USING EMBEDDED COMPUTER-ASSISTED INSTRUCTION TO TEACH SCIENCE TO STUDENTS WITH AUTISM SPECTRUM DISORDERS

by

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ABSTRACT

BETHANY RENEE SMITH. Using embedded computer-assisted instruction to teach science to students with autism spectrum disorders. (Under the direction of DR. FRED SPOONER)

The need for promoting scientific literacy for all students has been the focus of recent education reform resulting in the rise of the Science Technology, Engineering, and Mathematics movement. For students with Autism Spectrum Disorders and intellectual disability, this need for scientific literacy is further complicated by the need for individualized instruction that is often required to teach new skills, especially when those skills are academic in nature. In order to address this need for specialized instruction, as well as scientific literacy, this study investigated the effects of embedded computer-assisted instruction to teach science terms and application of those terms to three middle school students with autism and intellectual disability. This study was implemented within an inclusive science classroom setting. A multiple probe across participants research design was used to examine the effectiveness of the intervention. Results of this study showed a functional relationship between the number of correct responses made during probe sessions and introduction of the intervention. Additionally, all three participants maintained the acquired science terms and applications over time and generalized these skills across materials and settings. The findings of this study suggest several implications for practice within inclusive settings and provide suggestions for future research investigating the effectiveness of computer-assisted instruction to teach academic skills to students with Autism Spectrum Disorders and intellectual disability.

DEDICATION

First and foremost, I dedicate this dissertation to my parents, without your support and guidance it would have never been possible to achieve this goal. The words “thank you” will never be enough. I also could never have dreamed a dream as big as completing a doctoral degree without my family. Second, I dedicate this dissertation to George and Mark, two young men with autism who changed my life forever. Since the seventh grade when people would ask what occupation I wanted to be when I grew up, the answer has been a special educator because of these two guys. Many people, including teachers, laughed or scoffed at such a focused middle school student, but I was never deterred and stayed the path because for these two young men giving up was never an option. Finally, I dedicate this dissertation to all of the people with disabilities and their families that that have welcomed me into their lives. You have motivated me throughout my career and helped to mold me into the educator I am today.

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CHAPTER 1: INTRODUCTION

Statement of the Problem

Education reform over the past decade has targeted the need for scientific literacy as evidenced by the rise in the Science, Technology, Engineering, and Mathematics (STEM) education movement. Since the push for education reform, many organizations and programs have begun to specifically target the need for STEM for students from Kindergarten through high school. For example, the Department of Education along with over 500 businesses, education organization, and members of Congress have teamed up forming the STEM Education Coalition. Like other organizations that focus on furthering the STEM movement, this organization's mission is to educate policy makers and key stakeholders in the role STEM plays in the ability of United States citizens to remain competitive as an economic and technological leader in the global market place (www.stemedcoalition.org).

Despite efforts to increase the scientific literacy in this country, the reality is that the majority of America's students will graduate from high school without a working knowledge of science concepts, processes, or skills (Roseman & Koppel, 2008). According to the Trend in International Mathematics and Science Study (TIMSS, 2008), while student scores in mathematics have risen in the past decade, the student scores in science have remained stagnant since 1995. Since the publication of *Science for All Americans* by the American Association for the Advancement of Science (AAAS, 1989), scientific literacy has been a goal for all American high school graduates. Components of scientific literacy include (a) experiences and wonder about the natural world, (b) the ability to identify and use the scientific process and principles, (c) ability to engage in scientific debate, and (d) productivity using scientific knowledge and understanding (AAAS, 1989).

In 1996, the National Research Council developed eight National Science Education Standards (NSES) as a pathway to reach scientific literacy. These standards include: science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and social perspectives, and history and nature of science (NSES, 1996). In addition to the NSES standards, legislation such as the Individuals with Disabilities Education Act (IDEA, 2004) and No Child Left Behind (NCLB, 2002) now requires all students, including those with disabilities, access to the general education curriculum. Specifically the NSES state, “Standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science” (NRC, 1996, p.2). These mandates, in combination with the discouraging statistics demonstrating a lack of scientific knowledge (TIMSS, 2008) for many high school graduates has left many educators of students with disabilities struggling with the task of how to teach grade-aligned scientific content to students who require specialized instruction to acquire new skills.

Although the literature base for teaching grade-aligned science to students with developmental disabilities (e.g., intellectual disability, autism) is growing, a lack of studies teaching academic skills (e.g., completing an experiment, identifying parts of an ecosystem) within the curricular area of science still exists. According to a review of research studies, to date the majority of research has focused on teaching skills which fall under the NSES standard of science in personal and social perspectives (Spooner, Knight, Browder, Jimenez, & DiBiase, 2011). Many of the skills taught within these studies include mobility in the community, a variety of first aid skills (Gast, Winterling, Wolery, & Farmer, 1992; Marchand-Martella, Martella, Christensen, Agran, & Young, 1992; Spooner, Stem, & Test, 1989), and safety skills like reading warning labels (Collins & Griffen, 1994; Collins & Stinson, 1995).

Despite a high number of studies teaching functional skills, previous studies have demonstrated that students with intellectual disability acquire grade-aligned science knowledge. These studies have also demonstrated that after students acquire these skills, they also maintain the skills over time, and possibly generalize the skills across materials and settings (Collins, Evans, Creech-Galloway, Karl, & Miller, 2007; Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007; Jameson, McDonnell, Polychronis, Johnson, & Riesen, 2008; McDonnell et al., 2006; Riesen, McDonnell, Johnson, Polychronis, & Jameson, 2003). Additionally, according to Jimenez, Spooner, Browder, DiBiase, and Knight (2008) grade-aligned science instruction can provide students with intellectual disability the tools and opportunities to understand the world around them and their place in the natural world.

One way that researchers have taught students with intellectual disability, including autism, science content knowledge is through systematic instruction (Collins, 2007; Snell, 1983; Stokes & Baer, 1977; Wolery, Bailey, & Sugai, 1988). According to Spooner et al. (2011) systematic instruction includes: (a) teaching socially relevant skills; (b) providing observable and measureable definitions of those skills; (c) using data to show functional relationships between introduction of an intervention and acquisition of targeted skills; (d) using components of applied behavior analysis to promote transfer of stimulus control (e.g., differential reinforcement); and (e) teaching skills that can generalize to different settings, people, and/or materials.

One systematic instructional procedure used to provide instruction to students with intellectual disability or students with Autism Spectrum Disorders (ASD) is explicit instruction. To date three studies have examined the use of explicit instruction, a systematic instruction strategy, to teach academics to students with ASD (Flores & Ganz, 2007; Ganz & Flores, 2009; Hicks, Bethune, Wood, Cooke, & Mims, 2012; Knight, Smith, Spooner, & Browder, 2011). While two studies focused on teaching literacy skills (i.e., reading comprehension, symbol identification) to students with ASD, only one study taught skills within the science curricula. Knight, Smith, Spooner, et al. (2011) taught three elementary aged students with ASD and a severe intellectual disability to identify common science descriptors (e.g., light, change, wet, different).

The addition of embedded instruction including systematic instruction practices is another instructional strategy that researchers have demonstrated effectiveness in teaching students with developmental disabilities science content knowledge. Research has suggested the use of embedded instruction to teach both academic and developmental skills to students with intellectual disability including autism (Jameson et al., 2007, 2008; McDonnell et al., 2006). The use of embedded instruction is loosely defined within the literature as providing instruction on skills within on-going routines or activities within the performance setting versus massed trials in a special education setting (McDonnell, 2011). For example, teaching a student with a disability the concept of living *vs*. dead within a science general education class during a lesson about the plant and animal life cycle. These embedded trials might occur during a warm-up activity, independent practice, or during a hands-on experiment.

According to a comprehensive literature review by Spooner et al. (2011), only a few published articles have examined the use of embedded instruction to teach science academic content. For example, Riesen et al. (2003) used constant time delay and simultaneous prompting embedded in a general education classroom to teach science vocabulary and definitions. Jameson et al. (2007) compared the effects of embedded instruction in a general education classroom and massed trials in a special education classroom to teach vocabulary and definitions to four middle school students with a severe intellectual disability.

In addition to using embedded instruction to teach academic content to student with intellectual disability, computer-assisted instruction (CAI) is also a growing area of research in which results have suggested it to be effective in teaching students with ASD academic content (Blischak & Schlosser, 2003; Pennington, 2010). Panyan (1984) suggested the nature of technology can (a) benefit students with ASD due to their differences in attention and motivation from typically developing peers, (b) decrease stereotypic behaviors, (c) provide students with consistent feedback, and (d) increase language. In a recent literature review Pennington (2010) reviewed CAI research from 1997 to 2008. Overall, he found that although there is a body of research supporting CAI, research designed to evaluate its effectiveness in teaching core content-related material is limited. Additionally, he suggested that future studies should evaluate the effectiveness of

CAI in various instructional arrangements and evaluate commercially available software (e.g., PowerPoint).

Significance of Study

In a comprehensive literature review, Spooner et al. (2011) identified only 17 total studies which taught science skills to students with intellectual disability or ASD. Of those 17 studies, only 14 were deemed to be of high or acceptable quality when compared to the Horner et al. (2005) quality indicators for single-subject research. Of those 14 studies, six studies taught skills that fall under the NSES science standard of science personal and social perspective (e.g., Collins & Griffen, 1996; Collins & Stinson, 1995; Spooner et al., 1989). Few studies addressed academic content outside of first aid and safety skills.

The current study expands the current body of research providing general curriculum access for students with intellectual disability and ASD by teaching grade-aligned vocabulary and definitions. Both Mastropieri and Scruggs (1992) and Scruggs, Mastropieri, and Okolo (2008) have suggested that one barrier students with disabilities, face in learning science content is a lack of vocabulary. Acquisition of vocabulary is often most difficult for students with ASD because of the lack of oral language abilities that often accompany ASD diagnoses (McDuffie, Yoder, & Stone, 2005).

Additionally, few science-based studies have examined the delivery of systematic instruction procedures within an embedded instruction format (e.g., Jameson et al., 2007, 2008; McDonnell et al., 2006; Riesen et al., 2003). The need for further research to examine the factors that influence the effectiveness and feasibility exists and is documented by many of the previously published studies (Jameson et al., 2007, 2008; McDonnell et al., 2006; Riesen et al., 2003).

Additionally, none of the studies that implemented instruction using an embedded format used technology to provide instruction. In all of the previously mentioned studies the embedded instruction was delivered by a paraprofessional, special educator, or general educator. Literature addressing factors that influence inclusion have often reported that the presence of an adult may be stigmatizing. Carter, Sisco, Brown, Brickham, and Al-Khabbaz (in press) found that students who are accompanied by an adult had fewer interactions with their peers than those who were not accompanied by an adult. Similarly, Giangreco, Yuan, McKenzie, Cameron, and Fialka (2005) suggest the presence of an additional adult may by stigmatizing for students with disabilities and result in isolation from their peers in class. The use of technology to provide instruction not only addresses one common barrier to inclusion (i.e., the presence of another adult), CAI could also promote student independence and require less teacher supervision (Mechling, 2008).

Purpose of the Study

Due to an overall need for research on teaching grade-aligned science to students with ASD and intellectual disability, the purpose of the current study was to investigate the effectiveness of embedded CAI on the acquisition of science terms and applications for students with ASD. Furthermore, because embedded instruction was implemented via tablet (e.g., iPad 2), this study also addressed the need for further demonstrations of the effectiveness CAI to teach acquisition of academic skills. Finally, results of this study increased the growing body of evidence which supports that students with intellectual disability and ASD can learn grade-aligned core content knowledge within an inclusive general education setting. The following research questions will be addressed:

1. What is the effectiveness of embedded, explicit CAI on student acquisition of science terms and applications for students with ASD and intellectual disability?
2. To what extent will students generalize targeted science terms and applications to a class activity within the inclusive setting?
3. What are the participants' perceptions of using CAI within the inclusive setting?
4. What are teacher perceptions of using CAI within the inclusive setting?
5. What are the peers without disabilities perceptions of using CAI within the inclusive setting?

Delimitations

This study will evaluate the effectiveness of embedded, explicit CAI on the number of acquired science terms and applications correctly identified during probe sessions. It is important to define the boundaries of the current study so that readers interpret the study results accurately. The study will evaluate the effectiveness of the intervention using single-case methodology. Within single-case designs the ability to generalize findings to populations other than study participants is limited. Internal validity of the study is strengthened by adherence to criteria outlined by Horner et al. (2005) for single-case designs. The external validity of the study may be strengthened with replication of the intervention described.

Definitions

Computer-assisted instruction. The application of computer software to address a student's educational needs that often focus on providing instruction to remediate deficits of facts and concepts.(Edyburn, Higgins, & Boone, 2005; The Access Center: Improving Outcomes for All Students, K-8, 2009).

Developmental disabilities. Severe and chronic disabilities that manifest before age 22 that results in functional limitations in three or more adaptive areas (Collins, 2007).

Explicit instruction. An unambiguous, direct approach to teaching that includes instructional design and delivery procedures. Explicit instruction includes supports where students are lead through the learning process, clear expectations, and supported by feedback until the student is able to perform the skill independently (Archer & Hughes, 2011).

Embedded instruction. Explicit, unambiguous, systematic instruction that distributes instructional trials across on-going routines and activities within the general education classroom (McDonnell, Johnson, & McQuivey, 2008).

Grade-aligned instruction. Instruction that is commensurate with the student's chronological grade level (Browder & Spooner, 2011).

Inclusive setting. A classroom setting where students with disabilities learn alongside their chronologically same-aged peers without disabilities within their neighborhood school (Ryndak & Alper, 2003).

Intellectual disability. This term replaces the use of mental retardation in the literature. Students with intellectual disability exhibit difficulties in both intellectual functioning and application of adaptive behavior skills and can be associated with other disabilities (e.g., Down Syndrome, ASD). The age of onset is before the age of 18

(Browder & Spooner, 2011; Luckasson et al., 2002; Schalock, Luckasson, & Shogren, 2007).

Students with ASD. One of the fastest growing disability categories with a prevalence of one in every 150 children in 2008 (National Autism Center, 2009). ASD is a “spectrum” disorder due to the variability in symptoms, age of onset, and associations with other disabilities (National Autism Center, 2009). Students with ASD often exhibit difficulties in the area of communication, socialization, and adaptive behavior (A. Simpson, Langone, & Ayers, 2004; R. Simpson, 2004; R. Simpson, McKee, Teeter, & Beytien, 2007; Stichter, Randolf, Gage, & Schmidt, 2007).

Systematic instruction. Typically includes five steps (a) define the outcome, (b) describe the procedure, (c) implement procedure with fidelity, (d) collect on-going data, and (e) make decisions about effectiveness of procedure (Drasgow, Wolery, Halle, & Hajiaghamohseni, 2011). Additional components of systematic instruction include using components of applied behavior analysis to promote the transfer of stimulus control such as differential reinforcement and training for generalization across settings, people, and/or materials (Spooner et al., 2011).

CHAPTER 2: REVIEW OF LITERATURE

Despite education reform focused on improving students' scores on high stakes assessment and the long-standing call for scientific literacy (AAAS, 1989) most students graduate from high school without scientific literacy (Roseman & Koppel, 2008). In fact, while reading and mathematical standardized test scores have increased over the past decade, scores in science have remained stagnant since 1995 (TIMMS, 2008). In an effort to address these deficits both IDEA (1997, 2004) and NCLB (2002) included science along with reading and mathematics on all state-level assessments as part of adequate yearly progress. In 1996 the National Research Council (NRC) disseminated the National Science Education Standards (NSES) outlining eight content standards for science instruction. Those standards include science as inquiry, physical science, life science, earth and space science, science and technology, science in personal and social perspectives, and history and nature of science. This chapter includes an overview of literature in teaching science to all students, the use of embedded instruction to teach students with intellectual disability and ASD, as well as a discussion of the growing literature base for using explicit instruction for students with more severe developmental disabilities (e.g., intellectual disability, ASD). Finally, the last section will outline the literature base for providing instruction using technology, specifically CAI for students with ASD.

Teaching Science to All

The call for science instruction in combination with increased levels of accountability is often a challenge for general and special educators in meeting students' needs for scientific literacy while addressing many of other academic and functional skills necessary to survive in a post-school environment. In fact, recent articles have suggested that perhaps the focus on providing academic instruction for students with intellectual disability is unwarranted (Ayers, Lowrey, Douglas, & Sievers, 2011). In response, researchers such as Courtade, Spooner, Browder, and Jimenez (2011) suggest that providing a standards-based curriculum affords students with disabilities a complete educational opportunity. They further suggested that academic instruction need not preclude life skills instruction. Instead, they suggest that combining both academic and life skills curricula can provide students with disabilities academic instruction within a personally relevant context. For example, academic instruction on the forces of erosion may mean more to a student with intellectual disability who lives in the mountains if the teacher activated the student's background knowledge and experiences with living on a landform shaped by erosion.

When compared to their same aged peers, students with disabilities had increased challenges in science that result in lower performance outcomes (Carnine & Carnine, 2004; Cawley, Kahn, & Tedesco, 1989; Lynch et al., 2007). Similarly, the literature focused on teaching science to students with disabilities, particularly developmental disabilities (e.g., intellectual disability, ASD), is sparse. In a comprehensive literature review, Spooner et al. (2011) found a total of 17 published single subject studies that taught students with a severe intellectual disability, including students with ASD, skills that fell within the eight NSES (NRC, 1996; 2007) content standards. Of those 17 studies, 14 met quality indicators outlined by Horner et al. (2005) and were retained for analysis. Analysis of these 14 studies revealed that the majority of published studies fell into NSES Standard F: Science in Personal and Social Perspectives. These studies focused predominately on teaching skills that fell within a traditional functional curriculum (e.g., skills relating to health, safety, and nutrition). Collins and Griffen (1996) used a multiple probe across participants single subject design to examine the effectiveness of constant time delay to teach four elementary school students with a moderate mental retardation to read product warning labels found on cleaning supplies. The researchers also collected data on a trained motor response (e.g., move away from the product, do not drink the product) once the participant successfully read the warning label. In an effort to promote generalization, the researchers provided multiple exemplars of warning labels as they appeared on different products. Results of the study showed a functional relationship between the number of participants' correct responses and introduction of the intervention. Additionally, findings indicated that students were able to generalize the targeted skills across settings, materials, and people.

In a more recent example, Taber, Alberto, Seltzer, and Hughes (2003) used a multiple probe across participants research design to examine the effectiveness of task analytic instruction on teaching cell phone use when lost in the community to six secondary students with a moderate cognitive abilities. In this study, once participants were able to successfully perform the targeted behaviors (i.e., determine they were "lost," use speed dial to make a call, or answer a ringing cell phone to provide location) in the school setting, the researchers used generalization settings within the community to assess setting/situation generalization. Results of the study indicated a functional relationship for all participants between the number of correct responses made on the task analyzed steps and introduction of the intervention. The authors suggested that future replications examine factors which may prohibit students from successfully manipulating cell phones (e.g., touch screen, small buttons). Other examples of skills taught within Content Standard F: Science in Personal and Social Perspectives include: (a) first aid skills (Spooner et al., 1989); (b) safety skills (Collins & Stinson, 1995; Winterling, Gast, Wolery, and Farmer, 1992); and (c) mobility when lost in the community (Taber, Alberto, Hughes, and Setzer, 2002; Taber et al., 2003).

In addition to teaching skills which are functional, the remaining studies in science focused on teaching academic skills such as content vocabulary and definitions (Collins et al., 2007; Riesen et al., 2003; Jameson et al., 2007, 2008; McDonnell et al., 2006). Riesen et al. (2003) used an alternating treatment single subject research design to examine the effectiveness of constant time delay, simultaneous prompting, and embedded instruction in a general education classroom on the percent of correct responses on word lists and definitions (e.g., gram, mass, gravity, plate tectonics) with four middle school students with moderate intellectual disability, severe intellectual disability, and ASD. Two paraprofessionals that provided modifications and support for the students with a moderate to severe intellectual disability, including students with ASD, in the general education setting implemented the constant time delay and simultaneous prompting instructional sessions within the general education setting. Results of the study showed that both embedded response prompting procedures were effective for all four participants and data indicated a functional relationship between the number of correct responses on vocabulary and introduction of the interventions. Additionally, results suggested that paraprofessionals implemented instructional sessions with fidelity and within on-going activities in the general education classroom.

General Education *vs*. Special Education

Similar to the debate within the special education of what to teach students with disabilities, the same is true in terms of who is the best person to deliver this specialized instruction. Recently, within the *Handbook of Special Education*, Zigmond and Kloo (2011) suggest several reasons why general and special education are and should remain different. Among their most notable reasons to keep general education and special education separate are: (a) while general education teachers are prepared to teach the content to a large group of students, special education teachers are prepared to apply pedagogical and instructional strategies to teach individuals or small groups of exceptional students with specific learning needs; (b) highly qualified general education teachers are not and should not be the same as a qualified specialist or special education teacher; and (c) while general education is a place, special education is a service. While it remains true that teacher preparatory programs for general and special educators remain vastly different in coursework and methods, educating children is often a team approach. Because collaboration in education is essential, general education teachers and special education teachers can and should collaborate on an on-going basis in order to ensure they are providing all students with a free, appropriate public education (IDEA, 2004).

In one study that required collaboration between special and general educators, Jimenez, Browder, Spooner, and DiBiase (2012) used a multiple probe across behaviors single subject research design to examine the effectiveness of peer-mediated time delay to teach science content (i.e., identification of picture vocabulary and responses to a KWHL chart (What you Know, What you Want to know, How are you going to find out, and What did you Learn) within an inclusive middle school science classroom. In this study, the general educator and author worked together to identify the most salient vocabulary across three science units and general education peers implemented the constant time delay procedures. As an additional responsibility, the general educator was also responsible for incorporating the KWHL chart into her lecture and prompted all students in the class to fill in the chart during the appropriate time. Results of this study indicated that following introduction of the intervention, students increased the number of pictures they accurately identified. Additionally, the authors noted observations of generalization in use of the KWHL chart to untrained science units within the inclusive setting.

In the second reason to keep special and general education separate, Zigmond and Kloo assert that the NCLB (2002) definition of a highly qualified teacher is inappropriate to apply to special educators. While it is true that the skill set of general and special educators may differ (content *vs*. pedagogy); research studies have demonstrated that special educators, who may not know the content, when trained, can provide grade-aligned academic instruction to students with intellectual disability and ASD. Courtade, Browder, Spooner, and DiBiase (2010) individually trained four teachers to implement a science inquiry lesson via a 12 step task analysis. In addition to examining if the teachers could implement these lessons with fidelity, the researchers assessed the ability of eight students with a moderate or severe intellectual disability to independently and accurately complete a 12 step task analysis that corresponded with the task analysis provided to the teacher. For example, one step required the teacher to provide vocabulary instruction using the constant time delay response prompting procedure. In addition to collecting data on whether the teacher implemented the procedure with fidelity, the researchers also collected data on the student responses during this step of the lesson. Results of this study indicated that following the training all four teachers successfully implemented the task analyzed inquiry lessons with fidelity. Not only did the teacher perform the trained lessons with high rates of fidelity, but the teachers were also able to generalize the task analysis to teach untrained lessons to their students. Results for the students indicate a functional relationship between the number of steps performed correctly during the inquiry lesson and implementation of the teacher training.

Browder et al. (2010) also used a quasiexperimental group design to evaluate the ability of special education teachers to provide grade-aligned math and science instruction to students with developmental disabilities. In this study, five teachers provided mathematical instruction and five teachers provided science instruction and all teachers met the NCLB definition for “highly qualified” to teach students with moderate and severe developmental disabilities. Of the 21 students who participated in the science group, 10 had a moderate or severe intellectual disability and 11 students had an ASD diagnosis. To evaluate the effectiveness of the science intervention, the researchers collected pretest and posttest assessment data and compared the percentage of change from pretests to posttests. Within the science group, researchers focused on four units (i.e., microbiology life science, chemistry and physical science, and two earth science units) in four professional development workshops. Teachers were trained to implement five lessons per unit delivering instruction via inquiry lesson plans that included an inquiry lesson plan, systematic training on science terms, and materials for at least one hands-on experiment/activity. Results of this study supported that students who received science instruction in fact did score higher on posttest measures following intervention. Results of this study also indicate that although participating teachers were not “highly-qualified” to provide science instruction, they could implement grade-aligned science inquiry lesson plans with high levels of fidelity.

In a more recent study, Smith, Spooner, Jimenez, and Browder (2011) used a multiple probe across behaviors with concurrent replication across participants research design to examine the effectiveness of an early science curriculum specifically designed for students with intellectual disability on the acquisition of science vocabulary and concepts for three elementary aged students with multiple developmental disabilities (e.g., physical impairments, severe intellectual disability, Cri du Chat Syndrome). In this study, the semi-scripted lessons and materials were provided for the special education teacher. These scripted lessons also included an experiment and activity, as well as opportunities for students to make and reflect on predictions which are all components of the NSES content standard science as inquiry. Similar to the Courtade et al. (2011) study, the researchers collected data on both the teacher’s ability to implement these lessons with fidelity and the number of correct responses participating students made during unit assessment probes. Results of this study demonstrate a functional relationship between the number of correct responses made by participants in the unit assessment probes and introduction of the intervention (i.e., semi-scripted science lessons). Additionally, the teacher was successful in implementing these lessons with high levels of fidelity (mean 97.5%) despite not meeting the definition of highly qualified according to NCLB (2002).

Both studies demonstrate a special educator's ability to implement quality grade-aligned academic instruction with minimal training. These studies also showed that once the academic instruction was provided, students with varying level of disability acquired the targeted grade-level content (e.g., vocabulary, concept statements).

As a final rationale, Zigmond and Kloo (2011) emphasize that general education is a place and special education is a service. Based on this declaration, then in theory, special education services can be implemented anywhere, despite the setting (Brown, 2003; Kauffman & Hallahan, 2005). Research on instructional strategies like embedded instruction and CAI has provided growing support for how to successfully implement specialized instruction within general education settings and the overall benefits of providing instruction within integrated settings (Bratlinger, 1997; Jameson et al., 2007; McDonnell et al., 2006).

In summary, published research supports providing academic instruction in the curricular area of science to students with ASD and intellectual disability (Browder & Spooner, 2011; Spooner et al., 2011). Despite concerns pertaining to the differences between special and general education (Zigmond & Kloo, 2011), research has provided evidence that trained special educators can teach grade-level content with high levels of fidelity (Courtade et al., 2011; Jimenez et al., 2012; Smith et al., 2011). Finally, published literature supports and promotes the collaboration between general and special educators in an effort to provide students a full educational opportunity (Bratlinger, 1997; Jameson et al., 2007; McDonnell et al., 2006). The next section of this paper will examine the literature on using embedded instruction to deliver academic content within general education settings, as well as to deliver the specialized instruction students with disabilities often require to make academic gains.

Embedded Instruction

One instructional strategy with increasing empirical support in providing academic instruction to students with developmental disabilities is embedded instruction. Copeland and Cosbey (2008-2009) suggest that embedded instruction is one way to provide students access to the general education curriculum within the general education context. Within published literature for students with and without disabilities embedded instruction has included many different components.

For the purposes of this review embedded instruction includes four components (a) teaches a socially important skill, (b) embedded trials are distributed across the class period, (c) distributed trials occur during the typical routines or daily activities within a general education classroom, and (d) include some component of systematic instruction (Jameson et al., 2007, 2008; Kennedy & Horn, 2004; McDonnel et al., 2006). One of the key features of embedded instruction is that trials are distributed across a class period versus massed trials sessions that occur once, for a short period of time, during a class period. In this example, a paraprofessional or peer might embed one trial for every word on a biology sight wordlist during class warm-up, prior to the teacher lecture, during guided practice, during independent practice, and before dismissal. This contrasts massed trial delivery of sight word identification that might include pulling a student to the side during the teacher lecture and implementing five massed constant time delay trials for each word.

One component of an embedded instruction is systematic instruction (Jameson et al., 2007, 2008; McDonnell et al., 2006, 2008; McDonnell, Johnson, Polyschronis, & Riesen, 2002). Embedded instruction dictates how and when trials are distributed within the general education setting and the systematic instruction component dictates how the skill will be taught to the student. Spooner et al. (2011) developed an operational definition of systematic instruction. The Spooner et al. (2011) definition of systematic instruction includes teaching (a) socially relevant skills, (b) providing observable and measureable definitions of those skills, (c) using data to show functional relationships between introduction of an intervention and acquisition of targeted skills, (d) using components of applied behavior analysis to promote transfer of stimulus control (e.g., differential reinforcement), and (e) teaching skills that can be generalized to different settings, people, and/or materials.

Published research has supported the use of embedded instruction to teach both academic and functional skills to students with developmental disabilities as well as students who do not receive special education services (McDonnell, 2011; McDonnell et al., 2006; Jameson et al., 2007, 2008). The majority of published research within the general curriculum centers on embedded vocabulary or phonics instruction within literacy instruction in a general education classroom. Proctor, Dalton, and Grisham (2007) embedded the definitions of key vocabulary words within reading comprehension instruction. The class activity included students reading a short passage on the computer and answering multiple choice comprehension questions based on the reading. For 40 fourth-grade students who did not speak English as their primary language and lacked background vocabulary knowledge, the researchers embedded vocabulary instruction within the passage using hyperlinks. In the embedded instruction condition, when the student clicked the hyperlinked word they were provided an oral definition of the hyperlinked vocabulary word as a means to increase reading comprehension of the passage. Results of the study indicated an association between the acquisition of vocabulary (e.g., matching the word with the definition) and the number hyperlinked words provided in text. Despite the relationship, the association was not statistically significant ($p < .05$).

In two separate studies of students without disabilities, Coyne, McCoach, and Kapp (2007) compared three instructional formats, (a) incidental instruction, (b) embedded vocabulary, and (c) extended instruction during storybook reading, on the receptive and expressive identification of word definitions. For the incidental instruction condition, target words were presented during story book time and students heard them, but the teacher did not highlight or emphasize the words in any way. During the extended instruction condition, students were provided with instruction pertaining to the pronunciation of targeted words and their definition. Additionally, researchers asked students open ended questions based on the targeted word during storybook instruction. During the embedded instruction condition, students were only provided a simple definition of the targeted words during storybook reading each time the word occurred within the book. Thirty-six kindergarten students participated in the first study and 56 different kindergarten students participated in the second study. When results for both studies were compared, for the majority of students, extended instruction was the more favorable mode of instruction for students. Despite these findings, results indicate that for students who were at a greater risk for language and reading delays, embedded instruction was associated with greater increases identifying the definition of words over the extended instruction condition.

Finally, Chamber et al. (2008) compared embedded technology skills (multi-media) that included phonics and vocabulary videos to computer-assisted tutoring within literacy instruction for 156 first graders. Results indicated that general education first grade students who received multimedia embedded instruction scored higher during posttest than students in the computer-assisted tutoring group on Woodcock Letter-Word Identification and Gray Oral Reading Test (GORT) Total scores. Students in the embedded instruction condition also scored marginally higher on GORT fluency.

Embedded Instruction for Students with intellectual Disability

To date, most of the research investigating the effectiveness and efficiency of embedded instruction practices include participants with developmental disabilities. Specifically, Collins, Karl, Riggs, Galloway, and Hager (2010) discuss the use of a variety of response prompting strategies (e.g., time delay, simultaneous prompting) as an effective means to embed functional application skills within core content for students with developmental disabilities. Within the article, the authors outline procedural considerations for embedding trials within a general education classroom such as keeping a minimum of 10 minutes between each trial. They also provide implications for allowing peers to implement embedded trials within the general education context. For example, the authors address a common myth that the grade of a peer assisting a student with a disability may decrease due to the distraction of implementing the procedure. In conclusion, the authors not only support the need for further research on the effect of embedded instruction, but also they encourage the examination of embedded instruction implemented by non-traditional agents in the special education literature (e.g., general education teacher, peer with a high incidence disability, culturally diverse students).

In an example where researchers used embedded instruction to teach academic skills to students with intellectual disability, Polychronis, McDonnell, Johnson, Riesen, and Jameson (2004) compared the effectiveness of embedded instruction distributed across a 30 minute time period *vs*. distributed across a 120 minute time period for students with developmental disabilities (i.e., severe intellectual disabilities, Down Syndrome) within a general education setting according to the subject area at the time (e.g., researchers embedded number identification and telling time trials during mathematic instruction). In both conditions, general education teachers provided the embedded instruction to teach state capitals, number identification, identification of familiar people, and telling time to the quarter and half hour. Within their description of the study, the authors did not describe specific aspects of the traditional instruction such as if there was a designated curriculum used, key features of a typical lesson, or description of class activities. During the embedded instruction condition, instructors used a constant time delay response prompting procedure to provide embedded instruction on target skills. Findings indicated that although students increased independent correct responding on their specified targeted skills under both conditions, students made gains at a quicker pace when embedded instruction trials were distributed over a 30 minute time span. Similar to other study, results also indicate that general education teachers were able to implement embedded instruction with a high rate of fidelity while providing their standard daily instruction.

Johnson, McDonnell, Holzworth, and Hunter (2004) also examined the effectiveness of embedded instruction for students with developmental disabilities. In this study, the researchers used a multiple probe across behaviors design to examine the effectiveness of embedded communication skills (e.g., making requests using an alternative augmented communication device), answering questions, and sight word identification skills of three elementary schools students with developmental disabilities (i.e., moderate intellectual disability, moderate mental retardation, and ASD) within a general education setting. Again, the researchers chose the response prompting strategy constant time delay to implement instruction during the embedded instruction sessions. Although the researchers describe the different general education classrooms where students received embedded instruction (e.g., fine arts, science, language arts), they did not describe aspects of the instruction provided to the class such as classroom activities or curricula used. Not only did results suggest that embedded instruction was effective in the acquisition and maintenance of skills for all three students, but results also indicated that both general education teachers and special education paraprofessionals implemented embedded instruction using constant time delay with a high level of fidelity.

Another study conducted by Johnson and McDonnell (2004) examined the effectiveness of embedded functional sight word instruction (e.g., help) and identifying "greater than" for three students with developmental disabilities (i.e., Down Syndrome, cerebral palsy, mental retardation) during traditional academic instruction. During the embedded instruction condition, constant time delay instructional trials were embedded within the general educator's instruction in distinguishing spiders from other insects and the parts of a plant cell. Similar to the previously described study, the authors did not include details describing the traditional academic instruction provided to all students in the class (e.g., description of class activities and lesson components). Results showed that for two of the three students embedded instruction was effective in acquisition and maintenance of functional sight word identification. No specific findings were discussed about whether or not students with disabilities could independently and correctly discriminate between a spider and other insects, and parts of a plant cell. Findings also indicated that both general education teachers who implemented embedded instruction were able to do so with high rates of fidelity during their typical delivery of instruction.

Finally, Jameson et al. (2008) taught same-aged peers without disabilities to implement an embedded constant time delay procedure in the general education setting to teach a variety of academic skills (e.g., organ functions). Three students with a severe intellectual disability participated. Authors of the study did not indicate when in the general education setting embedded trials were implemented nor did they describe the types of activities or instruction occurring for all students within the classroom. Results of the study indicated that peer delivered embedded instruction was effective and peers can be trained to implement embedded constant time delay instruction. It is also important to note that according to social validity measures, peers enjoyed implementing embedded instruction and would be likely to participate again in the future.

Embedded instruction to teach science. Scientific literacy is an expectation for all high school students across the nation regardless of disability (AAAS, 1989). Anthony, Tippett, and Yore (2000) suggest that one way to increase scientific literacy is to embed reading comprehension skills into science instruction. In one example, Jameson et al. (2007) used a single subject alternating treatment design to compare the effects of one on one embedded instruction in the general education classroom and massed trials in the special education classroom. The researchers measured the percent of correct responses on targeted definitions (e.g., states of matter) for four middle school students with developmental disabilities. During embedded instruction sessions, the special educator or paraprofessional used the constant time delay procedure to teach targeted definitions and symbols during naturally occurring breaks and during transitions in the general education science classroom. Although results indicated that massed trials in the special education classroom was more efficient for two of the participants, results also indicated that one participant reached criterion at a faster rate via embedded instruction in the general education classroom. There was no difference between both interventions in terms of the fourth participant. Despite mixed results, data did indicate that students can acquire science definitions and symbols when it is embedded within the general education classroom. In addition to supporting that students can acquire grade-aligned science definitions and symbols when presented using embedded instruction, both studies also support that paraprofessionals can be trained to implement embedded instruction using constant time delay within these general education settings.

Embedded instruction for students with ASD. Similar to the research in teaching students with low incidence disabilities, embedded instruction has also been shown effective in teaching a variety of skills to students with ASD. It is important to note that embedded instruction research with children with autism is limited and often focuses on non-academic skills and activities (e.g., self-injurious behavior, compliance to directives). In an effort to understand the effects of embedding instruction across a range of disabilities, studies which may address non-related or non-academic skills are included.

Sigafoos et al. (2006) compared self-injurious behavior and correct responding when one student with autism was provided embedded instruction or discrete-trial instruction on adaptive behavior skills (e.g., requesting more). These behaviors were measured during three routine activities (i.e., walking, swinging, and during music) throughout the student's day. Following a functional analysis of the self-injurious behavior and introduction of the intervention, results of this study indicate that the student exhibited lower levels of self-injurious behaviors during the discrete-trial condition; however, levels of self-injurious behaviors also decreased within the embedded instruction condition. Researchers noted that during the initial embedded instruction condition self-injurious behavior occurred across a mean of 2.9% intervals. When the shift was made to the discrete-trial instruction the mean occurrence of the behavior jumped to 53%. Once researchers implemented embedded instructional trials, the mean occurrence of the behavior decreased again to a mean of 3% of intervals. Importantly, the authors noted the preferred use of embedded instruction when the function of the problematic behavior was escape because within the embedded instruction format, trials are short in duration and allow the student access to the function of his behavior.

In a study that did not use time delay as the only systematic instruction component, Kurt and Tekin-Iftar (2008) compared constant time delay and simultaneous prompting delivered in an embedded instruction format to teach leisure skills (i.e., taking a picture, turning on a CD player) to four elementary aged boys with autism. This leisure skill instruction was embedded within the daily routines and activities (e.g., circle time, imaginative play, story time) of the inclusive preschool classroom. Results of this study indicated that both response prompting procedures, when delivered in an embedded instruction format, were effective in teaching participants their designated leisure skill. Additionally, social validity data indicates that all instructors reported they would incorporate embedded instruction into their daily instructional practices and would advise their colleagues to do so as well. Most of the instructors also reported that embedded instruction would be a convenient inclusive practice within a general education setting.

Finally, McDonnell et al. (2006) used an alternating treatment design to compare vocabulary instruction for four middle school students with intellectual disability, one with autism, using an embedded and small-group instructional format. During the embedded instruction condition, the researchers implemented constant time delay to deliver instruction in a one to one instructional format. Other instructional procedures implemented in both the embedded instruction and small-group instruction format were identical. During instructional sessions, vocabulary definitions were embedded within the U.S. History and science general education classes. Embedded instructional sessions occurred during the established routines within the science and social studies classroom at the discretion of the paraprofessional. These instructional sessions most often occurred during transitions within activities in the classroom (e.g., between lecture and guided practice). Results of the study indicate that both embedded instruction and small group instruction were equally effective in vocabulary acquisition.

In summary, the reviewed research, implemented with a range of students with and without disabilities, and support the use of embedded instruction to teach a range of academic and functional skills effectively. Although the general education and high incidence studies described in the review did not use specific response or antecedent systematic prompting strategies, they did implement components of systematic instruction such as differential reinforcement, prompting hierarchies, and error correction during the embedded instruction conditions. Within the research including participants with intellectual disability and ASD, constant time delay was the response prompting procedure most frequently implemented by researchers during embedded instruction conditions. There remains a need for research that uses response prompting strategies other than time delay such as simultaneous prompting.

The reviewed research also supports the use of embedded instruction procedures to teach students with ASD academic science content like scientific definitions. Specifically, the included literature suggests science word and definition instruction as a means to increase scientific literacy. Finally, the research reviewed promotes inclusionary practices within science general education classrooms and suggests embedded instruction can be implemented by general education teachers, special education teachers, and same-aged peers without disabilities. The following section will outline the use of explicit instruction to deliver academic instruction for students with ASD and/or intellectual disability.

Explicit Instruction

Explicit instruction, an instructional strategy with over 30 years of empirical support for teaching students with high incidence disabilities that was originally conceived for use in inclusive classroom settings, primarily capitalizes on how incoming information is both processed and organized by the learner (Engelmann & Carnine, 1991; Goeke, 2009; Rosenshine & Stevens, 1986). Explicit instruction is considered an active process that emphasizes the learner’s role within the learning process (i.e., how they process the instruction provided). Explicit instruction focuses jointly on the information presented and how the learner processes that information. Because its conceptualization followed the increase of educating students within their age-appropriate general education classrooms, explicit instruction often includes research-based elements such as active engagement, systematic instruction, activation of background knowledge, and the use of explicit models to provide instruction (Goeke).

The support or scaffolds provided by explicit instruction are the cornerstone for making the process successful in teaching new skills or behaviors to a variety of learners (Rosenshine, 1987). These scaffolds or supports are delivered using some variation of a model, lead, test format (Engelmann & Carnine, 1991). Explicit instruction always includes at least two phases (i.e., model and test), but often may include three phases (i.e., model, lead, test; Engelmann & Carnine). The first phase in explicit instruction, often referred to as “I do” or “my turn,” provides an opportunity for the instructor or teacher to model the desired task, skill, or behavior (Archer & Hughes, 2010). For example, when teaching a student to verbally read a new vocabulary word, the teacher may read a new vocabulary word aloud. This phase is often, but not always, followed by guided practice, also referred to in the literature as “we do” or “with me” (Archer & Hughes). During this phase, the instructor and learner perform the task together. Using the same example used above, during this phase the instructor and student may read the vocabulary word aloud together. The final phase of explicit instruction is often called “You do” or “your turn” (Archer & Hughes). During this phase the learner is expected to perform the task independently; in this case, the teacher may hold up the vocabulary word printed on an index card and the student would read the word independently.

Explicit Instruction for Students with Learning Disabilities

Explicit instruction to teach literacy skills. To date, the majority of published research using explicit instruction to teach academic skills to students with disabilities has concentrated on teaching a variety of literacy skills (e.g., decoding [Ryder, Runmer, & Greaney, 2007], reading fluency [Wexler, Vaughn, Roberts, & Denton, 2010], spelling [Darch, Kim, & Johnson, 2000; Fulk, 1996; MacAruther, 1990], vocabulary [Rupley & Nichols, 2005; Taylor, Mraz, Nichols, Rickelman, & Wood, 2009], and rights and responsibilities [Wood, Kelley, Test, & Fowler, 2010]) to students with learning disabilities. Wanzek et al. (2006) conducted a comprehensive literature review of studies published between 1995 and 2003 and found a total of 19 interventions that taught spelling skills to students with specific learning disabilities in the area of reading using explicit instruction. In addition suggesting further replication in using explicit instruction to teach other academic skills, they also suggested that the inclusion of CAI within the explicit instruction and providing multiple opportunities to practice spelling skills were also key factors for students' success within those 19 studies.

In addition to spelling, many published studies have examined the use of explicit instruction to teach reading comprehension skills. In 1984, Baumann used a group experimental design to investigate the effectiveness explicit instruction to teach 66 middle school students with learning disabilities to identify the main idea from a short passage. Participants were randomly assigned to three groups: control, basal, and strategy for a three week period. Participants in the control group maintained the school district's current literacy instruction (i.e., eight 30 minute lessons). Participants in the basal group received the district's current literacy instruction as well as eight massed basal lessons that focused on main idea comprehension via the *Ride the Sunrise* curriculum (Clymer & Venezky, 1982). Finally, participants in the strategy or experimental group received eight explicit instruction lessons on how to identify the main idea within both paragraphs and short passages. Participants in the strategy group were explicitly taught to first identify a main idea within a paragraph (e.g., the main idea was a stated topic sentence) then to identify an implicit main idea within a paragraph (e.g., the main idea was not a topic sentence within the paragraph). Following the initial instruction, participants were also provided instruction on how to find explicit and implicit main ideas within short passages (3-5 paragraphs). Each lesson included five steps (a) introduction, (b) example, (c) explicit instruction, (d) teacher-directed application, and (e) independent practice application. Results of the posttest show that the strategy group outperformed both the control and basal groups in their ability to identify the explicit and implicit main idea in both paragraphs and passages. Similarly, the author notes the superior performance of participants in the strategy group across all measures evaluating the participants' ability to generalize identification of the main idea to novel paragraphs and passages over the performance of participants in both the control and basal groups. As a result of these findings, Baumann suggests further replication to explore the effects of other factors which may explain the increased performance of participants within the strategy group (e.g., environmental factors, written versus verbal instruction, teacher fidelity in implementing basal lessons).

Another literary skill with substantial research supporting the use of explicit instruction focuses on teaching phonemic awareness and decoding strategies. Ryder et al. (2007) used a group experimental design to examine the effect of 56 semi-scripted lessons delivered by a teacher assistant across 24 weeks on phonemic awareness, decoding strategies, and reading comprehension. These 56 lessons were taught using explicit instruction procedures to 24 struggling readers between 6 and 7 years old. The authors used standardized tests such as the Phonological Awareness Test (Robertson & Salter, 1997) and the Neale Analysis of Reading Ability Revised (Neale, 1988) to compare the scores of the intervention and control groups' scores using a pre/posttest format. Results of the study suggest that students who received the intervention scored significantly higher (i.e., $p < .05$) than the students in the control group in the areas of phonemic awareness, pseudo-word decoding, context-free word recognition, and reading comprehension. Specifically, the authors report an effect size of .72 for the Burt raw score and .81 for the Neale Accuracy raw score. Additionally, a two year follow up indicated that these effects were maintained overtime and the skills had generalized to word recognition accuracy within a variety of reading passages.

Explicit instruction to teach mathematical skills. Although fewer studies are published examining explicit instruction to teach mathematical skills for students with high incidence disabilities, published research does exist. Gersten et al. (2009) conducted a meta-analysis of literature pertaining to mathematical instruction for students with a learning disability published from January 1971 to August 2007. The authors specifically looked at four categories of instructional components (a) approaches to instruction, (b) formative assessment and feedback for teachers, (c) formative assessment and feedback for students, and (d) peer-delivered instruction. Of the 42 studies they retained for analysis, 11 studies used explicit instruction to provide mathematical interventions. Following initial coding of these articles, authors noted that when comparing these studies to the remaining 31 studies, interventions which included explicit instruction as a component were narrower in focus than studies which did not include explicit instruction. Owen and Fuchs (2002) taught participants to find half of a quantity *vs*. Hutchinson (1993) who taught students with learning disabilities complex strategies for solving multiple step algebra problems. Findings of the study also suggest that of the instructional components analyzed (e.g., explicit instruction, think alouds, peer-delivered instruction), explicit instruction was one of two instructional components that were statistically significant when compared to the outcomes of other interventions (e.g., use student feedback, use of heuristics or generic approach) within the analysis. The authors reported a mean effect size for explicit instruction studies of 1.22 ($p < .001$). Due to the lack of literature supporting the use of explicit instruction as the sole mode for delivering instruction for students with disabilities, the authors suggest future replications examine explicit instruction independently *vs*. explicit instruction as part of an intervention package.

Witzel, Mercer, and Miller (2003) used a pre-post group experimental design to examine the effectiveness of “explicit concrete to representational to abstract instruction” (p. 1203) to teach 68 middle school students with and without a learning disability to solve algebra transformation equations with multiple variables. Thirty-four middle school students with disabilities (e.g., specific learning disability, attention deficit disorder) were matched with 34 middle school students who did not have a disability across 10 classrooms. While students in the control group received the school district’s traditional instruction, students in the experimental groups received explicit instruction on how to solve transformations (e.g., reducing expressions, solving inverse operations) via a 19 lesson sequence. Results of the study indicate that while students in both groups made gains, students who received explicit instruction outperformed students who had received traditional instruction on the post-test and follow-up exams. Similar to other published studies examining explicit instruction for students with high incidence disabilities (e.g., specific learning disability), authors suggest future research continue to examine explicit instruction independently *vs*. as part of an intervention package and further replication with students with developmental disabilities.

Explicit instruction to teach science skills. While an exhaustive literature search returned only one empirical study examining the use of explicit instruction to teach science skills, several of the reviewed studies focus on teaching skills (e.g., vocabulary, reading comprehension, mathematical problem solving) necessary for success in the curricular area of science. For example, in order for a student to successfully complete a science experiment, that student may be required to read and comprehend a theory or rationale to conduct such an experiment (e.g., Newton's Laws of Motion). During implementation of an experiment, students may then need to collect mathematical data during the experiment. Finally, after completing the experiment, the student may be required to report their finding via oral or written report. Since explicit instruction has been shown to be effective in teaching a variety of literacy and mathematical skills that are included in the curricular area of science, it is reasonable to assume that despite the context, skills such as reading fluency, reading comprehension, vocabulary acquisition, and mathematical problem solving could also be taught using explicit instruction. Steele (2007) specifically discusses the benefits of incorporating explicit instruction within inquiry science instruction as a means to provide additional supports to students who may not soar in the constructivist context inquiry provides.

McCleery and Tindal (1999) used a group experimental design to examine the effectiveness of explicit instruction the scientific method to 57 middle students with learning disabilities in an urban school district located in the Pacific Northwest. Participating students were randomly assigned to three conditions: the control group (Period B), the comparison group (Period A), or the pull-away group. The control group received the current traditional instruction in their regularly scheduled science classroom. Period A received the same district instruction with the inclusion of hands-on constructivist experiences (e.g., with some emphasis on concepts. The pull away group received 40 minutes per week pull away instruction during their regularly scheduled 90 minutes science class for six weeks in addition to the hands-on experiences, and the traditional instruction. During this pull away instruction, students were taught using explicit instruction as well as examples and nonexamples of steps within the scientific method. Results of the study indicate that during post-test measures students in the pull away outperformed students in the control and comparison group (p=.004). Additionally, authors report a statistically significant difference between the pull away group and the control and comparison group in terms of the richness of the explanation provided on the scientific method (p =.0010).

Knight (2011) used a multiple probe across participants design to evaluate the effectiveness of the Book Builder™ paired with explicit instruction on the acquisition of science vocabulary and use of vocabulary terms on literal comprehension and application questions for four middle school students with ASD. Results of the study indicate that data did not demonstrate a functional relationship between the number of assessment items answered correctly and introduction of the Book Builder™ program. Once the additional component of explicit instruction was added to the intervention, student performance data does demonstrate a functional relationship between the number of assessment items answered correctly and implementation of explicit instruction. Finally, not only did participants maintain science vocabulary over time, but also participants were also able to generalize that acquired knowledge to untrained exemplars.

Explicit Instruction for Students with ASD and intellectual Disability

Although the majority of published literature using explicit instruction has focused on academic instruction for student with high incidence disabilities (e.g., specific learning disability), there are a few studies which have begun to examine the effectiveness of explicit instruction for a student with ASD including intellectual disability (i.e., Flores & Ganz, 2007; Ganz & Flores, 2009; Hicks et al., 2012; Knight, Smith, Spooner, et al., 2011). Similar to the majority of explicit instruction literature for students with high incidence disabilities, Flores and Ganz (2007), Ganz and Flores (2009), and Hicks et al. (2012) taught literacy skills to secondary students with ASD.

Flores and Ganz (2007) used a multiple probe across behaviors single subject research design to examine the effectiveness of explicit instruction on teaching use of facts, statement inference, and analogies to four elementary students with ASD and intellectual disability. During 20 minute sessions, the researcher used scripted lessons to provide explicit instruction on these reading comprehension strategies. Results of the study demonstrate a functional relationship between the increase of correct reading comprehension questions answered and introduction of the intervention for all participants across all tiers (i.e., answering questions using facts, answering inference questions, and correct use of an analogy). Flores and Ganz suggest that future studies examine the effectiveness of the intervention when it is not implemented by a trained researcher in the field of direct instruction. Additionally, they suggest the need for more replications demonstrating effectiveness of the intervention for this population of students.

In a follow-up study, Ganz and Flores (2009) used a single subject changing criterion design to examine the effectiveness of explicit instruction to teach three elementary aged students with ASD to verbally identify objects. Results of the study demonstrated a functional relationship for all participants following introduction of the intervention. Additionally, findings indicate that not only was explicit instruction effective in teaching the verbal identification of objects, but also indicate that once the skill was acquired the participants maintained the skill overtime and were able to generalize the skill in the special education classroom. Again, the authors discuss the overall need for replication studies examining the effectiveness of explicit instruction for this population and the need for further generalization measures such as generalization within a general education classroom.

Hicks et al. (2012) used a multiple probe across behaviors with concurrent replication across participants to examine the effectiveness of explicit instruction on preposition acquisition for two middle school students with a severe intellectual disability. In this study, explicit instruction was delivered in a model-test instructional sequence. The researchers measured preposition acquisition using cumulative recording on the number of correct responses during daily probes. Results of the study indicate a functional relationship between introduction of the intervention and an increase in the number of prepositions identified correctly. The authors suggest future studies include pre and post generalization measures to determine the extent to which participants were able to generalize the acquired skills before, during, and after intervention began. The authors also suggest future studies consider examining the use of explicit instruction in group instructional formats.

In a follow-up study, Hicks (2011) used a multiple baseline single subject research design to examine the effectiveness of explicit instruction on preposition acquisition and generalization for three elementary school students with intellectual disability. Similar to the finding of the previous study, results indicated a functional relationship between preposition use and introduction of the intervention. In addition to the acquisition and application of three prepositions, data also indicated that participants were also able to maintain this knowledge of an extended period of time (i.e., 56 days).

In another study that provided explicit instruction using a model-lead-test format, Knight, Smith, Spooner, et al. (2011) used a multiple probe across behaviors with concurrent replication across participants to examine the effect of explicit instruction to teach science descriptors (e.g., heavy, change, living, dead) to three elementary aged students with ASD and a severe intellectual disability. Results of this study demonstrated a functional relationship between explicit instruction and all behaviors (i.e., receptive identification of science descriptors) and like both preceding studies, the participants were able to maintain acquired skills over time. Generalization measures implemented following the intervention demonstrated that while students were able to generalize identification of science descriptors to novel materials and within a general education inquiry lesson at high rates, participants were not able to generalize identification of descriptors to pictures representing each descriptor. In addition to suggesting the need for further replication of studies examining explicit instruction for this population, authors suggest that future studies examine the use of examples and nonexamples to assess understanding of science descriptors versus sight word reading to increase comprehension for students within this population.

In summary, the research examining explicit instruction for students with high incidence disabilities far outweigh the number of published studies examining the use of explicit instruction for students with ASD and intellectual disability. Within the published research using explicit instruction to teach an academic skill more studies focus on teaching literacy skills than those teaching mathematical or science skills. Therefore, there exists a great need for studies examining the use of explicit instruction to teach academics to students with ASD and intellectual disability (National Autism Center, 2009; Pennington, 2010). Finally, future research should consider the other sources to provide this explicit instruction outside of trained direct instruction researchers. The following section will explore how technology can be used to provide explicit instruction. Specifically, the following section will describe the literature base for using CAI with students who have ASD.

Computer-Assisted Instruction

Advances in technology have revolutionized everyday life, especially in the field of education. In order for students to become successful in the post secondary environment, children now need advanced technological training (Lefever-Davis & Pearman, 2005). In 2001, statistics show that approximately 90% of students ages five through seven use computers on a daily basis (National Center on Educational Statistics). Research examining the potential benefits of infusing CAI into traditional academic instruction is not limited to students with developmental disabilities. A variety of research has also examined the use of CAI for students with learning disabilities or mild intellectual disabilities.

CAI for Students with Mild Disabilities

Within the research investigating the effects of CAI for students with mild disabilities (e.g., learning disabilities, behavior disorders, mild intellectual disability), the use of CAI to teach self-determination skills is growing. Wehmeyer (1996) defines self-determination as “acting as the primary causal agent in one’s life and making choices and decisions regarding one’s quality of life free from undue external influence or interference” (p. 24). Additionally, Carter, Lane, Pierson, and Stang (2008) defined seven components of SD including (a) choice making, (b) goal setting and attainment, (c) decision making, (d) self-advocacy, (e) problem solving, (f) self-awareness or self-knowledge, and (g) self-management or self-regulation.

In one example, Mazzotti, Wood, Test, and Fowler (2010) used a multiple probe across participants design to examine the effectiveness of CAI on participants’ knowledge of the Self-Directed Learning Model of Instruction (SDLMI) and level of disruptive behavior for three elementary school students with challenging behavior. Participant knowledge of the SDLMI was assessed using a 27 item assessment probe and to assess levels of disruptive behavior (e.g., spitting, writing notes, talking out); the researchers used a partial interval recording system with each interval lasting 10s. Participant performance data on the assessment probe demonstrated a functional relationship between introduction of the intervention and the number of assessment items answered correctly. Similarly, behavior data indicate that in addition to raising assessment scores, participants decreased the number of intervals they exhibited disruptive behavior following introduction of the intervention. In addition to the report effectiveness data, Mazzotti et al. also report teacher social validity data that support the use of CAI to address other skills within the classroom.

Mazzotti, Test, Wood, and Richter (2010) used a multiple baseline across behaviors design to investigate the effectiveness of CAI on participants' knowledge of post-school outcomes for four high school students with mild to moderate intellectual disability. Participant knowledge of post-school options across three areas (i.e., employment, education, and independent living) was assessed using a 30 item assessment probe. Study findings indicated a functional relationship between the number of assessment items participants answered correctly and introduction of the CAI intervention. Results also indicate that participants were able to maintain this knowledge over time. In addition to suggesting the need for further replications in examining the effectiveness of CAI to teach a variety of self-determination skills, researchers also suggest a need for further demonstrations teaching skills which are academic in nature.

In one study that examined a skill more academic in nature, Wood, Mustian, and Lo (in press) used a multiple probe across participants design to evaluate the effectiveness of CAI peer tutoring on the phoneme segmentation for four Kindergarten students identified as "at risk" for reading failure. In addition to the CAI intervention, this study also used peer tutors who completed the CAI intervention with a participant of the study. Results of the study indicated that the addition of peer-tutors to the CAI intervention was effective in teaching phoneme segmentation to the participating Kindergarten students. Wood et al. suggest future studies examining the effectiveness of CAI also address possible peer-tutoring implications. Specifically, the researchers suggest future studies examine the feasibility and implications of pairing CAI with peer-tutoring within a classroom setting *vs*. a separate setting.

CAI for Students with ASD

Many researchers have suggested the benefits of using technology, specifically CAI, to deliver instruction to students with ASD (Blischak & Schossser, 2003; Braddock, Rizzolo, Thompson, & Bell, 2004; Colby, 1973; Pennington, 2010). Moore, McGrath, and Thorpe (2000) suggest that the use of CAI with students with ASD could ameliorate the social deficits which are typically a common characteristic of students with ASD. Additionally, Payan (1984) suggests the use of technology also addresses (a) common challenges attention and motivation, (b) the occurrence of stereotypic behaviors, and (c) the benefits of consistent, immediate feedback for students with ASD. The use of technology to provide academic instruction give an instructor the ability to highlight, slow down, or repeat critical components of features that in addition to addressing the need for academic instruction would also address the need for providing social instruction within social contingencies in controlled formats (Moore et al., 2000).

In one of the first studies examining the use of technology to teach students with ASD, Colby (1973) used various computer games to provide academic instruction in literacy to 17 non-verbal students with ASD. For example, in one computer game, when a child pressed a letter on the computer, the computer software verbally identified the letter. In another game when a child pressed a letter on the key board, the computer would match that letter with a corresponding animal (e.g., H is for horse) and the animated animal travelled across the computer screen. The purpose of this study was to teach participating students letters and their phonemes as well as demonstrate that words can form expressions. Results of the study indicate that 13 of the 17 students increased the occurrence of involuntary speech as well as were motivated and enjoyed playing the computer games. Due to the time period in which the study was conducted, the study does not report an experimental design or information about the participants (e.g., ages, medical diagnosis).

Basil and Reyes (2003) used a quasi-experimental research design to examine the effectiveness of CAI multimedia software to teach the verbal identification of letters, syllables, words, text (e.g., a sentence), reading comprehension, and composition for two elementary aged and one middle school aged student with ASD and intellectual disability. Results of the study indicate that participants showed growth in sentence writing, phonological synthesis skills, and writing skills. Despite promising results, the researchers were not able to demonstrate a functional relationship between the dependent variables and introduction of the intervention. The authors did not describe any measures taken to ensure the intervention was implemented reliably and with fidelity, describe critical features of the physical environment, nor provide repeated measures of the dependent variable in a baseline phase to establish a pattern of responding prior to introduction of the intervention.

In another empirical study examining CAI, Chen, Wu, Lin, Tasi, and Chen (2009) used an alternating treatment single subject design to compare the effects of CAI with text, pictures, or speech support to teach reading comprehension strategies to three high school aged students with ASD. Results of the study indicate that the CAI presenting using a picture to text format was most effective in increasing the number of reading comprehension questions answered correctly following a short passage (i.e., between three and five paragraphs). Similar to the previous studies reviewed in this section, Chen et al. also including limitations such as no description of fidelity or reliability measures, no description of critical features of the physical setting, no repeated measures in a baseline phase to establish a responding patterns prior to introduction of the intervention, and no description of procedures that would promote replication.

Among the published CAI literature, the lack of reporting critical components of single subject research (e.g., fidelity and reliability measures) has plagued successful applications of this research for practitioners and successful replications seeking to replicate these interventions for researchers. Pennington (2010) examined studies published from 1997 to 2007 in which CAI was used as an intervention or part of an intervention package to provide academic instruction to students with ASD. Pennington retained a total of 15 articles for analysis and the analysis yielded three major findings. First, the literature review establish that a number of published studies have examined the use of CAI to teach the acquisition of academic skills across instructional contexts (e.g., general education classroom, special education setting). Of the potential curricular areas, the only curricular area represented by studies published until 2007 taught literacy skills (e.g., expressive and receptive identification of vocabulary). In an effort to increase the breadth of literature using CAI, Pennington suggests future research provide instruction in academic areas other than literacy.

Second, the majority of the articles reviewed not only addressed acquisition of a skill or behavior, but the authors also addressed maintenance and generalization of the skill within the study. The use of CAI to promote generalization of skills is particularly interesting since generalization of skills is often an area of concern for students with ASD (Koegel & Koegel, 1995). Pennington (2010) and Wood, Van Norman, Mackiewiez, and Cooke (2007) also call for further studies utilizing widely available software like Microsoft PowerPoint *vs*. specially designed software programs in an attempt to expand the literature using affordable and accessible technologies.

Finally, despite these favorable findings, the analysis also reveals the high number of these studies that do not include key features of high quality single subject research like overt measurement of fidelity of implementation or providing a description of the procedure to allow for replication. Pennington suggests an overall need for more high-quality empirical studies examining the use of CAI to provide academic instruction for students with ASD.

In a more recent and comprehensive literature review, Knight, Smith, and Saunders (2011) examined studies using CAI to provide academic instruction for students with ASD from 1973 to 2010. Unlike the Pennington (2010) review, Knight et al. examined studies to determine (a) number of participants identified with autism or ASD, (b) type of research design used, (c) content area for the targeted skill, (d) intervention, (e) dependent variables, (f) results, and (g) limitations. Additionally, Knight et al. examined each study based on quality indicators developed by the National Secondary Transition Technical Assistance Center's (NSTTAC, 2010; Test et al., 2009) corresponding to Horner et al. (2005) criteria for single subject research. Twenty-four articles including 184 participants were retained for analysis. Unlike the Pennington (2010) reviews, Knight et al. found one study which provided mathematical instruction via CAI for students with ASD (Chen & Bernard-Opitz, 1993) and one study which used a group experimental design to examine the effectiveness of CAI (Whalen et al., 2010). Similar to Pennington (2010) findings, there remains a need for additional empirical studies examining the use of CAI to deliver academic instruction for students with ASD. Of the 24 studies found in the literature search, three single-subject studies and zero group design studies met criteria established by the NSTTAC quality indicators for meeting moderate or high quality. Specifically, the majority of studies did not report data pertaining to measures of fidelity and reliability and did not implement repeated measures of the dependent variable within a baseline phase to establish a pattern of responding.

In summary, while a large number of studies examining the effectiveness of CAI to teach academics to students with ASD and intellectual disability exist, the need for high quality studies which address the Horner et al. (2005) criteria for single subject remains. Additionally, there is also a need for empirical studies examining using CAI to teach skills outside of the curricular area of English Language Arts. There are no published studies examining the use of CAI to teach science skills to students with ASD and intellectual disability.

Summary of Research

Scientific literacy is a goal for all students, including students with disabilities (AAAS, 1989). While research supports that students with disabilities can learn grade-aligned academics within a special education setting, research also supports and demonstrates the benefits in providing this instruction within an inclusive setting. Within the general education classroom, the use of embedded instruction is one format which is gaining support from published literature (Copeland & Cosbey, 2008-2009; McDonnell, 2006). To date, there is a growing literature base demonstrating the effectiveness of providing academic interventions teaching science skills to students using embedded instruction practices within inclusive classrooms (McDonnell, 2006; Jameson et al., 2007, 2008).

One way that teachers and researchers have effectively taught academic skills in the curricular area of science is through systematic instruction (Drasgow et al., 2011; Spooner et al., 2011). One systematic instruction procedure with a strong research base in teaching academics to students with high incidence disabilities is explicit instruction (Engelmann & Carnine, 1991; Goeke, 2009). Recently, researchers have begun to examine the effectiveness of explicit instruction for students with developmental disabilities including ASD (Flores & Ganz, 2007; Ganz & Flores, 2009; Hicks et al., 2012; Knight, Smith, Spooner, et al., 2011). To date, only one published study has examined the effect of explicit instruction in teaching science skills to students with ASD and intellectual disability (Knight, Smith, Spooner, et al., 2011).

Another area of excitement for researchers and practitioners educating students with ASD and intellectual disability is the use of technology or CAI to provide academic instruction. While there are a large number of studies examining the use of CAI with students with ASD, those studies exclude key quality components for single-subject research and are all within the context of teaching literacy skills. Currently, there is only one study examining CAI teaching a mathematical skill and none teaching a science skill.

Currently, no study has examined the use of CAI within an embedded instruction format to teach science skills to students with ASD and intellectual disability.

In an effort to address major limitations and suggestions for future research within the reviewed literature, this study examined the use of embedded instruction, but delivered via CAI. Implementing the intervention via technology may address some of the common barriers to inclusion for students with disabilities (e.g., stigma of hovering adults) as well as the use of CAI to deliver the intervention addresses the need for further replications in using CAI to teach skills that are academic in nature. The current study also addressed limitations surrounding the quality of single-subject research in using CAI by collecting and reporting data pertaining to effectiveness of the program, reliability data, fidelity data, and social validity data from the participants as well as educators and students within the inclusive classroom who do not have disabilities. Finally, unlike the previously published research using embedded instruction, this study used explicit instruction in addition to CAI to teaching science terms and applications of those terms within the classroom.

CHAPTER 3: METHOD

Participants

Three middle school students from a metropolitan school district in a southeastern state participated. Inclusion criteria for participants included: (a) an IQ of 70 or below, (b) adequate visual discrimination to select familiar pictures from an array, (c) adequate auditory discrimination to select familiar pictures named by the computer software, (d) motor ability to point to objects and pictures, (e) the ability to respond to intraverbal stimuli presented in multiple modes (e.g., pictures, adapted text), and (f) an independent diagnosis of autism consistent with the Diagnostic and Statistical Manual IV criteria (American Psychiatric Association, 2000; Childhood Autism Rating Scale, Schopler, Reichler, & Renner, 1980; Gilliam Autism Scale, 1995). Based on these inclusion criteria, the participants' special education teacher nominated potential participants. Prior to participating in the study, the interventionist solicited parent permission via a University of North Carolina at Charlotte's Institutional Review Board approved letter. This letter was sent home to parents explained the study, its purpose, and all data collection procedures (e.g., procedural fidelity data collected via videotape) implemented throughout the study. Similarly, the interventionist developed an age and developmentally appropriate script to solicit assent from each participant that returned a signed parent permission slip. Only students who submitted parent permission and student assent forms participated in the study. The following sections described the three students including information on ages, grade, gender, diagnosis/disability, evaluation test scores, strengths, and weaknesses.

Matt was a 12-year-old Asian/Pacific Islander seventh grade male with autism and intellectual disability. According to his most recent evaluation data, Matt had an IQ of 69 (Weschler Intelligence Scale for Children, WISC-IV, Weschler, 2003) and adaptive behavior scores placing him in the mentally deficient range (Vineland Adaptive Behavior Scales, Second edition, VIN-II, Sparrow, Cicchetti, & Balla, 2005). Matt received the majority of academic instruction within inclusive settings and did require special accommodations at times. For example, Matt was often tested in a tutor room to minimize distractions and allow for a reader when requested. At school, Matt had a large social network of friends, mostly peers from his inclusion classes, and performed most tasks during the school day independently (e.g., completion of worksheets, note taking). Although Matt had an upbeat and friendly personality, he was often quiet and reserved in large group settings. He did not like loud noises and would avoid all conversation in the presence of loud auditory stimulus whenever possible. For example, Matt would not talk to a teacher or student when the bell signaled students to transition classes. In addition to transition times, Matt often exhibited anxiety (e.g., wringing of hands, speaking quietly to self while rocking in seat) on days he was informed there would be a fire drill or school assembly. Matt’s strengths include reading on grade level and independence in completing daily living tasks like getting ready in the morning, catching the bus, and following a schedule.

David was an 11-year-old biracial (African American and Caucasian) sixth grade male with autism and attention deficit hyperactivity disorder. According to his most recent evaluation data, David had an IQ of 59 (WISV-IV, Weschler, 2003) and adaptive behavioral scores that placed him in the mentally deficient range (VIN-II, Sparrow et al., 2005). Unlike Matt, David received most academic instruction in a special education resource room with other students with ASD. David also exhibited anxiety associated with loud noises including sirens signaling fire or lock down drills. In addition to the anxiety associated with loud noises, David also exhibited behaviors associated with social anxiety that often included repetitive question asking (e.g., “Who do I know in there?” or “Who are these people?”) in large social settings like lunch or school-wide assemblies. Throughout the school day, David was most successful using a token economy system to reinforce behaviors such as completing tasks without reminders and following his schedule without the persistent asking of “What’s next?” David’s strengths included reading on grade level and completing most tasks independently given a task analysis.

Ken was a 12-year-old Native Hawaiian/ Other Pacific Islander seventh grade male with autism. According to his most recent evaluation data, the school psychologist was unable to provide an accurate IQ score due to his unwillingness to participate. According to evaluation notes, Ken simply refused to answer any questions. Ken’s adaptive behavior scales scores placed him in the mentally deficient range (VIN-II, Sparrow et al., 2005). Overall, Ken had a pleasant demeanor and was often observed laughing or smiling. Like David, Ken was not included in academic classes due to a lack of personnel to accompany him and address behaviors (e.g., squealing, humming, repetitive statements from movies) that had been distracting to both teachers and peers in past inclusive settings. Ken’s strengths included reading on grade level, independently completing complex tasks with four or more steps without reminders or additional instructions, and transitioning from preferred (e.g., computer) to non-preferred (teaching group) activities without abhorrent behaviors.

Setting

Pre-training sessions to assess participants' ability to use the Ipad 2 occurred in the special education classroom in a one to one instructional format. Probe sessions to address any prior knowledge of targeted science terms and applications also occurred in the student's special education classroom. The interventionist implemented generalization probes in the context of the inclusive science classroom pre-intervention and post-intervention for that unit. Intervention sessions occurred in the seventh grade general education science classroom and included Keynote Software and a tablet. The interventionist accompanied participants to the inclusive science classroom. The general education science classroom included 25 students, one general education teacher, and one paraprofessional assigned to assist another peer with disabilities and physical limitations in the inclusive classroom. Study participants were seat throughout the class at tables with four peers without disabilities.

Interventionist

The author served as primary interventionist and data collector. She was a doctoral student at a local university and had over 10 years experience working with students who have intellectual disability and ASD. She was employed by the University of North Carolina at Charlotte as a graduate research assistant on the General Supervision Enhancement Grant. The focus of this grant is on general curriculum access and alternate assessment for students with developmental disabilities, including ASD. In addition to her teaching experience, she had also worked as a behavior consultant and autism specialist for her school district. The doctoral student had experience implementing and collecting data using single subject studies and had published manuscripts of previously completed single subject work. Additionally, she has published her research findings in several peer-reviewed special education journals.

Second Observers

Two people, both the general education and special education teacher, collected reliability and fidelity data during all pre-training, baseline, intervention, maintenance, and generalization probe sessions. The first second observer was the special educator teacher. The participant's classroom teacher had over five years experience teaching students with ASD. In addition to being a veteran teacher, she also held a Master's degree in Special Education, and had a history of participating in past empirical studies conducted by local university staff. She collected reliability and procedural fidelity data during pre-training and probe sessions.

The general education science teacher also served as a second observer and collected procedural fidelity intervention data implemented within the inclusive science setting using the intervention log included in Appendix D. The general education science teacher was a first year teacher with a bachelor's and Master's degree in Science Education. During her graduate work, the general education classroom teacher worked as a graduate research assistant within the special education department at a local university. Because of this past experience, she was already familiar with the implementation and data collection procedures for single-subject research.

Materials

Materials used throughout the duration of the study included: (a) one 16 gigabyte iPad2 with 1GHz dual-core A5 CPU, video output support, and 10 hours of battery life; (b) four different versions of the probe and intervention slide show presentations; (c) data sheets to record participant responses during probe sessions; (d) one generalization probe activity sheet per unit, and (e) one video camera to record probe sessions to collect reliability and fidelity data. The interventionist developed all slide show presentations used during probe and intervention sessions across conditions in accordance with guidelines suggested by Payan (1984), Wood et al. (2007), and Pennington (2010). These slide show presentations consisted of 12 instructional slides. Each slide show presentation provided instruction on a set of three science terms per unit. Each slide presented a written discriminative stimulus paired with an identical verbal discriminative stimulus and four response options (i.e., one correct and three incorrect).

The interventionist developed four different versions of these slide show presentations to vary the placement of correct and incorrect response options as well as to vary the slide order. In addition to randomizing placement of the response options across each slide show, application stimuli also varied. For example, each slide show included different pictures of plant cells, microscopes, and organs.

Data Collection

Dependent variables. In this study, the dependent variable measure was the number of correct and independent responses (i.e., the number terms and applications) made during probe sessions. The interventionist used a discrete trial data collection method. Participants were assessed on their responses to nine terms (three terms across three units of study) and applications during each probe. Only correct responses made during probe sessions were graphed. Only responses made during probe sessions counted toward criterion-based performance which was independent and correct responses for at least 14 out of 18 trials. The interventionist collected generalization data using an activity sheet to assess terms and applications within the general education setting (See Appendix G).

Content validity. The interventionist validated the selected vocabulary terms, application questions, and the various stimuli (e.g., pictures, practical applications) with the general education science teacher to ensure the terms are the most salient terms within the three units of study and are commensurate across units. All application questions reflected the comprehension and application levels of Bloom's taxonomy (e.g., participants will explain, examine, distinguish). The researcher validated all application questions with a reading expert to validate they are commensurate in difficulty within and across science units.

Reliability/procedural fidelity. Classroom teachers collected interobserver reliability data across at least 30% of pre-training, baseline, intervention, maintenance, and generalization probe sessions. Procedural fidelity data collection occurred across a minimum of 30% of pre-training, probe, intervention, maintenance, and generalization probe sessions. Procedural fidelity data was calculated by dividing the number of observed behaviors by the number of planned behaviors and multiply by 100 (Billingsley, White, & Munson, 1980). During intervention sessions within the inclusive classroom, the interventionist did not provide the participant any prompts to elicit a correct response on the slide show. The interventionist did provide prompts (e.g., "Keep going" or "It's time to work”) to continue the slide show if the participant became distracted or was interrupted during the intervention. Interventionist behaviors for fidelity of intervention sessions included (a) navigate iPad 2 to correct slide show, (b) allows participants to self-navigate through slide show presentation, and (c) praise for participation on an intermittent schedule.

Response Definition and Measurement

The interventionist assessed participant responses across baseline, intervention, maintenance, and generalization probe sessions. Probes included the presentation of pictures representing or the definition for nine targeted science terms, distracters, and applications of those science terms. Applications included but are not limited to personally relevant questions that will assess a participant’s understanding of the term. For example, if the targeted vocabulary is immune system, application questions included “Which system helps you not get sick?” or if the term was homeostasis an application question might be “When your body shivers to warm you up because your cold, this is an example of _____ (homeostasis). Each probe assessed participants’ correct, independent responses to nine science terms and application questions. These terms came directly from the science general education class depending on future units of study (e.g., cells, organs, organ systems). Correct responses required the participant to touch the correct answer within 5 s once presented on the tablet (e.g., iPad 2). The interventionist scored each probe based on the number of correct responses made across numbers of opportunities (i.e., 18 total opportunities to respond in each probe).

Experimental Design

This study used a single subject multiple probe across participants design (Cooper, Heron, & Heward, 2007; Horner & Baer, 1978; Tawney & Gast, 1984). Due to constraints of the population (e.g., low number of participants who share common characteristics), single-subject research designs may be preferable to a group-design which require a high number of participants divided into homogenous groups. In contrast to group designs, the unit of analysis in single-subject research designs is the participant. Within single-subject research designs effectiveness of the independent variable on the dependent variable is established through a functional relationship (Cooper et al., 2007). This functional relationship is determined via visual analysis of the graph.

The multiple probe design has three features: (a) an initial probe to determine a participant's level of performance of the skill, (b) a series of intermittent probes assessing performance of the skill throughout intervention for each participant, and (c) prior to introduction of additional participants, a probe to assess their performance of the skill (Cooper et al., 2007). A multiple probe across participants experimental design is useful when curricula build and progress throughout instruction. For example, in the curricular area of science, once a student learns about the life cycle of a frog, they may generalize acquired knowledge across life cycles of other animals or insects (e.g., life cycle of a butterfly).

Procedures

The interventionist collected baseline data for five sessions and until data were stable across all terms and application questions across all nine terms. During baseline procedures the interventionist did not reinforce participant responses, but did reinforce their behavior intermittently for participation during all probe sessions. Following baseline sessions, intervention sessions on the first set of three science terms and their applications began for the first participant.

During instructional sessions in the general education classroom, participants received training on three science terms and applications per unit via the tablet. The tablet delivered instructional information using a model-test explicit instruction format for science terms (Bursuck & Damer, 2007). During intervention sessions, if a participant made an incorrect response (e.g., touches the incorrect choice or does not initiate a response within 5 s of the presentation of materials), the participant received corrective feedback via CAI using slide show software. For example, if a participant selected the picture showed “mitosis” rather than “homeostasis,” the slide show highlighted the correct answer. Upon touching the correct response, the slide show then progressed to the next term. If the participant made a correct response within 5 s of the discriminative stimulus, the program highlighted the student’s selection.

Once the data path for the dependent variable demonstrated a change in level for the first participant, the interventionist probed the remaining participants across all terms and application questions and began intervention on the first unit, provided their data remained stable. The interventionist followed the same intervention and probe procedures for the third participant. After a participant met criterion based performance on the first unit’s terms and applications (i.e., independent and correct responding to 4 of the 6 term or application slides for that unit), the interventionist probed across all nine terms and applications and began intervention on the second unit’s set of terms and application questions. The interventionist implemented one maintenance probe session one week following criterion based performance on all science terms. The interventionist implemented one generalization probe per unit to assess whether or not participants generalized knowledge across materials and situations used within a classroom activity sheet in the general education science setting.

Pre-training sessions. Pre-baseline training sessions to determine if students meet inclusionary criteria took place in the student's special education classroom using the tablet (e.g., iPad 2). As part of these training sessions, the interventionist assessed the participants' ability to manipulate the computer software. The slide show presentation displayed four pictures of familiar objects, identified by the classroom teacher, along with a written and verbal discriminative stimulus, "Touch _____". Following the discriminative stimulus, each student will have 5 s to touch the picture (i.e., pencil, stapler). If they touched the correct picture independently, the slide show advanced. If they did not touch the picture or touched a different picture, a prompt in the form of a yellow star highlighted the correct response option. These training sessions consisted of three trials for the student to touch the familiar objects on the tablet. The interventionist did not begin probe sessions with the student until they demonstrated correct responding on the pictures of familiar objects on the tablet across all three trials within the pre-baseline training session.

Baseline/probe procedures. Baseline probe sessions began with the presentation of the tablet with the slide show presentation already loaded. Following that attention cue, the participant began the intervention in which science terms and application questions for each term were presented in random order. Written task directions were presented on each screen (e.g., "What is this a picture of?")." Identical verbal prompts accompanied written prompts within the slide show presentation. These stimuli varied across the four versions of the probe slide show presentation. During each trial, each slide presented the correct response along with three distracters. The presentation read all response options aloud. Response options always included the targeted science terms and distracters. The interventionist varied which version of the slide show presentation she used to prevent students from memorizing where the correct answer was located on the slide. Stimuli for each term varied across slide shows. In one version, the picture for mitosis may be vertical and in color and in another presentation the stages of mitosis may be presented horizontally in black and white. The slide show waited 5 s for participant's responses. If the participant touched the correct object within 5 s of the task direction, the interventionist recorded a correct response (i.e., "+") and the program progressed to the next slide. If the student touched a response option object within 5 s, but it was an incorrect option, or if the participant did not make a response within 5 s of the discriminative stimulus, the interventionist recorded an incorrect responses (i.e., "-") and the program progressed to the next slide. The preceding procedure continued for all three terms and application questions in that unit. The interventionist did not reinforce participant responses, but reinforced for participation using a variable ratio schedule on every third response option.

Computer-assisted instruction package. Participants engaged in the unit CAI intervention slide show three times within the 40 minute period they were present in the inclusive classroom. During these intervention sessions, the participant completed the slide show presentation with another peer in the class without disabilities at least once a week across all three unit terms and applications. The features (e.g., placement of discriminative stimuli, response options, pictures used, voice output) of the slide show presentation were identical during probe and intervention sessions. Following the attention cue of the interventionist or peer handing the participant the tablet with the program already loaded, each slide displayed a written discriminative stimulus (e.g. "What does the picture show?"), the correct response options, and three distracters. These slide shows consisted of a model slide that provided students the correct answer via prompt followed by a test slide that provided the same stimuli as the model slide without the prompt present.

Similar to baseline procedures, a verbal discriminative stimulus accompanied the written text and the participant had 5 s to touch a response option. Additionally, the response options were read aloud similar to probe procedures. Unlike probe procedures, the consequence for each response was provided by the slide progression. For example, if a student made an incorrect response, the program highlighted the correct answer and the participant touched the correct response. If a participant made a correct response, the program highlighted their answer. During intervention, the interventionist, peer, or general education teacher provided intermittent feedback for participation throughout the intervention session. For example, if the participant began to rush through the slide show presentation, peers were trained to reset the slide show and remind students to "try their best."

Maintenance and generalization. The interventionist collected maintenance data one week following criterion based performance (i.e., correct responses to 14 of 18 trials for terms and applications). Additionally, the interventionist collected in vivo generalization data on correct and incorrect responses across terms and application questions immediately before and following intervention. The interventionist used the pre-developed activity sheets that the teacher used to assess participants ability to generalize terms and applications in the naturally occurring setting across materials and situations (See Appendix G). Common characteristics of these activity sheets included matching the term to the definition, completing sentences using the correct term from a word bank, and a puzzle (e.g., a cross word puzzle using the terms).

Social validity. The interventionist, via questionnaire, collected data pertaining to whether or not students enjoyed participating in the study and whether or not they felt participating in the study increased their knowledge across content throughout their school day. Additionally, the interventionist assessed the general educator perspectives related to (a) were the skills taught in the study generalized to activities within the science classroom, (b) was the intervention intrusive in the inclusive setting, (c) was the intervention was easy to implement, (d) what were their perception of the of whether or not these were socially important skills to learn, (e) would they continue using embedded CAI following the conclusion of the study, and (f) if CAI cost effective.

CHAPTER 4: RESULTS

Interobserver Reliability

Interobserver reliability was collected on probe sessions for all participants across all conditions. Second observers collected interobserver reliability data for 100% of pre-training sessions, 46% of probe sessions, and 42% of intervention sessions across all participants. Interobserver agreement was determined by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. Below are the results for interobserver agreement for each condition of the study followed by the results for procedural fidelity.

Pre-training. Second observers collected interobserver reliability data for 100% of pre-training sessions for Matt, David, and Ken. Inter-observer agreement was 100% for all participants.

Probe sessions. Second observers collected interobserver reliability for 40% of baseline probe sessions for Matt, 60% of baseline probe sessions for David, and 40% of baseline probes sessions for David. The interobserver agreement across all participants for baseline probe sessions was 100%. Following introduction of the intervention, second observers collected interobserver reliability data on 57% of probe sessions for Matt, 38% of probe sessions for David, and 67% of probe sessions for Ken. Again, interobserver agreement across all participants for probe sessions following introduction of the intervention was 100%.

Procedural Fidelity

Procedural fidelity data were collected for implementation of probe procedures and implementation of CAI intervention sessions. Because the intervention was delivered via tablet, second observers collected procedural fidelity data across intervention sessions using the intervention log found in Appendix F. Procedural fidelity data were collected across 100% of pre-training sessions, 46% of probe sessions across all conditions, and 42% of CAI intervention sessions for all participants. Procedural fidelity agreement was calculated by dividing the number of correct interventionist behaviors performed by the number of interventionist behaviors planned and divided by 100 (Billingsley, White, & Munson, 1980). The mean procedural fidelity for implementation across probe procedures for all participants was 100%. The mean procedural fidelity for implementation of the CAI intervention delivered in an embedded format for all participants was also 100%.

Results for Question 1: What is the effectiveness of embedded, explicit CAI on student acquisition of science terms and applications for students with ASD and intellectual disability?

Results showing the effects of embedded CAI on the correct identification of science terms and applications are shown in Figure 1. The graph shows the number of correct responses on probe slide shows across all conditions of the study. During baseline probes, all three participants show low levels of correct responding. Following introduction of the intervention, all three participants showed a change in level or increase in the number of correctly identified science terms and applications. Visual inspection of the graph indicated a functional relationship between the CAI intervention and an increase in the number of correct responses in probe sessions for all participants.

Matt. Matt’s baseline performance data were low, and demonstrated a stable trend. During baseline probe sessions, Matt’s mean score was 2.6 (range 2-4). Once the intervention was introduced, Matt’s probe scores immediately showed a change in level increasing to six. As intervention sessions continued, Matt’s scores during probe sessions continued to increase in both level and trend. During probes following introduction of CAI, Matt’s mean score increased to 10.8 (range 6-14). Matt reached criterion-based performance for all units (i.e., correct identification of 14 out of 18 science terms and applications) after seven CAI sessions. During a maintenance session implemented one week following criterion-based performance, the number of correct responses made was 13.

David. David’s baseline performance data were low, and demonstrated a stable trend. During baseline probe sessions, David’s mean score was 2.6 (range 2-4). Once the intervention was introduced, David’s probe scores immediately showed a change in level increasing to six. As intervention sessions continued, David’s scores during probe sessions continued to increase in both level and trend. During probes following introduction of CAI, David’s mean score increased to 11.1 (range 6-16). David reached criterion-based performance for all units (i.e., correct identification of 14 out of 18 science terms and applications) after eight CAI sessions. During a maintenance session implemented one week following criterion based performance, the number of correct responses made was 12.

Ken. Ken's baseline performance data were low, and demonstrated a stable trend. During baseline probe sessions, Ken's mean score was 2.2 (range 1-4). Once the intervention was introduced, Ken's probe scores immediately showed a change in level increasing to seven. As intervention sessions continued, Ken's scores during probe sessions continued to increase in both level and trend. During probes following introduction of CAI, Ken's mean score increased to 10.8 (range 7-14). Ken reached criterion-based performance for all units (i.e., correct identification of 14 out of 18 science terms and applications) after six CAI sessions. During a maintenance session implemented one week following criterion based performance, the number of correct responses made was 13.

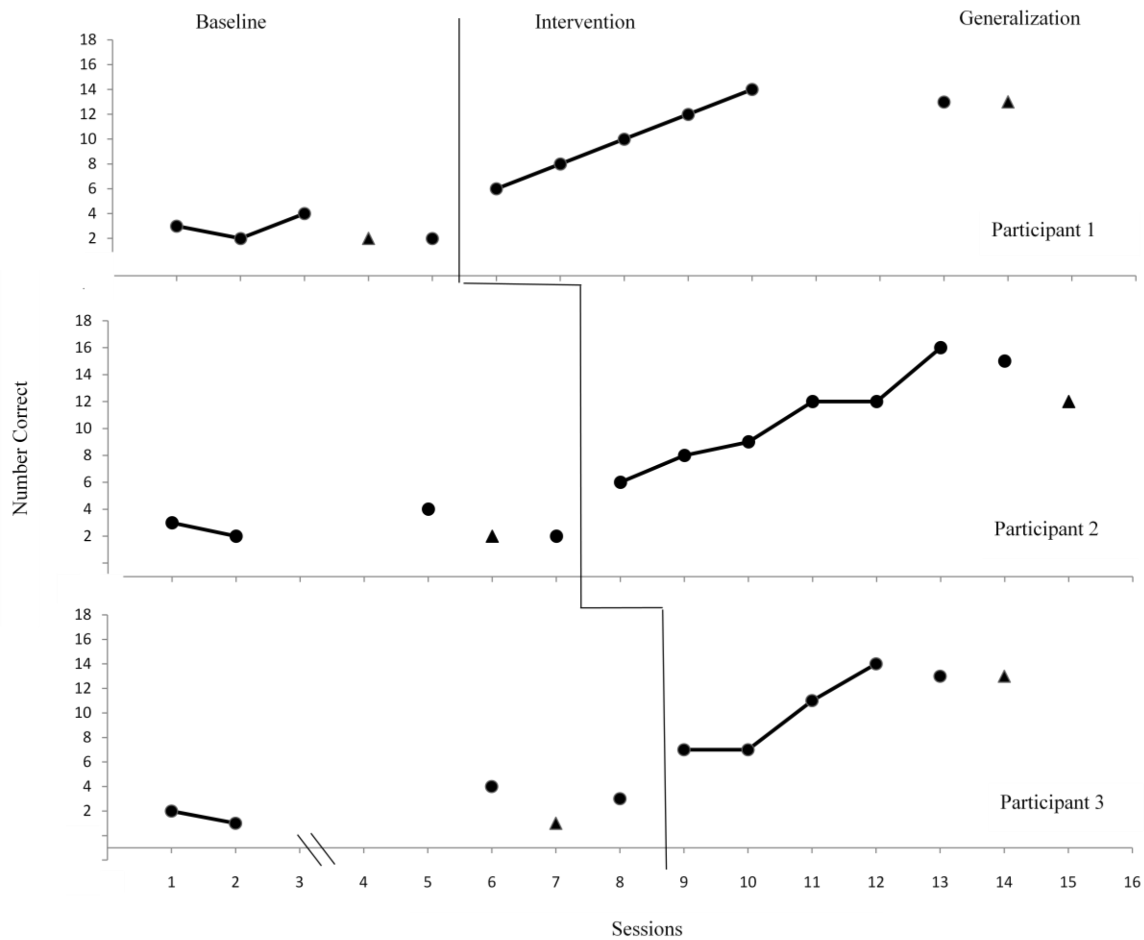


Figure 1. Participant's correct responding during probe sessions

Note. Triangles represent scores made during generalization probes. The double line on the x-axis represents a three week break in data collection due to winter break for schools.

Results for Question 2: To what extent will students generalize targeted science terms and applications to class activities within the inclusive setting?

Results of the generalization probes are shown in Figure 1 depicted as black triangles. Results indicated that the CAI intervention was effective in promoting the generalization of acquired science terms and applications. For all participants, the number of correctly identified science terms and applications decreased by one compared to their scores during probe sessions following the last intervention session.

In the baseline generalization probe session, Matt correctly identified two science terms or applications. During the generalization session, the number of correct responses increased to 13. In the baseline generalization probe session, David correctly identified two science terms or applications. Following intervention sessions, the number of correct responses made during the generalization probe increased to 14. In the baseline generalization probe session, Ken correctly identified one science term or application. Following intervention sessions, the number of correct responses increased to 13.

Results for Question 3: What are the participants' perceptions of using CAI within the inclusive setting?

Study participants answered a social validity questionnaire to determine their: (a) perceptions of the effectiveness of the CAI intervention; (b) the effectiveness of varied stimuli (i.e., pictures, videos, application questions); (c) if they would like to continue using technology; (d) if the intervention was isolating; and (e) if they would participate in another study using an iPad 2. The results of the participant's social validity survey indicated that peers agreed science was important for everyone, the CAI intervention was effective, and they would like to receive instruction using an iPad 2 (see Table 1).

Table 1 *Participant Social Validity Data (n=3)*

	Yes	Maybe	No
1. Did you enjoy using the iPad to learn science?	3		
2. Would you rather use the book to learn science words?			3
3. Did the pictures help you learn the science words and applications?	3		
4. Did the video clips help you answer the questions?	3		
5. Would you like to use an iPad to learn about another subject like math or social studies?	3		
6. Would you like to continue using the iPad in science class?	3		
7. When working on the iPad, did you feel isolated from class?			3

Results for Question 4: What are teacher perceptions of using CAI within the inclusive setting?

Both classroom teachers completed social validity questionnaires that included questions pertaining to (a) the effectiveness of the intervention, (b) the obtrusiveness of the intervention, (c) the appropriateness of the intervention, and (d) the effectiveness of key components of the slide show presentations (e.g., pictures and videos). The results of the classroom teachers (special and general educators) indicated that they agreed time engaged in the study was time well spent and the CAI intervention was effective in teaching the targeted science terms and applications (see Table 2). Both teachers also noted in the additional comments section of the questionnaire their growing interest in using technology within their classrooms and the benefits of the inclusive experience.

Table 2 *Teacher Social Validity Data (n=2)*

	5 Strongly agree	4	3	2	1 Strongly Disagree
1. The targeted skills selected for intervention are important for students.	2				
2. The time spent in the study was a good use of student time during the school day.	2				
3. Computer-assisted instruction helped my students increase science vocabulary.	2				
4. The vocabulary knowledge has generalized to other activities within the science classroom or to other areas through the school day	2				
5. The computer-assisted instruction was disruptive to class.				1	1
6. I would consider incorporating computer-assisted instruction into other areas or routines during the school day.	2				
7. I think the pictures/videos promoted comprehension of the science terms and their applications.	2				
8. I would allow my students to participate in future research studies	2				

Comments:

“Great study that has introduced me to the use of an iPad in the classroom. I love that this study took place in a regular ed. Class with peer buddies!”

“After this study I’m strongly considering implementing the same activities and technologies in my own inclusion classroom. My students have benefited, especially those helping the other students!”

Results for Question 5: What are the peers without disabilities perceptions of using CAI within the inclusive setting?

As part of the intervention, participants completed the CAI intervention slide show presentations with a peer buddy in the inclusive science class, minimally, once a week. One participant (David), completed the CAI intervention slide show with a peer once each class to help decrease social anxiety and promote a smooth transition into the inclusive setting. These peers without disabilities completed a social validity questionnaire pertaining to their perceptions of (a) the importance of science for everyone, (b) the importance of learning science terms and applications, (c) the effectiveness of CAI, (d) and using an iPad within their own studies. Results of the peer social validity questionnaire are included in Table 3. The majority of peers without disabilities also noted their eagerness to use iPads and that they enjoyed assisting the students in completing slide show presentation in the additional comments section of the questionnaire.

Table 3 *Peer's Without Disabilities Social Validity Data (n=8)*

	5 Strongly agree	4	3	2	1 Strongly Disagree
1. Science is important for all students to learn, even people with disabilities.	6	2			
2. Learning science terms and applications will help students be more successful in the science classroom.	6	2			
3. Computer-assisted instruction is a good way to provide extra instruction to students with disabilities.	5	3			
4. The computer-assisted instruction was disruptive to class.				4	4
5. I would like to practice skills using iPads within the science classroom.	8				
6. Computer-assisted instruction could help me learn terms in other subject areas (social studies, math)	8				

Comments:

"I think it was cool that the iPad was used. I think it worked and I would like to use one myself. I think it was effective."

"I think this really helped the students. I liked helping them. I think it would be cool if we got to use an iPad for study."

"It seemed to help these students with disabilities so the education board should consider buying iPads for everyone."

"The iPad was a great idea. I would like to use one. I liked helping and it was great people skills."

CHAPTER 5: DISCUSSION

The purpose of this study was to determine if embedded CAI was effective in teaching science terms and applications of those terms to students with ASD and intellectual disability. A multiple probe across participants design was used to determine the impact of the independent variable on the dependent variable.

The following outcomes were found for the research questions that guided the investigation. In response to the first research question, (i.e., What is the effectiveness of embedded, explicit CAI on student acquisition of science terms and applications for students with ASD and intellectual disability?), visual inspection of the data revealed a functional relationship between introduction of the intervention and the number of assessment items answered correctly. In response to the second research question (i.e., To what extent will students generalize targeted science terms and applications to class activities within the inclusive setting?), visual inspection of the data showed that all three participants were able to generalize the targeted science terms at high levels to the science terms activity sheet completed in the inclusive science setting. In response to questions three and four (i.e., What are teacher perceptions of using CAI within the inclusive setting? and What are the peers without disabilities perceptions of using CAI within the inclusive setting?), both the study participants, teachers, and peers without disabilities overwhelmingly strongly agreed that the intervention was effective and appropriate. Additionally, all of the peers without disabilities strongly agreed that they would like to use iPads across their school day.

Overall, these findings are consistent with previous studies evaluating the use of embedded instruction within an inclusive setting to teach an academic skill (Jameson et al., 2007, 2008; McDonnell et al., 2006). Findings in using explicit instruction to teach an academic skill to students with ASD are also consistent with the results of Flores and Ganz (2007), Ganz and Flores (2009), Hicks et al. (2012), and Knight, Smith, et al., (2011). Discussions of specific findings, organized by themes (i.e., teaching science to students with ASD, embedded instruction, explicit instruction, and computer-assisted instruction) are presented below followed by the limitations of the study, as well as implications for practice and suggestions for future research.

Teaching Science to Students with ASD

Published research has demonstrated that not only can students with ASD and intellectual disability learn grade-aligned science content, but they can also maintain that knowledge over time (Courtade et al., 2010; Knight et al., 2011; Spooner et al., 2011). Similar to the findings of these previously discussed studies, the results of this investigation also demonstrate the participants' acquisition of the nine science terms and applications of those terms. Additionally, this study demonstrates the participants' ability to maintain those acquired skills over time and generalize them to an activity sheet completed in the inclusive setting.

Another suggestion from the published body of literature on providing better science instruction to students with ASD is to teach vocabulary and attach that vocabulary to a meaningful activity (Mastropieri & Scruggs, 1992; Scruggs et al., 2008). In this study, the stimuli participants responded to varied across slide show presentations and included practical applications using those science terms. For example, for the targeted term homeostasis, stimuli included a picture of a healing wound, the definition (i.e., When the cells in your body fight to stay the same), as well as practical examples (e.g., When you're cold and your body shivers to warm you up, this is an example of _______). These stimuli allowed the interventionist to collect data pertaining to literal recall questions (e.g., definitions), but also collect data on the participant's ability to apply the term to a situation demonstrating comprehension of the meaning for each science term. It is possible that these applications were instrumental in decreasing the amount of time it took each participant to reach criterion-based performance (i.e., correct responding to four out of six possible stimuli) on the science terms in each unit of study.

Embedded Instruction

For students with ASD and intellectual disability, generalization of acquired skills across materials, settings, and situations is often a concern for educators (Bambara, Warren, & Komisar, 1988; Frederick-Dugan, Test, & Varn, 1991; Gena, Krantz, McClannahan, & Poulson, 1996). Generalization in this study was promoted in a variety of ways. First, the slide show presentation included multiple exemplars of varied stimuli (e.g., pictures, questions, definitions). Cooper et al. (2007) suggest the use of multiple exemplars as one means to promote generalization of acquired skills.

Another way interventionists have attempted to promote generalization across settings and situation is through the use of embedded instruction. Embedded instruction requires instructional trials to be embedded within the naturally occurring activities and routines within a classroom setting (McDonnell, 2011). In this study, participants were assessed based on their ability to complete probe slideshow presentation in the special education setting and generalization activity sheets within the inclusive setting. Similar to the published research evaluating the generalization of skills taught in embedded instruction formats, participants in this study were able to generalize acquired terms and applications to an activity sheet completed within their inclusive science setting at high rates.

Third, unlike the previously published studies using embedded instruction to teach academics, in this study the instruction was delivered via an iPad 2. In addition to the benefits previously discussed in using technology to provide instruction to students with ASD (Payan, 1984), CAI also may mitigate some of the barriers to inclusion such as the high level of intrusiveness of an adult hovering over the student with a disability. In this study, the necessity of having an adult monitor participant’s progress was decreased compared to studies where a paraprofessional or special education teacher implemented the intervention. This decrease in adult supervision may have contributed to the positive perceptions of peers within the science classroom and the classroom teacher in regards to the intervention not being obtrusive or distracting during class. Additionally, the use of an iPad 2 may have positively affected the eagerness of peers without disabilities in completing the intervention with a study participant on a regular basis.

In a final effort to address generalization, the activity sheets used during these probes were closely matched to the vocabulary worksheets that students completed regularly at the beginning of each unit of study. These generalization probes demonstrated each participant’s ability to generalize the terms taught to the activity sheets. These activity sheets included matching a picture to the correct term and completing definitions or application questions using the correct science term provided in a word bank.

Explicit Instruction

Another growing practice in providing academic instruction for students with ASD is the use of explicit instruction. Common components of explicit instruction include at least two phases of instruction (i.e., model and test), but can include up to three phases (i.e., model, lead, test). Additionally, explicit instruction includes scaffolds to support student learning that are faded systematically (Engelmann & Carnine, 1991). To date four studies have used explicit instruction to teach academic skills including reading comprehension (Flores & Ganz, 2007), symbol identification (Ganz & Flores, 2009), preposition identification (Hicks et al., 2011), and science descriptors identification (Knight et al., 2011). In this study, explicit instruction presented in a model-test format was used to teach three students with ASD and intellectual disability nine science terms and applications of those terms using pictures, definitions, and scenarios. The findings of this study align with those of the four published explicit instruction studies in that explicit instruction was again found to be effective in teaching the science terms.

Computer-assisted instruction

The benefits of using technology to teach academics to students with ASD have long been theorized within published literature (Payan, 1984; Pennington, 2010). These possible benefits include high levels of engagement, immediate feedback for participant responses, and increased in motivation to complete activities using technology (Payan, 1984; Pennington, 2010). CAI has been effective in teaching numerous skills such as self-determination skills (Mazzotti, Wood, et al., 2010), and literacy skills such as phoneme identification (Wood et al., in press) for students with mild disabilities. CAI has also been successfully used to teach skills such as letter identification (Basil & Reyes,

2003) and reading comprehension strategies (Chen et al., 2009) for students with ASD and intellectual disability. Similar to the published literature evaluating the use of CAI, this study's findings also supports the effectiveness of CAI in teaching the discreet task of science term identification. Participants in this study not only acquired the science terms and applications, but were trained to operate the iPad 2 with minimal effort.

The quality of CAI studies teaching academic skills to students with ASD published that meet quality indicators suggested by Horner et al. (2005) or Gersten et al. (2005) are sparse. Specifically, most empirical studies did not describe key features of the study's methodology such as procedural fidelity, key components of the software used, and what if any training was required for students to learn to manipulate the technological device used in the intervention.

Specific Contributions of the Study

The current study addresses many recommendations or gaps in the published literature in teaching students with ASD and intellectual disability academic skills, especially in the curricular area of science. First, this study demonstrates that specialized or individualized instruction can be implemented within a general education setting.

Second, this study extends the research using explicit instruction for students with ASD and intellectual disability. While explicit instruction has a strong body of evidence for students with high incidence or mild disabilities, the body of research supporting this practice for students with more severe disabilities is growing. In another extension of the explicit instruction literature, this study implemented the explicit instruction procedure via iPad 2. To date, few published studies have examined the effectiveness of explicit instruction delivered via technology (e.g., Mazzotti et al., 2007; Wood et al., 2010).

Third, Pennington (2010) specifically identifies the need for empirical research supporting the use of CAI to teach academic skills outside of literacy. While this study in a sense addresses a literacy skill (i.e., the identification of terms), this occurs within the context of science. Additionally, this study goes beyond simply word identification, but also includes practical applications that promote comprehension of the meaning of the term or definition. For example, participants not only learned to identify pictures of DNA and the definition for DNA, stimuli for this targeted term also included "______ determines how you look."

Finally, this study addressed the many recommendations and suggestions for future research (e.g., Pennington, 2010; Knight, Smith, & Saudners, 2011) in evaluating the effectiveness of CAI for students with ASD. Unlike the previously published studies, this study include (a) a description of reliability and procedural fidelity measures, (b) a thorough description of systematic instruction procedures used as part of the intervention (e.g., stimulus prompts, feedback), and (c) a detailed description of key components of the intervention including sample probe and intervention slides.

Limitations and Recommendations for Future Research

Several limitations should be considered when analyzing the results of the study, including restrictions of the software. The first limitation of the current study pertained to the intervention package. Because the intervention included several components such as the use of technology, explicit instruction, embedded instruction, and peers it is unclear which pieces of the intervention package were responsible for the change in the number of assessment items answered correctly. Future researchers should consider each component and the potential effects independently. In terms of the use of peers to provide social praise within the inclusive setting, future research may want to compare the effectiveness of CAI using peer praise and not using peers in any capacity.

In a technological limitation, the iPad 2 is the only tablet on the market capable of showing animations within slide show presentations. In the current study, these animations were necessary because they provided the prompt (i.e., star) indicating the correct response if participants did not make the correct response initially. As more tablets become available, educators should consider this feature if they intend on replicating this intervention within their classrooms. Similarly, future researchers may also consider implementing CAI using applications published by third parties. Using already established applications may decrease the amount of time needed to build slideshow presentations.

A third limitation includes the inability to program hyperlinks (e.g., hot spots on a slide that when touched progress the slide show) on slides as they are shown using the Keynote software. Despite the ability to use this feature within PowerPoint on a computer, the feature does not transfer. This means that regardless of where a participant touches the slide, the slide show presentation will advance. In order to ensure participants were touching the correct or prompted response, the interventionist or a peer did have to monitor participants during intervention slide shows. At times, this monitoring did require the presence of an adult. Despite this intrusion, peers without disabilities overwhelming responded positively to their willingness and eagerness to assist participants during the intervention. It is possible that because the intervention used highly motivating technological equipment, peers responded positively indicating they would like to receive vocabulary instruction using an iPad 2 themselves and were not distracted by the occasional hovering adult. As more applications are released (e.g., Choicemaker) that have the capability to provide explicit instruction using a model-test format, teachers should research their options when selecting software to provide CAI.

A final technological limitation of the study was the inconsistency in synching PowerPoint with Keynote and transferring slide shows to the iPad 2. At times, the transfer to iPad 2 would reverse the order of transitions. For example, all slides were programmed to begin the verbal discriminative stimulus (e.g., "What does this picture show?") followed by a five second interval before providing the star prompt indicating the correct answer. During some slide shows, the order of these animations was reversed meaning the prompt would appear before the oral reading of the discriminative stimulus and response options. Although, this was easily remedied by resaving the slide show in keynote and transferring the slide show again, this could be a strong deterrent to teachers who are not computer savvy. Educators replicating this intervention should preview all slide shows on the tablet to ensure the transfers of animations are accurate prior to training.

Implications for Practice

This study demonstrates several implications for both special education and general education teachers. First, in order to provide students with the most meaningful instruction within an inclusive setting, collaboration between the general educator and their special education counterpart, including paraprofessionals, is key. As a part of this collaborative effort, the general education teacher provided the interventionist with many activities, activity sheets, and experiments to assist the interventionist in selecting appropriate and accurate pictures, definitions, and applications when designing the slide show presentations. Future researchers should consider the time requirements of all parties when planning for academic inclusion to ensure that students are learning the most salient and important information.

Second, this study provides some aspects of inclusion teachers should strongly consider before placing students in academic inclusive settings. For one participant (David), going into a classroom where he did not know anyone caused high levels of anxiety (e.g., repetitive statements like “Who are these people”). Despite this anxiety, once David was present in the inclusive setting, he enjoyed the experiments, videos, and demonstrations that were included within the teacher lecture. Students who are transitioning into inclusive settings for the first time may exhibit social anxiety; therefore, teachers should promote a smooth transition by (a) discussing the change in schedule weeks before the change occurs, (b) creating a written or picture schedule students can refer to on their own, or (c) starting to include students for a small period of time and systematically increasing the time spent in inclusion. In this study, David waited outside the classroom for a peer without disabilities. That peer and David would then walk into class together and David would complete the slide show presentation for the appropriate unit with the peer. This interaction appeared to decrease David’s anxiety going into the inclusive setting.

Third, embedded instruction was intended to add to the inclusive experience by incorporating systematic instruction into the naturally occurring routines or activities in a class versus intervention where students are pulled from class. Because of this key component, there was one intervention date where participants only completed the slide show presentation twice due to a class experiment because the interventionist found it more advantageous for participants to complete the experiment. Despite this decrease by one intervention session, all three participants met criterion (i.e., correct identification of four out of six science terms for that unit) and proceeded to the next unit of study. Future researchers should consider the frequency of intervention sessions, especially when considering replication with students with different disabilities. Previous research has suggested that using technology may address some of the common concerns for students with ASD such as decreased motivation, preferred isolation, and reliance on visual stimuli (Payan, 1984). This intervention may not have the same effect for students who rely heavily on auditory stimuli or who do not transfer from preferred activities to non-preferred activities with ease. It is possible that students may require more opportunities to complete the slide show presentations or require a firmer prompt to ensure the participant touches the correct response on each slide.

Finally, the results of the social validity questionnaires completed by teachers, participants, and peers overwhelmingly expressed their desire to use technology within the classroom setting. When considering the use of a tablet to provide academic instruction teachers may want to consider their own technological skills. This study required the interventionist to (a) create slide show presentations using PowerPoint software, (b) program auditory stimuli and the prompt animation, (c) program timing of prompts and discriminative stimuli to accurately implement the explicit instruction procedure, (d) convert the slide show to Keynote software, and (e) transfer those slide shows to the iPad 2. With the rapid pace new applications are released for tablets, future educators should consider applications that require little teaching programming.

REFERENCES

AAAS (American Association for the Advancement of Science). (1989). *Science for all Americans*. New York, NY: Oxford University Press.

Agran, M., Cavin, M., Wehmeyer, M., & Palmer, S. (2006). Participation of students with moderate to severe disabilities in the general curriculum: The effects of the self-determined learning model of instruction. *Research and Practice for Persons with Severe Disabilities*, *31*, 230-241.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text revision). Washington, DC: Author.

Anthony, R. F., Tippett, C. D., & Yore, L. D. (2010). Pacific CRYSTAL project: Explicit literacy instruction embedded in middle school science classrooms. *Research in Science Education*, *40*, 45-64.

Archer, A. L., & Hughes, C. A., (2011). *Explicit instruction: Effective and efficient teaching*. New York, NY: Guilford Press

Ayres, K. M., Douglas, K. H., Lowrey, K. A., & Sievers, C. (2011). I can identify Saturn but I can't brush my teeth: What happens when the curricular focus for students with severe disabilities shifts. *Education and Training in Autism and Developmental Disabilities, 46*, 11-21.

Basil, C., & Reyes, S. (2003). Acquisition of literacy skills by children with severe disability. *Child Language Teaching and Therapy, 19*, 27-49.

Bambara, L. M., Warren, S. F., & Komisar, S. (1988). The individual curriculum sequencing model: Effects on skill acquisition and generalization. *The Journal of The Association of Persons with Severe Handicaps*, *13*, 8-19.

Baumann, J. F. (1984). The effectiveness of a direct instruction paradigm for teaching main idea comprehension. *Reading Research Quarterly*, *20*, 93-115.

Billingsley, F., White, O., & Munson, R. (1980). Procedural reliability: A rationale and an example. *Behavioral Assessment, 2,* 229-241.

Blischak, D. D., & Schlosser, R. W. (2003). Use of technology to support independent spelling by students with autism. *Topics in Language Disorders*, *23*, 293-304.

Braddock, D., Rizzolo, M. C., Thompson, M., & Bell, R. (2004). Emerging technologies and cognitive disabilities. *Journal of Special Education Technology*, *19*(4), 49-56.

Bratlinger, E. A. (1997). Using ideology: Cases of nonrecognition of the politics of research and practice in special education. *Review of Educational Research*, *67*, 425-460.

Browder, D. M., & Spooner, F. (2011). *Teaching students with moderate and severe* disabilities. New York, NY: Guilford Press.

Browder, D. M., Trela, K., Courtade, G. R., Knight, V. F., & Flowers, C. (2010). Teaching mathematics and science standards to students with moderate and severe developmental disabilities. *The Journal of Special Education*. Advanced online publication. doi: 10.1177/0022466910369942

Brown, L. (2003, September 14). Special education is a 'service' not a place. *Hawaii Reporter, Inc*. Retrieved from http://www.hawaiireporter.com/story.aspz?44dfa42c-2db5-4c28-935a-850fe2299f53

Bursuck, W. D., & Damer, M. (2007). *Reading instruction for students who are at risk or have disabilities*. Boston, MA: Allyn & Bacon.

Carnine, L., & Carnine, D. (2004). The interaction of reading skills and science knowledge when teaching struggling secondary students. *Reading and Writing Quarterly*, *20*, 203-218.

Carter, E. W., Lane, K. L., Pierson, M. R., & Stang, K. K. (2008). Promoting self-determination for transition-aged youth: Views of high school general and special education teachers. *Exceptional Children*, *75*, 55-70.

Carter, E. W., Sisco, L. G., Brown, L., Brickham, D., & Al-Khabbaz, A. A. (in press). Peer interactions and academic engagement of youth with developmental disabilities in inclusive middle and high school classrooms. *American Journal on Intellectual and Developmental Disabilities*.

Cawley, J. F., Kahn, H., & Tedesco, A. (1989). Vocational education and students with learning disabilities. *Journal of Learning Disabilities*, *22*, 630-634.

Chambers, B., Slavin, R. E., Madden, N. A., Abrami, P. C., Tucker, B. J., Cheung, A.,…& Gifford, R. (2008). Technology infusion in success for all: Reading outcomes for first graders. *The Elementary School Journal*, *109*(1), 1-16.

Chen, S. A., & Bernard-Opitz, V. (1993). Comparison of personal and computer-assisted instruction for children with autism. *Mental Retardation*, *31*, 368-376.

Chen, M., Wu, T., Lin, Y., Tasi, Y., & Chen, H. (2009). The effect of different representations on reading digital text for students with cognitive disabilities. *British Journal of Educational Technology*, *40*, 764-770.

Clymer, T., & Venezky, R.L. (1982). *Ginn reading program*. Lexington, MA: Ginn and Company.

Colby, K. M. (1973). The rationale for computer-based treatment of language difficulties in nonspeaking autistic children. *Journal of Autism and Childhood Schizophrenia*, *3*, 254-260.

Collins, B. C. (Ed.). (2007). *Moderate and severe disabilities: A foundational approach*. Upper Saddle River, NJ: Prentice Hall.

Collins, B. C., Evans, A., Creech-Galloway, C., Karl, J., & Miller, A. (2007). Comparison of the acquisition and maintenance of the teaching functional and core content sight words in special and general education settings. *Focus on Autism and Other Developmental Disabilities*, *22*, 220-233.

Collins, B. C., & Griffen, K. A. (1996). Teaching students with moderate disabilities to make safe responses to product warning labels. *Education & Treatment of Children*, *19*, 30-45.

Collins, B. C., Karl, J., Riggs, L., Galloway, C. G., & Hager, K. (2010). Teaching core content with real-life applications to secondary students with moderate and severe disabilities. *TEACHING Exceptional Children*, *43*(1), 52-59.

Collins, B. C., & Stinson, D. M. (1995). Teaching generalized reading of product warning labels to adolescents with mental disabilities through the use of key words. *Exceptionality*, *5*, 163-181.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis* (2nd ed.). Upper Saddle River, NJ: Pearson/Merrill/Prentice-Hall.

Copeland, S. R., & Cosbey, J. (2008-2009). Making progress in the general curriculum: Rethinking effective instructional practices. *Research and Practice for Persons with Severe Disabilities*, *33-34*, 214-227.

Courtade, G. R., Browder, D. M., Spooner, F. & DiBiase, W. (2010) Training teachers to use an inquiry-based task analysis to teach science to students with moderate and severe disabilities. *Education and Training in Autism and Developmental Disabilities*, *45*, 378-399.

Courtade, G., Spooner, F., Browder, D. M., & Jimenez, B. (in press). Seven reasons to promote standards-based instruction for students with severe disabilities. A reply to Ayers, Lowrey, Douglas, and Sievers (2011). *Education and Training in Autism and Developmental Disabilities*.

Coyne, M. D., McCoach, D. B., & Kapp, S. (2007). Vocabulary instervention for kindergarten students: Comparing extended instruction to embedded instruction and incidental exposure. *Learning Disability Quarterly*, *30*, 74-88.

Darch, C., Kim, S., & Johnson, J. H. (2000). The strategic spelling skills of students with learning disabilities: The results of two studies. *Journal of Instructional Psychology*, *27*, 15–26.

Daugherty, S., Grisham-Brown, J., & Hemmeter, M. L. (2001). The effects of embedded skill instruction on the acquisition of target and non-target skills in preschoolers with developmental delays. *Topics in Early Childhood Special Education*, *21*, 1-8.

Drasgow, E., Wolery, M., Halle, J., & Hajigahmohseni (2011) Systematic instruction of students with severe disabilities. In J. M., Kauffman & D. P. Hallahan, (Eds.), *Handbook of Special Education* (pp. 516-530). New York, NY: Routledge.

Edyburn, D., Higgins, K., & Boone, R. (2005). *Handbook of special education technology research and practice*. Whitefish Bay, WI: Knowledge by Design, Inc.

Engelmann, S. & Carnine, D. (1991). *Theories of instruction: Principles and applications*. Eugene, OR: ADI Press.

Flores, M. M., & Ganz, J. B. (2007). Effectiveness of direct instruction for teaching statement inference, use of facts, and analogies to students with developmental disabilities and reading delays. *Focus on Autism and Other Developmental Disabilities*, *22*, 244–251.

Frederick-Dugan, A., Test, D. W., & Varn, L. (1991). Acquisition and generalization of purchasing skills using a calculator by students who are mentally retarded. *Education and Training in Mental Retardation, 4*, 381-387.

Fulk, B. M. (1996). The effects of combined strategy and attribution training on LD adolescents' spelling performance. *Exceptionality, 6*, 13–27.

Ganz, J. B., & Flores, M. M. (2009). The effectiveness of direct instruction for teaching language to children with autism spectrum disorders: Identifying materials. *Journal of Autism and Developmental Disorders, 39*, 75-83.

Gast, D. L. Winterling, V., Wolery, M., & Farmer, J. A. (1992). Teaching first-aid skills to students with moderate handicaps in small group instruction. *Education & Treatment of Children, 15*, 101-124.

Gena, A., Krantz, P. J, McClannahan, L. E., & Poulson, C. L. (1996). Training and generalization of affective behavior displayed by youth with autism. *Journal of Applied Behavior Analysis, 29*, 291-304.

Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research*, *79*, 1202-1242.

Giangreco, M. F., Yuan, S., McKenzie, B., Cameron, P., & Fialka, J. (2005). "Be careful what you wish for…": Five reasons to be concerned about the assignment of individual paraprofessionals. *TEACHING Exceptional Children*, *37*(5), 28-34

Gilliam, J. E. (1995). *Gilliam autism rating scale*. Austin, TX: Pro-Ed.

Goeke, J. L. (2009). *Explicit instruction: A framework for meaningful direct teaching*. Upper Saddle River, NJ: Merrill

Hicks, S. C. (2011). *Effects of direct instruction on the use of and response to prepositions by students with intellectual disability* (Unpublished doctoral dissertation). University of North Carolina at Charlotte, Charlotte, NC.

Hicks, S. C., Bethune, K. S., Wood, C. L., Cooke, N. L., & Mims, P. J. (in press). Effects of direct instruction on the acquisition of prepositions by students with intellectual disabilities. *Journal of Applied Behavior Analysis*.

Horner, R. D., & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline. *Journal of Applied Behavior Analysis*, *11*, 189-196.

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*, 165-180.

Hutchinson, N. L. (1993). Effects of cognitive strategy instruction on algebra problem solving of adolescents with learning disabilities. *Learning Disability Quarterly*, *16*, 34–63.

Individuals with Disabilities Education Improvement Act of 2004, PL 108-466, 20 U. S. C. §1400, H. R. 1350.

Jameson, J. M., McDonnell, J., Johnson, J. W., Riesen, T., & Polychronis, S. (2007). A comparison of one to one embedded instruction in the general education classroom and one to one massed practice instruction in the special education classroom. *Education & Treatment of Children*, *30*, 23-44.

Justice, L.M., & Pullen, P. C. (2003). Promising interventions for promoting emergent literacy skills. *Topics in Early Childhood Special Education*, *23*(3), 99-113.

Jameson, J. M., McDonnell, J., Polychronis, S., & Riesen, T. (2008). Embedded, constant time delay instruction by peers without disabilities in general education classrooms. *Intellectual and Developmental Disabilities*, *46*, 346-363.

Jimenez, B. A., Browder, D., Spooner, F., & DiBiase, W. (2012). Inclusive inquiry science using peer-mediated embedded instruction for students with moderate intellectual disability. *Exceptional Children, 78*, 301-317.

Jimenez, B., Spooner, F., Browder, D., DiBiase, W., & Knight, V. (2008). *A conceptual model for science for students with significant cognitive disabilities*. [Brochure]. Retrieved from http://education.uncc.edu/access/

Johnson, J. W., & McDonnell, J. (2004). An exploratory study of the implementation of embedded instruction by general educators with students with developmental disabilities. *Education &Treatment of Children*, *27*, 46-63.

Johnson, J. W., McDonnell, J., Holzwarth, V. N., & Hunter, K. (2004). The efficacy of embedded instruction for students with developmental disabilities enrolled in general education classes. *Journal of Positive Behavior Interventions*, *6*, 214-227.

Kauffman, J. M., & Hallahan, D. P. (2005). *The illusion of full inclusion* (2^{nd} ed.). Austin, TX: PRO-ED

Kennedy, C. H., & Horn, E. M. (2004). *Including students with severe disabilities*. Upper Saddle River, NJ: Pearson.

Knight, V. F. *Effects of supported electronic text and explicit instruction on science comprehension by students with autism spectrum disorders* (Unpublished doctoral dissertation). University of North Carolina at Charlotte, Charlotte, NC.

Knight, V. F., Smith, B. R., & Saunders, A. (2011). A review of technology-based interventions to teach academic skills to students with autism spectrum disorder. Manuscript in preparation.

Knight, V. F., Smith, B. R, Spooner, F., & Browder, D. M. (2011). Using explicit instruction to teach science descriptors to students with autism spectrum disorders. *Journal of Autism and Developmental Disorders*. Advance online publication. doi: 10.1007/s10803-011-1258-1

Koegel, F. L., & Koegel, L. (1995). *Teaching children with autism*. Baltimore, MD: Brookes Publishing.

Kurt, O., & Tekin-Iftar, E. (2008). A comparison of constant time delay and simultaneous prompting within embedded instruction on teaching leisure skills to children with autism. *Topics in Early Childhood Special Education*, *28*, 53-64.

Lefever-Davis, S., & Pearman, C. (2005) Early readers and electronic texts: CD-ROM storybook features that influence reading behaviors. *Reading Teacher, 58*, 446-454.

Luckasson, R., Borthwick-Duffy, S., Buntinx, W. H. E., Coulter, D. L., Craig, E. M., Reeve, A… & Tasse´, M. J. (2002). *Mental retardation: Definition, classification, and systems of supports* (10th ed.). Washington, DC: American Association on Mental Retardation.

Lynch, S., Taymans, J., Watson, W. A., Ochsendorf, R. J., Pyke, C., & Szesze, M. J. (2007). Effectiveness of a highly random science curricula for students with disabilities in general education classrooms. *Exceptional Children*, *73,* 202-223.

MacArthur, C. A. (1999). Word prediction for students with severe spelling problems. *Learning Disability Quarterly*, *22*, 158–172.

Marchand-Martella, N. E., Martella, R. C., Christensen, A. M., Agran, M., & Young, K. R. (1992). Teaching a first-aid skill to students with disabilities using two training programs. *Education & Treatment of Children, 15*, 15-31.

Mastropieri, M. A., & Scruggs, T. E. (1992). Science for students with disabilities. *Review of Educational Research*, *62*, 377-411. doi: 10.3102/00346543062004377

Mazzotti, V. L., Test, D. W., Wood, C. L., & Richter, S. (2010). Effects of computer-assisted instruction on students' knowledge of postschool options. *Career Development for Exceptional Individuals, 33*(1), 25-40.

Mazzotti, V. L., Wood, C. L., Test, D. W., & Fowler, C. H. (2010). Effects of computer-assisted instruction on students' knowledge of the self-determined learning model of instruction and disruptive behavior. *The Journal of Special Education*. Advance online publication. doi: 10.1177/0022466910362261

McCleery, J. A., & Tindal, G. A. (1999). Teaching the scientific method to at-risk students and students with learning disabilities through concept anchoring and explicit instruction. *Remedial and Special Education*, *20*, 7-18.

McDonnell (2011). Instructional contexts. In J. M Kauffman & D. P. Hallahan (Eds.), *The handbook of special education* (pp. 532-543). New York, NY: Routledge.

McDonnell, J., Johnson, J. W., & McQuivey, C. (2008). *Embedded instruction for students with developmental disabilities in general education classrooms*. Arlington, VA: Division on Developmental Disabilities of the Council for Exceptional Children.

McDonnell, J., Johnson, J. W., Polyschronis, S., & Reisen, T. (2002). The effects of embedded instruction on students with moderate disabilities enrolled in general education classes. *Education and Training in Mental Retardation and Developmental Disabilities, 37*, 363-377.

McDonnell, J., Johnson, J., Polychronis, S., Riesen, T., Jameson, M. & Kercher, K., (2006). Comparison of one-to-one embedded instruction in general education classes with small group 31 instruction in special education classes. *Education and Training in Developmental Disabilities*, *41*, 125-138.

McDuffie, A., Yoder, P., & Stone, W. (2005). Prelinguistic predictors of vocabulary in young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research*, *48*, 1080-1097.

Mechling, L. C. (2008). Thirty year review of safety skill instruction for persons with intellectual disabilities. *Education and Training in Developmental Disabilities*, *43*, 311-323.

Moore, D., McGrath, P., & Thorpe, J. (2000). Computer-aided learning for people with autism: A framework for research and development. *Innovations in Education and Training International*, *37*, 218-228.

National Autism Center (2009). *National standards report*. Retrieved from http://www.nationalautismcenter.org/pdf/NAC%20NSP%20Report_FIN.pdf

National Center on Educational Statistics (2001). Computer and internet use by children and adolescents in 2011. Washington, DC: U.S. Department of Education.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Secondary Transition Technical Assistance Center (2010). *Decision rules*. Retrieved from: http://www.nsttac.org/ebp/LiteratureReview.aspx

Neale, M. M. (1988). *Neale analysis of reading ability—revised*. Camberwell, Victoria, Australia: Australian council for educational research.

No Child Left Behind Act of 2001, Pub. L. No. 107-110, 115, § 1425, 20 U.S.C. §§ 6301 *et seq*. (2002).

Owen, R. L., & Fuchs, L. S. (2002). Mathematical problem-solving strategy instruction for third-grade students with learning disabilities. *Remedial and Special Education*, *23*, 268–278.

Payan, M. V. (1984). Computer technology for autistic students. *Journal of Autism and Developmental Disorders*, *14*, 375-382.

Pennington, R. C. (2010). Computer-assisted instruction for teaching academic skills to students with autism spectrum disorders: A review of literature. *Focus on Autism and Other Developmental Disabilities*. Advance online publication. doi: 10.1177/1088357610378291

Polychronis, S. C., McDonnell, J., Johnson, J. W., Riesen, T., & Jameson, M. (2004). A comparison of two trial distribution schedules in embedded instruction. *Focus on Autism and Other Developmental Disabilities, 19*, 140-151.

Proctor, C. P., Dalton, B., & Grisham, D. L. (2007). Scaffolding English language learners and struggling readers in a universal literacy environment with embedded strategy instruction and vocabulary support. *Journal of Literacy Research, 39*, 71-93.

Riesen, T., McDonnell, J., Johnson, J. W., Polychronis, S., & Jameson, M. (2003). A comparison of time delay and simultaneous prompting within embedded instruction in general education classes with students with moderate to severe disabilities. *Journal of Behavioral Education*, *12,* 241-260.

Robertson, C., & Salter, W. (1997). The *phonological awareness test*. East Moline, IL: LinguiSystems, Inc.

Roseman, J., & Koppal, M. (2008). Using national standards to improve k-8 science materials. *The Elementary School Journal*, *109*, 104-122.

Rosenshine, B. (1987). Explicit teaching and teacher training. *Journal of Teacher Education*, *38,* 34-36.

Rosenshine, B., & Stevens, R. (1986). Teaching functions. In M. C. Witrock (Ed.), *Handbook of research on teaching* (pp. 376-391). New York, NY: Macmillan.

Rupley, W. H., & Nichols, W. D. (2005). Vocabulary instruction for the struggling reader. *Reading & Writing Quarterly, 21*, 239-260.

Ryder, J. F., Tunmer, W. E., & Greaney, K. T. (2008). Explicit instruction in phonemic awareness and phonemically based decoding skills as an intervention strategy for struggling readers in whole language classrooms. *Reading and Writing*, *21*, 349-369.

Ryndak, D. L., & Alper, S. (2003). *Curriculum and instruction for students with significant disabilities in inclusive settings* (2nd ed.). Boston, MD: Allyn & Bacon.

Schalock, R. L., Luckasson, R. A., & Shogren, K. A. (2007). The renaming of mental retardation: Understanding the change to the term intellectual disabilities. *Intellectual and Developmental Disabilities*, *45*, 116-124.

Schopler, E., Reichler, R. J., & Renner, B. R. (1980). *The childhood autism rating scale*. Los Angeles, CA: Western Psychological Services.

Scruggs, T. E., Mastropieri, M. A., & Okolo, C. M. (2008). Science and social studies for students with disabilities, *Focus on Exceptional Children*, *41*, 1-24.

Sigafoos, J., O'Reilly, M., Ma, C. H., Edrisinha, C., Cannella, H., & Lancioni, G. E. (2006). Effects of embedded instruction versus discrete-trial training on self-injury, correct responding, and mood in a child with autism. *Journal of Intellectual & Developmental Disability, 31*, 196-203.

Simpson, A., Langone, J., & Ayres, K. M. (2004). Embedded video and computer based instruction to improve social skills for students with autism. *Education and Training in Developmental* Disabilities, 39, 240-252.

Simpson, R. L. (2004). Finding effective intervention and personnel preparation practices for students with autism spectrum disorders. *Exceptional Children*, *70*, 135-144.

Simpson, R. L., McKee, M., Tetter, D., & Beytien, A. (2007). Evidence-based methods for children and youth with autism spectrum disorders: Stakeholder issues and perspectives. *Exceptionality*, *15*, 203-217.

Smith, B. R., Spooner, F., Jimenez, B. A., & Browder D. (2011). *Using an early science curriculum to teach science vocabulary and concepts to students with severe developmental disabilities*. Manuscript submitted for publication

Snell, M. E. (Ed.). (1983). *Systematic instruction of the moderately and severely handicapped* (2nd ed.). Columbus, OH: Merrill.

Snell, M. E., & Brown, F. (Eds.). (2006). *Instruction of students with severe disabilities* (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland adaptive behavior scales, second edition*. Minneapolis, MN: NCS Pearson, Inc.

Spooner, F., Knight, V., Browder, D. M., Jimenez, B., & DiBiase, W. (2011). Evaluating evidence-based practices in teaching science content to students with severe developmental disabilities. *Research and Practice for Persons with Severe Disabilities, 36*, 62-75.

Spooner, F., Stem, B., & Test, D. W. (1989). Teaching first aid skills to adolescents who are moderately mentally handicapped. *Education and Training in Mental Retardation, 24,* 341-351.

Steele, M. (2007). Science success for students with special needs. *Methods & Strategies*. Retrieved from http://www.nsta.org

Stichter, J. P., Randolf, J., Gage, N., & Schmidt, C. (2007). A review of recommended social competency programs for students with autism spectrum disorders. *Exceptionality*, *15*, 219-232.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis*, *10*, 349-367.

Taber, T. A., Alberto, P. A., Hughes, M., & Seltzer, A. (2002). A strategy for students with moderate disabilities when lost in the community. *Research and Practice for Persons with Severe Disabilities*, *27*, 141-152.

Taber, T. A., Alberto, P., A., Seltzer, A., & Hughes, M. (2003). Obtaining assistance when lost in the community using cell phones. *Research and Practice for Persons with Severe Disabilities*, *28*, 105-116.

Tawney, J. W., & Gast, D. L. (1984). *Single subject research in special education*. Columbus, OH: Merrill.

Taylore, D. B., Mraz, M., Nichols, W. D., Rickelman, R. J., & Wood, K. D. (2009). Using explicit instruction to promote vocabulary learning for struggling readers. *Reading & Writing Quarterly*, *25*, 205-220.

Test, D. W., Fowler, C., H., Richter, S. M, White, J., Mazzotti, V., Walker, A. R., … Korting, L. (2009). Evidence-based practice in secondary transition. *Career Development for Exceptional Individuals*, *32*, 115-128. doi: 10.1177/0885728809336859

The Access Center: Improving Outcomes for All Students K-8 (2009). *Computer assisted instruction and mathematics*. Retrieved from http://www.k8accesscenter.org/training_resources/computeraided_math.asp

Trends in International Mathematics and Science Study (2008). Retrieved from http://nces.ed.gov/timss/results07.asp

Wanzek, J., Vaughn, S., Wexler, J., Swanson, E. A., Edmonds, M., & Kim, A. (2006). A synthesis of spelling and reading interventions and their effects on the spelling outcomes of students with LD. *Journal of Learning Disabilities*, *39*, 528-543.

Wechsler, D. (2003). *Wechsler intelligence scale for children, fourth edition*. San Antonio, TX: Psychological Corp.

Wehmeyer, M. L. (1996). Self-determination as an Educational Outcome: Why is it important to children, youth, and adults with disabilities? In D.J. Sands and M.L. Wehmeyer (Eds.), *Self-determination across the lifespan: Independence and choices for people with disabilities* (pp. 17-35). Baltimore, MD: Paul H. Brooks.

Westling, D. L., & Fox, L. (2009). *Teaching students with severe disabilities* (4th ed.). Upper Saddle River, NJ: Merrill.

Wexler, J., Vaughn, S., Roberts, G., & Denton, C. A. (2010). The efficacy of repeated reading and wide reading practice for high school students with severe reading disabilities. *Learning Disabilities Research & Practice*, *25*(1), 2-10.

Winterling, V., Gast, D. L., Wolery, M., & Farmer, J. A. (1992). Teaching safety skills to high school students with moderate disabilities. *Journal of Applied Behavior Analysis*, *25*, 217-227.

Witzel, B., Mercer, C. D., & Miller, M. D. (2003). Teaching algebra to students with learning difficulties: An investigation of an explicit instruction model. *Learning Disabilities Research and Practice*, *18*, 121–131.

Wolery, M., Bailey, D. B., & Sugai, G. M. (1988). *Effective teaching: Principles and procedure of applied behavior analysis with exceptional students*. Boston, MA: Allyn & Bacon.

Wood, C. L., Kelley, K. R., Test, D. W., & Fowler, C. H. (2010). Comparing audio-supported text and explicit instruction on students' knowledge of accommodations, rights, and responsibilities. *Career Development for Exceptional Individuals*, *33*(2), 115-124.

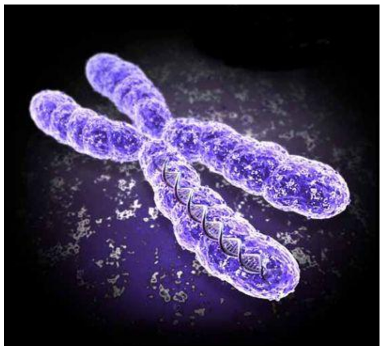
Wood, C. L., Mackiewicz, S. M., Van Norman, R. K., & Cooke, N. L. (2007). Tutoring with technology. *Intervention in School and Clinic*, *43*(2). 108-115.

Wood, C. L., Mustian, A. L., & Lo, Y-y. (in press). Effects of supplemental computer-assisted reciprocal peer tutoring on kindergartners' phoneme segmentation fluency. *Education & Treatment of Children*.

Zigmond, N. P., & Kloo, A. (2011). General and special education are (and should be) different. In J. M. Kauffman & D. P. Hallahan (Eds.), *The handbook of special education* (pp. 160-172). New York, NY: Routledge.

APPENDIX A: SAMPLE PROBE SLIDE

This picture shows



pizza

organ

chromosomes

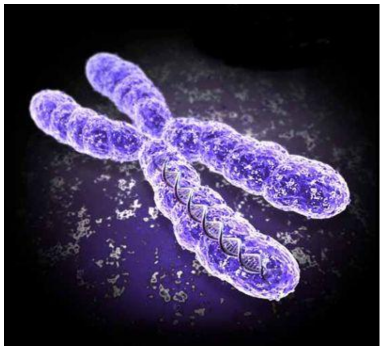
mitosis

Stimulus for application question

Response options

APPENDIX B: SAMPLE INTERVENTION SLIDE

My turn: This picture shows



pizza

organ

chromosomes

mitosis

Yellow star prompting correct response

APPENDIX C: PROBE DATA COLLECTION FORM

Student Name:

Session Types: Baseline (BL) Intervention (IV) Maintenance (M) Generalization (G)

Date													
Type of Session													
Plant cell													
Plant cell													
Unicellular													
Unicellular													
Mitosis													
Mitosis													
Organ													
Organ													
Microscope													
Microscope													
Chromosomes													
Chromosomes													
Immune system													
Immune system													
Homeostasis													
Homeostasis													
DNA													
DNA													

Key

+ correct response

Notes/Comments:

APPENDIX D: INTERVENTION LOG

Instructor Initials	Date	Student	Time started	Time ended	Comments

APPENDIX E: PRE-INTERVENTION EVALUATION

Name:
Data Collector:

Date													
Touch (student name)													
Touch (student name)													
Touch (student name)													
Total # of Correct													

Key

+ correct response

Notes/Comments:

APPENDIX F: PROCEDURAL FIDELITY

Student	Date	Navigate to powerpoint	Give student tablet	Allow student to navigate through intervention	Reinforce Intermittently

Key

+ interventionist performed behavior

- interventionist did not perform behavior

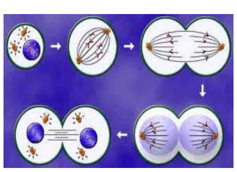
APPENDIX G: GENERALIZATION PROBE

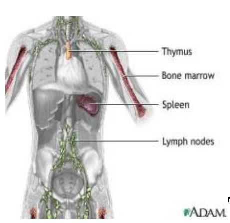
Directions: Match the picture to its definition

1. Plant cell	A double stranded structure that holds genetic material
2. Unicellular	A system that helps you not get sick
3. Mitosis	A tool to see a cell
4. Organ	An organism with one cell
5. Microscope	A group of tissues that do one job
6. Chromosomes	The cycle of cells
7. Immune system	Threadlike structures in the nucleus
8. Homeostasis	When cells fight to stay the same
9. DNA	A cell with a cell wall

Directions: Use the words in the word bank to fill in the sentence

Word Bank		
Plant cell	Organ	Microscope
Unicellular	Chromosomes	Immune System
Mitosis	Homeostasis	DNA

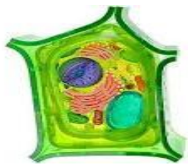
10.  This picture shows a _______________.

11. 

ADAM This picture shows a ______________.

12. When you sweat to cool down your body it is called ______________________.

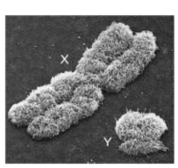
13. ______________ determines how you look.

14.  This picture shows a __________________.

15.  This picture shows a __________________.

16. Your lungs are an ____________________.

17.  This picture shows a __________________ organism.

18. 

This picture shows a __________________ organism.

APPENDIX H: SOCIAL VALIDITY QUESTIONNAIRE FOR STUDENTS

Directions: Please read questions aloud to students. Students should point to or circle the answer they agree with.

1. Did you enjoy using the iPad to learn science words?

YES MAYBE NO

2. Would you rather use the book to learn science words?

YES MAYBE NO

3. Did the pictures help you learn the science words and applications?

YES MAYBE NO

4. Did the video clips help you answer the questions?

YES MAYBE NO

5. Would you like to use an iPad to learn about another subject like math or social studies?

YES MAYBE NO

6. Would you like to continue using the iPad in science class?

YES MAYBE NO

7. When working on the iPad, did I feel isolated from the class?

YES MAYBE NO

APPENDIX I: SOCIAL VALIDITY QUESTIONNAIRE FOR TEACHERS

Teacher: ______________________ Date: ___________

Please rank the degree to which you agree or disagree with each of the statements below.

Statements		Responses				
1.	The targeted skills selected for intervention are important for students.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2.	The time spent in the study was a good use of student time during the school day.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3.	Computer-assisted instruction helped my students increase science vocabulary.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.	The vocabulary knowledge has generalized to other activities within the science classroom or to other areas throughout the school day	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.	The computer-assisted instruction was disruptive to class.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	I would consider incorporating computer-assisted instruction into other areas or routines during the school day.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.	I think the pictures/videos promoted comprehension of the science terms and their applications.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.	I would allow my students to participate in future research studies.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Additional Comments:

APPENDIX J: SOCIAL VALIDITY QUESTIONNAIRE FOR OTHER STUDENTS IN THE SCIENCE CLASSROOM

Date: ___________

Please rank the degree to which you agree or disagree with each of the statements below.

Statements	Responses				
1. Science is important for all students to learn, even people with disabilities.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
2. Learning science terms and applications will help students be more successful in the science classroom.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
3. Computer-assisted instruction is a good way to provide extra instruction to students with disabilities.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4. The computer-assisted instruction was disruptive to class.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5. I would like to practice skills using iPads within the science classroom.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6. Computer-assisted instruction could help me learn terms in other subject areas (social studies, math).	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Additional Comment