particular day.

Effectiveness Data for Research Question #3

3. What effect will using both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary when completing end-of-unit reflection sheets?

At the beginning of each Unit of Inquiry, the general education classroom teacher gave each student a reflection sheet. The reflection sheet was a piece of paper with a few headings. The headings were generally three topics related to the central idea of the Unit of Inquiry. Next, the classroom teacher told the students to write everything they already knew about the Unit of Inquiry they were about to study. At the end of each Unit of Inquiry, the general education teacher gave the students a clean copy of the reflection sheet and asked them to write down

everything they knew about the Unit of Inquiry. I also added a verbal prompt: "Write down everything you learned from the iPad." After each participant completed the end-of-unit reflection sheets, I tallied the number of Unit of Inquiry vocabulary words each participant had used on the end-of-unit reflection sheet. The results, which depict the effectiveness of the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app on the ability of the participants to functionally use Unit of Inquiry vocabulary when they completed reflection sheets, are shown in Tables 8-12.

Edward

The results from Edward's end-of-unit reflection sheets are displayed in Table 8. Data are presented for several different factors. Narrative information describing Edward's reflection sheets is provided below Table 8.

Table 8

Edward's Reflection Sheets

	Prior to Intervention	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Number of topic related sentences	0	0	0	1
Number of topic related phrases	0	1	0	1
Number of topic related words	0	0	0	3
Number of vocabulary words	0	5	0	2
Number of vocabulary words correctly defined	NA	0	0	0

Edward's reflection sheets. At the beginning of each Unit of Inquiry, the general education teachers usually ask their students to fill in a reflection sheet. The information on the

reflection sheet gives the teachers an idea of what the students already know as well as providing an indication of any misconceptions surrounding the new Unit of Inquiry. When given a reflection sheet at the beginning of Unit of Inquiry A, Edward left the paper blank. However, at the end of the unit, Edward was able to draw a circle and write the first three of the six stages of the inquiry cycle.

When given a reflection sheet at the beginning of Unit of Inquiry B, Edward wrote the words, "Don't know," next to one out of three of the questions, and he wrote the words, "Don't know," or else put a slash next to each of the vocabulary words. Later, when he completed the end-of-unit reflection sheet, Edward was not able to write complete definitions for the vocabulary words. However, what he wrote indicated some learning had occurred. For example, on the Futaba Game, the definition for community was a place where people live and work together. On the end-of-unit reflection sheet, Edward wrote that the definition for community was working together. For some of the other vocabulary words, he wrote a short definition, but it was next to the wrong vocabulary word.

Edward experienced the greatest success with Unit of Inquiry C. For this unit, each student was allowed to choose one of five topics of study. Edward stayed with his general education teacher who was guiding children to explore various crafts such as weaving, knitting, and sewing. The first question on the reflection sheet asked students to list techniques that artists use to show change. At the beginning of the Unit of Inquiry, Edward wrote "they do explore." However, on the end-of-unit reflection sheet, Edward was able to accurately list weaving, sculpture, knitting, and painting. He also wrote, "robot computer." This was his way of referring to the class where the students were exploring robotics and computer animation.

Additionally, whereas at the beginning of Unit of Inquiry B, Edward wrote, "Don't know" or drew a slash next to each vocabulary word, at the beginning of Unit of Inquiry C, Edward did write a word or phrase next to each vocabulary word. Most of the words or phrases seemed to be associative in nature. For example, next to cross-stitch, Edward wrote cross roads. The previous year Edward had gone on a field trip to Cross Roads, a nonprofit organization. When completing the end-of-unit reflection sheet, Edward rapidly said phrases but only wrote down part of what he said. For example, Edward said that a card loom is used for weaving. However, next to card loom, he only wrote the word weaving. As was his usual practice, Edward rushed through the reflection sheet.

Emmanuel

The results from Emmanuel's end-of-unit reflection sheets are displayed in Table 9. Data are presented for several different factors. Narrative information regarding Emmanuel's reflection sheets is provided below Table 9.

Table 9

Emmanuel's Reflection Sheets

	Prior to Intervention	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Number of topic related sentences	0	2	1	7
Number of topic related phrases	0	0	0	0
Number of topic related words	0	0	0	0
Number of vocabulary words	0	5	0	0
Number of vocabulary words correctly defined	NA	9 out of 9	5 out of 9	14 out of 14

Emmanuel's reflection sheets. At the beginning of Unit Inquiry B, Emmanuel was required to answer the question on the reflection sheet in order to explain how a group works together to complete a project. He wrote the steps in the Inquiry Cycle for his answer. Next Emmanuel completed the intervention lessons, which included the various roles of members of a group such as: (a) leader, (b) recorder, (c) researcher, and (d) presenter. Also, the intervention lessons included an explanation of what each of these group members does to contribute to the completion of the group project. Even though Emmanuel read these lessons many times, when he completed the reflection sheet a second time, he still wrote the steps of the Inquiry Cycle.

Jesse

The results from Jesse's end-of-unit reflection sheets are displayed in Table 10. Data are presented for several different factors. Narrative information regarding Jesse's reflection sheets is provided below Table 10.

Table 10

Jesse's Reflection Sheets

	Prior to Intervention	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Number of topic related sentences	0	0	1	2
Number of topic related phrases	0	2	0	3
Number of topic related words	0	0	0	0
Number of vocabulary words	0	7	0	0
Number of vocabulary words correctly defined	NA	8 out of 9	4 out of 9	10 out of 15

Jesse's reflection sheets. An analysis of Table 10 indicates that Jesse did learn some vocabulary words, and he did use some of these words when answering questions on the reflection sheets. Of the three units of inquiry, Jesse experienced the greatest success with Unit of Inquiry A. On the end-of-unit reflection sheet, Jesse was able to draw and accurately label five out of six steps of the inquiry cycle as well as add some brief descriptions. Most likely Jesse's difficulties with regulating his attention negatively impacted the amount of learning that took place during Unit of Inquiry B and C.

Nevertheless, of the three participants involved in the Year 6 Exhibition, Jesse was the participant who was most successful in filling out a reflection sheet related to the Year 6 Exhibition. Jesse's responses on the Year 6 Exhibition reflection sheet indicated that he had been able to comprehend and apply the information from Unit of Inquiry A and B.

Seth

The results from Seth's end-of-unit reflection sheets are displayed in Table 11.

Table 11

Seth's Reflection Sheets

	Prior to Intervention	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Number of topic related sentences		2	4	6
Number of topic related phrases		0	0	0
Number of topic related words		0	0	9
Number of vocabulary words		5	6	5
Number of vocabulary words correctly defined	NA	12 out of 14	6 out of 9	14 out of 15

Seth's reflection sheets. The results of Seth's reflection sheet, prior to beginning Unit of Inquiry C, are depicted in Figures 10 and 11. Seth was able to list one natural event and give the definition for one vocabulary word. The concept maps used during the intervention for Unit of Inquiry C are depicted in Figures 12, and the Futaba Games vocabulary word list used during the intervention for Unit of Inquiry C is depicted in Figure 13. Next, Seth's end-of-unit reflection sheets are depicted in Figures 14 and 15. A comparison of Figures 10 and 11 with Figures 14 and 15 give an indication of what Seth was able to learn by the end of the Unit of Inquiry. A comparison of Figures 12 and 13 with Figures 14 and 15 give an indication of the impact of the intervention on the Seth's learning as well as his ability to provide written evidence of what he had learned.

On the end-of-unit reflection sheet, Seth was able to list all 11 natural events, which were listed on the first concept map. He also listed scarcity as a natural event. When answering the second question, Seth remembered the word atmospheric, but he did not remember the words geological or hydrological. Instead, he used the words, land and storms. Additionally, when Seth answered the second question, he did not actually describe the causes of natural events. Instead, he reproduced the clusters of information on the first concept map, which listed types of natural events. This finding may indicate that the intervention was effective in teaching Seth information. However, the iPad® intervention may be more effective when combined with direct interaction with an adult. For example, a teacher or educational assistant could have checked on Seth's understanding of cause and effect.

For the last question, Seth was able to describe the impact of natural events. However, Seth's answer did not provide as many details as I would have hoped for, based on the intervention. Whereas he was able to list natural events and reproduce relatively accurate

concept maps, Seth found it more difficult to formulate detailed sentences for his answer to the third question.

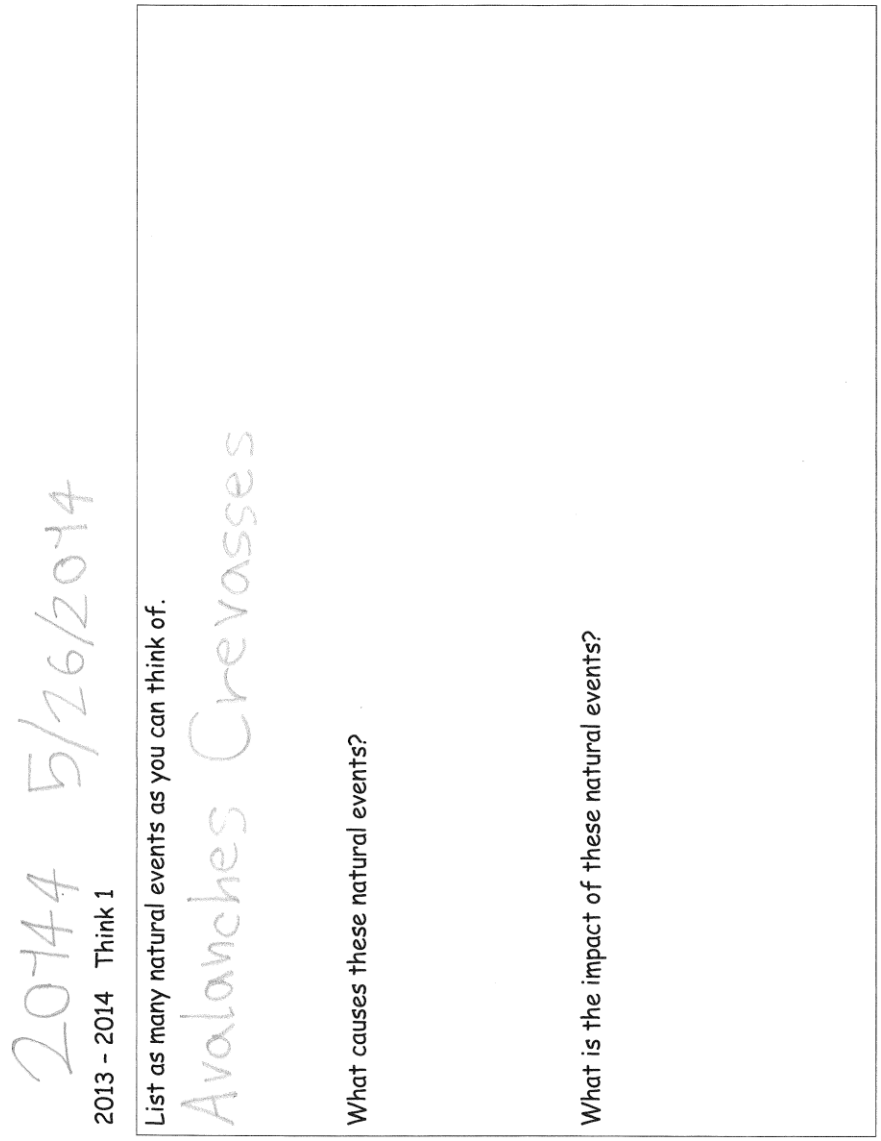
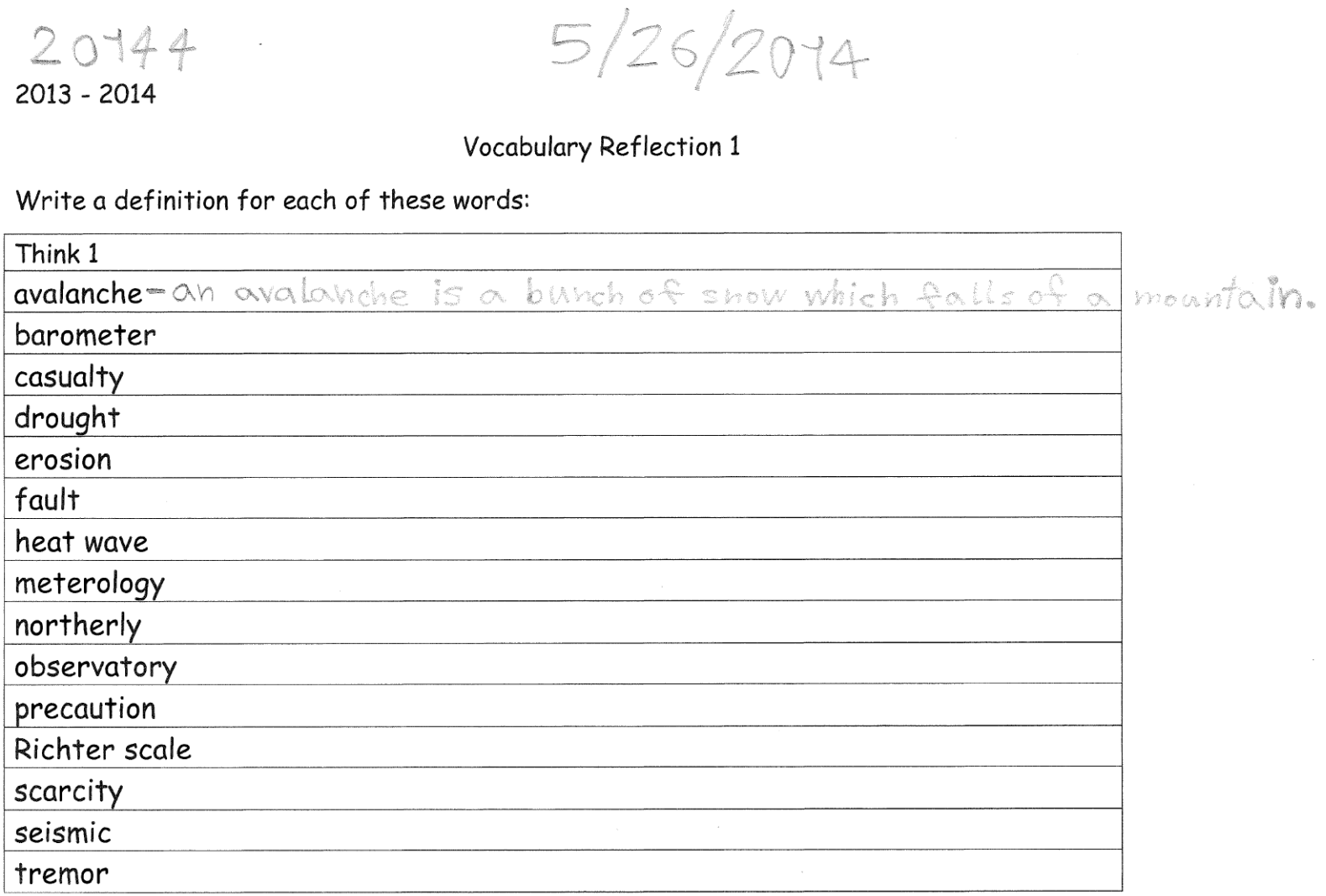


Figure 10. Part A of Seth's reflection sheet prior to beginning Unit of Inquiry C.



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Vocabulary Reflection 1

Write a definition for each of these words:

Think 1
avalanche - an avalanche is a bunch of snow which falls of a mountain.
barometer
casualty
drought
erosion
fault
heat wave
meterology
northerly
observatory
precaution
Richter scale
scarcity
seismic
tremor

Figure 11. Part B of Seth's reflection sheet prior to beginning Unit of Inquiry C.

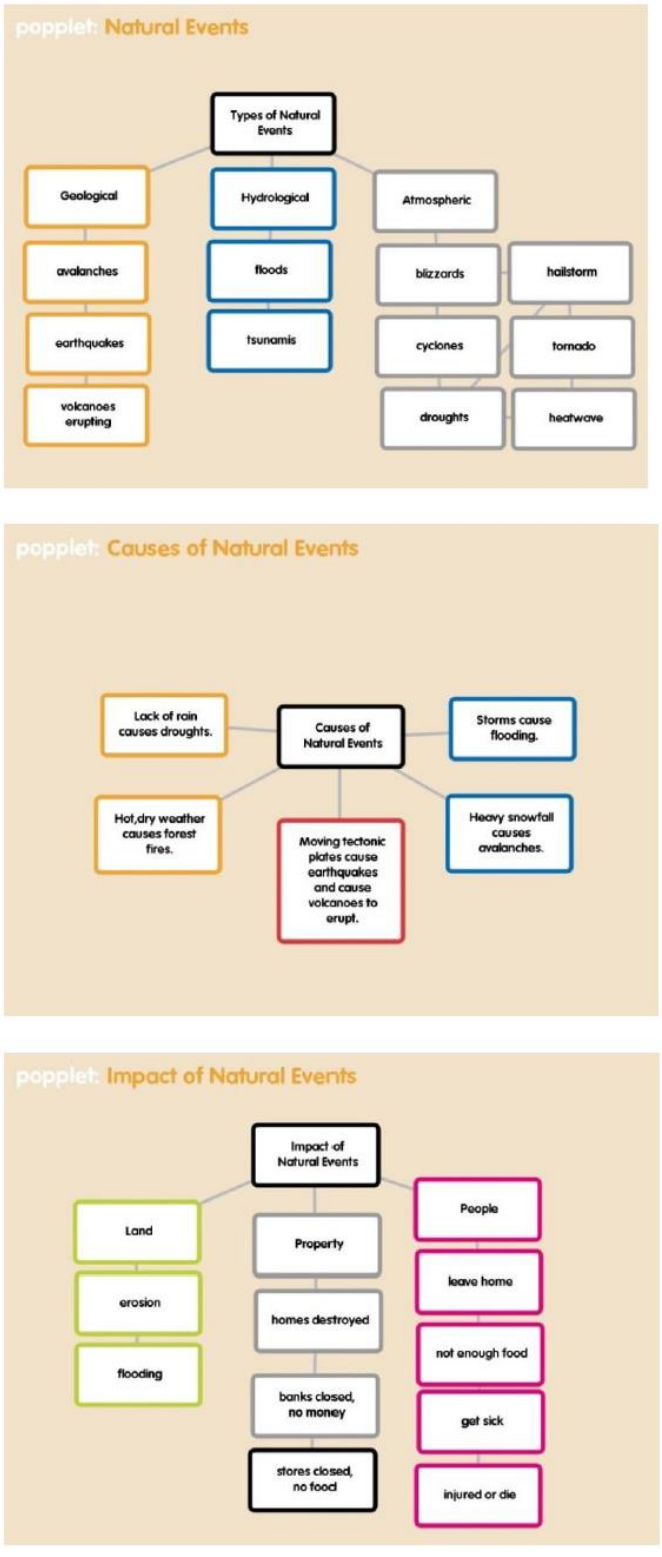


Figure 12. Popplet concept maps used during the intervention for Unit of Inquiry C.

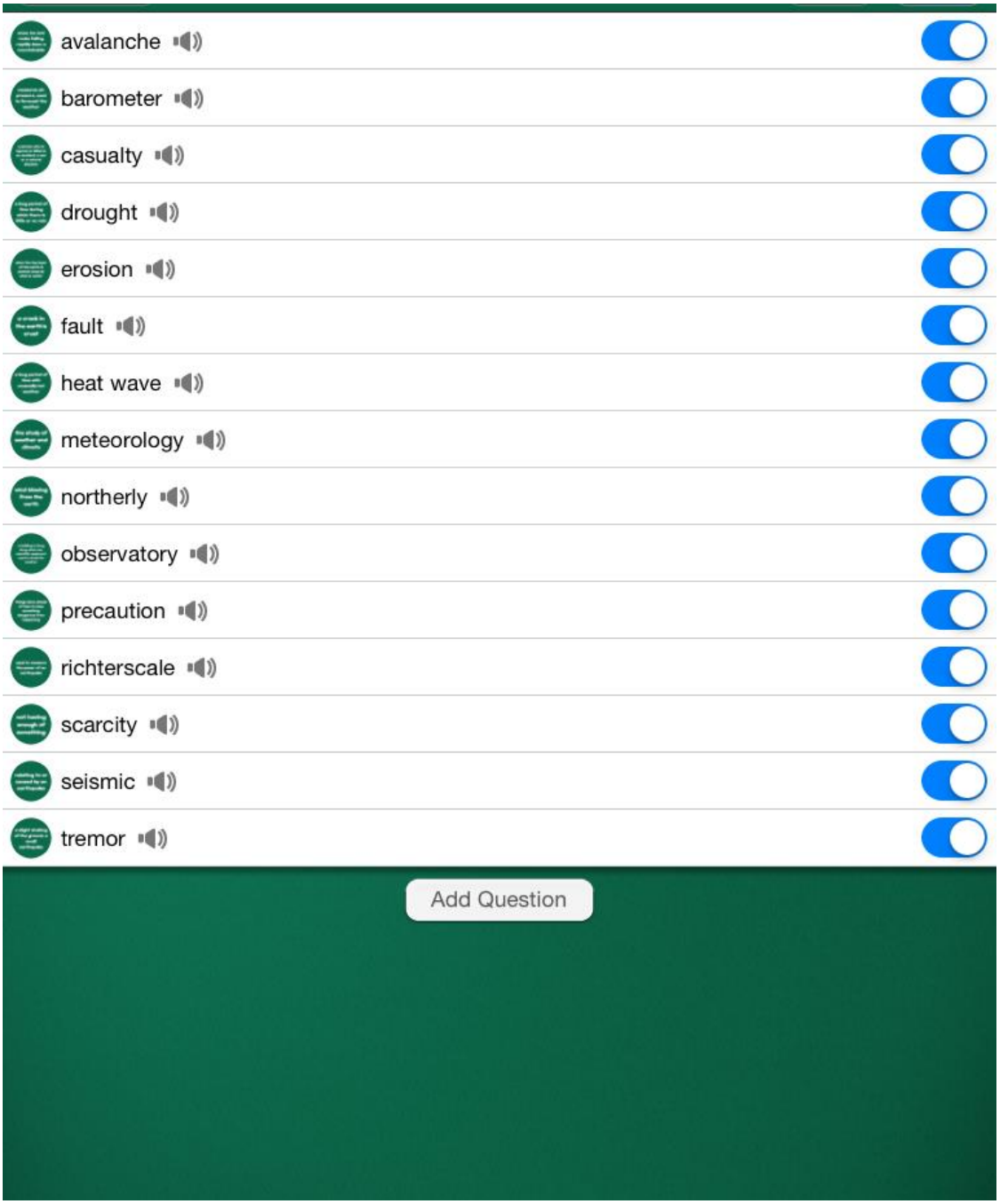


Figure 13. Futaba Vocabulary Game used during the intervention for Unit of Inquiry C.

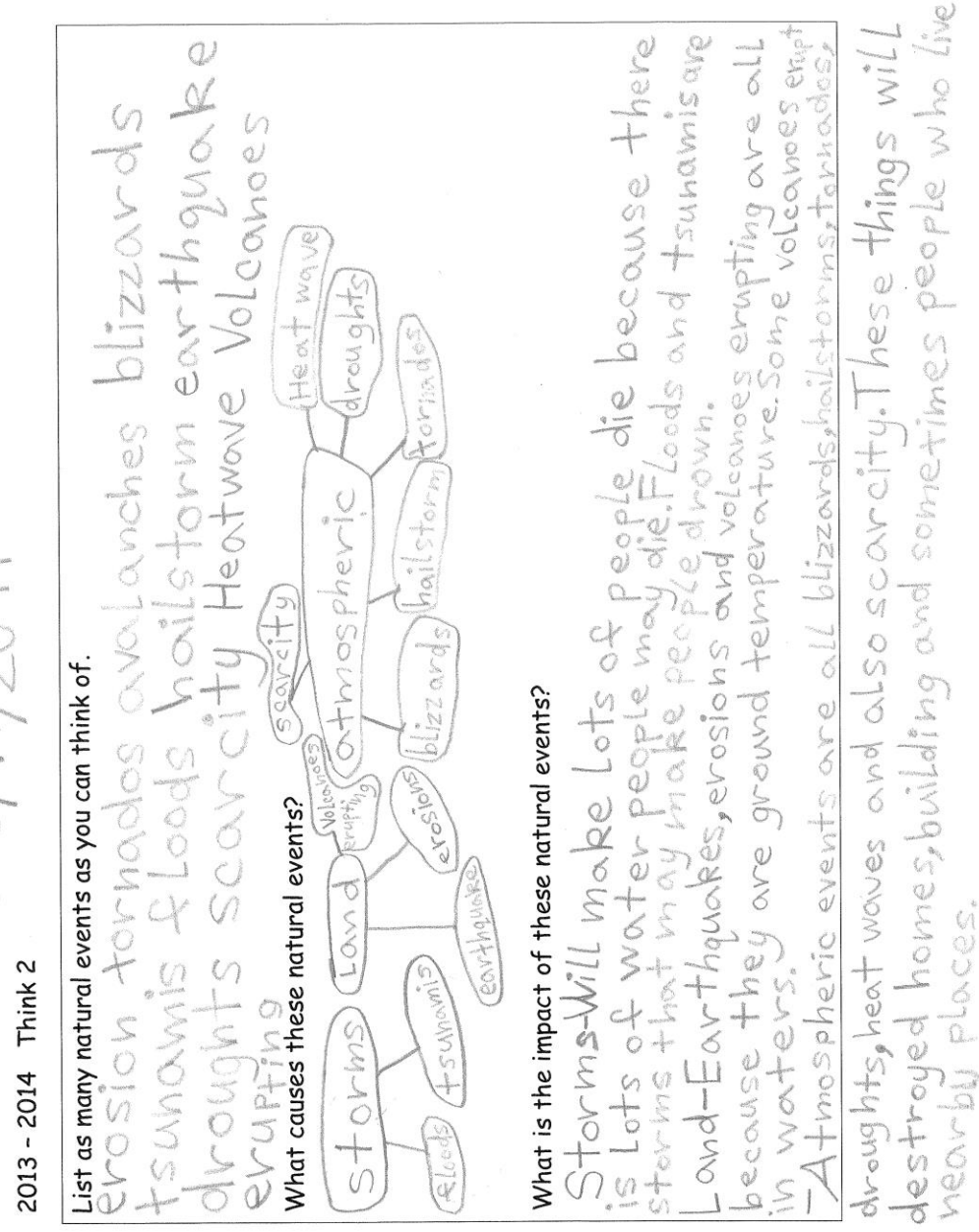
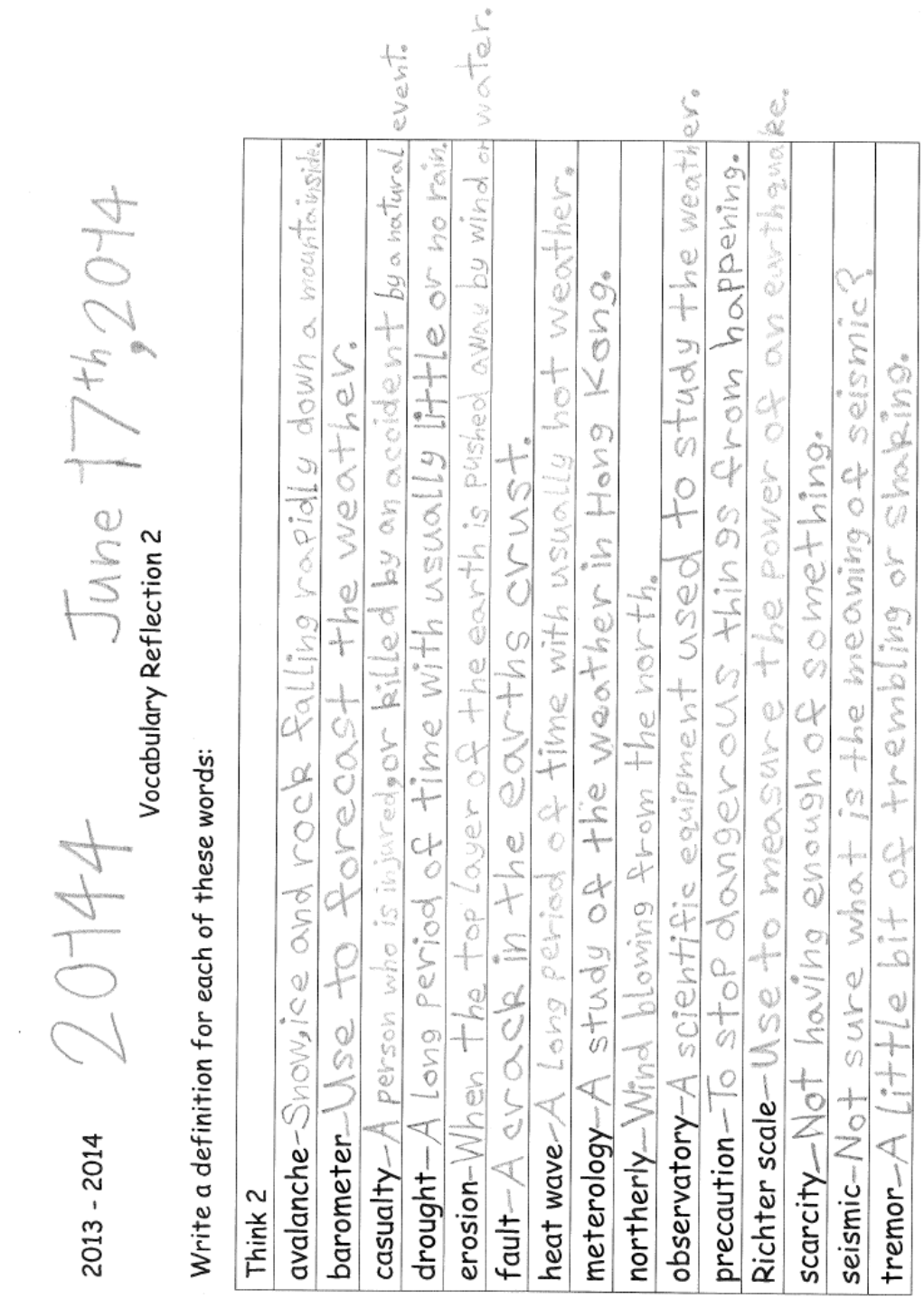


Figure 14. Part A of Seth's end-of-unit reflection sheet for Unit of Inquiry C.



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Vocabulary Reflection 2

Write a definition for each of these words:

Think 2
avalanche–Snow, ice and rock falling rapidly down a mountainside.
barometer–Use to forecast the weather.
casualty–A person who is injured, or killed by an accident by a natural event.
drought–A long period of time with usually little or no rain.
erosion–When the top layer of the earth is pushed away by wind or water.
fault–A crack in the earths crust.
heat wave–A long period of time with usually hot weather.
meterology–A study of the weather in Hong Kong.
northerly–Wind blowing from the north.
observatory–A scientific equipment used to study the weather.
precaution–To stop dangerous things from happening.
Richter scale–Use to measure the power of an earthquake.
scarcity–Not having enough of something.
seismic–Not sure what is the meaning of seismic?
tremor–A little bit of trembling or shaking.

Figure 15. Part B of Seth's end-of-unit reflection sheet for Unit of Inquiry C.

Theo

The results from Theo's end-of-unit reflection sheets are displayed in Table 12. Data are presented for several different factors. Narrative information regarding Theo's reflection sheets is provided below Table 12.

Table 12

Theo's Reflection Sheets

	Prior to Intervention	Unit of Inquiry A	Unit of Inquiry B	Unit of Inquiry C
Number of topic related sentences		0	3	3
Number of topic related phrases		1	0	1
Number of topic related words		4	1	3
Number of vocabulary words		3	3	11
Number of vocabulary words correctly defined	NA	12 out of 14	9 out of 9	14 out of 15

Theo's reflection sheets. Theo demonstrated consistent results on his end-of-unit reflection sheets throughout the three Units of Inquiry. For Part A of each end-of-unit reflection sheet, Theo would give short answers to the questions. Sometimes part of his answer consisted of rephrasing the question rather than actually giving a detailed response to the question. A quick glance at Table 12 suggests that Theo did notably better in Unit of Inquiry C. However, in actual fact, Theo was able to write 11 vocabulary words on Part A of the end-of-unit reflection sheet, because the first question asked him to list as many natural events as he could think of.

For Part B of each end-of-unit reflection sheet, Theo was able to write the vocabulary definitions he had learned from playing the Futaba Game during the intervention phase. The

iPad® intervention was effective in teaching Theo the meaning of the vocabulary words for the units of inquiry. However, as with Seth and his reflection sheets, the iPad® intervention would probably be more effective if an adult worked with Theo to discuss the concept maps and provide Theo with opportunities to articulate his learning.

Further questioning. One observation, which was made during this study, was that the participants would often write more when I gave a simple prompt such as "Can you write down anything else? or "Do you remember anything else from the iPad?" This observation supports previous research conducted by McCrory, Henry, and Happé (2007). These researchers concluded that the assessments, which involve free recall of information, did not appear to give an accurate measure of memory in students with ASD, and that through further questioning, these students can often demonstrate greater levels of recall of information.

Observation and Measurement

Research data were collected prior to the intervention for the purpose of establishing a baseline. Throughout each Unit of Inquiry, data were collected on both vocabulary acquisition and the functional use of Unit of Inquiry vocabulary during speaking activities in the inclusive classroom. At the end of each Unit of Inquiry, data were collected from the end-of-unit reflection sheets. Detailed descriptions of data collection procedures can be found in the following paragraphs.

Baseline data. I gathered baseline data by sitting next to the participant and watching the participant play the iPad® app game, which had been prepared for Unit of Inquiry A. The participant played the game four times, and each time I recorded the number of correct responses. At the beginning of Unit of Inquiry B, this procedure was repeated with the iPad® app game, which had been prepared for Unit of Inquiry B. Finally, at the beginning of Unit of

Inquiry C, the baseline data collection procedure was repeated with the iPad® app game, which had been prepared for Unit of Inquiry C.

Vocabulary acquisition. For multiple probe design research, intervention data are collected intermittently. Consequently, I gathered vocabulary acquisition data approximately two to three times a week. I sat next to the participant and watched the participant play the Futaba iPad® app game which has been prepared for Unit of Inquiry A. During this time I used the probe data collection form (Appendix L) to record each response. A plus sign indicated a correct response, and a minus sign indicated an incorrect response. Additionally, during some of the data collection sessions, the research assistant sat or stood near the participant and watched the participant play the Futaba iPad® app game. The research assistant used the probe data collection form (Appendix L) to record each of the participant's responses. Inter-observer agreement is reported in the section on procedural fidelity and reliability. This procedure of intermittent data collection was repeated for Unit of Inquiry B and Unit of Inquiry C.

Audio and video recordings. The research assistant or I digitally video and audio recorded each of the participant's interactions during Unit of Inquiry speaking activities. Then the research assistant used the recordings to tally the number of topic related sentences, topic related phrases, topic related words, and actual vocabulary words taught on the Popplet iPad® app. Later, I repeated this procedure. Inter-rater agreement is reported in the section on procedural fidelity and reliability.

End-of-unit reflection sheets. The participants completed the end-of-unit reflection sheet for Unit of Inquiry A, B and C. The research assistant recorded the number of topic related sentences, topic related phrases, topic related words, and actual vocabulary words taught on the Popplet iPad® app. Later, I also recorded the number of topic related sentences, topic related

phrases, topic related words, and actual vocabulary words taught on the Popplet iPad® app. Inter-rater agreement is reported in the next section on procedural fidelity and reliability.

Procedural Fidelity and Reliability

The research assistant used the participant script as a checklist to collect procedural fidelity data for the intervention sessions. Procedural fidelity data were collected for: (a) 55% of Edward's intervention sessions, (b) 53% of the Emmanuel's intervention sessions, (c) 62% of Jesse's intervention sessions, (d) 50% of Seth's intervention sessions, and (e) 55% of Theo's intervention sessions. I only needed to collect procedural fidelity data for 33% of the intervention sessions. However, I arranged for the research assistant to collect additional data to ensure that enough data had been collected. The research assistant collected varying amounts of procedural fidelity data for each participant, due to varying responsibilities. Procedural fidelity data indicated that all participants followed the intervention script accurately 100% of the time.

Also, the research assistant collected inter-observer data for intervention probe sessions. Inter-observer data were collected for: (a) 41% of the probe sessions with Edward, (b) 50% of the probe sessions with Emmanuel, (c) 56% of the probe sessions with Jesse, (d) 40% of the probe sessions with Seth, and (e) 40% of the probe sessions with Theo. The data I collected were compared with the data collected by the research assistant. An agreement was scored when my data matched the data collected by the research assistant. A disagreement was scored when my data did not match the data collected by the research assistant. Inter-observer agreement was then calculated by dividing the number of agreements (A) by the number of agreements and disagreements (A + D) and then multiplying by 100. Inter-observer agreement for the probe sessions was 100%.

Additionally, the research assistant collected inter-observer data for the audio and video recordings. Inter-observer data were collected for: (a) 75% of the recordings which included Edward, (b) 20 % of the recordings which included Emmanuel, (c) 60% of the recordings which included Jesse, (d) 33% of the recordings which included Seth, and (e) 33% of the recordings which included Theo. Once again, an agreement was scored when my data matched the data collected by the research assistant. Differences in the two sets of data were scored as disagreements. Inter-observer agreement was calculated by dividing the number of agreements (A) by the number of agreements and disagreements (A + D) and then multiplying by 100. Percentage agreement for the recordings ranged from 86% to 100% with a mean of 91%.

Finally, the research assistant collected inter-rater data for 33% of each participant's reflection sheets. Inter-rater agreement was calculated by dividing the number of agreements (A) by the number of agreements and disagreements (A + D) and then multiplying by 100. Percentage agreement for the reflection sheets ranged from 88% to 100% with a mean of 95%.

Social Validity

Prior to the beginning of the intervention, the general education classroom teachers and teachers' aides, who worked directly with the participants, were asked to complete a social validity questionnaire (see Appendix I). Once the study was completed, these teachers and teachers' aides were asked to complete the social validity questionnaire again. Researchers use social validity questionnaires to report the perceived effectiveness of an intervention in an educational setting (Carter, 2009). One individual was unable to complete the social validity questionnaire again at the end of the study, since she moved to Burma before the study was completed. The results from the social validity questionnaire are displayed in Table 13. The results indicated that, prior to the intervention, these teachers and teachers' aides viewed it as:

(a) acceptable, (b) beneficial, (c) realistic, and (d) potentially effective. These educators continued to view the intervention favorably after the study was completed. In fact, one individual wrote that the intervention was "more effective, I think" than other interventions, which had been used with the participants in the past.

Engagement. During the middle of Unit of Inquiry A, I observed a whole class Unit of Inquiry lesson in the general education classroom at International Primary School B. I observed that each time the general education teacher said one of the vocabulary words from the Futaba Game, Seth, one of the participants, would look over at me and smile. Seth listened, raised his hand to answer questions, and added to the comments of his classmates. After the lesson, the general education teacher walked over to me and stated that she had "never seen Seth so engaged in the lessons.". Additionally, she stated that "in the past, Seth did not pay attention because the discussion was just going over his head." The general education teacher concluded with the comment that I "should have been working with Seth all year." The comments of this general education teacher notably strengthened the results from the social validity questionnaire (see Appendix I).

Table 13

Social Validity Questionnaire Results

	1 = Strongly disagree	2 = Disagree	3 = Slightly disagree	4 = Slightly agree	5 = Agree	6 = Strongly agree
1. This would be an acceptable intervention for students with ASD.					2 **1**	2 **2**
2. Most educators would find this intervention appropriate for students with other educational needs besides ASD.					2	2 **3**
3. This intervention should prove effective in changing the child's learning.					2 **1**	2 **2**
4. I would suggest the use of this intervention to other educators.					2 **1**	2 **2**
5. The child's learning difficulties are serious enough to warrant the use of this intervention.					2 **1**	2 **2**
6. Most educators would find this intervention suitable for students with ASD.					2 **1**	2 **2**
7. I would be willing to use this intervention with students.					2 **1**	2 **2**
8. This intervention will not result in negative side effects for the child.					1 **1**	3 **2**

Table 13 (cont.)

	1 = Strongly disagree	2 = Disgree	3 = Slightly disagree	4 = Slightly agree	5 = Agree	6 = Strongly agree
9. This intervention would be appropriate for a variety of children.					2 **1**	2 **2**
10. This intervention is consistent with other interventions which I have tried with students.					3 **3**	1
11. The intervention is a realistic way to handle the learning difficulties of students with ASD.					2 **1**	2 **2**
12. The intervention is reasonable for the learning difficulties encountered by students with ASD.					3 **1**	1 **2**
13. I like the procedures in this intervention.					3 **1**	1 **2**
14. This intervention is a good way to handle the learning difficulties of students with ASD.					3 **1**	1 **2**
15. Overall, the intervention will be beneficial for the child.					3 **1**	1 **2**

Note. Top set of data = answers prior to intervention. Bottom set of data highlighted in bold = answers subsequent to intervention

Conclusion

The use of the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app to embed direction instruction into the inclusive classroom appears to have been most effective in helping the participants to learn the vocabulary words and concepts. Additionally, for Emmanuel, Jesse, Seth, and Theo, the intervention equipped them to be able to provide oral and written definitions of the vocabulary words. Edward was less successful in providing oral and written definitions, and this difference in achievement is most likely attributed to his borderline cognitive abilities. Also, use of the intervention supported some of the participants to be more engaged in the learning activities. Use of the intervention assisted Jesse, Seth, and Theo to be more involved in the speaking activities. However, it was less effective for Edward, with borderline intellectual capabilities, and Emmanuel, who did not always respond to teachers. In addition, use of the intervention was less effective than anticipated, in regard to the participants' ability to demonstrate what they knew on the end-of-unit reflection sheets. The contributing factors may have been that the participants: (a) found it difficult to provide detailed answers to open-ended questions, (b) did not modify their thinking based on the acquisition of new knowledge, (c) were excited about special events, and (d) were rushing to be finished. The findings from the social validity questionnaires provided further support for the acceptance of this intervention as being beneficial to students with ASD.

CHAPTER FIVE: DISCUSSION

The purpose of this study was to examine the effectiveness of the use of two iPad® apps on the ability of students with autism spectrum disorder (ASD) to learn vocabulary words and functionally use those words in speaking activities and on assessments. The intent of the study was to embed direct instruction for students with ASD into the Primary Years Programme (PYP) Unit of Inquiry lessons. A single subject multiple probe across behaviors with concurrent replication across five participants was employed for this study. Single subject graphs were used to record data points, which depicted the number of correct responses during: (a) the baseline session, (b) the intervention sessions, and (c) the maintenance session. Data points were analyzed for: (a) level changes, (b) level stability, and (c) data trends (Gast, 2010).

This study was based on the information processing model (Broucher & Bowler, 2008). In the information processing model, the term, encoding, is used to describe the act of placing information in one's memory, and the term, retrieval, is used to describe the act of locating that information in one's memory (Brown & Craik, 2000). The concepts of encoding and retrieving information are considered fundamental to the theory of memory (Broucher & Bowler). Various researchers (Frith, 1989; Just, Cherkassky, Keller, & Minshew, 2004; Takare, Minshew, Luna, & Sweeney, 2007) suggested that weak central coherence and poor neural connectivity may provide explanations for why individuals with ASD demonstrate difficulties with information processing and information retrieval (Coben & Meyers, 2008). Therefore, weak central coherence and neural underconnectivity were the two theories of autism which formed the theoretical framework for this study. Weak central coherence refers to the manner in which individuals with ASD notice the details, but often fail to weave the details together to understand the main idea (Frith, 1989; Happé & Booth, 2008; Levy, 2007; Rajendra & Mitchel, 2007).

Additionally, the results from Magnetic Resonance Imaging (MRI) suggest underconnectivity between regions of the brain in individuals with ASD (Coben & Myers, 2008; Just et al., 2004; Takare et al., 2007).

The intervention used in this study was designed to assist students with ASD to both encode and retrieve information. Pennington (2010) recommended that future researchers examine the effectiveness of the use of commercially available computer programs with students with ASD. More recently, Knight, Spooner, Browder, Smith, and Wood (2013) suggested that future researchers study the effectiveness of the use of a personal iPad® to teach vocabulary to students with ASD. Consequently, two inexpensive, commercially available iPad® apps were used for the intervention in this study. Since individuals with ASD demonstrate weak central coherence, and these participants were enrolled in the Primary Years Program (PYP) curriculum, where children are expected to "integrate a great deal of information" (International Baccalaureate Organization, 2002, p. 5), the Popplet iPad® app was used to create concept maps. Additionally, the Futaba Classroom Games for Kids iPad® app was used to provide multiple opportunities for matching the vocabulary words and definitions. As noted in Chapter 3, the participants' actions during this study supported the theory of weak central coherence. When initially presented with the concept maps, each participant enlarged the iPad® screen and then examined each piece of information in isolation.

Presented in the next section of this chapter is a summary of the findings. This summary is followed by a discussion of the findings, as well as the implications of the findings**.** The chapter concludes with recommendations for future research.

Summary of the Findings

Research Question #1: What effect will the use of both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to learn Unit of Inquiry vocabulary in the inclusive classroom?

A visual inspection of the graphs associated with Research Question #1 indicated a functional relationship between the intervention and the ability of each of the participants to learn Unit of Inquiry vocabulary words. The percentage of non-overlapping data was 100% for all five of the participants for each of the three Units of Inquiry. These results mean that the participants always correctly identified more vocabulary words during the intervention phase than they had previously identified during the baseline data collection phase. Results from the maintenance probe sessions for the three Units of Inquiry indicate that: (a) Edward retained 46% of all the vocabulary words, (b) Emmanuel retained 93% of all the vocabulary words, (c) Jesse retained 84% of all the vocabulary words, (d) Seth retained 83% of all the vocabulary words, and (e) Theo retained 100% of all the vocabulary words.

Research Question #2: What effect will the use of both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary during Unit of Inquiry lessons in an inclusive classroom setting?

Visual inspection of the tables associated with Research Question #2 indicated a functional relationship between the intervention and the ability of students with ASD to functionally use the vocabulary words in speaking activities in the general education classroom. Information gathered from a functional speech questionnaire indicated that, prior to this study,

the participants rarely contributed verbally during Unit of Inquiry lessons in the inclusive classroom. Consequently, during this study, audio and video recordings were used to collect information on the ability of the participants to functionally use Unit of Inquiry vocabulary words during lessons in the inclusive classroom. Next, the total number of vocabulary words as well as topic related words, phrases, and sentences were tallied and then recorded in table format. The findings indicated that the participants functionally used Unit of Inquiry vocabulary more often during lessons in the inclusive classroom than they had prior to this study.

However, there was variability in the results among participants and Units of Inquiry. Lower cognitive abilities and a preference for working on one's own were two factors that hindered participation in discussions. The findings of this study provide further support for the findings of Gabig (2008), who conducted a study on verbal working memory and language ability. Gabig concluded that stored vocabulary knowledge has a direct impact on the number of words per phrase or sentence spoken by students with ASD.

Additional narrative descriptions were necessary to provide a context for the numbers recorded in the tables. For example, during a group discussion in Unit of Inquiry A, Edward recited the intervention information, but he was not able to take pieces of the information and use them at the appropriate time or in an appropriate manner. Emmanuel was not comfortable speaking in small group settings and did not participate in speaking activities during Unit of Inquiry A or B. However, during Unit of Inquiry C, he was quite willing to participate in a partner situation. Jesse found it difficult to regulate his attention, and this difficulty impacted directly on his ability to follow the conversation and respond appropriately. Seth's ability to contribute to the conversation was influenced by whether he was with a group of children who included him in the conversation. Theo did not want to work with any of his classmates during

Unit of Inquiry C. Consequently, while the results do indicate a functional relationship between the intervention and functional use of Unit of Inquiry vocabulary words by students with ASD, other factors continue to serve as barriers to participating in conversations in the inclusive classroom.

Research Question #3: What effect will the use of both the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® app have on the ability of students with autism spectrum disorder to functionally use Unit of Inquiry vocabulary when completing end-of-unit reflection sheets?

Visual inspection of the charts associated with Research Question #3 indicated a functional relationship between the intervention and the ability of the participants to functionally use the vocabulary on the end-of-unit reflection sheets. Prior to this study, Edward, Emmanuel, and Jesse would generally sit and write nothing on the end-of-unit reflection sheets. Each of these participants required much adult support to respond to these reflection sheets. In contrast, throughout this study, the participants were able to retrieve information from their memories and independently record written responses on the end-of-unit reflection sheets.

Even though Edward demonstrated lower cognitive abilities than the other participants, he was able to draw a circle and write the first three out of six stages of the inquiry cycle. Emmanuel was able to draw and label the entire inquiry cycle. Jesse was able to draw and label five out of six stages of the inquiry cycle as well as provide a brief explanation of each stage. Seth and Theo were able to list 11 natural disasters. Seth was able to reproduce many of the visual images from the intervention. Use of the interventions evoked a positive impact on the ability of each participant to complete end-of-unit reflection sheets.

Discussion of the Findings

This research demonstrates that it is possible to use technology to embed direct instruction for students with ASD into inclusive classrooms where general education teachers use an inquiry-based method of teaching. Consequently, the findings from this study support those found in the Knight, Smith, Spooner, and Browder (2012) study on the use of direct instruction to teach vocabulary to students with ASD, and the Knight et al. (2013) study on the use of direct instruction combined with graphic organizers to teach students with ASD. In addition, these current findings support the previous results of Schenning, Knight, and Spooner (2013) on the use of direct instruction combined with graphic organizers to teach students with ASD in the context of inquiry-based lessons. Furthermore, due to a failure to meet quality indicators for single subject research, Smith (2012) noted that there was little quality research on the use of embedded computer assisted instruction (CAI) to teach students with ASD. Thus, the findings from this study contributed to the literature through the examination of the use of inexpensive, commercially available apps to embed direct instruction combined with graphic organizers in the context of two inquiry-based classrooms.

In addition to suggesting a teaching and learning strategy for students with ASD, the findings from this current study provide further support for the information already available on the topics of: (a) engagement, (b) further questioning, (c) generalization, (d) rehearsal strategies, and (e) weak central coherence. Students with ASD generally demonstrate motivation and enjoyment when they participate in computer-based lessons (Pennington, 2010). Similarly, the participants in this study were eager to use the iPad® and, after beginning the intervention, one of the participants was much more engaged in the Unit of Inquiry lessons in the inclusive classroom. Moreover, McCrory, Henry, and Happé (2007) noted that further questioning elicited

greater levels of recall in students with ASD. Likewise, the participants in this study demonstrated greater recall when given simple prompts such as "Can you write down anything else?" or "Do you remember anything else from the iPad?" Additionally, researchers question the ability of students with ASD to demonstrate generalization of their learning (Charlop, Schreibman, & Thibodeau, 1985; Chiang & Carter, 2008; Koegel, 2000; Spencer & Higbee, 2012). In this study, some of the participants were able to generalize their learning.

Furthermore, researchers (Bebko & Ricciuti, 2000; Phelan et al., 2011; Rhee, 2009) note the importance of teaching rehearsal strategies to students with ASD. In this study, two of the older participants demonstrated spontaneous rehearsal strategies while studying the concept maps on the Popplet app. However, the youngest two participants never demonstrated overt rehearsal strategies. Finally, individuals with ASD often demonstrate weak central coherence (Happé & Frith, 2006). Weak central coherence refers to a strength in noticing details and a corresponding weakness in identifying the main idea. The participants in this study demonstrated a similar focus on details. Each participant enlarged the concept maps on the iPad and read each piece of information in isolation. These observations serve as links between previous research and this study.

This study also addresses the recommendations of Boucher, Mayes, and Bigham (2012) for more studies that directly compare memory in lower functioning individuals with ASD (e.g., Edward) with memory in individuals with high functioning ASD (e.g., Emmanuel, Jesse, Seth, and Theo). Lastly, this study addresses the recommendations of Wong et al. (2014) regarding the conduct of studies with a more culturally diverse set of individuals with ASD. Whereas the majority of participants in previous studies have been Caucasian (Wong et al., 2014), the participants in this study were Asian.

Assumptions and Limitations

Assumptions

One of the fundamental assumptions**,** which underlie single-subject design studies**,** is that each individual is unique and "constitutes a complete basis for legitimate conclusions" (Johnson & Pennypacker, 2009, p. 260). A more comprehensive list of basic assumptions for single-subject design research would include the need for: (a) dependent and independent variables to be clearly defined, (b) systematic observations to take place, and (c) data to be analyzed visually (Kratochwill, et al., 2010). An additional assumption in single subject research is that how participants perform during the baseline phase is a good indicator of how those participants would perform if no intervention was provided for them (Golper & Frattali, 2012).

Limitations

Autism is a spectrum disorder, which includes children with widely varying profiles. Since each child demonstrates a unique combination of autistic characteristics, researchers have found it difficult to provide statistical analysis on large groups of children with autism. For this single-subject study, visual analysis was used to examine the data. Gast (2010) cautioned that one of the limitations in visual analysis is the possibility that the researcher will commit a Type I error. A Type I error is committed when the researcher concludes that a treatment is effective when, in actual fact, the treatment is ineffective (Gast, 2010). The researcher is less likely to commit a Type I error when multiple characteristics of the data are thoroughly examined. Consequently, in Chapter 4, the: (a) range, (b) median, (c) mean, (d) relative level change, (e) absolute level change, (f) trend stability, (g) trend direction and (h) percentage of non-overlapping data (PND) were reported for the data collected in this study.

Another limitation to this study was the lack of consistency among the recorded speaking activities. During one of the speaking activities, Seth and Theo were seated at a round table with three classmates. These three classmates sat together as they looked at a website displayed on the screen of a laptop. There was little conversation, and the students made little effort to include Seth and Theo in the activity. In contrast, during the next recording session, Seth worked with three classmates who actively included him in the conversations. Conversely, on that same day, Theo did not want to work with any of his classmates, and he completed his work in solitude.

A final limitation to this study was the inability to collect long-term maintenance data. After completion of the study, the participants began their summer holiday. Additionally, after the summer holiday, three of the participants transitioned from primary school to secondary school. If a study was conducted at the beginning of a school year, it would allow time for long-term maintenance data collection.

Implications

Theoretical Implications

This study was based on the information processing model (Boucher & Bowler, 2008), a model which focuses on the encoding and retrieval of information. The two theories of autism, which informed this study, were the theory of weak central coherence proposed by Frith (1989) and the theory of neural underconnectivity (Just et al., 2004). Roberts and Joiner (2007) addressed the issue of weak central coherence by the use of concept maps with students with ASD. The results from their research study demonstrated a fourfold increase in learning through the use of concept maps. In this current study, the findings added to the literature regarding the positive results of the use of concept maps with students with ASD. Additionally, as noted in the

previous chapter, the participants' actions during this study supported the theory of weak central coherence. When initially presented with the new concept maps, each of the participants enlarged the iPad® screen and then studied each piece of information in isolation. Based on this observation, it is necessary to explicitly teach students with ASD the purpose of concept maps.

Methodological Implications

Research design. The findings from this study support the effectiveness of the single subject multiple probe across behaviors with concurrent replication across participants research design (Gast, 2010; Horner & Baer, 1978, Tawney & Gast, 1984) for conducting research with students with ASD. The use of this research design facilitated the collection of detailed data on the participants. Additionally, the use of this design enabled the study of the effectiveness of this intervention for several Units of Inquiry.

Use of technology. This study included the use of iPads to: (a) deliver the intervention, (b) collect probe data, and (c) record the participants during Unit of Inquiry lessons in the inclusive classroom. Any intervention, which involves the use of technology, is prone to technological difficulties. Although the school had numerous recharging boxes for mini- iPads®, there was no recharging box for the regular iPads®, which were used in this research study. Consequently, on one occasion, one iPad® was not charged, when it was time for the intervention. On another occasion, an iPad® ran out of storage space in the middle of a recording session. From then on, the recordings were systematically downloaded to a laptop and then deleted from the iPad®. Lastly, another unexpected situation occurred when it was discovered that one classroom was so small that, literally, there was no place to set up a tripod for recording. Consequently, the iPads® and microphones had to be handheld during the recording sessions. In summary, practitioners need to have a system in place for deleting old data and recharging the iPads®.

Practical Implications

Researchers hope that their research will inform practice. However, practitioners are more likely to act on research findings when the methods suggested by researchers are practical (Parsons et al., 2013). This next section looks at factors that would make the intervention more effective for practitioners.

Modification of apps. Although inexpensive, commercially available apps can allow this intervention to be used in school, tutorial, and home settings, there are some features of each app, which should be modified for use with students with ASD. For example, for children who have been diagnosed with an intellectual disability, it would be more effective to redesign the Futaba game with the option to incorporate Errorless Learning (Matson, 2009). Errorless Learning is a method of teaching that ensures that the child answers correctly each time and does not have the opportunity to learn an incorrect answer. Consequently, the Futaba Game could be programmed so that only the one correct choice would appear, and the child would press on that one correct choice. This modification would reinforce the correct answers and allow the child to experience success. In order to measure progress, future researchers or educators could have a second game available, and the second game could have two to four choices from which the participant would make a choice. Alternatively, the Futaba Game could be designed with different levels of difficulty similar to many video and computer games.

It would also be worthwhile to consider changing some of the programmed responses. For example, when the participants in this study played the vocabulary game on the Futaba Classroom Game for Kids® app, they lost an earned point each time they pressed a wrong answer. Many students with ASD are perfectionists who hate making a mistake, and they would think it is unfair to have an earned point taken away from them. It would be better to design the game so that earned points are not taken away from the players. Additionally, if a participant did

complete the entire Futaba cycle, the app would tell how long it took to complete the cycle and make a comment such as "Try harder next time." This feature does not motivate a student with ASD who has tried their best. It would be better to design the game with positive feedback no matter how long the student took to complete the cycle.

Furthermore, the Popplet app, which allows individuals to create their own concept maps, would be even more useful if the designers included a feature, which would read the concept map aloud and highlight the words that are being read. Many current designers of apps welcome feedback from customers. Consequently, I sent one email to the designer of the Popplet iPad®app and another email to the designer of the Futaba Classroom Games for Kids® app. In the emails, I included a description of and rationale for suggested improvements to the apps.

Multiple-choice questions. The participants in this study demonstrated varying degrees of improvement in the quantity and quality of their written responses on the end-of-unit reflection sheets. However, previous research (Beversdorf, Narayanan, Hillier, & Hughes, 2007) on free recall by students with ASD, indicated a 30% decrease in the number of words recalled in comparison to students without ASD. Therefore, it is possible that the open-ended nature of the task did not allow the participants to demonstrate all that they had learned during the Unit of Inquiry.

Several researchers (Bowler, Gaigg, & Gardiner, 2010; Phelan et al., 2011; Sze, 2009) have recommended providing semantic cues to address difficulties with free recall in students with ASD. Additionally, Mayes and Calhoun (2008) recommended the use of multiple-choice questions to address deficits in free recall in students with ASD. Therefore, in addition to the intervention described in this study, it would be good for practitioners to modify end-of-unit reflection sheets by adding word banks and multiple-choice questions. These two modifications

would allow a more in-depth examination of the breadth and depth of learning that took place throughout the Unit of Inquiry.

Rehearsal strategies. In this study, the term "rehearsal strategies" refers to strategies for practicing information over and over until the information is retained. As previously noted, only the two oldest participants, Emmanuel and Jesse, consistently practiced rehearsal strategies while they completed the intervention. Edward demonstrated spontaneous rehearsal on a few occasions. However, the two youngest participants, Seth and Theo, never demonstrated rehearsal strategies. Consequently, it would be useful for special education teachers, general education teachers, and their assistants to be cognizant of the need to gradually and explicitly teach rehearsal strategies to students with ASD.

Technology. As mentioned previously in the section on methodological implications, the use of iPads® for classroom instruction requires the monitoring of readiness for use. From a practical viewpoint, it is best to designate someone or ask for a volunteer to be responsible for ensuring that the iPads® are being recharged on a consistent basis. Recharging boxes are now commercially available to recharge multiple iPads® simultaneously.

Recommendations for Future Research

Based on the results from this study, researchers and educators may want to consider the following recommendations for future research:

1. The researcher should strive to work as closely as possible with the general education teacher. The more closely the researcher ties the intervention to the activities of the classroom, the greater the impact of the intervention on the ability of the participants to learn and participate in the classroom activities.

2. It would be better to shorten the length of time of the recordings, as well as the number of expected video and audio recording sessions. For the participants in this study, the 10 minute recording sessions were too long. Recording sessions of 5 minutes would be more reasonable. Additionally, with all the special activities, such as swimming lessons, trips to the theatre, piano competitions, and teacher in-service days, it was not possible to have three recording sessions per Unit of Inquiry. One recording session per Unit of Inquiry is more realistic and would be viewed as less intrusive in the eyes of the general education classroom teacher.
3. Whenever possible, place password protected locks on all materials prepared on apps. During Unit of Inquiry C, Emmanuel took Edward's iPad®, went into the settings, and changed some of the vocabulary words and definitions. Emmanuel also deleted one of the concept maps from Edward's iPad®. "I wanted to surprise him," Emmanuel said.
4. More studies should be conducted that directly compare memory in lower functioning individuals with ASD (e.g., Edward) with memory in individuals with high functioning ASD (e.g., Emmanuel, Jesse, Seth, and Theo).
5. It would be useful to replicate this study with students who struggle in school due to: (a) receptive-expressive language disorder, (b) attention deficit hyperactivity disorder **(**ADHD), (c) English as an Additional Language, (d) low average abilities, or (e) global delays.
6. It would be useful to examine the effects of blending this intervention with interaction with a teacher or educational assistant. Through examination of the end-of-unit reflection, I discovered that some participants demonstrated

misunderstandings. For example, Seth wrote that scarcity was a type of natural disaster. Adding interaction with an adult to the intervention would allow the identification of misconceptions and provide opportunities for clarification when necessary.

7. In this study, two of the older participants demonstrated rehearsal strategies. However, the youngest two participants did not demonstrate overt rehearsal strategies. Consequently, future researchers might consider studying the effects of combining the intervention in this study with the explicit teaching of rehearsal strategies.

8. Through this study, it became apparent that there was a great deal of variance in the ability of general education classmates to work with their peers who displayed ASD characteristics. Jones and Frederickson (2010) noted that school personnel tend to emphasize social skills training for students with ASD. Based on their study related to predictors of social inclusion, these two researchers recommended that social skills training for students with ASD should be augmented with training general education classmates to work with students with ASD. More recently, Camargo et al.(2014) conducted a review of the literature on teaching social skills to students with ASD in the context of the inclusive classroom. These researchers recommended that the need for peer training be included in the analysis of data on social skills acquisition by students with ASD. Therefore, a further recommendation for this study would be that future researchers could focus on the impact of peer training on the ability of students with ASD to participate in speaking activities in the inclusive classroom.

Summary

This study was focused on the effectiveness of the use of two iPad® apps to embed direct instruction for students with ASD into the PYP Unit of Inquiry lessons. The intervention was successfully implemented with five students in two international primary schools in Hong Kong. The intervention was also implemented in two different grade levels, in order to study a variety of topics across three different Units of Inquiry. The results from this research study contributed to the recent body of literature (Knight et al., 2012; Knight et al., 2013; Schenning et al., 2013; Smith, 2012), in regard to information retrieval in students with ASD. In addition, this study documents a practical way for educators to provide effective instruction for students with ASD. Furthermore, the results from this study provide support for the concept of embedding direct instruction for students with ASD into inquiry-based lessons in the inclusive classroom.

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APPENDICES

APPENDIX A

Permission Letters from Principals

24th January 2013

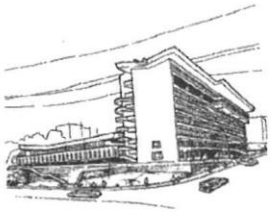
To Whom It May Concern.

Please note that Mrs Mary Briggs has been given permission to carry out research at School, Hong Kong linked to her Doctorate studies.

Yours sincerely

Principal

SCHOOL



Principal

Hong Kong

Tel (852) Fax (852)
E-Mail www.

4th February 2013

Re: Mary Briggs Research Project at School, Hong Kong

To, Whom it may concern,

I am writing to confirm that permission has been granted for Ms. Mary Briggs to carry out her research at School in regards to her dissertation proposal.

Please do not hesitate to contact me should you require any further details.

Kind regards,

Principal

APPENDIX B

Updated Information Letter for Principals

September 22, 2013

Dear _____ & _____,

Thank you for granting your permission for me to conduct my research in _____ School and _____School. Although we have talked about the research, I wanted to ensure that you had written information which you could refer to as needed.

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree in Teaching and Learning. The title of my research project is *Enhancing the Ability of Students with Autism Spectrum Disorder to Retrieve Vocabulary for Use in an Inquiry-Based Classroom: A Single Subject Multiple Probe Design Study*, and the purpose of my research is to investigate the use of two iPad® apps as a means of increasing the academic achievement of students with autism spectrum disorder within an inquiry-based classroom setting. In this study, a particular focus will be placed on vocabulary, as vocabulary acquisition has been identified as the greatest indicator of academic success.

Participants from your school will be asked to: 1) complete a standardized receptive vocabulary test, and 2) complete intervention sessions involving the use of two iPad® apps during regular Unit of Inquiry lessons. Additionally, participants will be video and audio recorded during some Unit of Inquiry lessons in the mainstream classroom. Multiple viewings of the recordings will increase the likelihood of a more accurate count of vocabulary words spoken during Unit of Inquiry activities in the mainstream classroom. The data will be used to determine the effects of two iPad® apps on the academic achievement of students with autism spectrum disorder who have been placed in an inquiry-based classroom.

Parents of participants will be presented with informed consent information prior to participation. I am attaching the informed consent form for your perusal. Taking part in the research study is voluntary, and participants will be allowed to withdraw from the study at any time.

Thank you for allowing me to conduct research in your schools.

Sincerely,

Mary Fay Briggs

APPENDIX C

Participant Recruitment Letter

January 2014

Dear Mr. and Mrs. _____,

As a graduate student in the Education Department at Liberty University, I am conducting research as part of the requirements for a Doctor of Education (Ed.D.) in Teaching and Learning, and I am writing to invite your child to participate in my study.

The purpose of the study is to investigate the use of two iPad® apps as a means of increasing the academic achievement of students with autism spectrum disorder within an inquiry-based classroom setting.

If you agree for your child to participate in this study, then your child will begin by completing the Peabody Picture Vocabulary Test (PPVT). This test takes approximately 10 – 20 minutes to complete and provides a measure of your child's receptive vocabulary. After this preliminary test, the researcher will show your child how to use the two iPad apps. When your child can use the iPad apps independently, then he/she will use the two iPad® apps to learn vocabulary during Unit of Inquiry lessons in the mainstream classroom. Your child will use the two iPad apps three times during a 45 – 90 minute Unit of Inquiry session. Each time your child will spend approximately five minutes using the iPad. Your child will also complete periodic vocabulary acquisition assessments and be video and audio recorded during some mainstream Unit of Inquiry lessons. The purpose of the recordings is to count the number of vocabulary words spoken by your child during Unit of Inquiry lessons.

The results of this study will be published in a dissertation and a condensed version may be published in a peer reviewed journal. Please be assured that published materials will not include personal information which would make it possible for others to identify your child as a participant in this study.

An informed consent document is attached to this letter. The informed consent document contains additional information about my research.

If you are interested in having your child participate in this study, please contact me at
Sincerely,

Mary F. Briggs
Learning Support Class Manager
_____ School

APPENDIX D

Consent Form

Enhancing the Ability of Students with Autism Spectrum Disorder
to Retrieve Vocabulary for Use in an Inquiry-Based Classroom:
A Single Subject Multiple Probe Design Study

Mary F. Briggs
Liberty University
School of Education

Your child is invited to participate in a research study exploring the use of two iPad apps as a means of increasing your child's learning and participation within Unit of Inquiry lessons. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Mary F. Briggs, Doctoral Student at Liberty University and a staff member of _____ School

Background Information

The purpose of this study is to investigate the use of two iPad® apps as a means of increasing the academic achievement of students with autism spectrum disorder within an inquiry-based classroom setting. In this study, a particular focus will be placed on vocabulary, as vocabulary acquisition has been identified as the greatest indicator of academic success.

Procedures:

The researcher will read the iPad Activities Explanation sheet with your child to help your child understand the purpose and design of the research. Next your child will complete a standardized receptive vocabulary test. After that, the researcher will train your child to use the Popplet iPad® app and the Futaba Classroom Games for Kids iPad® apps to learn Unit of Inquiry vocabulary. Prior to the intervention phase, your child will use the game app approximately three to five times to provide evidence of which words your child already knows.

Your child will complete the intervention activities three to four times per week. The intervention activities will include having your child use the two iPad® apps at three convenient times throughout the Unit of Inquiry lesson. Each time your child will use the iPad for around five minutes. Approximately twice a week, the researcher will record your child's responses in order to measure acquisition of vocabulary. Additionally, your child will be video and audio recorded during at least three speaking activities for each of the three Units of Inquiry. Each recording session will last approximately 10 minutes.

In summary, if you agree for your child to be in this study, you are giving permission for your child to: 1) complete a standardized receptive vocabulary test, 2) use two iPad® apps to learn

vocabulary during Unit of Inquiry lessons in the mainstream classroom, 3) complete periodic vocabulary acquisition assessments and 4) be video and audio recorded during some mainstream Unit of Inquiry lessons. The purpose of the recordings is to count the number of vocabulary words spoken by your child during Unit of Inquiry lessons.

If, at any given time, your child does not want to use the teaching or games app, then the researcher will not force your child to use the apps and will not discipline your child for not wanting to use the apps.

Risks and Benefits of the Study:

The risks of this study are no more than your child would encounter in everyday life.

The potential benefits to participation are: 1) increased mastery of vocabulary words associated with your child's Unit of Inquiry, 2) increased participation in Unit of Inquiry lessons and 3) increased demonstration of understanding on Unit of Inquiry reflection sheet.

Educational Psychologist's Report

The researcher will need to view your child's educational psychologist's report to confirm a diagnosis of ASD. The researcher will also use the educational psychologist's report to confirm you child's age. The researcher will not keep a copy of your educational psychologist's report.

Evidence of Learning

The researcher will need to view your child's end-of-unit reflection sheet for the last Unit of Inquiry and record the number of Unit of Inquiry vocabulary words your child used when completing that reflection sheet. The researcher will then have a basis for comparing if your child uses more vocabulary words on the reflection sheet as a result of using the iPad apps. The researcher will also ask your child's mainstream classroom teacher, learning support class teacher and learning support class educational assistant to complete a Functional Speech Questionnaire. This questionnaire will provide the researcher with information regarding the frequency and nature of your child's involvement in speaking activities in the mainstream classroom. The researcher will then have a basis for comparing if your child participates more often in speaking activities as a result of using the iPad apps.

Compensation:

There will be no monetary compensation for participation in this study. However, motivation is considered to be a key factor contributing to academic success. Therefore, in order to encourage daily cooperation, students will receive green stickers for demonstrating cooperation throughout each session. Participants will have the option of using 15 green stickers to choose a prize from the small Treasure Box or using 30 green stickers to choose a prize from the big Treasure Box.

Confidentiality:

Each participant will be assigned a number so that all data can be coded. The coded data will be stored on a password protected computer that is not part of a network system. The results of this study will be published in a dissertation and a condensed version may be published in a peer reviewed journal. Published materials will not include personal information which would make it possible for others to identify your child as a participant in this study. Research records including recordings will be stored securely on a USB. The USB will be kept in a locked file drawer. The research records will be deleted after three years.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect his/her current or future relations with _____ School, _____ School, or Liberty University. If you decide to allow your child to participate, he/she is free to not answer any question or withdraw at any time without affecting those relationships.

How to Withdraw from the Study:

You can withdraw your child from the study at any time by contacting the researcher at _____ School, phone number or email address.

In the event that you choose to withdraw your child from the study, the researcher will destroy any recordings which include only your child. If a recording includes your child along with other participants, the researcher will use inpainting software to erase your child's image from the recording and audio editing software to remove your child's voice from the recording.

Contacts and Questions:

The researcher conducting this study is Mrs. Mary Briggs. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at _____School, phone number or email address. Additionally, you may contact the Chair of the Dissertation Committee, Dr. Barbara White, at bawhite2@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24515 or email at irb@liberty.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:

☐ I have read and understood the above information.

☐ I have asked questions and have received answers.

☐ I give consent for the researcher to view my child's educational psychologist's report.

☐ I give consent for the researcher to view my child's last Unit of Inquiry reflection sheet.

☐ I give consent for my child to be video and audio recorded.

☐ I give consent for my child to participate in this study.

Signature of parent or guardian: _____ Date: _____
(If minors are involved)

Signature of Investigator : _____ Date: _____

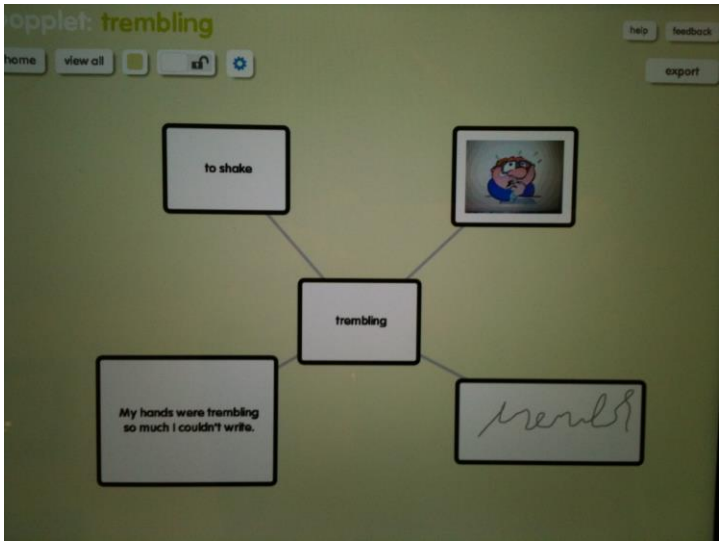
IRB Code Numbers: 1805.030614 **IRB Expiration Date:** March 6, 2015

APPENDIX E

iPad Activities Explanation

Here are some of the things that I will do during my lessons:

1. I will use the iPad to learn words for my Unit of Inquiry.
2. I will open the Popplet app.



3. I will read all the words.
4. I will watch the video.
5. Next, I will open the Futaba app.
6. I will play the game for two minutes. The game will help me to practice the new words.
7. I will use the iPad like this three times during the Unit of Inquiry lesson.
8. I will learn new words. I can use my new words when I am talking with my classmates. I can use my new words when I do the Unit of Inquiry

The Treasure Box

1. I will have a sticker chart. My sticker chart will look like this:

Please note that the sticker charts will be customized to each child. Each child will have three targets. Once sticker charts have been prepared, they will be included in the Appendix.

2. If I don't want to use the iPad that is OK, but I won't get any stickers.
3. I will get stickers when I use the iPad.
4. When I have 15 stickers, then I can choose a small prize from the small Treasure Box.
5. OR I can save my stickers until I have 30 stickers so I can choose a bigger prize from the bigger Treasure Box.

APPENDIX F

Script and Form for Student Consent

Hello, _____ ,. . . my name is Mrs. Briggs, and this is Miss Pang.

We are doing a project to see if students can learn new words by using the iPad.

We want to ask you to help us see if using an iPad is a good way to learn.

Let's read about how this will work. Let's look at this paper. It says "Learning New Words." (Read the iPad Activities Explanation sheet which describes the research procedure and the Treasure Boxes.)

(Pointing to iPad Activities Explanation sheet that was just read) If you want to help us with our project, this is what you would do.

What I learn from this project may also help other children to learn new words.

Do you have any questions? (Answer questions.)

Do you want to help us with the study? (If yes, then read consent form with student, and ask student to sign the form.)

Assent of Child to Participate in a Research Study

What is the name of the study and who is doing the study?

Mrs. Briggs and Miss Pang are doing a study called "Using the iPad to Learn New Words."

Why are we doing this study?

We are interested in studying to see if students can use iPads to learn new words for their Unit of Inquiry lessons.

Why are we asking you to be in this study?

You are being asked to be in this research study because we think using the iPad will help you learn new words for your Unit of Inquiry lessons.

If you agree, what will happen?

If you are in this study, you will use the iPad to learn new vocabulary words.

Do you have to be in this study?

No, you do not have to be in this study. If you want to be in this study, then tell us. If you don't want to, it's OK to say no. We will not be angry with you. You can say yes now and change your mind later. It's up to you.

After you start the study, you might decide you don't want to be in the study anymore. You can tell your parents. We will not be angry with you.

Do you have any questions?

You can ask questions any time. You can ask now. You can ask later. You can talk to us. If you do not understand something, please ask us to explain it to you again.

Signing your name below means that you want to be in the study.

_____ _____

Signature of Child Date

Researcher - Mrs. Mary Briggs
Dissertation Chair – Dr. Barbara White bawhite2@liberty.edu
Liberty University Institutional Review Board,
1971 University Blvd, Suite 1837, Lynchburg, VA 24502
or email at irb@liberty.edu.

APPENDIX G

Visual and Audio Recording Consent Form

Mary F. Briggs
Liberty University
School of Education

Your child is invited to fill a vital role in a research study exploring the use of iPad® apps as a means of increasing children's learning and participation within Unit of Inquiry lessons. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Mary F. Briggs, Doctoral Student at Liberty University and a staff member of _____ School.

Background Information:

The purpose of this study is to investigate the effects of iPad® apps as a means of increasing academic achievement in an inquiry-based classroom setting. In this study, a particular focus will be placed on vocabulary, as vocabulary acquisition has been identified as the greatest indicator of academic success.

As is often required in research studies, actual participants in this study have been selected from a pool of potential participants meeting set criteria. As part of the research, these students will be recorded during lessons in your child's classroom. While your child is not an actual participant in this research, it is highly likely that at some point your child might be recorded as part of the recordings of the actual participants.

Procedures:

If you agree for your child to be recorded during this study, then there is the possibility that your child may be recorded during Units of Inquiry lessons that take place throughout the duration of this study.

Risks and Benefits of the Study:

Recordings of various school activities are a part of the everyday culture of learning at your child's school. Therefore, the risks of this study are no more than your child would encounter in everyday life.

The potential benefits to participation are that children may one day benefit from the findings of this research.

Compensation:

There will be no monetary compensation for participation in this study.

Confidentiality:

The results of this study will be published in a dissertation and a condensed version may be published in a peer reviewed journal. Published materials will not include personal information which would make it possible for others to identify you your child as a participant in this study. Research records will be stored securely on a password protected computer that is not part of a network system and only the researcher will have access to the records. The research records will be deleted after three years.

Voluntary Nature of the Study:

As a parent/guardian, you can decide whether or not to allow your child to appear in the recordings. Your decision will not affect your current or future relationship with _____ School, _____School, or Liberty University. If you prefer that your child not appear in the recordings, please indicate your decision in the Statement of Consent at the bottom of this form. The researcher and teacher will ensure that the participants are not seated near your child. Likewise, if you decide to allow your child to appear in the recordings, you can indicate so in the Statement of Consent at the bottom of this form.

How to Withdraw from the Study:

You can withdraw your child from being recorded at any time by contacting the researcher at _____ School, 2394, phone number or email address. In the event that you choose to withdraw your child from the study, the researcher will use inpainting software to erase your child's image from the recordings and audio editing software to remove your child's voice from the recordings.

Contacts and Questions:

The researcher conducting this study is Mrs. Mary Briggs. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at _____School, phone number or email address. Additionally, you may contact the Chair of the Dissertation Committee, Dr. Barbara White, at bawhite2@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24515 or email at irb@liberty.edu.

Statement of Consent:

_____ I have read and understood the above information.
_____ I give permission for my child to be recorded during Unit of Inquiry lessons.
_____ I do not give permission for my child to be recorded during Unit of Inquiry lessons.

Student's Name_____ Class_____

Signature of parent or guardian: _____ Date: _____
(If minors are involved)

Signature of Investigator : _____ Date: _____

IRB Code Numbers: 1805.030614 **IRB Expiration Date:** March 6, 2015

APPENDIX H

Consent Form for Teachers and Educational Assistants

Mary F. Briggs
Liberty University
School of Education

You are invited to fill a vital role in a research study exploring the use of iPad® apps as a means of increasing children's learning and participation within Unit of Inquiry lessons. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Mary F. Briggs, Doctoral Student at Liberty University and a staff member of _____ School.

Background Information:

The purpose of this study is to investigate the effects of iPad® apps as a means of increasing academic achievement in an inquiry-based classroom setting. In this study, a particular focus will be placed on vocabulary, as vocabulary acquisition has been identified as the greatest indicator of academic success.

Procedures:

You will be asked to anonymously complete a Social Validity Questionnaire prior to the beginning of the research and again at the end of the research. You will also be asked to anonymously complete a Functional Speech Questionnaire. This questionnaire will provide the researcher with information regarding the frequency and nature of each participant's involvement in speaking activities in the mainstream classroom. Each questionnaire will take approximately 5 – 10 minutes to complete. You may also be asked to prompt a participant to use an iPad app during Unit of Inquiry lessons. Furthermore, it is possible that you may be recorded during sessions where the researcher or research assistant is digitally audio and video recording one of the participants in this study. Finally, you will be asked to adhere to the regular timetable as much as possible and to provide advance notice to participants regarding changes to the regular timetable.

Risks and Benefits of the Study:

The risks of this study are no more than you would encounter in your everyday life at school.

The potential benefits to participation are that children may one day benefit from the findings of this research.

Compensation:

There will be no monetary compensation for participation in this study.

Confidentiality:

The results of this study will be published in a dissertation and a condensed version may be published in a peer reviewed journal. Published materials will not include personal information which would make it possible for others to identify you. Research records will be stored securely on a password protected computer that is not part of a network system and only the researcher will have access to the records. The research records will be deleted after three years.

Voluntary Nature of the Study:

You can decide whether or not you wish to participate in this study and whether or not you wish to appear in the recordings. Your decision will not affect your current or future relationship with _____School, _____School, or Liberty University. If you prefer not to appear in the video recordings, please indicate your decision in the Statement of Consent at the bottom of this form. The researcher will ensure that the participants are not seated near you. Likewise, if you decide to appear in the recordings, you can indicate so in the Statement of Consent at the bottom of this form.

How to Withdraw from the Study:

You can withdraw from this study or from being recorded at any time by contacting the researcher at _____School, phone number or email address. In the event that you choose to withdraw from the study, the researcher will use inpainting software to erase your image from the recordings and audio editing software to remove your voice from the recordings.

Contacts and Questions:

The researcher conducting this study is Mrs. Mary Briggs. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at _____School, phone number or email address. Additionally, you may contact the Chair of the Dissertation Committee, Dr. Barbara White, at bawhite2@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Suite 1837, Lynchburg, VA 24502 or email at irb@liberty.edu.

Statement of Consent:

_____ I have read and understood the above information.
_____ I agree to be involved in this study.
_____ I give permission for the researcher to record me during Unit of Inquiry lessons.
_____ I do not give permission for the researcher to record me during Unit of Inquiry lessons.

Signature_____ Date: _____

APPENDIX I

Social Validity Questionnaire

The purpose of this questionnaire is to obtain information that will aid in the selection of teaching and learning interventions. These interventions will be used by educators who support students with autism spectrum disorder (ASD). Please circle the number that best describes your agreement or disagreement with each statement using the scale below.

1 = strongly agree **2** = disagree **3** = slightly disagree **4** = slightly agree **5** = agree **6** = strongly agree

1. This would be an acceptable intervention for students with ASD.	1 2 3 4 5 6
2. Most educators would find this intervention appropriate for students with other educational needs besides ASD.	1 2 3 4 5 6
3. This intervention should prove effective in changing the child's learning.	1 2 3 4 5 6
4. I would suggest the use of this intervention to other educators.	1 2 3 4 5 6
5. The child's learning difficulties are serious enough to warrant use of this intervention.	1 2 3 4 5 6
6. Most educators would find this intervention suitable for students with ASD.	1 2 3 4 5 6
7. I would be willing to use this intervention with students.	1 2 3 4 5 6
8. This intervention will not result in negative side effects for the child.	1 2 3 4 5 6

1 = strongly agree **2** = disagree **3** = slightly disagree **4** = slightly agree **5** = agree **6** = strongly agree

9. This intervention would be appropriate for a variety of children.	1 2 3 4 5 6
10. This intervention is consistent with other interventions which I have tried with students.	1 2 3 4 5 6
11. The intervention is a realistic way to handle the learning difficulties of students with ASD.	1 2 3 4 5 6
12. This intervention is reasonable for the learning difficulties encountered by students with ASD.	1 2 3 4 5 6
13. I like the procedures in this intervention.	1 2 3 4 5 6
14. This intervention is a good way to handle the learning difficulties of students with ASD.	1 2 3 4 5 6
15. Overall, the intervention will be beneficial for the child.	1 2 3 4 5 6

Thank you for completing this questionnaire.

APPENDIX J

Participant Script and Procedural Fidelity Checklist

Participant's Name _____ Date _____

Directions: Place a check mark √ beside each step after it is completed.

First Time:

_____ 1. Open the Popplet app.

_____ 2. Open the Lesson titled _____.

_____ 3. Read and listen to the lesson one time.

_____ 4. Open the Futaba app.

_____ 5. Open the Game titled _____.

_____ 6. Practicing the lesson will help you to remember the lesson. Play the game one time.

_____ 7. Close the cover on the iPad.

Second Time:

_____ 1. Open the Popplet app.

_____ 2. Open the Lesson titled _____.

_____ 3. Read and listen to the lesson one time.

_____ 4. Open the Futaba app.

_____ 5. Open the Game titled _____.

_____ 6. Practicing the lesson will help you to remember the lesson. Play the game one time.

_____ 7. Close the cover on the iPad.

Third Time:

_____ 1. Open the Popplet app.

_____ 2. Open the Lesson titled _____.

_____ 3. Read and listen to the lesson one time.

_____ 4. Open the Futaba app.

_____ 5. Open the Game titled _____.

_____ 6. Practicing the lesson will help you to remember the lesson. Play the game one time.

_____ 7. Give the iPad to _____.

APPENDIX K

Sample Researcher's Log

Day	International School A	International School B	Notes
Mon.			
Tues.			
Wed.			
Thurs.			
Fri.			
Sat.			
Sun.			
Mon.			
Tues.			
Wed.			

APPENDIX L

Sample Probe Data Collection Form

Student's Name _____

Type of Session: Baseline Probe (BP) Intervention Probe (IP) Maintenance Probe (MP)

Date:									
Session Type:									
Actual Vocab Words Inserted Here									
Vocab									
Vocab									
Vocab									
Vocab									
Vocab									
Vocab									
Vocab									
Vocab									
Etc.									

Key:
+ correct response
- incorrect response

APPENDIX M

Transcription Collection Form

Student's Name_____ Date_____

Start Time_____ Stop Time_____ = _____ minutes

Directions for Transcription: When the speaking activity begins in the classroom, record the start time, and then record the Unit of Inquiry words, phrases and sentences spoken by the participant during the speaking activity. When the speaking activity ends, record the stop time and calculate the numbers of minutes for the speaking activity.

Total Number of On-Task Sentences Spoken _____ Total Number of On-Task Phrases Spoken _____ Total Number of On-Task Words Spoken _____ Total Number of Vocabulary Spoken _____

APPENDIX N

Reflection Sheet Collection Form

Student's Name_____ Date_____

Name of Unit of Inquiry_____

Directions: Tally the number of topic related sentences, phrases and vocabulary used on the end-of-unit reflection sheet.

Number of topic related sentences _____

Number of topic related phrases _____

Actual Vocab Inserted Here	
Vocab	
Vocab	
Vocab	
Vocab	
Vocab	
Vocab	
Vocab	
Vocab	
Etc.	

Additional observations: _____

_____

APPENDIX O

Functional Speech Questionnaire

The purpose of this questionnaire is to provide information on the frequency and nature of each participant's involvement in speaking activities in the mainstream classroom. To ensure confidentiality, please complete this questionnaire anonymously. Please do not write your name on this form.

Name of Student Participant_____

Directions: Please think of a recent speaking activity which you observed in a **Unit of Inquiry** lesson in the mainstream classroom. In your mind, please focus on a 10 minute segment of that speaking activity. Please use this 10 segment as a basis for answering the following questions.

1. Place a ✓ by each phrase which describes the student participant's involvement in the Unit of Inquiry speaking activity?

_____ says nothing
_____ needs adult prompting to join the speaking activity
_____ initiates conversation
_____ answers questions
_____ uses single words to add to the conversation
_____ uses phrases to add to the conversation
_____ uses complete sentences to add to the conversation
_____ stays on topic
_____ echolalia (repeats what others say)

2. Circle the approximate number of topic-related vocabulary words spoken by the student participant during that 10 minute Unit of Inquiry speaking activity.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 more than 20

3. Circle the approximate number of topic-related phrases spoken by the student participant during that 10 minute Unit of Inquiry speaking activity.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 more than 20

4. Circle the approximate number of topic-related sentences spoken by the student participant during that 10 minute Unit of Inquiry speaking activity.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 more than 20

APPENDIX P

IRB Approval Letter

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

March 6, 2014

Mary F. Briggs
IRB Approval 1805.030614: Enhancing the Ability of Students with Autism Spectrum Disorder to Retrieve Vocabulary for Use in an Inquiry Based Classroom: A Single Subject Multiple Probe Design Study

Dear Mary,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master's thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

Fernando Garzon, Psy.D.
Professor, IRB Chair
Counseling

(434) 592-4054

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