EFFECTS OF SYSTEMATIC INSTRUCTION ON LISTENING COMPREHENSION OF SCIENCE e-TEXTS FOR STUDENTS WITH MODERATE INTELLECTUAL DISABILITY

by

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ABSTRACT

ALYSON LEAH WOOD. Effects of systematic instruction on listening comprehension of science e-texts for students with moderate intellectual disability. (Under direction of DR. DIANE M. BROWDER)

A multiple probe across participants design was used to examine the effects of systematic instruction (constant time delay and a system of least prompts) on both generating and answering questions about science e-texts for students with moderate intellectual disability. Three elementary aged students with moderate intellectual disability participated in this study. Two special education teachers served as the primary interventionists. The students were pretrained using constant time delay and visual and auditory cues delivered on an iPad2™ to access and navigate e-texts on the Internet. The primary dependent variable was the number of comprehension questions correctly answered after students generated a question and listened to a science e-text. Additional questions examined (a) the students' ability to generate questions both with and without the support of an iPad2™ template, (b) the generalizability of generating questions and answering questions about science e-texts in a general education science setting, and (c) stakeholder perceptions. A functional relationship was demonstrated for both generating questions using an iPad2™ and answering comprehension questions. All three students demonstrated an ability to correctly answer questions by either saying an answer from memory or independently searching the e-text and replaying target text to find the correct answer. A functional relationship also was demonstrated between constant time delay instruction and the points earned accurately generating questions using an iPad2™.

DEDICATION

I dedicate this dissertation to Marc, Olivia, and Ty. They have all believed in me throughout this mammoth process, and I am grateful for their support, their hugs, and their endurance as we all weathered this journey together. I am also deeply grateful for my mom and dad. They have always encouraged me to follow any path I choose, and it has filled me up to know that they are proud. Finally, I dedicate this to my cohort at UNC Charlotte. The friendship, support, and kindness I have experienced from these wonderful people have been a joy and an honor. It was a hard, long road, but without them, there would not have been nearly as much light or laughter.

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CHAPTER 1: INTRODUCTION

Comprehending language or text is a skill that is heavily emphasized not only in school but also in the broader community. Listening comprehension is the ability to understand language (Adlof, Catts, & Little, 2006) and reading comprehension is the ability to decode (i.e., recognize words in print) and construct meaning from text. Within school, compared to previous educational standards, the Common Core State Standards (CCSS, 2010) include comprehension instruction across content areas. Beyond the scope of school, comprehension is valued throughout society (Morgan, Cuskelly, & Moni, 2011). For example, society expects people to comprehend ubiquitous community text (e.g., street signs, written correspondence, menus, labels). Notably, in this time of rapid technological growth, the use of texting and emailing has surged, often replacing practices like face-to-face interactions or engagement in phone conversations. In school, the expectation for students to understand written or spoken content is often infused across content areas through the presentation of narrative and expository (or informational) texts. In the community, individuals are expected to understand public services announcements, interpret street and safety signs, and follow written or oral directions within the course of a typical day. Morgan et al. (2011) emphasized the importance of recognizing literacy as a social practice and a necessary skill for people to gain independent living. Similarly, in her book on teaching literacy skills to people with significant disabilities, Downing (2005) described the myriad of benefits that can result from understanding text, including increased independence, an increased ability to make life choices (critical or mundane), and an increased sense of competence. People with significant or severe disabilities often are dependent on listening comprehension skills to understand text read aloud to them. Additionally, as listening comprehension is a critical component of reading comprehension, individuals must be proficient in listening comprehension and decoding skills if they are to one day gain meaning from texts read independently. Learning to understand spoken text is a skill that can have marked benefits for individuals with severe disabilities in regards to their increased independence as a reader and their ability to derive meaning from information academic and community text (Browder, Gibbs, et al., 2009).

Understanding or comprehending content is a necessary component of college and career readiness (CCSS, 2010; Conley, 2007). Mastropieri and Scruggs (1997) described comprehension as the most important postschool outcome. Students need to learn critical thinking strategies, including inquiry skills, in order to maximize comprehension in preparation for postschool environments. These strategies should involve cognitive processes more in depth than basic recall of facts. The goal of comprehending content is for individuals to retain information over time and apply this information in other, eventually job related, contexts (Kearns et al., 2011). For students with disabilities, the ability to generalize skills to new contexts is critical for long-term outcomes (Kleinert, Browder, & Towles-Reeves, 2009), particularly as college and postsecondary employment opportunities are becoming continually more accessible for people with severe disabilities (Hart & Grigal, 2010; Papay & Bambara, 2011). Likewise, teaching students with severe disabilities to generalize listening comprehension skills to contexts (e.g., across academic content areas) is one way educators may improve the likelihood individuals with severe disabilities will prosper both in and outside of school. Currently, relatively few students with severe disabilities are able to decode text. Consequently, many of these students rely on another person to read text aloud.

How Readers Access Text

Students entering school first access texts through listening to read-alouds in which books or other information is read to students. When students listen to texts read to them, they have the opportunity to gain an interest in literacy and an increased concept of print. Students are able to develop awareness of text structure, which varies based on the type of text. For example, narrative text structure includes elements such as plot, setting, and characters. Expository text structure typically includes: (a) description, (b) sequence, (c) comparison and contrast, (d) cause and effect, and (e) problem and solution (Wood, Browder, & Mraz, 2014). Listening to texts also provides students with a model for writing or developing their own products. Often teachers use read-alouds as an opportunity to engage students in discussions about the text. Teachers can ask questions about the text and encourage students to make predictions. Through this process of engaging in a text read aloud, students can increase comprehension of the text (R. Vacca, Vacca, & Mraz, 2011). Students who develop typical reading skills begin reading independently in the early elementary school years, expanding their repertoire of accessible material. In recent years, technology has provided another avenue for accessing text.

Technology to Promote Access to and Comprehension of Texts

R. Vacca et al. (2011) described technology as a common and long-standing gateway to a multitude of texts in general education classrooms. Traditionally, students have accessed text by listening to or independently reading books, but the development of computers first changed the course of technological access to text. Since the 1980s, computers have been used in most classrooms across the country. Initially, computers were used for word processing capabilities and skills practice. In the 1990s, the development of CD-ROMs increased the interactivity of computers and availability of electronic print (Labbo, 2000). In the past two decades, the availability of the Internet has expanded students' access to all varieties of text astronomically (J. Vacca et al., 2006). Mulligan (2003) described technology as a way to not only improve access to text, but also as a way to improve educators' ability to assess and increase students' comprehension. Recently, further technological innovations have emerged that offer students alternative modalities for both accessing text and promoting comprehension. Students can access electronic texts (i.e., e-texts) on the Internet through a desktop or laptop computer. Tablets (e.g., iPads™) and e-readers (e.g., Kindle™) can be used to access texts on the Internet, or e-texts that can be loaded directly onto the device. Some texts are available through apps, or software, that often use Internet connectivity (More & Travers, 2012). The use of electronic devices and the Internet to access texts broadens the category of traditional literacy sources (e.g., physical books) to a wider array of multiliteracies (Wood et al., 2014). These multiliteracies now are commonplace in many general education classrooms (Wood et al., 2014). An account executive for Apple described the number of iPads™ sold to and used by schools as "in the millions" (P.

Davis, personal communication, June 6, 2013). Additionally, Apple has produced and released over 20,000 educational apps for use with the iPad™ (http://www.apple.com/education/ipad/). For example, *Discovery Education* is a Web site that provides a network of digital media for use in classrooms. Students can access digital textbooks or e-texts across content areas, view video clips, and engage in interactive activities. The availability of e-text access through electronic devices is ubiquitous in schools across the country, and for the most learners, accessing these multiliteracies is a skill learned easily and at a very young age.

How Students with Severe Disabilities Access Text

Historically, students with severe disabilities have not been granted the same access to literacy as their counterparts without disabilities (Katims, 2000; Kliewer, Biklen, & Kasa-Hendrickson, 2006). Kliewer (1998) conducted an ethnographic study of the school experiences of students with severe disabilities and discovered reading instruction was not emphasized in the education of these students. The little instruction some students received consisted of sight word instruction on vocabulary related to daily living skills. When literacy instruction is reduced to recognition of sight words, students may have little to no exposure to the connected text typical of books and other school resources.

In a conceptual framework of literacy for students with severe developmental disabilities, Browder, Gibbs, et al. (2009) noted that students with severe disabilities can access text through reading or listening. With intensive instruction, some students with severe disabilities develop emerging or even independent reading skills (Allor, Mathes, Roberts, Cheatham, & Champlin, 2010; Ahlgrim-Delzell, Browder, & Wood, in press).

These students should be given the support and opportunity to access texts independently. Other students with severe disabilities may still require opportunities to engage in literacy through read-alouds (e.g., Hudson, Browder, & Jimenez, in press). For these students, developing listening comprehension skills is paramount to teaching students to draw meaning from text. Comprehending text is a life skill that can help students gain meaning from a variety of texts in order to improve overall quality of life. In either respect, for students who develop emerging reading skills or access text read aloud to them, the ultimate goal of literacy is comprehension.

Adapting Text for Read-alouds for Students with Severe Disabilities

When conducting a read aloud, teachers may use original or adapted texts. Some texts, particularly books for younger students, are already written in a style and complexity that is easy to understand. Often these books include pictures. Some students with severe disabilities require further adaptations to access texts. Both the physical features of the text and the content of the text can be adapted as needed to meet the needs of students. Examples of adaptations that augment physical access include the use of lamination to increase durability, Velcro or Popsicle sticks affixed to the edges of pages to add a grip for turning pages, or increased font size. Examples of adaptations that support cognitive access include summarized text rewritten at a lower level of complexity, pictures paired with key words, and the use of a repeated story line that highlights a major event or theme in the story. Cognitive adaptations such as these are the most critical for promoting comprehension for students with severe disabilities. Some students may benefit from listening to or reading texts that have been summarized or rewritten to match the students reading and comprehension level. For example, Browder, Hudson, and Wood (2013) adapted middle school chapter books (e.g., *Holes, A Wrinkle in Time*) to a kindergarten to first grade reading level. Three students in middle school with moderate intellectual disability read the books aloud and answered questions about each chapter. All three students improved in their comprehension of the books they read.

Browder, Trela, and Jimenez (2007) adapted middle school chapter books that were read aloud to students. These texts were adapted by summarizing the content and pairing picture symbols with key vocabulary. Browder et al. (2007) taught teachers to deliver the steps of a 25-item task analysis to teach students to engage with the text and comprehend the content. Steps of the task analysis included strategies, such as finding the chapter and completing repeated story lines. All three teachers improved in the number of steps of the task analysis performed correctly. Similarly, all students made gains once their teacher entered the intervention phase of the study. All of the Interactive read-alouds (sometimes called "story-based lessons" when applied to narrative texts) like the one in Browder et al. (2007) have been found to be an evidence-based practice for teaching literacy skills to students with moderate and severe disabilities (Hudson & Test, 2011).

Fisher, Flood, Lap, and Frey (2004) examined the effects of an interactive reading process in which teachers engaged students in discussions of adapted books that were read aloud to the students. First, Fisher et al. observed 25 teachers and determined seven common read-aloud practices. These practices included: (a) texts selected based on students' grade level and personal interests, (b) teachers practiced delivery of text prior to teaching, (c) teachers established an identifiable purpose for teaching the text, (d) teachers read fluently, (e) teachers read with expression and animation, (f) teachers paused during reading to check for student understanding and engagement, and (g) teachers linked the read-aloud to additional reading and writing activities. Next, the authors examined the extent to which these seven practices occurred within the daily practices of a larger group of teacher (*n*=120). Teachers were most consistent in their use of text selection based on grade-level and student interest, reading with animation and expression, and asking students questions throughout the reading. Teachers were less likely to make connections to other reading and writing activities, previewing the text prior to reading it, and establishing a clear purpose for teaching the text. Browder et al. (2007), unlike Fisher et al. taught students to follow along in their own books, which were summaries of grade-aligned texts with picture symbol supports. Additionally, the task analysis used by Browder et al. promoted teacher fidelity of the implementation of the read-aloud because teachers were trained in the delivery of specific steps.

In a final study by Shurr and Taber-Doughty (2012), the texts were not adapted. Instead the authors provide students with supplemental materials to increase comprehension of the stories. Shurr and Taber-Doughty (2012) also taught middle school students with moderate intellectual disability to comprehend grade-aligned texts. Shurr and Taber-Doughty selected texts from the SRA Specific Skills Series: Getting the Main Idea (Boning, 1997). The texts were brief, expository texts including topics such as biographies and science that did not have to be summarized. In addition to the texts, which were read aloud to the students, Shurr and Taber-Doughty used a picture strip with five photos related to text elements (e.g., settings, characters). The interventionist asked students to describe the pictures on the strip prior to reading the text aloud. All three students improved in the number of comprehension questions answered correctly after receiving the picture discussion intervention.

System of Least Prompts to Teach Comprehension

In addition to access and text engagement, students need models for learning to locate the answer. One option used in the literature on read-alouds is a system of least prompts. A system of least prompts is a procedure that was originally used to teach daily living skills to people with severe disabilities (Wolery, Ault, & Doyle, 1992). Traditionally, the model consists of a hierarchy of verbal, model, and physical prompts, which are delivered only if the student is unable to independently perform a specific skill. Typically, a system of least prompts includes physical prompting as needed due to the motoric nature of many tasks (e.g., putting on one's coat). Comprehension is a cognitive task, and the prompts of a system of least prompts can be modified to match the needs of this higher-level thinking skill. For instance, Mims (2009) used a system in which the first prompt was a reread of a portion of the text that contained the answer. Next, if needed, teachers provided a model prompt by pointing to the correct answer from an array. Mims, Hudson, and Browder (2012) modified this system of least prompts further by embedding rules for using WH words. For instance, students were told the meaning of each word (e.g., If you hear *who*, listen for *people*) prior to answering comprehension questions. All students demonstrated an increase in comprehension skills across the five texts used in the study. Surprisingly, one student who was believed to be a nonreader began reading the texts aloud and answering the comprehension questions without help. Hudson et al. (in press) adjusted the reread prompts to provide additional opportunities for the student to find the answer before receiving the model prompt. First, the instructor reread a small portion (approximately three sentences) of text in which the answer was contained. If another prompt was needed, the instructor would reread only the sentence containing the answer. Then, if needed, the instructor would deliver the model prompt by pointing to the answer in text and on the response board. All three participants demonstrated an increase in comprehension questions answered during the intervention sessions. As noted previously, Browder et al. (in press) replicated this modified system of least prompts. Similar to Mims, students in the Browder et al. (in press) study received instruction in the definition of WH words. Browder et al. (in press) found that emergent readers improved in the number of comprehension questions answered correctly after receiving instruction using the modified system of least prompts procedure.

Generating Questions

While teaching students to locate the answers to recall questions is a common comprehension strategy for all students, teaching students to generate questions is a strategy that has produced large effect sizes in studies of students with learning disabilities (Mastropieri & Scruggs, 1997). Generating question (also known as self-questioning) is a strategy that emerged from the findings that developing questions aids in the acquisition of comprehension skills by helping students evaluate their understanding of text material before, during, or after exposure to the text (Mastropieri & Scruggs, 1997; Palincsar & Brown, 1984). This strategy promotes reasoning skills by requiring students to identify and understand the main idea of a text, make predictions, summarize content, and activate prior knowledge. Students are guided to ask and then answer their own questions through the reading process (Kucan & Beck, 1997). Generating questions has been identified as one of the seven best practices for promoting comprehension by the National Reading Panel (2000). Mastropieri, Scruggs, Bakken, and Whedon (1996) reviewed 82 studies in which comprehension skills were taught to students with and without disabilities. They concluded studies in which participants learned to generate questions resulted in the highest overall effects. In a literature review of 26 qualifying studies spanning 1969 to 1992, Rosenshine, Meister, and Chapman (1996) identified generating questions as an effective cognitive strategy for increasing the comprehension skills of students with or without disabilities. They discovered a large median effect size of .86 across studies in which the impact of question-generating interventions was measured using comprehension tests developed by the experimenter.

In contrast, comprehension strategies such as generating questions are not typically taught to students with severe disabilities. One study, Wood, Browder, and Flynn (2014), examined the effects of teaching elementary students with moderate intellectual disability to ask and then answer questions about grade-aligned expository text. Wood et al. demonstrated a functional relationship between the system of least prompts procedures and students' ability to both generate and answer comprehension questions about a social studies text. Students increased in both the numbers of questions asked and answered, and these findings generalized to a general education social studies context.

Purpose and Variables

Within the decades worth of research supporting the use of systematic instruction to teach skills to students with severe disabilities, there is a growing body of research supporting the use of a system of least prompts procedures to teach text comprehension. Several studies have taught text comprehension using both a system of least prompts and a read-aloud procedure (e.g., Browder et al., in press; Hudson & Browder, 2014; Hudson et al., in press; Mims, Browder, Baker, Lee, & Spooner, 2009; Mims et al., 2012; Wood, Browder, & Flynn, 2014). Although students gained some comprehension skills in each study, only Wood et al. (2014) taught students with moderate intellectual disability to generate questions.

The National Reading Panel recommended teaching students to ask or generate questions as a comprehension strategy, and Berkley, Mastropieri, and Scruggs (2011) demonstrated students with mild disabilities can increase comprehension of expository text when taught to generate questions using a graphic organizer. At least one study (i.e., Wood et al., 2014) has demonstrated using a system of least prompts to teach question asking can increase the number of questions students with severe disabilities ask and correctly answer. The need exists for more studies examining the effects of question generating on the text comprehension of students with severe disabilities.

Finally, because of technological advances for accessing text, many supports are embedded in online e-texts (e.g., highlighting text, text-to-speech software, pictures). One study has demonstrated students with severe disabilities can learn the skills to access information on the Internet (i.e., Zisimopoulos, Sigafoos, & Koutromanos, 2011). A few studies have demonstrated students with severe disabilities can learn comprehension of e-texts (e.g., Coyne, Pisha, Dalton, Zeph, & Smith, 2012; Douglas, Ayers, Langone, & Bell, 2011). The purpose of this study was to teach students with moderate intellectual disability to ask and answer questions about expository e-texts using systematic instruction delivered via an iPad2™.

Independent variables. The intervention was comprised of three major components. First, students were taught to ask one question about a text before listening to the text on the computer. Second, teachers used constant time delay procedures to teach students to use a graphic organizer, delivered on an iPad2™, to generate each question prior to listening to the text. Finally, teachers used a system of least prompts procedure to teach students to answer questions (both the question the students poses and novel questions) after students listened to the text on the computer.

Dependent variables. Seven dependent variables were measured. The first dependent variable was the number of points participants earn by asking questions about science e-texts when given a graphic organizer. The second dependent variable was the number of comprehension questions students answered about a science e-text read aloud. The third dependent variable was the number of points students earned by asking questions about science e-texts without the use of a graphic organizer. The fourth dependent variable was the number of points participants earned by asking comprehension questions during general education lessons. The fifth dependent variable was the number of questions answered during a science lesson in a general education classroom. The sixth dependent variable was the pretest and posttest scores on the *Woodcock Language Proficiency Battery™ Revised* (Woodcock, 1991; WLPB™-R) listening comprehension subtest. The seventh dependent variable was the perceptions (i.e., ratings) of stakeholders regarding the procedures, materials, and outcomes.

Significance of this Study

This study contributes to existing research in several ways. First, this study adds to research on using a system of least prompts procedures to teach text comprehension to students with moderate intellectual disability. Similar to other studies, teachers delivered prompts that include a reread of a large portion of the text, and then a smaller portion of the text, and finally the answer. Unlike other studies, teachers in this study will use the supports embedded in the e-texts to highlight text and activate the text-to-speech software to provide prompts as needed. A second way this study contributes to existing research is to add to research on teaching the comprehension strategy of generating questions. Many studies have examined question generating for students without disabilities or students with mild disabilities (Rosenshine et al., 1996). Only one other study has examined the effectiveness of teaching students with moderate intellectual disability to generate questions (i.e., Wood et al., 2014). A third contribution is that this study added to research on teaching expository texts to students with moderate intellectual disability. A small but growing body of research demonstrates that students with severe disabilities can comprehend expository texts including biographies (e.g., Mims et al., 2012; Shurr & Taber-Doughty, 2012), social studies texts (e.g., Hudson et al., in press; Wood et al., 2014), and science texts (e.g., Hudson et al., in press; Shurr & Taber-Doughty, 2012). Specifically, students in this study will listen to science e-texts. A fourth contribution will be the use of a graphic organizer. Graphic organizers are used to teach many skills to students with disabilities (e.g., Berkeley, Marshak, Mastropieri, & Scruggs, 2011; Gardill & Jitendra, 1999; Knight, Spooner, Browder, Smith, & C. Wood, 2013; Ozmen, 2011), however only one study has used a graphic organizer to teach students with moderate intellectual disability to generate a question (Wood et al., 2014). This study differs from the Wood et al. study in that students will use a template on an iPad2™ to generate questions. A fifth contribution is the use of technology to promote comprehension of and access to e-texts. In addition to the use of an iPad2™ as a graphic organizer for generating questions, students will learn to access e-texts through a Web site on a classroom computer. Zisimopoulos et al. (2011) taught students to access information using the Internet, but the authors did not measure comprehension. Coyne et al. (2012) and Douglas et al. (2011) both taught students to comprehend e-text, but neither used an iPad2™ to teach a comprehension strategy (i.e., generating questions). A sixth contribution is the demonstration of generalization of a comprehension strategy (i.e., generating questions) without prompting or use of the graphic organizer. Students will have two opportunities at the end of each session to generate additional questions about a science e-text. A seventh contribution is a demonstration of generalization across contexts. Hudson, Browder, and Wood (2013) reviewed literature in which academic skills or content was taught to students with severe disabilities in a general education setting. In the 17 identified studies, the most common dependent variable was sight word recognition of vocabulary words related to the class content. Embedded constant time delay was typically used to teach recognition of sight words. In this study, students will be given an opportunity to generate and answer question about science e-texts in a science class alongside peers in the third grade. These sessions occurred four times throughout the study as a generalization across contexts measure. An eighth and final contribution of this study is the ratings from stakeholders. Stakeholders will be asked to complete a questionnaire indicating their perceptions of the procedures, materials, and outcomes demonstrated in this study.

Research Questions

The research questions asked in this study include:

(a) What is the effect of constant time delay on students' ability to generate questions about science e-texts?

(b) What is the effect of posing questions combined with a system of least prompts on the ability of students with moderate intellectual disability to locate answers within science e-texts?

(c) How does the use of a question template affect students' ability to generate new questions?

(d) Does the skill of generating questions about science e-texts generalize to other settings?

(e) Does comprehension of science generalize to other settings?

(f) Do effects of the proposed treatment package generalize to a distal measure of comprehension, as measured by the WLPB™-R?

(g) Do stakeholders rate the procedures, materials, and outcomes favorably?

Definitions

Augmentative and alternative communication (AAC) – Systems of communication consisting of aided (e.g., voice output devices, picture symbols) or unaided (e.g., sign language) devices (Browder, Spooner, & Mims, 2011)

Comprehension – Gaining meaning from text (National Institute of Child Health and Human Development, Report of the National Reading Panel, 2000)

Computer Assisted Instruction (CAI) – The use of computers to teach and assess learning content to individuals (Anohina, 2005)

Constant time delay – A systematic instruction procedure in which a prompt is presented concurrently as a target stimulus. Eventually, the prompt is faded by systematically inserting small increments of time between the presentation of the stimulus and the response over successive trials. With constant time delay, the length of the delay is fixed across trials. For instance, following the initial trials in which there is no delay (0-s delay rounds), subsequent trials might all utilize a 4-s delay between the stimulus and prompt. Time delay promotes a transfer of stimulus control from the prompt to the target stimulus (Cooper, Heron, & Heward, 2007; Snell & Gast, 1981).

e-readers – Devices used to read digital texts, such as a Kindle™ or iPad™ (Anderson-Inman & Horney, 2007)

e-text – Digital text (i.e., literature, documents, articles) that often has built in supports, including text-to-speech capabilities, pictures, hyperlinks, or text highlighting; e-texts have three main components: (a) an e-text file, (b) software to read the e-text, and (c) a hardware device for reading the e-text (Cavanaugh, 2002)

Generating questions – Developing a question about a text (Berkeley, Marshak, et al., 2011; Palincsar & Brown, 1984)

Generalization – Responding correctly in instances other than the training instance across people, settings, materials, stimuli, natural consequences, or time (Stokes & Baer, 1977; Wolery et al., 1992)

Graphic organizer – Information displayed visually and spatially to promote learning of text; graphic organizers include lines and shapes or spatial arrangements to present and organize material (Darch & Eaves, 1986)

Listening comprehension – Gaining meaning from content heard (Browder, Gibbs, Ahlgrim-Delzell, Courtade, & Lee, 2007)

Literacy – Reading, decoding, and comprehending language (Hoover & Gough, 1990)

Read-alouds – A method of reading texts aloud to promote access of grade-aligned literary material (Browder, Mims, Spooner, Ahlgrim-Delzell, & Lee, 2008)

Supported e-text – Electronic text enriched with physical and cognitive supports (Anderson-Inman & Horney, 1997, 1998)

Students with moderate intellectual disability – Students with significant intellectual and adaptive behavioral limitations that affect social, conceptual, and adaptive skills; this disability manifests prior to age 18 (American Association on Intellectual Developmental Disabilities, AAIDD, 2010, http://aaidd.org/intellectual-disability/definition#.Ug5kwZKmg01)

Students with severe disabilities – Encompasses students with an IQ of 55 or below; students with moderate or severe intellectual disability; students with autism; student with significant disabilities in intellectual, physical, or social functioning (Heward, 2003)

System of least prompts – A response prompting procedure in which an individual is provided only the level of prompting necessary to perform a correct response. After a brief period of wait in which the individual is given an opportunity to perform the correct response independently, the instructor delivers prompts from a hierarchy, beginning with the least intrusive prompt (Collins, 2012; Doyle, Wolery, Ault, & Gast, 1988)

Systematic instruction – The practice of teaching socially significant content and skills through the systematic application of prompting and fading procedures (Snell, 1983)

Template – A type of graphic organizer that categorizes information and demonstrates

Text-to-Speech – Voice generated digitally (Douglas, Ayres, Langone, Bell, & Meade, 2009)

CHAPTER 2: REVIEW OF THE LITERATURE

Comprehending text is important for all students (Mastropieri & Scruggs, 2007). The impact of understanding content read or heard can improve the quality of life for students both in and out of school (Conley, 2007; Downing, 2005; Morgan et al., 2011). Advances in technology can increase opportunities for students to access a variety of texts, including expository e-texts. Combining research-based practices for teaching students to comprehend text with technology supports may increase the listening comprehension of students with severe disabilities. This chapter reviews the literature on technology, comprehension, science, and systematic instruction for students with disabilities.

Technology Supports

The percentage of students who use computers regularly in school has been climbing steadily over the past three decades. According to the National Center for Education Statistics (NCES), the total percentage of school aged students who used computers in the school setting jumped from 59% in 1993 to 83.5% in 2003. Recently, in 2009, computers were located in 97% of classrooms for school aged students, and 93% of the computers in these classrooms were connected to the Internet. Forty percent of teachers reported students used computers in school "often," and 29% of teachers reported students used computers in school "sometimes." The integration of an influx of new and changing technology can be problematic for teachers (Mishra & Koehler, 2006).

Mishra and Koehler (2006) suggested a theoretical framework for understanding the knowledge teachers should have if they are to effectively integrate technology into their practice. Technological Pedagogical Content Knowledge (TPACK) is a theory that expanded the preexisting theory of Pedagogical Content Knowledge (Shulman, 1986), which described the combined effects of pedagogical knowledge and content knowledge on teacher performance. TPACK adds a third element to this construct, technological knowledge. The extent to which a teacher effectively understands and uses classroom technology is dependent on the degree to which there is overlap among the three components (technological knowledge, pedagogical knowledge, and content knowledge; Mishra & Koehler, 2006). While nearly all students in typical school settings have access to technology throughout each school day, these statistics are not representative of the ability of teachers to effectively use the technology (TPACK). Additionally, the prevalence of technology does not typically extend to students with intellectual disability, who experience disproportionate use of computer and Internet technology (Edyburn, 2013).

In 2004, Wehmeyer, Smith, Palmer, and Davies conducted a review of literature to identify studies in which students with intellectual disability were using technology to learn skills. Despite the ubiquitous use of technology, such as computers, by students without disabilities, students with disabilities are far less likely to access or learn from the use of technology (National Center on Educational Statistics, 2001). Wehmeyer et al. identified reasoning, production of ideas, and cognitive speed as possible barriers for students with intellectual disability to benefit from the use of technology. The authors suggested certain features of technology that may help mediate these barriers. These features include: (a) the use of visual examples paired with e-text, (b) embedded auditory content, (c) providing visual supports to help students locate information using technology (e.g., making display elements salient by enlarging buttons on a screen or providing visual cues for navigation), and (d) including mechanisms to adjust the rate of audio feedback and allow for repetitions of material. Wehmeyer et al. identified over 20 studies in which technology was used to teach skills to students with intellectual disability in an educational setting. The academic skills included, handwriting, telling time, word recognition, addition, and subtraction. Most of the participants in these studies had mild intellectual disability. In contrast, Langone, Shade, Clees, and Day (1999) discovered that the use of multimedia technology increased the matching skills of students with moderate and severe intellectual disability.

Several other literature reviews support the use of technology to teach skills to students with disabilities. Hall, Hughes, and Filbert (2000) found 17 studies in which computers were used to teach English Language Arts skills to students with learning disabilities. The most common skills taught in these studies included word recognition and comprehension. None of the studies included participants with intellectual disability. Pennington (2010) conducted a review to examine literature in which computer-assisted instruction (CAI) was used to teach academic skills to students with autism spectrum disorder (ASD). Pennington identified 15 studies in which CAI was used to teach students with ASD, but only five of these studies demonstrated a functional relationship between the intervention (CAI) and improved learning outcomes. In a similar review, Knight, McKissick, and Saunders (2013) broadened the scope of literature by identifying studies in which technology-based interventions were implemented to teach academic skills to students with ASD. In this review, Knight, McKissick et al. identified 25 studies meeting their search criteria. Only three of these studies met criteria for design quality. Similar to Pennington's findings, the majority of these studies used CAI to teach academics.

One additional literature review examined the use of iPads™ to teach students with ASD or intellectual disability. Kagohara et al. (2013) examined literature in which these devices were used as an instructional tool. The authors identified 15 studies meeting inclusion criteria. Within these studies, iPods™ and iPads™ were used to (a) teach content, (b) teach the steps to use a technological device, or (c) teach the steps for students to access another target stimuli. The results of the majority of the studies suggested the use of iPods™ and iPads™ can be effective tools for teaching skills to students with ASD or intellectual disability.

Accessing and learning from the Internet. The Internet has become prevalent in modern daily life, and accessing information via the Internet is a skill most people readily learn to do independently during childhood. People with disabilities, particularly intellectual disability, may encounter barriers that prevent them from accessing information on the Internet with ease. Zisimopoulos et al. (2011) examined the effects of using video prompting and systematic instruction to teach students with intellectual disability to search the Internet for information related to a corresponding history lesson. Using a multiple baseline across participants design, the authors used time delay with a video model to teach the steps from a task analysis for accessing the Internet. The participants, three students with moderate intellectual disability in the 5^{th} or 6^{th} grade, all demonstrated an increase in the number of steps performed independently across phases.

Additionally, participants generalized these Internet access steps to other environments around the school (e.g., the student computer lab).

One limitation of the Zisimopoulos et al. (2011) study is participants did not learn academic content. Another study by Okolo, Englert, Bouck, Heutsche, and Wang (2011) investigated the effects of using the Internet to move beyond only access. In this exploratory study, the authors created a Web-based learning environment (i.e., the Virtual History Museum) in which they compiled various online media related to thematic units in history. Participants were middle school students with disabilities (including one student with a mild intellectual disability), students without disabilities, and honors students. Teachers modeled how to access and navigate the Virtual History Museum in order to view online artifacts (articles and images) related to a history topic. While viewing Web-based artifacts, participants developed and used graphic organizers to compare and contrast key events in the history related to the unit. Using pretest, posttest measures, the authors examined participants' understanding of key concepts, factual knowledge, and written positions before and after use of the Virtual History Museum. All students made gains in comprehension of key concepts and factual knowledge, and the gains made by students with disabilities were commensurate to those without disabilities. These findings indicate students with disabilities may benefit from the use of Web-based learning tools specific to grade aligned content including content presented via electronic texts.

Supported electronic text (e-text). Electronic texts (e-texts) enhance print-based curricula through technology. E-texts include electronic books (e-books), documents, articles, newspapers, and any other form of digital text that is read using a computer or digital reader (e.g., iPod™, iPad™, Kindle™; Anderson-Inman & Horney, 2007). E-books are forms of e-texts that have three different components: (a) an e-book file, (b) software to read the e-book, and (c) a hardware device for reading the e-book (e.g., computer, digital reader, Cavanaugh, 2002). Teachers can develop e-books using Microsoft PowerPoint™ (Rhodes & Milby, 2007). Additionally, many e-books are available through Web sites on the Internet. Usually pages are displayed individually to simulate a book in typical print. E-books, like other e-texts, often have capabilities teachers can use to embed accommodations or supports prior to using the book for instruction. Some e-texts have advance organizers or note-taking capabilities. Supported e-text provides students with disabilities access to a broad range of grade-aligned information. Specifically, supported e-texts are developed to promote comprehension and content area knowledge. Electronic texts are embedded with additional supporting media to enhance comprehension of the overall concepts of the material. Supported e-texts are also infused with structural supports that increase access and understanding. For instance, text-to-speech capabilities (Leong, 1995), highlighting key words, embedded vocabulary definitions, and graphic organizers are all supports that can be embedded in supported e-text.

The National Center for Supported Electronic Text (NCSeT, 2009) at the University of Oregon (Anderson-Inman, 2009), is a research center in cooperation with the U.S. Department of Education, Office of Special Education Programs (OSEP). The four primary purposes of the research initiatives directed by NCSeT include identifying: (a) the characteristics of supported e-text that promote or hinder both access and learning of academic content; (b) the capacity with which supported e-text improves learning of academic content in a typical educational environment; (c) student characteristics that impact the effectiveness of supported e-text; and (d) environmental factors that impact the effectiveness of supported e-text. NCSeT funded four research teams to investigate this research agenda across a range of disability groups. The work of two of these teams (Clay, Zorfass, Brann, Kotula, & Smolkowski, 2009; Douglas, Ayres, Langone, Bell, & Meade, 2009) is especially relevant for students with moderate intellectual disability.

Clay et al. (2009) compared the effects of different supports added to e-text on the comprehension of social studies concepts and content vocabulary. The participants were 212 students in middle school with and without disabilities. Treatment and comparison groups read the same e-texts during the two phases of the intervention. Students in the treatment condition read supported e-texts with a visual thesaurus, a feature embedded into the e-text that provides students with a field for typing an unknown word. When students search for a word, a visual array of responses appears on the screen as a semantic web, including definitions, synonyms, and antonyms. The student also receives hyperlinks to visual images on the Internet that illustrate the meaning of the word or concept. Students in the control group were directed to use an online dictionary (Merriam-Webster Online), which is not embedded into the e-text, did not provide results as a semantic web, and did not include illustrative picture supports. Results from an ANCOVA, which controlled for difference in students' pretest scores, revealed no statistical difference between the two types of supports (visual thesaurus or Merriam-Webster Online), though students in both groups scored significantly higher on posttest assessments, indicating both supports were effective (p<.001). The authors suggested these findings indicate there is utility in using a variety of comprehension supports.

Douglas, Ayres, Langone, Bell, and Meade (2009) conducted a series of six alternating treatment, single-case experiments to evaluate specific supported features of e-texts with students with moderate intellectual disability. First, Douglas et al. investigated the effects of digitized speech and video supports on the listening comprehension of high school aged students with moderate disabilities. The authors used leisure-reading material (i.e., adapted e-text versions of *Harry Potter and the Sorcerer's Stone*; Rowling, 1998). E-texts were created using Microsoft PowerPoint, and treatment conditions alternated between the presence and absence of a video clip from the film inserted prior to listening to the e-text each session. Student comprehension was measured by retelling activities and responses to multiple choice comprehension questions, each presented with an array of three response options. The data indicated neither the presence nor absence of video clips affected student ability to retell the story or answer comprehension questions.

Second, Douglas et al. (2009) examined the effectiveness of text highlighting and text-to-speech (TTS) supports. TTS is computer generated voice output that provides a vocalized reading of an electronic file (e.g., Microsoft Word documents, PDF files, e-texts). TTS software has been used primarily to assist students with mild disabilities, including learning disabilities and attention disorders (Elkind & Elkind, 2007). Specifically, a body of research supports the use of TTS to aid in reading speed (e.g., Elkind, 1998; Hecker, Elkind, Elkind, & Katz, 2002), reading endurance (Elkind, Cohen, & Murray, 1993), comprehension (Disseldorp & Chambers, 2002; Montoli & Lewandowski, 1996), sustaining attention (Hecker et al., 2002), and writing (Raskind & Higgins, 1995). Research on the use of TTS for students with severe disabilities is only beginning to emerge. Douglas et al. measured students' ability to read words in the supported e-text and retell events from the story passages. The e-texts were written by the authors and based on life skills and social skills topics. The participants, eight students with moderate intellectual disability from middle school and high school, made gains in measures of comprehension in both conditions (with highlighted TTS or without highlighted TTS), indicating students could gain comprehension skills with TTS, inconsequential of the use of text highlighting. The authors hypothesized that highlighting may still be a beneficial support, noting a limitation in the study was the lack of explicit instruction students received regarding attending to highlighted words.

In a third study, Douglas et al. (2009) used an alternating treatment design to evaluate the effects of repeated readings on e-texts supported with both TTS and highlighting. Again, in this study, students made commensurate comprehension gains in both conditions (with or without repeated readings). The authors concluded the use of repeated readings for e-texts may not be a necessary support for this population.

In addition to the research coming from Douglas et al. (2009), Ayres, Langone, Douglas, Mead, and Bell (2008) conducted a study examining the effects of multiple supports on students' ability to comprehend written directions. Eleven students with moderate intellectual disability participated in this study. Students were provided simple directions to tasks presented using PowerPoint. Each set of directions was paired with one of three supports (a) audio, (b) photographic, or (c) video. A fourth comparison group used e-texts without any of the three supports. Results indicated that students who used e-texts with video and audio supports had the greatest gains in comprehension measures.

Based on the findings that visual and audio supports increased comprehension, Douglas, Ayres, Langone, and Bell (2011) conducted a study to examine the combined effects of these supports and use of a graphic organizer on the comprehension of middle school students with moderate intellectual disability. Using a multiple probe across participants design, the authors examined the effect of the supported e-texts of recipes with pictorial graphic organizers on students' responses to questions related to the recipe procedures and ingredients. Results indicated a functional relationship between the pictorial graphic organizer used in conjunction with the supported e-text and comprehension of functional texts.

Findings from all six studies in this small body of research (i.e., Ayers et al., 2008; Douglas et al., 2009, 2011) indicate the use of supported e-texts presented on a computer support the listening comprehension of students with moderate intellectual disability. Specific supports with positive results include TTS, pictorial supports, and the combined use of graphic organizers. This particular line of research was limited to teaching functional life skills content to this population of students.

To date, only one team of researchers has examined the effects of e-text supports on the academic comprehension of students with moderate intellectual disability. Coyne et al. (2012) used technology to promote comprehension of electronic storybooks. The authors developed four narrative e-books for use in this study, two fantasies, one folktale, and one fiction. Supports included digitized voice output with synchronized text highlighting, pictorial supports, and embedded video clips. Nine teachers and 23 students in grades kindergarten through grade 2 participated in this study. An experimental pretest/posttest design was used. Results from an ANCOVA, which controlled for pretest scores across students, indicated the students who received the supported e-book treatment condition had statistically significantly higher scores on outcome measures than students in the control group. Students with significant intellectual disability had increased text comprehension compared to students who did not receive the technological supports.

Digital readers. Students can access supported e-texts on laptop or desktop computers or on hand-held digital readers, such as a Kindle™ (Amazon, www.amazon.com), Nook™ (Barnes & Noble, www.barnesandnoble.com), or iPad™ (Apple, www.apple.com/ipad). Larson (2010) conducted the only research to date investigating the effects of e-texts presented on a digital reader (i.e., Kindle™) on students' ability to generate and answer comprehension questions. Larson conducted this research in a second grade classroom with students without disabilities. The students listened to narrative stories on the Kindle™ using text-to-speech software. Comprehension was informally measured by counting the number of notes students generated while listening to the story. Larson categorized responses as comprehension, making personal connections, or generating questions. Students created a variety of notes throughout the study in all three categories.

Digital readers are used in a variety of ways to teach individuals with developmental disabilities. A recent literature review examined studies that involved iPads™ and students with autism spectrum disorder or intellectual disability. Kagohara et al. (2013) identified 15 studies that met the search criteria. Of these studies, only one was used to teach academic skills to this population of students. Kagohara, Sigafoos, Achmadi, O'Rielly, and Lancioni (2012) used video modeling delivered on an iPad™ to teach the steps for using the spell-check function of a word processor on a computer to students with ASD who were 10 to 12 years old. Results indicated this iPad™ delivered intervention was effective in increasing the students' correct use of the spell check function on the computer.

Kagohara et al.'s (2012) findings suggest iPads™ can be used as instructional tools to deliver supports that promote access and learning on other devices (i.e., classroom computers). In another recent study, Hart and Whalon (2012) used video self-modeling delivered on an iPad™ to increase comprehension and responses during science class for a high school student with moderate intellectual disability. Results indicated daily use of the iPad™ to view video reminders of on-task behaviors and task analyzed steps for responding to questions related to science increased the participant's frequency of correct, unprompted responses to science questions presented on a computer.

Apps on iPads™ have also been used to support learning for students with severe disabilities (More & Travers, 2012). Ahlgrim-Delzell, Browder, Wood, Kemp-Inman, & Preston (2014) conducted a randomized control study to examine the effects of a phonics curriculum delivered via the GoTalk NOW app on an iPad2™. GoTalk NOW is a communication app that allows users to select buttons to produce speech output using prerecorded speech or TTS. Video footage, photographs, and images from the Internet or GoTalk NOW virtual library can all be uploaded in the buttons on the app. By choosing different settings when developing communication pages using the GoTalk NOW app, students can select choices from an array of one item to 25 items. Students in both the experimental and the control group used material presented on the GoTalk NOW app on the iPad2™.

Summary of findings. Teaching students Internet access alone does not necessarily promote comprehension. Only when opportunities for response and engagement are included will learning likely occur (Boone & Higgins, 2003; Rose, Hasselbring, Stahl, & Zabala, 2005). Advances in technology offer promising implications for promoting both access and learning for students with disabilities. Several important findings should be noted from the small body of literature related to technology, academics, and students with moderate intellectual disability. First, students with moderate intellectual disability have learned to use computers for academic tasks. Using video supports, students learned the steps to (a) find academic content on the Internet (Zisimopoulos et al., 2011), and (b) use computer embedded supports (e.g., spell check; Kagohara et al., 2012). Another theme in the research is the use of e-texts to comprehend information. Ayers et al. (2008), Douglas et al. (2009), and Douglas et al. (2011) all taught secondary students with moderate intellectual disability to use supported e-texts to comprehend texts related to leisure or functional life skills. Additionally, the authors identified specific supports that supplement learning via e-texts (i.e., TTS, visual supports, auditory supports, graphic organizers). Two studies applied technology to interventions that taught students with moderate intellectual disability the skills needed to comprehend academic content. Okolo et al. (2011) taught students to access and comprehend social studies content from a Web-based program on the Internet. Coyne et al. (2012) used a UDL framework to teach students with moderate intellectual disability to comprehend e-text storybooks. Finally, two studies support the use of iPads™ to teach skill sets needed to perform academic tasks. Kagohara et al. (2012) used an iPad™ to teach students with moderate intellectual disability the steps to use spell check on a desktop computer, and Hart and Whalon (2012) used an iPad™ to teach students how to respond to comprehension questions in science class. Within the growing body of research on using technology to support the learning needs of all students is an inchoate but promising literature base for the application of these technologies to support comprehension of academic content for students with moderate intellectual disability.

Combining these technologies may further increase the complexity of tasks that students with disabilities learn to perform independently. The GoTalk NOW app has the capabilities to be used as a graphic organizer. Students can select desired buttons and construct full sentences. Picture and audio supports can be embedded in these graphic organizers. By using the jump-to-page feature, certain buttons (i.e., science topics) can be linked to specific, related pages (i.e., three column templates for generating a question based on the selected topic). Using graphic organizers to generate questions, students may be better prepared to answer comprehension questions about an online e-text presented on a laptop or desktop computer.

Comprehension

As described in Chapter 1, comprehending text is an important skill for all students to learn. Comprehension is an essential component of being literate. Although the skill of reading is considered a complex task, the simple view of reading (Gough & Tumner, 1986; Hoover & Gough, 1990) is that the skill of reading for understanding consists of only two primary factors: (a) the ability to decode or recognize words, and (b) the ability to comprehend language (i.e., listening comprehension). According to this model, reading is the product of these two factors (i.e., reading = decoding x listening comprehension). If an individual entirely lacks either decoding skills or listening comprehension skills (i.e., if decoding skills = zero or listening comprehension skills = zero), the product (reading) would mathematically equate to zero (i.e., 0 = factor x 0). In other words, both decoding and listening comprehension are, on their own, essential components to reading; in the absence of even one of these skills, reading cannot occur. Barth, Catts, and Anthony (2009) identified listening comprehension as a skill that gains importance as students become older. Fluency, the rate and accuracy with which one reads text, is impacted by one's proficiency with listening comprehension. Additionally, understanding language affects one's ability to distinguish between and comprehend various types of texts (e.g., narrative, expository). Similarly, Catts, Adlof, and Weismer (2006) described the importance of teaching listening comprehension across grade levels. According to Catts et al., students with poor reading comprehension skills often had deficits in language or listening comprehension as well. Students who are identified as having difficulty comprehending text in upper grades often did not demonstrate reading comprehension deficits in early grades. However, these students do demonstrate difficulty with listening comprehension skills across grade levels. Consequently, teaching students with severe disabilities listening comprehension skills may be one way, according to the simple view of reading, to develop one of the two necessary components of reading.

Another model addresses *how* to teach reading skills. Pearson and Gallagher (1983) developed the Gradual Release of Responsibility Model to demonstrate how teachers can transfer the process of understanding text from teacher lead to student lead. According to the model, teachers initially assume the responsibility of a student's comprehension of content by modeling and describing the processes necessary to understand text. In the next phase of the model, teachers work together with students as needed. In this phase students are encouraged to use cognitive processes independently, but teachers continue to provide supports and models for how to comprehend. In the final phase of the model, the teacher transfers this responsibility to the student by fading the level of supports available to the student. Now the student is able to independently engage in comprehension activities. Through this transfer of responsibility, students develop the skills to be proficient thinkers, and they gain the processing skills necessary to use comprehension strategies to understand text. One comprehension strategy that teaches students to identify the relatedness between questions, text, and prior knowledge is question-answer relationships (QAR; Raphael, 1982). Teachers can apply the Gradual Release of Responsibility model to teach students the concept and application of QAR. Essentially, through modeling, guided practice, and independent practice, students can learn how to determine how to locate or develop answers to questions (R. Vacca et al., 2011). For instance, answers to questions can be found in the text or not in the text. Determining how to locate or develop an answer is a skill that can increase a student's capacity to read independently. According to Harvey and Goudvis (2000), the value of learning comprehension strategies is just as important as the learning the content of the text. Teaching students with severe disabilities to think critically and independently use comprehension strategies may improve their ability to succeed in a literate world.

Berkeley, Scruggs, and Mastropieri (2010) conducted a meta-analysis of comprehension for students with mild disabilities and identified 40 studies that met inclusion criteria. The interventions with the largest effect sizes included reading instruction based on fundamental literacy skills, text enhancement, and questioning strategies. In contrast, a review of literacy interventions conducted by Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) identified comprehension as a skill not often taught to students with moderate and severe disabilities. While much is known about teaching comprehension to students with mild disabilities, far less is known about teaching comprehension skills to students with moderate or severe disabilities. Outcomes from a small body of studies (e.g., Browder, Lee, & Mims, 2011; Hudson & Browder, 2013; Shurr & Taber-Doughty, 2012; Wood et al., 2014) suggest teaching question answering and question generating may be effective ways to promote comprehension for students with moderate and severe disabilities.

Question answering. The most common way to test comprehension of students with moderate or severe disabilities is to ask questions about text. Typically, for this population of students, a teacher reads a text aloud, asks literal, text-dependent questions, and presents three or four response options. This multiple choice style response provides students with severe disabilities with word or picture choices to consider and select. Students can point to, look at, or vocalize a response. Reis (1986) conducted a study to examine the effects of text read aloud on the listening comprehension of students with mild disabilities and without disabilities. The text, questions, and response options were all presented orally to students, and questions measured students' knowledge of the main idea, major events, characters, and implied content (i.e., information that required inference). Students were assigned to one of four conditions. Students in the first condition received supplemental content information (e.g., descriptive information about the characters). Students in the second condition received supplemental information about the purpose of the story (i.e., prompts to listen for key events). Students in the third condition received both supplemental content information and information about the purpose of the story. The third condition was a control group, in which students did not receive any supplemental information. A significant main effect occurred for treatment ($F[3, 112] = 9.49$, $p < .01$), group ($F[1, 112] = 132.73$, $p < .01$), and questions answered ($F[2, 224] = 122.06$, $p < .01$). Students without disabilities answered more questions correctly than students with disabilities, and students in the group who received the most amount of supplemental information performed better overall than students in any of the other conditions. The results of this study suggest providing students with supports (i.e., information related to the text) may increase listening comprehension for students with and without disabilities.

Question answering during read alouds. Shurr and Taber-Doughty (2012) extended these findings by presenting students with severe disabilities with supplemental information prior to reading texts aloud to students. Specifically, as described in Chapter 1, Shurr and Taber-Doughty, tested a method intended to increase the listening comprehension of students with moderate intellectual disability. The authors taught students in middle school to comprehend grade-aligned texts by providing picture supports and engaging students in conversations about the pictures from the text prior to reading to the text to the students. After listening to the text, students were asked five multiple-choice comprehension questions. Three possible response options (one target response and two distractors) were developed for each question. The interventionist read questions and response options aloud, and students selected a response by saying or pointing to the answer. Picture supports were not used to supplement the text in the questions or response options. In this study, visual and discussion based intervention resulted in increased comprehension scores across all four participants.

Browder et al. (2007) taught teachers to implement a read-aloud using a 25-step task analysis to students in middle school with intellectual disability. Browder et al. (2007) also measured student responses to each component of the task analysis. One of the measures included listening comprehension. Teachers embedded comprehension questions either throughout the story or at the end of the story. Teachers asked questions out loud, and students were initially given an opportunity to respond to the answer by pointing to the answer on the page. All answers were embedded in the adapted text and represented by both a word and picture symbol. All six participants improved in the percent of independent correct responses to comprehension questions from baseline to intervention. Since the findings of Browder et al. (2007), several other studies have examined the effectiveness of read-alouds to promote listening comprehension for students with moderate and severe disabilities (Browder, Lee, & Mims, 2011; Browder, Mims, et al., 2008; Hudson & Browder, 2013; Hudson et al., in press; Hudson & Test, 2011; Mims et al., 2009; Mims et al., 2012; Spooner, Rivera, Browder, Baker, & Salas, 2009). These read-aloud studies will be reviewed in detail later in this chapter in the section on systematic instruction.

Question generating. Question generating is a strategy used to improve text comprehension for students with and without disabilities. Mastropieri et al. (1996) conducted a literature review of studies that taught specific comprehension strategies to students with or without disabilities. Mastropieri et al. identified 82 studies that met inclusion criteria, and the studies in which question generating was taught as the intervention had the highest effects on student comprehension scores. Rosenshine et al. (1996) conducted a review to look specifically at studies in which question generating was used to teach comprehension to students with mild disabilities or without disabilities and identified 26 studies that met their search criteria. Rosenshine et al. examined effect sizes to determine the effectiveness of the question generating strategy. The overall median effect size was 0.36 for standardized measures and 0.86 for experimenter-developed comprehension assessments, indicating question generating had overall positive effects on the comprehension skills of students in these studies.

Faggella-Luby, Schumaker, and Deshler (2007) compared the effects of Embedded Story-Structure (ESS) routine and the Comprehension Skill Instruction (CSI) on students in high school with learning disabilities and without disabilities. The ESS routine included three phases: (a) Teach students to generate questions prior to reading a text, (b) teach students to analyze story-structure while reading a text, and (c) teach students to summarize a text after reading. CSI was the control condition, and also included strategies presented before, during, and after the text was read. Prior to reading the text, students learned key vocabulary words. While reading the text, students learned about question and answer relationships. After reading the text, students were taught to use semantic summary maps to describe the main events in the text. Analysis of the data indicated a statistically significant difference between the groups, with students in the ESI group making the greatest gains in reading comprehension, $t(60.5) = -15.9$, $p < .001$, $d = .738$. For students in the ESI group, both students with and without disabilities made statistically significant gains in measures of use of strategies and reading comprehension.

While Faggella-Luby et al. (2007) taught students to improve comprehension of texts read independently, Manset-Williamson, Dunn, Hinshaw, and Nelson (2008) compared the effects of a self-questioning strategy on the comprehension of expository texts read to students via text-reader software presented on a computer. Six upper-elementary and middle school students with reading disabilities participated in this study. The text-reader software included the embedded supports of text-to-speech technology and text highlighting. To teach students to generate questions, students in this study were prompted to read the first sentence in a paragraph, generate one question that might be answered from reading that paragraph, and then (after listening to the paragraph via the text reader) determine if the question could be answered or not. Results from this study indicated students who received the question generating instruction prior to listening to books on a text-reader improved in their ability to answer comprehension questions.

Similarly, Bulgren, Marquis, Lenz, Deshler, and Schumaker (2011) measured the effects of teaching students a questioning strategy on the comprehension of expository texts. The participants in this study were in high school; students had learning disabilities, other health impairments, or no disabilities. One notable addition to this study was the use of a graphic organizer. Bulgren et al. taught students to use a graphic organizer designed to prompt students through the questioning process. A counterbalanced experimental design was used in which participants were randomly assigned to one of two groups. Each group received instruction under each condition, questioning and comparison (i.e., lecture). Results indicated students in the experimental group performed significantly better than students in the comparison group on literal recall, $F(1, 5.7)$ –

27.8, $p = .002$, ES = 1.42, and inferential test questions, $F(1, 10.2) = 18.7$, $p = .001$, ES = 1.16, for both instructional units.

Berkeley, Marshak, et al. (2011) also used a graphic organizer to teach students to generate questions about expository texts. Berkeley, Marshak, et al. investigated the effects of a question generating strategy on the comprehension of students in middle school without disabilities, with learning disabilities, with hearing impairments, and with other health impairments. Instruction occurred in an inclusive history classroom. Using a pretest posttest experimental design, the authors compared the effects of the question generating strategy and typical classroom instruction on the multiple choice and open-ended responses to comprehension tests. Results indicated a significant main effect for condition in favor of the question generating condition for both multiple choice responses $t(55) = 3.40$, $p = .001$, and open-ended responses, $t(55) = 5.96$, $p < .000$.

Question generation with students with moderate/severe disabilities. Wood et al. (2014) examined the effects of using systematic instruction to teach students to generate questions using a graphic organizer. In this study, elementary aged students with moderate intellectual disability listened to a grade-aligned social studies text read aloud by their special education teacher. Prior to listening to the story, students were taught to generate one question about the text using words from the heading using a question word template presented on a graphic organizer. The teacher described pictures from the text to provide context to the students. Teachers also modeled how to combine words from the heading with question words to form a complete question. Students were taught to listen for the answer to their question while the teacher read the text. After listening to the text read aloud, students were asked if they could answer the question they generated. If the answer to the question was in the text, students were asked to provide the answer. All students improved in their ability to generate and answer questions about the expository text. To date, this is the only study that focused on teaching students with moderate/severe disabilities to generate questions.

Summary of findings. Asking students questions is a common educational strategy for teaching and assessing comprehension for students with and without disabilities, including students with moderate intellectual disability. In the studies in which students were asked questions by an adult (Browder et al., 2007; Reis, 1986; Shurr & Taber-Doughty, 2012), students were given supporting materials or instruction prior to listening to a story read aloud. In the Reis (1986) study, students heard and saw supporting information about specific story content and key events. Shurr and Taber-Doughty (2012) used visual supports and verbal discussions to support comprehension prior to reading the stories aloud to students. Browder et al. (2007) trained teachers to ask students probing (i.e., prediction) questions, engage the student in parts of the book (i.e., orienting the book, finding the title, finding the author) or text (i.e., making a prediction, text pointing, reading the repeated story line, identifying key vocabulary terms). One difference is in the Reis study; students were shown or told information. In the Taber-Doughty and Browder et al. studies, students actively engaged in a prereading activity. In all three studies, students' listening comprehension improved. The findings of these studies suggest providing students with intellectual disability a prereading activity related to the text may improve their ability to answer questions about a text.

Teaching students to generate questions is a prereading activity that has been used in the literature typically with students without disabilities or with mild disabilities. In each of the studies described, students who received instruction in generating questions gained comprehension skills (Berkeley, Marshak, et al., 2011; Bulgren et al., 2011; Faggella-Luby et al., 2007; Manset-Williamson et al., 2008; Wood et al., 2014). In the studies in which question generating was compared to comprehension instruction that did not include question generating, students who generated questions performed better in measures of comprehension. Three studies (Berkeley et al., 2011; Bulgren et al., 2011; Wood et al., 2014) taught students to generate questions using a visual model presented on a graphic organizer. Only one study, Wood et al. (2014), examined the effects of using a question generating and a graphic organizer to teach comprehension of expository texts to students with moderate intellectual disability. The use of technology in the Manset-Williamson et al. (2008) study suggests students with mild disabilities can generate and answer questions related to a text presented on a computer, an implication that also may extend to students with moderate intellectual disability.

Science

Comprehension is an essential skill for all areas of the school curriculum. Students need to develop the ability to understand content from different subject areas in order to gain broad knowledge of the world. Text comprehension can be especially critical to students' ability to learn science. Since the publishing of *A Nation at Risk* by the National Commission on Excellence in Education in 1983, a national trend to improve students' understanding of science has developed, resulting in an influx of research focused on how to teach science. As modern technology continues to change and shape the job market and day-to-day life, students need to be equipped with the skills that will give them the capability to prosper in a scientific world. To address this need to improve science education for school aged students in the United States, the Committee on a Conceptual Framework for New K-12 Science Education Standards developed a framework that delineates the essential science skills all students need. These skills are intended to help students foster an appreciation for science, develop job-related skills based on scientific principles, gain knowledge of the different domains of science, and become critical consumers of scientific information both in and out of school (National Research Council, 2013).

To promote student achievement of critical scientific outcomes, the Committee on a Conceptual Framework for New K-12 Science Education Standards identified three primary dimensions of learning: (a) scientific and engineering practices; (b) scientific concepts that are applicable across other fields; and (c) core knowledge across the content areas of physical sciences, life science, earth and space sciences, and engineering, technology, and application of sciences. Within each dimension of the framework are subcategories. For instance, the first subcategory for scientific and engineering practices is asking questions. According to the framework, the ability to ask questions is a skill that will promote scientific understanding and proficiency. Collectively, this framework provides the conceptual model for the development of the Next Generation Science Standards (NGSS), a set of performance standards intended to promote the application, not just basic recall, of science skills.

Historically, students with severe disabilities have not had access to the broad range of skills and content embodied by the NGSS. According to the results of a literature review conducted by Spooner, Knight, Browder, Jimenez, and DiBiase (2011), the science skills most frequently taught to students with severe disabilities include knowledge of science vocabulary and daily living or health skills that are linked to scientific principles (e.g., cooking). Although vocabulary is important, consistent with the NGSS framework, educators also should consider how to teach the scientific skills posing questions about scientific process or phenomena. Spooner et al. proposed inquiry skills should be the primary focus of science education for students with severe disabilities. The steps of scientific inquiry, according to Spooner et al., include: (a) ask a question, (b) make a prediction, (c) conduct an experiment to test the prediction, and (d) find answers to the question. When inquiry is the primary goal of science instruction for this population of students, teachers are helping students deepen their understanding of science content in a way that is personally relevant.

Spooner et al. (2011) examined the literature in which science content was taught to students with severe disabilities. Spooner et al. identified 17 studies meeting inclusion criteria. Of these 17 studies, only one study (Agran, Cavin, Wehmeyer, & Palmer, 2006) was identified in which the inquiry process was embedded in the instructional procedures. The authors further analyzed the identified literature to determine if systematic instruction is an evidence-based practice for teaching inquiry to students with severe disabilities. Derived from the R. H. Horner et al. (2005) criteria for determining evidence-based practices, and using the decision rules developed by the National Secondary Transition Technical Assistance Center (NSTTAC), Spooner et al. determined systematic instruction is an evidence-based practice for teaching science to students with severe disabilities.

Agran et al.'s (2006) study was the only example identified by Spooner and colleagues in which inquiry skills were taught to students with severe disabilities. Agran et al. taught three students with moderate and severe intellectual disability in middle school to engage in student directed learning (e.g., setting goals, self-monitoring) in order to increase access to the general curriculum. Science content was included as a portion of the content students accessed in this study. Agran et al. taught students to ask themselves questions to identify what they already knew about each topic. However, students were not generating questions about the content. Since the publication of Spooner et al.'s literature review, several more studies have examined teaching science inquiry skills to students with severe disabilities. While none of these studies taught students to generate questions, many of these studies used systematic instruction, technology, or graphic organizers to teach science content to students with severe disabilities.

Courtade, Browder, Spooner, and DiBiase (2010) taught teachers to deliver steps of a task analysis to teach inquiry skills to students in middle school with moderate and severe disabilities. In this study, students were asked to identify what picture or material they would like to learn about further. Students were presented with response options (science pictures or materials) that represented possible instructional topics. The teachers were trained to implement steps of a task analysis that (a) promoted student engagement in the science lesson, (b) required students to investigate and describe scientific relationships, (c) taught students to construct an explanation of the experiment, and (d) taught students to report findings. Teachers were trained to deliver a system of least prompts as needed to teach students the steps of the task analysis. All four teachers improved in the number of steps of the task analysis performed correctly following individualized training sessions. The number of inquiry skills completed independently by students during inquiry lessons also increased after the teachers were trained.

Knight, Smith, Spooner, and Browder (2012) taught science descriptors (e.g., cold) to students with ASD in elementary school. The authors taught students to generalize knowledge of the descriptors to untrained objects and pictures during an inquiry science lesson. Using multiple exemplar training (e.g., teaching students to recognize both examples and nonexample) taught in a model-lead-test format, students learned to select requested science descriptors. Students also learned to generalize skills to novel objects within science inquiry lessons.

In a similar study, Knight, Spooner, Browder, Smith, and Wood (2013) used systematic instruction with graphic organizers to teach the science concept of convection to students with ASD and intellectual disability. Special education teachers taught three students in middle school to identify science words and definitions related to convection using constant time delay. Next, teachers taught the concept of convection by training the understanding of the vocabulary words embedded in the concept using multiple exemplars. Finally, using a model, lead, test format, teachers taught and tested use of a graphic organizer to display and teach the scientific concept (e.g., Heated water causes evaporation). Knight, Spooner, et al. (2013) identified a functional relationship between the intervention and the number of correct steps students completed on the task analysis.

Smith, Spooner, Jimenez, and Browder (2013) demonstrated the effectiveness of using systematic instruction and graphic organizers to teach inquiry skills to a broader population of students with severe disabilities. Smith et al. examined the effectiveness of an early science curriculum for students with moderate and severe disabilities by evaluating the acquisition of science vocabulary and concepts across three elementary students with multiple developmental disabilities. The instructional procedures included teaching students to make and later evaluate a prediction about a related experiment or demonstration of a scientific concept. Similar to the Courtade et al. (2010) study, Smith et al. (2013) also collected data about the teacher's ability to implement the steps of the task analysis for teaching the inquiry lesson with fidelity. Teachers were trained to use constant time delay procedures to teach the steps of the task analysis, which included teaching students to complete a KWHL (i.e., K = what do you know?, W = what do you want to know?, H = how do you find out?, L = what did you learn?) graphic organizer. Additionally, a SMART Board™, an interactive whiteboard, was used to present material via a computer and digitized screen. The SMART Board™ was used to present a related science story. Students also selected a response by touching the SMART Board™ to make a prediction about the science experiment related to the story and to answer questions about the results of the experiment. The authors identified a functional relationship between the intervention and student acquisition of grade-level science content.

In another study in which technology was used to support instruction, Smith, Spooner, and Wood (2013) investigated the effects of embedded computer-assisted instruction (CAI) to teach science to middle school students with ASD. Students were trained by the interventionist to identify key concepts related to science content taught in inclusive science lessons. Using an iPad2™, students viewed slides that modeled and taught identification of words and concepts such as mitosis and chromosome. Students viewed the instructional slide show presentation on the iPad2™ three times during each inclusive science lesson. The 12-slide presentation was presented to students during natural breaks in the lesson (e.g., transitioning to new activities). Three science terms were trained during each instructional session. Results of the study showed a functional relationship between the CAI on the iPad2™ and the number of assessment items correctly answered.

Jimenez, Browder, Spooner, and DiBiase (2012) also demonstrated the effectiveness of using graphic organizers to teach science skills to students with moderate intellectual disability. Jimenez et al. used peer-mediated time delay instruction to teach inquiry science skills to five students in middle school with moderate intellectual disability. Six peers from a general education class were trained to embed constant time delay across three science units. The intervention occurred in a general education classroom during daily science lessons. The general education teacher conducted whole class inquiry-based science lessons, which included the use of a KWHL graphic organizer. After students read a science passage, the teacher asked students to recall what they already knew about the related science topic. The teacher recorded student responses on the graphic organizer (KWHL chart). After conducting science experiments related to the target science topics, students were asked to report what they had learned from the experiments. Students with disabilities participated in the inquiry science lesson. Additionally, the participants received peer delivered instruction in related science vocabulary and concepts. Peers also taught participants use of the KWHL graphic organizer. Systematic instruction (i.e., constant time delay) was used to teach both vocabulary words and concepts and use of the graphic organizer. Results indicated a functional relationship between the peer-mediated embedded systematic instruction and the number of correctly identified vocabulary words and concepts. The intervention was also effective in increasing the participants' number of independent correct responses on use of the graphic organizer.

One final study does not fit the description of an inquiry-based science lesson, but findings from this study still contribute to the literature on teaching comprehension of science content to students with severe disabilities. Hudson et al. (in press) demonstrated the effectiveness of teaching listening comprehension of science texts. The authors examined the effects of peer-delivered system of least prompts package and academic read-alouds on the listening comprehension skills of students with moderate intellectual disability. Hudson et al. adapted grade-aligned science and social studies texts for use in the intervention. The texts were adapted to match the comprehension level of the participants (approximately a second grade listening comprehension level). Picture supports were paired with key vocabulary words in the texts. Fourth grade peers were trained in the delivery of read-aloud procedures and systematic instruction to teach listening comprehension. Peers delivered a system of least prompts procedure when a participant was unable to answer a comprehension question related to the adapted text. Results indicated the system of least prompts was an effective instructional method for teaching listening comprehension of grade-aligned science for three participants with moderate intellectual disability.

Summary of findings. These seven studies (Courtade et al., 2010; Hudson et al., in press; Jimenez et al., 2012; Knight et al., 2012; Knight, Spooner, et al., 2013; Smith, Spooner, Jimenez, et al., 2013; Smith, Spooner, & Wood, 2013) provide promising evidence that students with severe disabilities can learn inquiry-based skills and comprehension of science content. Several characteristics or themes are common across this body of studies. First, all of the participants in these studies were students with severe disabilities. Most of the studies (*N*=5) included students with moderate intellectual disability in either elementary school (Smith, Spooner, Jimenez, et al., 2013; Hudson et al., in press) or middle school (Courtade et al., 2010; Jimenez et al., 2012; Knight et al., 2012). Second, in most of the studies, special education teachers implemented the intervention (Courtade et al., 2010; Knight, Spooner, et al., 2013; Smith, Spooner, Jimenez, et al., 2013). In other studies, the intervention was implemented by either a researcher (Knight et al., 2012; Smith et al., 2013) or a trained peer (Jimenez et al., 2012; Hudson et al., in press). Third, in nearly all of the studies (*N*=5), the interventionist followed discrete steps of a task analysis to teach the science intervention (Courtade et al., 2010; Hudson et al., in press; Jimenez et al., 2012; Knight, Spooner, et al., 2013; Smith, Spooner, Jimenez, et al., 2013). Of note, in three of the studies (Courtade et al., 2010; Smith, Spooner, Jimenez, et al., 2013; Jimenez et al., 2012), students were asked to generate a prediction or select a topic to further explore throughout the science lesson.

Third, all of the studies taught students grade-aligned science content. Three of the studies incorporated science texts as either a primary or supplemental element to the instruction. Smith, Spooner, Jimenez, et al. (2013) provided teachers with Wonder Stories to read aloud to students prior to conducting a related science experiment. These stories provided background information about the science topic and modeled the concept of wondering about scientific phenomena. Similarly, in the Jimenez et al. (2012) study, the general education science teacher read a science passage related to the inquiry experiment aloud to students before prompting them to state what they knew about and wanted to know about the lesson topic. Hudson et al. (in press) adapted grade-aligned science texts books and trained peers to read passages aloud to participants. Participants were tested on their listening comprehension of the science text.

Fourth, three of the studies used graphic organizers as instructional elements to support comprehension of science concepts. Knight, Spooner, et al. (2013) designed graphic organizers specifically to match the science concept of convection. The graphic organizer contained a visual representation of the process of convection and included spaces for students to label the parts of the process using trained vocabulary words. Different versions of the graphic organizer were developed using different visual representations of the process to promote generalization of the concept. Two of the studies used KWHL charts as an instructional component (Jimenez et al., 2012; Smith, Spooner, Jimenez, et al., 2013). Smith, Spooner, Jimenez, et al. (2013) trained teachers to ask participants to provide information to address the four components of the chart. Teachers recorded student responses and used the chart as a visual referent throughout the lesson. Jimenez et al. (2012) trained peers to teach participants to complete the KWHL charts independently. In all three examples, participants learned to use or contribute to the graphic organizers.

A fifth commonality shared by two of the studies (Smith, Spooner, Jimenez, et al., 2013; Smith, Spooner, & Wood, 2013) is the use of technology to supplement instruction. Smith, Spooner, Jimenez, et al. (2013) integrated SMART Board™ technology, and Smith, Spooner, and Wood (2013) used an iPad2™. In both studies, technology was used to present content and provide response options. Additionally, Smith, Spooner, Jimenez, et al. used the SMART Board™ as a response mode for student predictions about the related science experiment.

A final theme across all seven studies is the use of systematic instruction to teach science content or concepts. Two of the studies (Knight et al., 2012; Knight, Spooner, et al., 2013) used components of explicit instruction (i.e., model-least-test and multiple exemplar training) to teach science vocabulary and concepts. Two studies (Knight, Spooner, et al., 2013; Smith, Spooner, Jimenez, et al., 2013) used constant time delay as an instructional procedure. Knight, Spooner, et al. (2013) first taught students to identify science vocabulary and definition words using constant time delay before using multiple exemplars taught using model-lead-test to teach broader scientific concepts. Two studies (Hudson et al., in press; Courtade et al., 2010) used a system of least prompts to teach target skills. Courtade et al. (2010) trained teachers to deliver a system of least prompts to teach participants the steps of the inquiry-based science lesson, which included asking students questions about the science content. Hudson et al. (in press) trained peers to deliver a system of least prompts to teach participants how to answer listening comprehension questions related to science texts. In both studies, participants gained either knowledge of science content or proficiency in engaging in inquiry learning.

These seven studies provide compelling evidence that students in elementary school can learn comprehension of grade-aligned science content when instruction is delivered systematically, perhaps using a system of least prompts. Participants with moderate intellectual disability can learn to use a graphic organizer and technology to access and answer questions about science. Special education teachers are able to deliver inquiry-based instruction with high fidelity. Finally, the use of science texts, including texts presented via technology, which match the listening comprehension level of students with moderate intellectual disability, is an effective instructional component for delivering science content. Based on the evidence that students with severe disabilities can make predictions and articulate content they want to further explore, students may be able to generate questions related to science content to increase their comprehension of grade-aligned science.

Systematic Instruction

Systematic instruction is based on the principles of applied behavior analysis (ABA), which is one of the four domains of behavior analysis (Cooper et al., 2007). The science and application of behavior analysis is comprised of behaviorism, experimental analysis of behavior, ABA, and professional practices guided by the science of behavior analysis. The domain of ABA represents the branch of behavior analysis dedicated to the discovery of functional relationships between behaviors with social significance and related variables. Systematic instruction is the specific application of the principles of ABA to teach socially significant skills or content. Snell (1983) was probably the first to define systematic instruction as precise, replicable, instructional procedures based on research. Snell further described the importance of collecting and analyzing performance data in order to modify instruction to promote the acquisition, generalization, and maintenance of learned skills. Behavior analytic principles relate to the antecedent, behavior, and consequence (or three-term contingency) of a given behavior. The antecedent, or environmental factors or events that occur immediately prior to the target behavior, is synonymous with a stimulus. The behavior that follows the antecedent (or stimulus) also is known as a response. Consequences can either increase the likelihood that a behavior or response will occur again (reinforcer) or decrease the likelihood of that reoccurrence (punisher). Educators can use knowledge and application of this contingency (stimulus-response-consequence) to teach students a variety of social, functional skills, or academic skills.

For more than 60 years, systematic instruction has been predominantly used to teach community and daily living skills to individuals with disabilities (Spooner, Browder, & Mims, 2011). Examples of applied research date back to Fuller's (1949) classic study in which a young man was trained to raise his right arm through operant conditioning. Nearly two decades later, the first issue of the *Journal of Applied Behavior Analysis* (*JABA*) was published. This seminal issue included Baer, Wolf, and Risley's (1968) article delineating seven dimensions of ABA. The introduction of this journal marked the inception of a prolific outlet for the dissemination of research related to this science. Eight of the 10 articles published in this first issue described the use of systematic instruction to teach skills to individuals with disabilities. Following the introduction of *JABA*, many studies have been conducted in which behavior analytic principles have been used to teach individuals with disabilities through systematic instruction. For example, Miller and Test (1989) compared the effects of constant time delay and most-to-least intrusive prompts on the laundry skills of students with moderate intellectual disability. Recently, with a growing shift to teach grade-aligned content, several literature reviews have documented the strong evidence for using systematic instruction to teach academic skills to students with severe disabilities (Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009; Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Browder et al., 2006; Hudson et al., 2013; Morse & Schuster, 2004; Spooner, Knight, et al., 2011; Spooner, Knight, Browder, & Smith, 2012). These reviews include evidence for systematic instructional practices of time delay to teach sight word or vocabulary word acquisition (Browder, Ahlgrim-Delzell, et al., 2009; Browder et al., 2006), task analytic instruction to teach literacy skills (Hudson & Test, 2011), and time delay and task analytic instruction to teach both math (Browder, Spooner, et al., 2008) and science skills (Spooner, Knight, et al., 2011).

One literature review has examined the evidence of story-based lessons (or read-alouds) to promote literacy skills for students with extensive support needs (Hudson & Test, 2011). Hudson and Test (2011) identified 13 studies meeting inclusionary criteria and determined using task analytic instruction to teach story-based lessons is an evidence-based practice for teaching literacy skills to students with severe disabilities. In addition to task analytic instruction, the majority of the studies identified by Hudson and Test utilized systematic prompting and fading procedures to teach the steps within the task analysis. The most common types of systematic instruction used within this specific body of studies were constant time delay (to teach related vocabulary words) and a system of least prompts (to teach text comprehension).

Constant time delay. Constant time delay has been used primarily to teach discrete skills (Snell & Gast, 1981; Wolery et al., 1992). In a literature review by Wolery et al. (1992) authors identified 36 studies in which time delay was used to teach discrete skills to students with mild and moderate disabilities. There is a strong evidence-base for the use of time delay to teach discrete literacy skills (Browder, Ahlgrim-Delzell, et al., 2009). In a literature review of studies in which time delay was used to teach literacy skills to students with severe developmental disabilities, Browder, Ahlgrim-Delzell, et al. (2009) identified 30 studies that met search criteria. The most common application of time delay was to teach picture and word identification. For example, Jameson, McDonnell, Polychronis, and Reisen (2008) trained peers to teach vocabulary definitions to three students with significant disabilities in middle school. The content targets were selected to align to standards taught in inclusive settings attended by the participants with disabilities. Participants learned a selection of words related to health and visual arts. Using constant time delay procedures with a 3-s delay, peers taught all three students to identify target definitions. In another study, Browder et al. (2013) taught middle school students with moderate intellectual disability the definitions to WH question words using constant time delay. Students learned to pair the WH word with definition word (e.g., who / people) using a 4-s delay procedure. Knight et al. (2013) used constant time delay procedures to teach students to identify science vocabulary and definitions using a 5-s delay procedure. Similarly, Smith, Spooner, Jimenez, et al. (2013) used a 5-s time delay procedure to teach science vocabulary and knowledge of concepts statements to students with severe disabilities in elementary school. In all four studies, functional relationships were established between the use of time delay and the identification of words or definitions.

Some evidence suggests time delay is effective for teaching multistep tasks. Schuster et al. (1998) reviewed the literature in which time delay was used to teach the skills in a chained task. Schuster et al. identified 20 studies meeting search criteria. The majority of participants were between the ages of 12 and 18. At least one participant with moderate intellectual disability was included in the majority of the studies, and most studies occurred in self-contained classrooms in public schools. Adults delivered all instruction across the studies, and the most common instructional format was one-on-one instruction. In one recent example, students learned steps to a chained task that taught skills for using technology and accessing academic content (Zisimopoulos et al., 2011). Zisimopoulos et al. (2011) taught elementary students with moderate intellectual disability to complete steps of a 29-step task analysis for conducting an Internet search on a classroom computer. Using constant time delay procedures, Zisimopoulos et al. allowed participants 5 s to initiate a response and 30 s to complete a response before delivering the video model prompt. All three students demonstrated an increase in independently performed steps of the task analysis to use a classroom computer and locate grade-aligned academic content.

System of least prompts. A system of least prompts (also known as least intrusive or least-to-most prompting) is another prompting system with a strong evidence base for teaching skills to students with disabilities. A traditional application of the system of least prompts begins with a natural cue. If a student is unable to independently perform the skill after a brief wait time (e.g., 5-s delay), the interventionist delivers the least intrusive prompt from the hierarchy (typically a verbal prompt). If the student is still unable to independently perform the skill after another wait time, the next prompt on the hierarchy is delivered. Subsequent prompts may include model and then physical prompts. Doyle et al. (1988) identified 90 articles in which a system of least prompts was used to teach skills to students with severe disabilities.

In most of the research that used a system of least prompts, students learned functional skills. For example, Mechling, Gast, and Langone (2002) taught students with moderate intellectual disability, ages 9 to 17, sight word identification and comprehension of grocery store words. Using computer based video modeling and a system of least prompts, Mechling et al. taught students to read grocery aisle signs and locate items. Recent literature has explored the use of a system of least prompts to teach academic skills, including listening comprehension, to students with severe disabilities.

Browder, Mims, et al. (2008) used a system of least prompts that was modified to fit the specific needs of individual students with multiple disabilities. The three participants in elementary school all demonstrated inconsistent use of AAC devices and had profound intellectual disability. Browder, Mims, et al. taught teams of educators to convene prior to instruction and develop a custom-made task analysis and prompting system based on each student's individual needs. Teachers used a system of least prompts to teach all steps of the task analysis, including asking students to make a prediction prior to hearing the story and evaluate the prediction after hearing the story read aloud. To evaluate the prediction, teachers asked the participants, "What was this story about?" The prompting system used to teach the steps of the task analysis was based on the traditional verbal – model – physical level of prompts typically used in a system of least prompts. A functional relationship was established between teaching steps of the task analysis using the system of least prompts and increased student engagement in the literacy activity.

Two additional studies examined the application of a system of least prompts for teaching the steps of a story-based lesson task analysis to teach engagement and comprehension for students with the most severe disabilities. Mims et al. (2009) taught shared-stories to two participants with severe disabilities and visual impairments in elementary school. Researchers served as interventionists and used a system of least prompts to teach comprehension questions about the stories. Participants were given an object representing the target response and another option as a distractor, and both students demonstrated an increase in unprompted correct responses across three books.

Browder et al. (2011) extended this literature by examining the effects of a system of least prompts and read-alouds on the listening comprehension of three elementary students who had limited or no symbolic understanding. Several elements of comprehension were embedded in the task analysis for the lesson, including making a prediction, completing repeated story lines, and answer questions about the text. Teachers delivered instructional procedures, including the system of least prompts, which consisted of a standard verbal – model – physical prompt. Teachers inserted a 5-s wait time between delivery of the directional cues and the subsequent prompts. These three examples (Browder et al., 2008, 2011; Mims et al., 2009) all demonstrate the effectiveness of a system of least prompts procedure to teach listening comprehension of students with the most severe disabilities.

Spooner et al. (2009) extended this research on read-alouds and a system of least prompts by training paraprofessional to teach the steps of a task analysis for a read-aloud using a system of least prompts to a 6-year-old student with a moderate intellectual disability. In this study, the participant received instruction in both Spanish (her native language) and English. The stories selected for use in the study were related to the participant's culture. The paraprofessional delivered a system of least prompts procedure with a 5-s wait time to teach the student engagement and listening comprehension skills across three adapted texts.

Additional studies have extended the application of a system of least prompts by changing the traditional prompting level of verbal – model – physical to explicitly teach students the *process* of answering comprehension questions. Mims et al. (2012) modified the first prompt in the system of least prompts by inserting a reread prompt in which the portion of text containing the answer was read again to the student. Mims et al. (2012) also taught students a rule for answering WH questions as a component of the first level prompt. Students were told to listen to specific information related to the WH word used in the comprehension question. For example, for a "who" question, students were told, "When you hear *who,* listen for a *person*." Then the relevant portion of the text was reread to the student. In this study, students with moderate intellectual disability in middle school listened to grade-aligned biographies read aloud. Three of the four participants increased the number of comprehension questions answered correctly following instruction that included this modified system of least prompts.

Hudson and Browder (2014) also examined the effectiveness of the modified system of least prompts on the listening comprehension skills of students with moderate intellectual disability. Hudson and Browder extended the literature by reminding students of the WH rule prior to asking each questions. Additionally, response options were organized and presented by question type. For example, if a participant was asked a *where* question, the student would be presented with a response board with only *where* response options (i.e., the response options would all be places). The peer-tutor (the interventionist for this study) asked the comprehension questions and waited 4 s for the student to respond or ask for help. The prompting procedure used in this study was similar to the procedures developed by Mims et al. (2012). In the first level of prompting, the peer stated the WH rule (e.g., "When you hear *what*, listen for a thing"). The peer also reread a portion of text containing the answer. The second prompt was a reread of the sentence with the target answer, and the third prompt was a model prompt, in which the correct answer was verbally stated. For the fourth prompt, the peer stated the answer and pointed to the answer on the response board. If a participant made an error, the peer pointed to a picture symbol for “help,” reminded the student to ask for help when needed, stated the correct answer, and pointed to the correct answer. Participants improved in their ability to answer questions (a) independently and correctly, or (b) only with a text prompt (i.e., prompts one through three only).

Hudson et al. (in press) further extended the literature on listening comprehension by teaching grade-aligned science and social studies texts. Hudson et al. examined the effects of a peer-delivered system of least prompts package and read-alouds of grade-appropriate adapted expository texts on listening comprehension for students with moderate ID. The setting for this study was a general education fourth grade classroom. The system of least prompts procedure was modified to include think-aloud prompts for inferential questions. Additionally, the package included opportunities to hear selections of the text again, opportunities to ask for help, and response boards and self-monitoring charts for participants. Instruction was delivered in the general education classroom by trained peer tutors. Using a multiple probe across participants design, results indicated the peer-delivered system of least prompt package was effective in teaching listening comprehension for the three participants, though generalization outcomes were mixed.

Finally, Wood et al. (2014) examined the effectiveness of a modified system of least prompts procedure on the ability of students to both generate and answer questions about expository text. Special education teachers were trained to deliver the intervention to three participants in upper-elementary school with moderate intellectual disability. Teachers followed scripted lessons with embedded system of least prompts procedures to teach students to generate and answer questions about a grade-aligned social studies text.

Prior to reading the target text aloud, teachers first read a page of related introductory text and talked about pictures related to the target text. Next, teachers asked participants to generate questions about the text using a graphic organizer containing WH words and section headings. If the participant was unable to ask a question, the teacher used a system of least prompts procedure to teach students to form a question. The teacher did not provide prompting for each step of forming a question; instead, the skill was taught as one discrete response. If the student was unable to generate a question when asked, the first prompt was a verbal reminder to use a question word and think about a heading word to ask a question. The second prompt was a model prompt. The teacher modeled pointing to a question word and pointing to a heading word and generating a question using both words. As participants generated questions verbally, the teacher recorded the questions on the graphic organizer.

Next, the special education teachers read the text aloud. Wood et al. (2014) did not adapt the grade-aligned texts. Instead, the teachers were trained to read small portions (no longer than half of one page in length). Each portion was read three times in the course of one session. Teachers were also instructed to embed definitions of unknown words and point to related pictures in the book as needed. After each read of a portion of text, teachers asked participants to answer the question that was generated (either by the participant or by the teacher as a model). Following a 4 s wait time, if participants were unable to answer the question, teachers provided a modified system of least prompts procedure, similar to the procedures used by Hudson and Browder (2014), Hudson et al. (in press), and Mims et al. (2012). All three participants gained skills in generating and answering questions about the expository text. Additionally, participants generalized these skills in a general education social studies class one time per week. During these sessions, participants worked in small groups with students in the general education classroom. All of the students in the groups, including students with disabilities, generated and answered questions about social studies texts read aloud to them by one of the researchers. These lessons were supplemented by extension activities following read-aloud and measurement of the two primary dependent variables (question generating and question answering).

Summary of findings. Traditionally systematic instruction has been used to teach daily living and communication skills to students with severe disabilities. Other research has examined the effects of time delay and a system of least prompts to teach both word and text comprehension. Most commonly, constant time delay has been used in the literature to teach discrete skills, such as vocabulary word and definition identification (e.g., Browder et al., 2013; Jameson et al., 2008; Knight et al., 2013; Smith, Spooner, Jimenez, et al., 2013). Studies have demonstrated the effectiveness of using time delay to teach skills related to academics to elementary aged students with severe disabilities (e.g., Smith, Spooner, Jimenez, et al., 2013; Zisimopoulos et al., 2011). Some studies have used time delay to teach students with moderate intellectual disability (Browder et al., 2013; Knight et al., 2013; Zisimopoulos et al., 2011). In a couple of instances, special education teachers have delivered the instruction (e.g., Knight et al. 2013; Smith, Spooner, Jimenez, et al., 2013). The amount of delay used in these examples ranged from 3 s to 5 s. In one study, constant time delay was used to teach a chained skill related to academics and the use of technology (Zisimopoulos et al., 2011). Notably, this study did not measure the acquisition of academics skills. Instead, Zisimopoulos et al. (2011)

taught students how to access grade-aligned academic content. More research is needed to determine if students can comprehend material they independently access using technology. Additionally, the findings from Schuster et al. suggest time delay may be an effective method for teaching chained comprehension skills (i.e., generating questions).

A system of least prompts also has been used to teach academic skills, including listening comprehension, to students with severe disabilities (e.g., Browder et al., 2011; Browder, Mims, et al., 2008; Hudson et al., in press; Mims et al., 2009), including students with moderate intellectual disability (e.g., Hudson & Browder, 2014; Hudson et al., in press; Mims et al., 2012; Wood et al., 2014). Several of these studies have included populations of students in elementary school (Browder, Mims, et al., 2008; Hudson & Browder, 2014; Hudson et al., in press; Mims et al., 2009; Wood et al., 2014). Of the studies reviewed, one was implemented by a member of the research team (Mims et al., 2009), three were implemented by a peer or paraprofessional (Hudson & Browder, 2014; Hudson et al., in press; Spooner et al., 2009), and three were implemented by a special education teacher (Browder et al., 2011; Browder, Mims, et al., 2008; Wood et al., 2014).

Of the studies reviewed in which a system of least prompts was used to teach listening comprehension of texts read-aloud, most of the studies used adapted versions of narrative stories or books (Browder et al., 2011; Browder, Mims, et al., 2008; Mims et al., 2009; Spooner et al., 2009). A few studies examined the effects of a system of least prompts on comprehension of expository texts (Hudson et al., in press; Mims et al., 2012; Wood et al., 2014). Types of expository texts included biographies, social studies, and science passages. A growing body of studies has extended the research of a traditional story-based lesson task analysis, in which both engagement and comprehension are typically primary dependent variables, to include a modified system of least prompts that teaches students how to find or think of an answer to comprehension questions (Hudson & Browder, 2014; Hudson et al., in press; Mims et al., 2012; Wood et al., 2014). These same studies included an element of telling students the meaning of WH words. Two studies prompted students to make a prediction about the story (Browder et al., 2011; Browder, Mims, et al., 2008), and in one study, a special education teacher taught students to generate questions about expository text using systematic instruction (Wood et al., 2014). These studies suggest elementary aged students with moderate intellectual disability may learn to answer questions about expository text when receiving instruction that adheres to a system of least prompts. More research is needed to determine if students can learn to generate questions using constant time delay when the skill is presented as a chained task.

Synthesis of Literature

Technology is not well represented in the literature on using systematic instruction to teach listening comprehension of expository texts to students with moderate intellectual disability. Incorporating the use of technology into instructional practices may be a way to supplement systematic instruction reading strategies that teach students with intellectual disability to comprehend academic texts. Recently, teachers have adapted texts for use with read-alouds (see Hudson & Test, 2011). Adapting texts allows students with disabilities to listen to or read texts that were otherwise inaccessible, due to the complexity of the text (e.g., story structure) or the physical characteristics of the original texts (e.g., thin pages, small font). These adaptations require a commitment of time and resources, particularly as texts increase in complexity. In the second grade, students in general education classrooms begin listening to chapter books read aloud by teachers (Browder et al., 2009). Adapting one chapter book requires summarizing and rewriting each chapter and analyzing the text complexity to approximate the listening comprehension, or sometimes the reading level, of the student. Teachers select key vocabulary words and embed these terms throughout the text. Picture symbols or pictures may be added, as needed, to support understanding. Students may require physical adaptations to be able to turn the page. Finally, teachers must write comprehension questions to accompany each chapter. Students with intellectual disability are often limited to a small and finite number of texts from which they can gain knowledge. The growing trend to shift texts from a printed to an electronic version has promise for increasing students' access to grade aligned texts.

Technology may enhance the effectiveness of teaching students to generate and answer questions related to science e-texts using systematic instruction. The versatility of technology can be used to provide interactive graphic organizers that may help students generate and answer questions. Zisimopoulos et al. (2011) demonstrated students with moderate intellectual disability could learn to access content on the Internet. One implication is students may also learn to access science e-texts. By combining technological advances with sound instructional procedures, teachers may be able to broaden students' understanding of science content.

CHAPTER 3: METHOD

Overview

This study measured the effects of teacher-delivered systematic instruction on the comprehension of science e-texts for students with moderate intellectual disability. The design of this study was developed in accordance to the single-case design standards for high quality research described by Kratochwill and colleagues (2013). These standards serve as a guide for identifying high quality research for the What Works Clearinghouse evidence base (http://ies.ed.gov/ncee/wwc/default.aspx). Student participants were in elementary school, and special education teachers were trained to deliver constant time delay to teach participants to generate questions and a system of least prompts to teach participants to answer comprehension questions about science e-texts that participants accessed on a desktop computer. The independent variable was a multicomponent comprehension package consisting of the following elements: (a) posing questions before reading, (b) constant time delay procedures to teach use of a graphic organizer to compose questions, and (c) a system of least prompts to recognize answers in the e-text. First, participants were pretrained to access science e-texts from the Web site http://www.discoveryeducation.com. The researcher trained two special education teachers to train students to access e-texts, use the GoTalk Now application on the iPad2™, navigate the Discovery Education site on the computer, deliver the instructional and response prompts (i.e., constant time delay and a system of least prompts), and collect participant data. One special education teacher conducted the pretraining sessions for accessing e-texts using constant time delay procedures and picture cues presented on an iPad2™.

Seven dependent variables were measured. The first dependent variable was the number of points participants earned while generating a question when given a question template presented on an iPad2™. A special education teacher taught participants to develop questions using constant time delay procedures and response options programmed into the GoTalk Now application. The second dependent variable was the number of correct responses to comprehension questions about expository science e-texts. Using a system of least prompts, a teacher taught participants to answer literal comprehension questions. The lead researcher developed five questions for every e-text selected for use in the study. Each question was literal (i.e., the response could be derived from the text with no inference or prior knowledge required), and there were a combination of *what*, *where*, and *when* question for each text. *Who* questions were used when possible, but due to the nature of science content, these question words were less prevalent. Students had an opportunity to generate one of these five questions using the question template prior to hearing each e-text. After hearing the e-text, participants were asked to first answer the question they generated as well as the additional questions created for each text. A third dependent variable measured the number of points participants earned when asked to generate new questions about a text they had just heard. After answering all five comprehension questions, teachers asked participants to ask one more question about the text. Participants were asked to generate one more question. Teachers said, “Think of one more question in your head.” After a 5-s pause, the teacher said, “Got it? Tell me your question.” The question template on the iPad2™ was available for reference during this measure. A fourth dependent variable measured the participants’ ability to generalize question asking to another context (i.e., inclusive science lessons). One time each week, students were asked to generate questions about a science e-text during a science lesson in a general education classroom. Students earned points for each step of generating a question that was performed correctly. A fifth dependent variable measured the participants’ ability to answer comprehension questions about a science e-text in this general education setting. A sixth dependent variable measured the effects of the treatment package on a distal measure of listening comprehension. The researcher administered a pretest and a posttest of the WLPB™-R in one-on-one sessions with each participant. Finally, a seventh dependent variable measured stakeholders’ (i.e., students, teachers, and parents) perceptions of the procedures, materials, and outcomes related to the study.

Participants

Students. Three participants were recruited for this study. All participants were in elementary school. In order to participate in the study, students: (a) were recommended by a special education teacher; (b) were eligible to take the alternate assessment based on alternate achievement standards; c) demonstrated a listening comprehension grade equivalency between kindergarten and second grade as measured by the WLPB™-R (see Browder et al., 2007); (c) possessed the physical ability of pressing a quarter-sized region of the iPad2™ screen; (d) had normal vision and hearing; (e) demonstrated the ability to verbalize a complete sentence; and (f) provided signed parental consent and student assent forms. Due to a recent change in policy by the accountability department of the participating school system, researchers were not permitted to obtain IQ scores or specific diagnosis on any participating student. However, the classroom from which the students were selected were "Specialized Academic Curriculum" classrooms, intended for students with moderate and severe intellectual disability who access the alternate assessment based on alternate achievement standards (AA-AAS).

Only students who were verbal were eligible to participate in this study (i.e., students who relied predominantly on AAC devices were not eligible to participate due to the requirement that students had the verbal capacity to generate a complete, novel question). Both nonreaders and emergent readers were eligible for participation in this study. Exclusionary criteria included students who had received previous instruction using the Discovery Education K-2 grade band science e-texts.

Prior to screening for participant eligibility, the researcher conferenced with the special education teachers and described the inclusion criteria and solicited recommendations of participants. The teachers were given a checklist of the eligibility criteria to consider in making recommendations. After receiving signed parental consent and participant assent forms, the formal screening process began. The teachers provided specific information about eligibility criteria from the students' cumulative folders (i.e., eligibility to take the AA-AAS, vision and hearing assessment information). The researcher administered the listening comprehension subtest of the WLPB™-R (Woodcock, 1991) using standard administration procedures, as outlined in the implementation guide for the WLPB™-R, to assess students' listening comprehension grade equivalency. Students with a listening comprehension grade equivalency scores between kindergarten and second grade continued with the screening process for eligibility.

Of the students who met the listening comprehension criteria, the researcher assessed students' ability to touch known items on a response board presented on an iPad2™. The researcher created response boards containing pictures of common objects (e.g., apple, star, boat). These response boards resembled the same layout and size of the response boards used in the intervention. Seated in a quiet room in a one-to-one format, the researcher asked students to touch requested items to ensure students could intentionally select specific items. To meet eligibility criteria for selection responses, students correctly and effectively selected 100% of the requested items. Prior to screening, to ensure students knew the names of all of the target items, the researcher confirmed knowledge of the items by asking the special education teachers. Of the students who met all eligibility criteria for participation, the three students with the best attendance record were selected for participation in this study.

Pseudonyms are used for all participant names. The three participants include Cate, David, and Chester. Cate was an 11-year-old Caucasian female in the fifth grade. Cate's teacher reported Cate could read basic sight words (approximately 200), but she did not yet decode connected text. Cate's WLPB™-R listening comprehension subtest score indicated a K.2 grade equivalency prior to beginning intervention. Cate completed the *Early Literacy Skills Builder* (Browder, Gibbs, Ahlgrim-Delzell, Courtade, & Lee, 2007), a seven-level early literacy curriculum, in spring of 2013. For the 2013 to 2014 school year, Cate's literacy instruction included daily phonics instruction using a teacher-made materials and story-based lessons. Cate was agreeable and willing to participate in all phases of the study. When asked, Cate would answer familiar questions about her classroom, her routine, or her home life (e.g., "What did you do over the weekend?" "I watched a movie with my dad.").

David was a nine-year-old African American male in the third grade. David's teacher reported David could recognize a small number of sight words (<50). He was not yet able to decode connected text. David's WLPB™-R listening comprehension subtest score indicated a K.0 grade equivalency prior to beginning intervention. At his previous school, David reportedly participated in the *Reading Mastery I* curriculum (Engelmann & Bruner, 1995). David's current teacher, Ms. Elliot, did not have information about David's progress in this curriculum. For the 2013 to 2014 school year, David's literacy instruction included daily phonics instruction using a teacher-made materials and story-based lessons. David had difficulty articulating speech sounds, but he was able to speak in complete sentences. He did not use a communication device. If others were not able to understand him, his routine was to repeat his response slowly. David would put his head down on the desk if he perceived he answered a question incorrectly. David was highly motivated by the iPad2™, and sometimes he was distracted by the iPad2™. He often asked if he could play games instead of working. Sometimes, he would ignore questions or requests to work and ask off-topic questions instead (e.g., "When do we go outside?"). David could be redirected throughout the study with first / then systems (i.e., "First work, then earn the iPad2™").

Chester was an eight-year-old African American male in the second grade. Chester's teacher reported Chester could read a small number of sight words (<10), and he could not yet decode connected text. Chester's WLPB™-R listening comprehension subtest score indicated a K.0 grade equivalency prior to beginning intervention. At his previous school, Chester reportedly participated in the *Reading Mastery I* curriculum. Ms. Elliot did not have information about Chester's progress in this curriculum. For the 2013 to 2014 school year, Chester's literacy instruction included daily phonics instruction using a teacher-made materials and story-based lessons. Chester did not have difficulty articulating speech, but he did not speak often.

See Table 1 below for a detailed description of participant characteristics.

Table 1: Description of participants

	Cate	David	Chester
Age	11-years-old	9-years-old	8-years-old
Race	Caucasian	African American	African American
Grade	5th	3rd	2nd
Educational placement	Specialized Academic Curriculum (39% or less of the day with peers without disabilities)	Specialized Academic Curriculum (39% or less of the day with peers without disabilities)	Specialized Academic Curriculum (39% or less of the day with peers without disabilities)
Hearing screening score	Normal Range (as reported by teacher)	Normal Range (as reported by teacher)	Normal Range (as reported by teacher)
Vision screening score	Normal Range (as reported by teacher)	Normal Range (as reported by teacher)	Normal Range (as reported by teacher)
Primary mode of communication	Vocal	Vocal	Vocal
WLBP listening comprehension score (pretest)	K.2	K.0	K.0

Previous experience with DE e-texts	None	None	None
Previous and current literacy instruction	Completed all levels of the ELSB in spring 2013; daily story-based lessons and Recipe for Reading phonics instruction	Previously received Reading Mastery instruction, but highest level is unknown; daily story-based lessons and Recipe for Reading phonics instruction	Previously received Reading Mastery instruction, but highest level is unknown; daily story-based lessons and Recipe for Reading phonics instruction
Present level of literacy skills	ID letter names and phoneme; identify approximately 200 sight words; decodes some CVC and CVCC words; inconsistently answers literal questions about text	ID letter names and most phonemes; identify <50 sight words; does not yet decode; inconsistently answers literal questions about text	ID <10 letter names and phonemes; identify <20 sight words; does not yet decode; inconsistently answers literal questions about text

Teachers. Two special education teachers were interventionists for this study. The first teacher, Ms. Elliot, volunteered to implement the baseline and intervention procedures in the special education classroom, because the identified participants were students in her class. A second special education teacher, Ms. Tatum, volunteered to implement the generalization probes in the science classroom. The special education teachers implemented all phases of the study (i.e., pretraining, baseline, intervention, generalization, and maintenance). Both special education teachers were recruited from the same elementary school. The school housed a special education program with three classrooms for students who access the AA-AAS. At the beginning of the 2014-2015 school year, 25 students with moderate and severe intellectual disability were enrolled in these classes. In order to participate as the interventionists, teachers met the following criteria: (a) were a certified special education teacher with a valid license or provisional license recognized by the state of North Carolina, (b) missed no more than three days of school during the last reporting cycle, (c) expressed willingness to participate in this study, and (d) demonstrated proficiency in pretraining tasks (i.e., accessing e-texts online, use of iPad2™ and GoTalk Now application, procedural fidelity for constant time delay and system of least prompts, recording participant data). The researcher conferenced with the special education teachers and shared eligibility criteria for both student participants and special education teacher eligibility during the same session. Pretraining sessions of special education teachers occurred after gaining consent and assent for student and teacher participation and after confirming eligibility of at least three student participants from the teachers' school. The researcher conducted pretraining procedures (described under the "Procedures" heading) with the special education teachers. The three students who met eligibility criteria were from Ms. Elliot's homeroom classroom. Ms. Elliot was trained to implement pretraining, baseline, and intervention procedures to mastery. Ms. Tatum was trained to implement generalization procedures to mastery.

Ms. Elliot was in her sixth year of teaching special education to students with moderate and severe disabilities. Ms. Elliot had a master's degree in teaching students with moderate and severe disabilities. All of her teaching experience was at the elementary level at this urban, public school site. Ms. Tatum was a National Board Certified Teacher in her 24th year of teaching special education. Ms. Tatum has taught students with mild, moderate, and severe disabilities across a variety of settings, including resource, public separate schools, self-contained classrooms in public schools, and a juvenile detention center. Both teachers reported familiarity with systematic instruction, acquired through coursework, previous participation in research projects, and daily practice in the classroom.

Setting

The study took place in a public elementary school in a large, urban school district in the Southeast. Screening and pretraining sessions occurred in a quiet setting at a rectangular table in the back of the classroom and at a computer table equipped with two desktop HP computes and one printer. Baseline and instructional sessions occurred in Ms. Elliot’s special education classroom at the computer table using one of the two desktop computers. The student participant sat in a chair in front of the computer used for the session, and the teacher sat either to the left or the right of the student. During IOA and fidelity sessions, the researcher sat a few feet behind the teacher and student. Eight students were enrolled in Ms. Elliot’s classroom at the time of the study, ranging in ages from 8 to 11. The layout of the classroom was oriented to allow for open space in the center of the classroom and clearly delineated centers positioned around the classroom perimeter. Teacher desks and supplies were situated against one wall, and the computer table was situated against another wall. A literacy station was located in the corner near the computer table by a large window. A large blue gymnastics mat was placed between this area and the computer table when sessions occurred simultaneous to literacy groups held at this adjacent table. A SMART Board™ was affixed to the wall at the front of the room, and a large kidney bean table was located in front of the SMART Board™. Most general classroom instruction occurred in small groups at either this central table or the literacy table near the computer area.

Generalization sessions occurred in a general education science classroom. At this school, science was taught to all students as a “special area” course one time each week. All students in the school attended this science classroom as a class (equipped with three desktop computers, a SMART Board™, and lab equipment) one time each week for 45 min. The participants in this study attended the science class one time per week with a preselected general education third grade class of 22 students. Six stations were set up in the classroom in an even arrangement across the room. No chairs were used at the stations. Students stood at the tables and participated in their assigned science activities each class period. Station activities matched the pacing guide provided by the school district by grade and all activities aligned to the CCSS. The participants in the study were assigned to stations along with their third grade peers. Only one participant was assigned to each group, and participants were introduced to the peers in the group at the beginning of each class. A teacher or researcher explained the activity directions to the participant and observed to make sure the participant was engaged in the activity throughout the class. Ms. Tatum conducted generalization probes at a computer desk located against the back wall of the classroom. Ms. Tatum conducted sessions one-on-one with a participant, pulling each participant from his or her small group for a 10 to 15 min long probe. Ms. Tatum sat in a chair next to the student at the computer table. During procedural fidelity and IOA sessions, the researcher stood approximately three feet behind Ms. Tatum and the participant to observe and collect data. The general education science teacher rotated around the room providing direction and instructive feedback to the different groups and monitoring the needs of the participants in the study.

Materials

A 12-step task analysis for accessing an e-text through the Web site http://www.discoveryeducation.com was developed and presented using a communication book created through the application GoTalk NOW. An iPad2™ was used to deliver the content on the application. Screen shot images of each step of the task analysis were paired with a recorded auditory directional cue and presented sequentially through the application. Students accessed the Web site and e-texts using a classroom desktop computer. Each student learned to access approximately 50 e-texts across various science content areas. To select e-texts for use in the study, the researcher first searched for science e-texts on the Discovery Education Web site that were leveled for students with a listening comprehension level of kindergarten through second grade (N=210). Only books that had a theme or topic related to the elementary level Next Generation Science Standards were included for use in the study.

The GoTalk NOW application was used to develop question templates. Question templates were created for each of the selected science e-texts. Question stems and pictures related to the e-texts were selected for each of the 50 e-texts used in this study. Each question template page was color coded with numbering for (1) the question stem (green), (2) the question content (yellow), and (3) the question mark (red). Students were able to touch any button to hear an auditory cue, or recording of the button content. To form a complete question, students selected one button from each column (1, 2, or 3). When all of the selected question components were pressed and appeared in the white bar at the top of the screen, students pressed the white bar to hear the complete question using text-to-speech software. The questions formed by the stems and pictures were literal questions derived from the e-texts. Four additional questions were developed for each e-text. All five of the questions developed by the researcher for each e-text were used as possible response options for generating a question prior to listening to the text. Components for building each question were built into the iPad2™ application.

Content validity. A science content expert reviewed the list of topics to validate they were related to the Next Generation Science Standards. A reading expert from the University reviewed the questions and answers developed for each e-text. The reading expert reviewed the answers to validate questions were literal (i.e., all correct answers could be derived from the e-text without requiring background knowledge or inference).

Dependent Variables and Data Collection

Dependent variables. Seven dependent variables were measured in this study. The first measure was the number of points earned when asked to generate a question using a template. Students used the iPad2™ to construct one question prior to listening to each e-text. One point was awarded for each component of generating a question that the participant performed correctly and without prompting. Teachers used a checklist to teach and score each step of question generating process. The steps of the checklist include: (a) first touch a green button to select a question starter (e.g., What is), (b) second, touching a yellow button to select a question topic (e.g., a hurricane), (c) third, touching a red button to add a question mark, and (d) fourth, touching the white bar to read a complete and logical question using text-to-speech software. Generating one question provided a student with the opportunity to earn four points. Students had two opportunities to generate questions using a template during each session, for a total of eight possible points a student could earn for generating questions each session. The teacher recorded each response in the checklist as correct (1), incorrect (0), or no response (NR) during baseline sessions. During instructional sessions, teachers recorded student performance as correct (1), prompted (P), incorrect (0), or no response (NR). To make a correct response, students had to touch the correct color button (green, yellow, red, or white) in sequence. For example, to earn the first point, the participant had to touch a green button. If the first button touched was not green, the participant received a score of 0 for the first step of the checklist. To earn the second point, the participant had to touch a yellow button. If the second button touched was not yellow, the participant received a score of 0. To earn the third point, the participant had to touch a red button. If the third button touched was not red, the participant received a score of 0. Finally, to earn the fourth point, the participant had to (a) touch the white bar to (b) voice a complete, logical question. No point was assigned if the participant did not touch the white bar and/or if the question was not complete or logical (see Table 2 in the Appendix for the data sheet for the measuring all variables during treatment). These data were graphed on a linear graph (see Figure 1).

The second measure was comprehension of the participant-generated question and teacher-delivered questions. A correct response was the verbally constructed response of an acceptable answer to each comprehension question. All questions and acceptable correct responses were listed in a binder for the teacher's reference. Acceptable responses included all of the possible logical and text-dependent responses that could fully address each comprehension question. Teachers located the section of the binder with the questions and acceptable responses prior to delivering instructions to access each new e-text. When participants provided responses to comprehension questions, teachers confirmed answers were correct or incorrect by referencing the list of acceptable responses in the binder. Five questions were asked for each e-text. Participants listened to two e-texts every session. Participants had an opportunity to answer 10 comprehension questions each session. If teachers asked a question and the participant, within 5 s, independently began to search the e-text for the answer (i.e., looked at a picture in the e-text, looked at the text, replayed the text or a portion of the text) and then stated the correct response within 30-s, the teacher scored this answer as correct. To differentiate between questions that were answered from memory and questions in which participants searched the text to find the answer, immediate correct responses (from memory) were coded "+" and correct responses that were preceded by participants' independent behavior of searching the text were be coded "S+." Teachers recorded performance on each response using the data sheet in Appendix A. Teachers recorded if each response was correct (+), correct after student searched for the answer in the text (S+), prompted (first reread prompt = R1, second reread prompt = R2, or model prompt = M), incorrect (-), or not answered (NR). These data were graphed using a linear graph (see Figure 2).

A third measure was the number of points students earned generating a question without the use of the template. Students had one opportunity after answering comprehension questions about each e-text to ask "one more question" about the text. "Think of one more question in your head." After a 5-s pause, the teacher would say, "Got it? Tell me your question." Teachers used a checklist to score each response. One point was awarded for each element of the criteria met: (a) contained a question starter (e.g., What is a), (b) contained science content related to the e-text, and (c) was a novel question (i.e., could not be a question asked previously during the session). The checklist was on the primary data sheet (see Appendix A), and teachers recorded student performance on each element of the checklist by writing a code for correct (1) or incorrect (0), or no response (NR). Participants could earn up to three points for each question generated. Teachers asked participants to generate one question without a template two times during each session for a total of six possible points earned for this dependent variable per session. Students could not touch the template on the iPad2™ to generate the questions. This dependent variable was measured as a probe; the teacher did not provide prompts to teach construction of this question. If the student asked a question, the teacher responded by answering the question. If the teacher did not know the answer, the teacher responded by telling the student a resource that could be used to find the answer (e.g., science teacher, Internet). The total number of points earned each session was graphed on a linear graph (see Figure 3).

A fourth measure was the number of points earned for generating questions about science e-texts embedded in a general education science lesson with same-aged peers. These generalization sessions were scheduled to occur once a week on Friday from 11:45 AM until 12:30 PM. Due to teacher absences and inclement weather, three of these sessions were cancelled and could not be rescheduled. One of the special education teachers, Ms. Tatum, embedded the e-text probe into the ongoing science lesson. Initially, participants entered the room and were assigned to small groups of third grade peers. During the class period, the Ms. Tatum called one participant at a time to a classroom computer for a generalization probe session. Before playing the e-text, the Ms. Tatum did a brief picture walk of an image related to the e-text topic and then asked the participant to use the iPad2™ to ask a question about the e-text. Ms. Tatum recorded participant data using the same procedures for data collection and recording used for measuring question generating using the template in the special education setting. Ms. Tatum used the same checklist to determine if each element of the question generating response was correct or incorrect. The steps of the checklist include: (a) first, touching a green button to select a question starter (e.g., What is), (b) second, touching a yellow button to select a question topic (e.g., a hurricane), (c) third, touching the red button to add a question mark, and (d) fourth, touching the white button to read the complete question using text-to-speech software. Students had two opportunities to generate questions using a template during each session. Ms. Tatum recorded each response as correct or incorrect during all sessions (see Appendix B for the data sheet); no prompting was delivered during these generalization sessions. These data were graphed on the same linear graph as the first dependent variable (i.e., asking questions in the primary intervention sessions; see Figure 1). Questions asked in the general education science context were graphed using a solid triangle on this same graph.

A fifth measure was the number of correct responses to the comprehension questions asked in the generalization sessions. Similar to the procedures in the special education classroom, a correct response was the verbally constructed response of an acceptable answer to each comprehension question. Ms. Tatum asked questions to each of the three participants during their one-on-one embedded probe. Ms. Tatum recorded the exact student response and the corresponding ratings of correct (+), correct with independent student search (S+), incorrect (-), or no response (NR). All questions and acceptable correct responses were listed in a binder for the teacher’s reference. Ms. Tatum was able to access the binder either in vivo or at the end of the lesson to score the student responses. Five questions were asked for each e-text. Students listened to two e-texts every session. Students had an opportunity to answer 10 comprehension questions each session. Ms. Tatum recorded performance on each response using the data sheet in Appendix B. These data were graphed on the same graph as comprehension questions asked during instructional sessions held in the special education classroom (see Figure 2), and the generalization probe data were denoted by solid triangles.

A sixth measure was a pretest/posttest distal measure of comprehension. The listening comprehension subtest of the WLPB™-R was administered in a quiet, one-on-one format first during the eligibility screening process (pretest) and next following completion of the intervention (posttest). The lead researcher administered both assessments following the standard testing protocol for test administration as described in the implementation guide for the WLPB™-R.

Social validity. Finally, a seventh measure was social validity outcomes. Social validity questionnaires were distributed to students with disabilities, special education teachers, and parents after the intervention was completed. A different questionnaire was developed for the different categories of stakeholders (e.g., students, teacher, parents), and there were nine Likert-type items for the parent and teacher instruments, and five items for the student instrument. Items measured stakeholder attitudes regarding the procedures, materials, and outcomes in the study (see Appendix C for social validity questionnaires). Teachers and parents received similar 5-point Likert-type rating scale questionnaires. Students received a questionnaire with statements related to the study. Students addressed each statement using a dichotomous scale (i.e., I liked this, I didn’t like this). The interventionist also scored items as “did not answer” when applicable.

Data collection. Either the special education teachers (Ms. Tatum or Ms. Elliot) or the lead researcher collected participant data on the first five dependent variables during every condition of the study (i.e., baseline, treatment, generalization probes, and maintenance). The researcher collected data on the sixth dependent variable (i.e., pre/posttest of the WLPB™-R). Ms. Elliot collected data for the first three dependent variables (i.e., the number of questions asked and answered, with and without the question template, in the special education classroom) for all but six of the sessions. The lead researcher conducted six intervention sessions in the special education classroom. Ms. Tatum collected data on the fourth and fifth dependent variables (i.e., asking and answering questions in the third-grade science classroom). During treatment, the interventionist recorded the specific prompting necessary to elicit each target response. Only correct, unprompted responses were graphed (see Figures 1, 2, and 3). The researcher collected data for the seventh dependent variable, the social validity measure, which were administered after all participants finished with the intervention phase of the study.

Experimental Design

A multiple probe across participants single-case design (R. D. Horner & Baer, 1978; Gast, 2010) was used in this study. Multiple probes allow for data to be collected periodically for students who remain in baseline once another participant begins intervention. Due to the nature of single case research, the determination of a functional relationship relies on visual analysis of the data and demonstration of effect across at least three participants. Positive effects of question generation both with and without the question template were determined by the presence of a clear, positive ascending trend across time, immediacy of effect, and an observable change in level. Analysis of increase in comprehension across settings occurred through visual inspection for changes in level and trend and immediacy of effect from baseline to intervention.

This multiple probe design was dependent on the two measures of comprehension (i.e., comprehension of e-texts during instructional sessions and comprehension of e-texts during generalization probes). In accordance with the What Works Clearinghouse criteria for single-case design (Kratochwill et al., 2013), each phase (i.e., baseline, intervention) had a minimum of five data points across students. Participants began the baseline sessions after all students met the pretraining criteria for accessing e-texts. The lead researcher selected the first participant to enter the treatment phase based on the stability of baseline data. After three sessions, the participant with the most stable, low-level baseline data was selected to receive two additional baseline probes. The other three participants continued to receive probes in baseline every eight sessions and immediately before another participant entered the treatment condition. The participant entering treatment received no less than three consecutive baseline probes before entering treatment. Once in treatment, participants received daily instructional probes (i.e., data were collected in the same session as the delivery of instructional prompts for comprehension questions asked in the special education classroom). Instructional probes occurred on the same day as generalization probes. Once a participant in treatment demonstrated a clear increase in level and trend, another participant began treatment. The decision to enter participants into the treatment phase continued to be based upon low level, steady baseline data. Treatment discontinued for participants once comprehension data represents a discernible rise in level from the baseline condition with an increasing trend throughout the treatment condition. Additionally, participants in treatment were required to have at least five data points before entering maintenance. Experimental control was demonstrated based on a clear increase in level and trend from baseline to treatment conditions staggered across all participants.

Procedures

Pretraining participants with disabilities. All sessions occurred in a one-on-one format. The researcher and Ms. Elliot pretrained the participants to follow the steps of the task analysis to access the e-texts using constant time delay and the picture and auditory cues for the task analysis presented on the iPad2™ (see Appendix D). Steps include: (a) Click the Windows icon on the bottom left of the screen, (b) Click “All programs” at the bottom of the list, (c) Click “Discovery Education,” (d) Type “germelman” in the login box, (e) Type “cortez” in the password box, (f) Click “login,” (g) Type search words from friend or teacher, (h) Click K-2 for “grades,” (i) Click “science” for subjects, (j) Click “e-text” for media types, (k) Click “submit, and (l) Find title on the screen and click it. The researcher collected data on the participants’ ability to access the e-texts in order to demonstrate student mastery of accessing e-texts. Additionally, the researcher and Ms. Elliot taught students to independently press the play button to start the text-to-speech reading of the e-text as well as to press the forward or backwards buttons to hear a page read again. Screen shots with embedded auditory cues were used to teach these skills as well. The first three sessions were at a 0-s delay. To conduct a 0-s delay session, the interventionist displayed the picture cue on the iPad2™, which automatically played the auditory directional cue for the first step of the task analysis (i.e., “Click the Windows icon on the bottom left of the screen”). The interventionist simultaneously pointed to the target item on the computer screen (i.e., the Windows icon). The interventionist continued to point to the target area on the computer screen until the student performed the behavior. This procedure was repeated for the remaining steps of the task analysis. The interventionist provided the pointing prompt to cue the student to perform the skills. The pointing prompt included pointing to target areas on the computer screen or keys on the keyboard depending on the step of the task analysis. Subsequent sessions were at a 4-s delay. During these sessions, the interventionist first delivered the directional cue by displaying the picture cue on the iPad2™ with the embedded auditory cue stating the step of the task analysis. After delivery of one directional cue (one step of the task analysis), the interventionist waited for 4 s before pointing to the target area on the screen or keyboard. The interventionist resumed a 0-s delay for a specific step if the student was unable to perform the step independently two or more times. If the student was still unable to respond correctly, the interventionist provided massed trial training of any unlearned steps. If the participant made an error at any time during the training, the interventionist said, “No,” displayed the target visual cue on the iPad2™, and pointed to the specific task location on the screen or keyboard. The interventionist then said, “Your turn,” and waited for the participant to perform the step correctly. Participants were required to reach mastery criteria of 100% accuracy two times before the visual and auditory prompts on the iPad2™ were faded. Instruction continued as needed throughout the intervention.

Pretraining teachers. Two teachers were trained to deliver the intervention and generalization probes. The researcher conducted the training session with the teachers in a one-to-one format in their special education classrooms on two separate dates. The teachers were given explicit training in the use of the iPad2™ (i.e., turning it on, opening and closing applications); use of the GoTalk NOW application (i.e., opening the communication books for the intervention, returning to the home screen, jumping to specific pages in the communication books if needed); navigation of the Discovery Education Web site (i.e., accessing the URL, entering the password protected site, searching for specific science e-texts, highlighting and replaying portions of the e-texts); and data collection procedures (i.e., event recording on a data sheet). Additionally, Ms. Eliot received training in systematic instruction procedures (i.e., procedures for prompting participants to ask and answer questions). Teachers were trained in the individual skills necessary to implement the intervention or generalization probes. Teachers were given training materials consisting of the skills necessary to implement the study. These skills were listed sequentially in a task analysis teachers used as a fidelity checklist during each session (see Appendix E for the fidelity checklist). The lead researcher provided demonstrations of all procedures and collected fidelity during the training sessions. The teachers achieved two consecutive sessions of 100% accuracy on the fidelity measure before beginning the intervention.

Baseline. E-texts were selected in a random order for each participant from the pool of 50 e-texts that were used throughout the study. Students listened to two e-texts during each session in the study (baseline and intervention). Prior to listening to each text, the students were shown a picture from the e-text and told the topic or title (e.g., animal habitats). Next, the teacher instructed students to ask a question about the e-text (i.e., measure of the first dependent variable). The iPad2™ was placed next to the student, cued to the page with the WH choice board. Then, the teacher told the student to play the e-text, which was read through text-to-speech software one time. After the story was over, the teacher asked the student the five comprehension questions. Immediately prior to asking each question, the teacher clicked to the page of e-text containing the answer. No additional reference to the text was made. No prompting, error correction, or reinforcement was delivered throughout baseline. After 5 s, the interventionist scored the response as correct or incorrect and then asked the participant to ask one more question. The iPad2™ with the question-making template was not referenced or presented at this time. The teacher said, “Think of one more question in your head.” After a 5-s pause, the teacher said, “Got it? Tell me your question” (i.e., measure of the third dependent variable).

Intervention. The intervention package included the use of systematic instruction (i.e., constant time delay and a system of least prompts) and question templates presented on an iPad2™. Students self-generated “I wonder” questions, then listened to a science e-text, and finally answered questions about the text. Constant time delay was used to teach the self-questioning skill, and a system of least prompts was use to teach listening comprehension skills. Constant time delay is a prompting system in which one specific response prompt is used to teach a behavior. After a zero delay round, in which delivery of the prompt immediately follows delivery of the directional cue, a delay (e.g., 4 s) is inserted between the delivery of the directional cue and the prompt for the first step of the checklist. To teach self-questioning, the teacher told the student the topic of the e-text and engaged the student in a brief (i.e., 30-s) conversation about the topic to activate background knowledge. Then the teacher showed the student the WH question template on the iPad2™. The teacher asked the participant to select the type of question to ask from the choices available on the iPad2™ “wonder page” (i.e., who, what, where, when). Selecting a WH word advanced the pages to a WH template page specific to the WH word selected by the participant. During the zero delay round, the teacher said the first directional cue of the task analysis, “Ask a question about the text. Start your question,” while immediately pointing to the target green button (i.e., the WH question starter). The teacher then said, “Your turn,” and continued pointing to the target button until the participant touched the button. After the participant touched the button, the teacher said, “Pick a science topic,” while immediately pointing to one of the yellow buttons. The teacher continued pointing to the target button until the participant touched the button. After the participant touched the button, the teacher said, “Finish your question,” while immediately pointing to the red button (i.e., the question mark). The teacher continued pointing to the target button until the participant touched the button. After the participant touched the button, the teacher said, “Play your question,” while immediately pointing to the white bar at the top of the screen. The teacher continued pointing to the white bar until the participant touched the button. Specific verbal praise was delivered for every correct or prompted response. If the participant did not respond or made an error, the teacher used physical guidance to lead the participant to the correct response. Then during the 4-s delay rounds (all subsequent instruction), the teacher began by asking the participant to select the type of question to ask (i.e., who, what, where, when). Selecting a WH word advanced the pages to a WH template page specific to the WH word selected by the participant. The teacher delivered the same directional cues for each step of the task analysis (1. Start your question, 2. Pick a science topic, 3. Finish your question, 4. Play your question). After the delivery of each directional cue, if the participant was unable to select a correct button after 4 s, the teacher delivered the controlling prompt of pointing to an appropriate target button, saying “Your turn,” and waiting for the participant to touch the target button. Following the model, the teacher said, “Your turn,” and waited for the student to select the button. These procedures repeated across all four steps of forming a question (see Appendix A).

Then, the teacher instructed the student to play the book to find the answer. The teacher placed the iPad2™ with the full question next to the computer monitor and verbally reminded the student to “think about the question.” To teach the student to answer comprehension questions, a system of least prompts was used. A system of least prompts is a form of systematic instruction in which a leveled system of prompts is delivered as needed to allow for the greatest degree of unaided response by the participant. After listening to the e-text one time, the teacher asked the student five comprehension questions, beginning with the question the student generated. Prior to asking each question, the teacher clicked on the page of e-text containing the target answer (just as in baseline procedures). Immediately after asking each question, the teacher added: “Don’t guess! Do you know the answer in your head, or do you need to find it in the book?” (a step that was added for intervention and not present in baseline). Students had 5 s to initiate a search for the response. Once a student began searching the text for the response, the student had 30 s to say an answer. If a student was unable to say a correct response (either an error or no response), the first prompt was delivered (i.e., the teacher said, “I heard the answer. I’m going to use the question topic words, find them in the text, and replay that part of the story. Listen again.” The teacher modeled looking at the topic words in on the iPad2™ template, locating the words in the text, and highlighting and replaying three sentences from the e-text in which the answer was embedded.). If a student was still unable to say the correct response, a second prompt was delivered (i.e., “I heard the answer. I’m going to use the question topic words, find them in the text, and replay that part of the story. Listen again.” The teacher modeled looking at the topic words in on the iPad2™ template, locating the words in the text, and highlighting and replaying the sentence in which the answer is embedded.). If a student was still unable to say the correct response, the third and final prompt was delivered (i.e., “I heard the answer. Listen again.” The teacher highlighted and activated only the answer and then repeated the answer. The teacher instructed, “Your turn,” and waited for the participant to say the correct response.). Participants were asked to generate one more question at the end of each session. Participants were not permitted to touch the iPad2™ with the question template for this response. Responses were scored as correct, incorrect, or no response, and no additional prompting was used if the student was unable to ask a question.

Once in intervention, participants received one to two instructional sessions per day over a period of approximately three weeks. When two sessions occurred in the same day, one occurred in the morning (typically between 7:15 AM and 8:45 AM) and the other occurred in the afternoon (typically between 11:45 AM and 1:45 PM). Maintenance data were collected one time per week for at least two weeks following completion of the final session in intervention. Maintenance procedures followed those used in the baseline sessions.

Generalization probes during science class. Four times throughout the study, Ms. Tatum conducted sessions in the general education science class. Procedures for these sessions were the same during baseline and treatment. All participants went to this same weekly session, and the same procedures applied for participants across all phases of the study. Participants were seated at the computer table in the back of the classroom for generalization probe sessions. Participants not receiving a probe session worked in small groups with general education peers on science inquiry activities assigned by the general education science teacher. Ms. Tatum led the probe sessions using the same procedures described for baseline sessions. First, Ms. Tatum told students to access a science e-text on the Discovery Education Web site using the title presented on the iPad2™. Next, Ms. Tatum engaged the student in a 30-s discussion about the picture related to the topic or title of the target e-text. Then the Ms. Tatum gave the iPad2™ with the question template page available for the students to use and said, “Can you ask a question about the book?” No additional prompts or instructions were delivered. Next, Ms. Tatum instructed the student to play the book on the computer. Finally, after listening to the book, students were asked to answer their question and the remaining four questions for each e-text. They were not asked if they knew the answer in their head, nor were they reminded they could find the answer in the book. No prompting, error correction, or specific reinforcement was delivered during generalization probes. After 5 s, Ms. Tatum recorded each response as correct, incorrect, or no response. In generalization probes, students were not asked if they could generate a question without the use of the iPad2™.

Procedural reliability. Procedural fidelity was collected for a minimum of 20% of all sessions across conditions. The researcher observed and scored the special education teachers’ implementation of baseline, treatment, generalization, and maintenance procedures. A trained doctoral student viewed and scored the fidelity of the researcher during 20% of the six sessions conducted by the researcher. The researcher calculated fidelity by dividing the total number of steps performed correctly by the total number of possible steps and multiplying by 100 (Billingsley, White, & Munson, 1980; see Appendix E for the procedural fidelity checklists). Acceptable criterion was 90% fidelity.

Interobserver agreement. Interobserver agreement (IOA) was collected for a minimum of 20% of all sessions across conditions. The researcher collected IOA data during the same sessions in which fidelity ratings are observed. The same trained doctoral student collected IOA data for two of the six sessions conducted by the researcher. Agreement counted when both the special education teacher and the lead researcher record the same response, which included agreement of a rating of incorrect, no response, correct, or prompted. For prompted responses, both observers had to agree on the specific level of prompt in order to qualify the ratings as agreement. IOA was calculated by dividing the total number of agreements by the total number of participant responses. This quotient is then multiplied by 100. Acceptable agreement was 90% of all sessions.

Threats to Internal and External Validity

Several considerations were met to ensure strong internal validity throughout the implementation of this study. Collecting baseline over a period of time and in a time lagged manner across participants, increased internal validity. Participants left baseline to begin treatment in a staggered entry format, controlling for threats including maturation and history. The potential inconsistency of instrumentation was a threat to internal validity. In this study, IOA was collected and measured for a minimum of 30% of all sessions. Additionally, the criterion for acceptable agreement was 90%. The special education teachers were the primary the interventionist, and the lead researcher trained them in specific procedures for implementing the study. Teachers met criterion of 100% accuracy on all measures before beginning the study. Similarly, in single-case research, the procedures and conditions of the intervention should be clearly defined and described to allow for replication. An inability to replicate the treatment is another potential threat to internal validity. If the results of the study are not effectively replicated, the effects of the intervention cannot be assessed with validity, and generalization of the effects has not occurred. All of the procedures and variables for the proposed study have been described in elaborate detail, and the dependent variables have all been operationally defined. Additionally, adhering to the What Works Criteria for high quality increases internal validity (Kratochwill et al., 2013). All participants met the minimum requirement for data points across all conditions, and all participants demonstrated a low, reasonably stable baseline pattern before advancing to the treatment condition. Internal validity was increased by the addition of a specific generalization measure. Participants had an opportunity to demonstrate generalization of both question asking and question answering skills to a third-grade science class. The participants were included as members in this class, and the procedures and measures were embedded into an inclusive science lesson. Students correctly asked and answered questions in this context, thus strengthening the external validity of this study's procedures. Finally, another measure to increase external validity was the use of the multiple probe design. In multiple probe designs, participants receive ongoing probes in the baseline condition rather than continuous probes. This minimizes the effects the baseline procedures will have an effect on the participants' performance in the treatment phase.

Single-case design is by nature at risk for low external validity. Due to purposeful selection of specific participants, a natural consequence of this design is low generalizability to others in the population. Replication built into single-case design is one way this issue of low external validity is addressed. In this study, the treatment was applied to three different individuals. Within each individual, an effect of treatment occurred from baseline to treatment. This effect replicated across all three participants.

CHAPTER 4: RESULTS

Reliability

Procedural reliability and interobserver agreement (IOA) data were collected across interventionists, participants, and phases. Procedural fidelity data were collected across 31% of the baseline and treatment sessions and 33% of generalization sessions. The mean procedural fidelity for Ms. Elliot was 96% (range = 92%-100%). The mean procedural fidelity for Ms. Tatum was 98% (range = 96%-100%). The mean procedural fidelity for the researcher interventionist was 99% (range = 98%-100%).

IOA data were collected for all participant responses across all phases. IOA data were collected for 31% of the baseline and treatment sessions and had a mean 98% (range = 96%-100%). IOA data were collected for 33% of the generalization sessions and was 100% across all four sessions.

Participant Data

Participants were asked to generate and answer questions throughout all phases in the study (baseline, intervention, generalization, and maintenance). During all phases conducted in the special education classroom, participants had an opportunity to form four questions per session (two using an iPad2™ template, and two without an iPad2™ template). During generalization probes, participants had an opportunity to form two questions per session (both using an iPad2™ template). Participants were instructed to answer 10 comprehension questions per session across all phases of the study. Across 27 sessions, Cate was asked to generate 100 questions and answer 270 questions. Across 29 sessions, David was asked to generate 116 questions and answer 290 questions. Across 29 sessions, Chester was asked to generate 116 questions and answer 290 questions.

Question 1: Impact of CTD on generating questions. Participants could earn up to 4 points for every question they were asked to generate, for a total of 8 points each session. All three participants increased in the number of points earned generating questions with an iPad2™ template. Table 2 describes the range and mean of points earned by each participant for generating questions using the iPad2™ template.

Table 2: Range and mean of points earned generating questions using an iPad2™

	Baseline	Base - Gen	Intervention	Int - Gen	Maintenance
Cate	*m*= 0	*m*= 0	*m*= 7.88	*m*= 8	*m*= 8
	range= 0	range= 0	range= 7-8	range= 8	range= 8
David	*m*= .75	*m*= 0	*m*= 7.41	*m*= 7.67	*m*= 8
	range= 0-2	range= 0	range= 4-8	range= 7-8	range= 8
Chester	*m*= .56	*m*= .5	*m*= 6.4	*m*= 4	*m*= 8
	range= 0-1	range= 0-1	range= 6-8	range= 4	range= 8

In baseline, none of the participants earned all 4 points for constructing a question during any of the opportunities to form questions. Analysis of median scores and graphed data for all three participants (see Figure 1 below) indicated a change in level and an immediacy of effect across baseline and intervention phases. In baseline, Cate earned 0 points across all five sessions. As demonstrated in Figure 1, Cate's data were low level and stable in baseline with a flat trend. In intervention, following 0-s time delay, Cate's points ranged from 7 to 8 (*m*=7.88). To temper the influence of extreme values, comparison of median scores across phases is recommended for visual analysis of graphed data (Gast, 2010). A comparison of Cate's median scores across phases (0 to 8) demonstrated an increase in level from baseline to intervention. Cate's data in intervention were stable with a high level and a slight increasing trend. Calculating the percentage of nonoverlapping data (PND) is an additional method for comparing data from two adjoining phases (e.g., baseline and intervention data). PND is calculated by (a) counting the number of data points in the second phase that are outside the range of data collected in the first phase, (b) dividing this number by the total number of data points in the second phase, and (c) multiplying the resulting number by 100 (Scruggs & Mastropieri, 1998). The PND for Cate's data across baseline and intervention was 100%. Finally, Cate earned 8 points for both maintenance probes.

In baseline, David scored a range of 0 to 2 points (*m*=.75). As demonstrated in Figure 1, David's data were low level and slightly variable in baseline with a flat trend. In intervention in the special education classroom, following 0-s time delay, David's points ranged from 4 to 8 (*m*=7.41). A comparison of David's median scores across phases (0.5 to 8) demonstrated an increase in level from baseline to intervention. David's data in intervention were stable, with the exception of variability in session 4. These data demonstrated a high level and a slight increasing trend. The PND for David's data across baseline and intervention was 100%. Finally, David earned 8 points during his maintenance probe.

In baseline, Chester scored a range of 0 to 1 points (*m*=.56). As demonstrated in Figure 1, Chester's data were low level and slightly variable in baseline with a flat trend.

In intervention, following 0-s time delay, Chester's points ranged from 6 to 8 (*m*=6.4). A comparison of Chester's median scores across phases (1 to 7) demonstrated an increase in level from baseline to intervention. Chester's data in intervention were slightly variable with a high level and a flat trend. The PND for Chester's data across baseline and intervention was 100%. Finally, Chester earned 8 points during his maintenance probe.

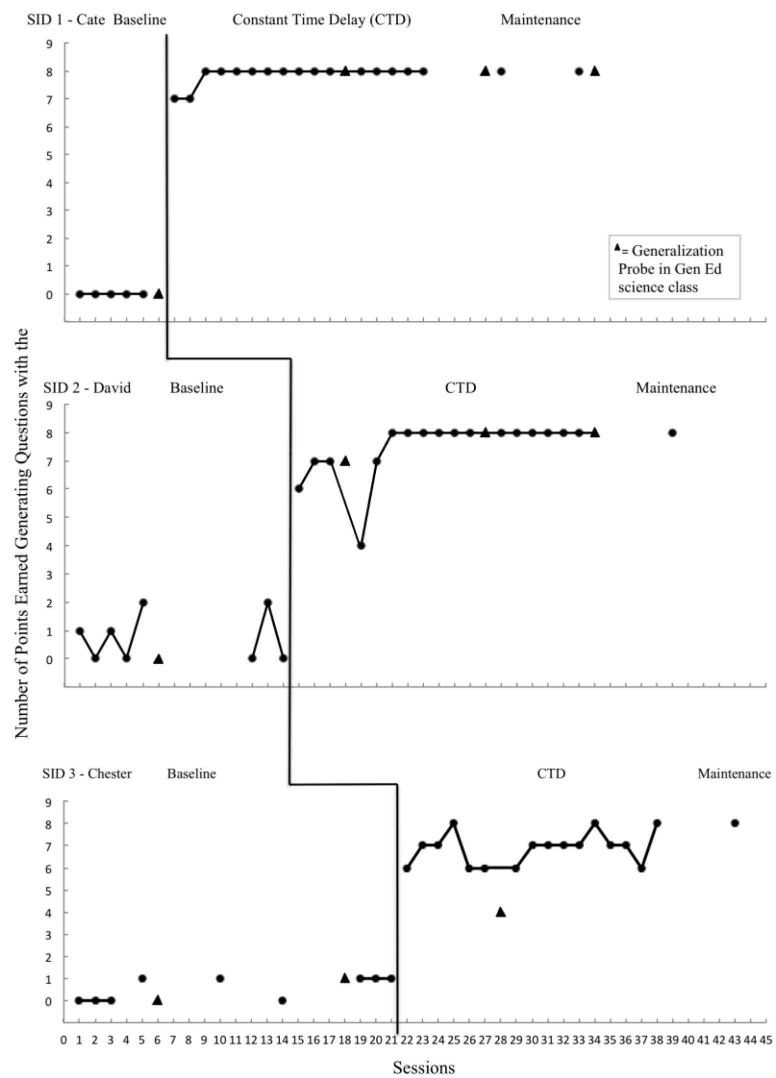

Figure 1: Multiple probe across students graph of points earned generating questions using the iPad2™ template. Graphed responses are independent correct responses. Probes that occurred in the general education classroom are denoted by a solid triangle. Students could earn a maximum of 8 points per session. Points were based on selecting buttons in a specific sequence in order to yield an accurate question.

Question 2: Impact of posing questions and a system of least prompts on locating answers. All three participants increased in the number of independent, correct responses made from baseline to intervention across settings. Visual analysis of the data indicated a change in level and trend from baseline to intervention across the three participants (see Figure 2). Table 3 summarizes the percentage of independent, correct responses across phases and students.

Table 3: Percentage of independent correct responses to comprehension questions

	Baseline	Base - Gen	Intervention	Int - Gen	Maintenance
Cate	40%	20%	71.25%	70%	85%
David	18.75%	10%	64.71%	66.67%	60%
Chester	.09%	.05%	60%	70%	70%

All three students increased in the number of times they independently referenced the text and identified correct responses across phases. Cate independently and correctly answered 174 questions out of 270 questions across all phases. In baseline, Cate's data were variable and moderately low with no increasing trend. In intervention, Cate's data stabilized slightly, with the exception of one low data point in the eight session of intervention. Cate's intervention data represented a clear change in level from baseline, as indicated by a median-level value of 4 in baseline and a median-level value of 7.5 in intervention. Cate's intervention data indicated an overall accelerating trend. There was no immediacy of effect from baseline to intervention, as indicated by an initial intervention score of 4, which matched the median score in baseline (i.e., 4). The PND for Cate's data across baseline and intervention was 68.75%. Cate's maintenance data were variable, with one high score of 10 points followed by a lower score of 5 points (see Figure 2).

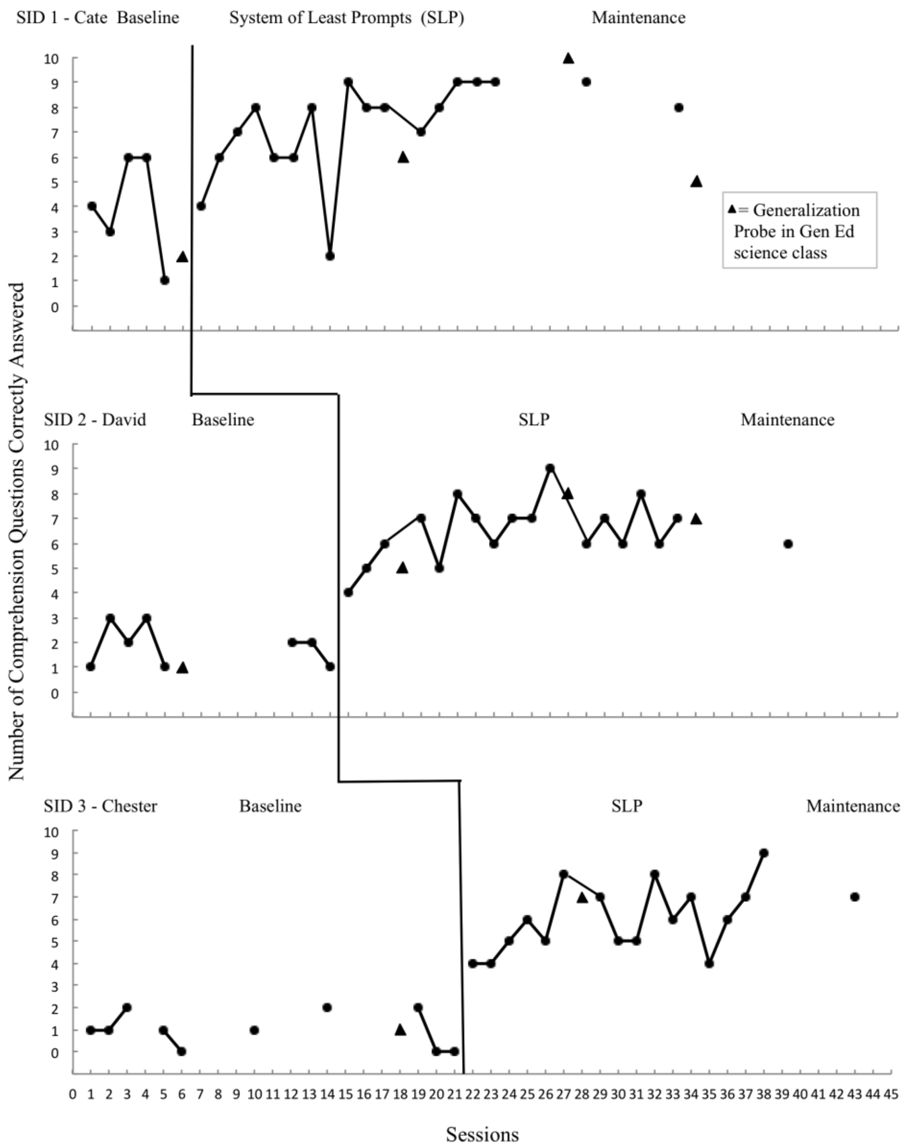

Figure 2: Multiple probe across students graph of the number of comprehension questions correctly and independently answered across phases of the study. Probes that occurred in the general education classroom are denoted by a solid triangle. Students could earn a maximum of 10 correct responses per session.

From baseline to intervention, Cate increased in percentage of independent, correct responses from 40% to 71.25%. Across generalization probes in the general education classroom, which occurred during both baseline and intervention phases, Cate increased in percentage of independent, correct responses from 20% to 70%. Cate's percentage of independent, correct responses in maintenance was 85%. Independent, correct responses were coded as either "+" (student stated answer correctly without referring to the text) or "S+" (student stated answer correctly after independently referring to the text). In baseline, across both settings, 100% of Cate's correct responses were "+." In intervention, 40.68% of Cate's responses were "+," and 59.32% of were "S+." For generalization probes that occurred during the intervention phase, 43.48% of Cate's correct responses were "+," and 56.52% were "S+." During maintenance, 58.82% of Cate's correct responses were "+," and 41.18% were "S+."

David independently and correctly answered 152 questions out of 300 questions across all phases. In baseline, David's data were moderately stable and low with no increasing trend. In intervention, David's data remained moderately stable. David's intervention data represented a clear change in level from baseline, as indicated by a median-level value of 2 in baseline and a median-level value of 7 in intervention. David's intervention data displayed an accelerating trend. There was an immediacy of effect from baseline to intervention, as indicated by an initial intervention score of 4, which was higher than the median baseline score of 2 and the baseline range of 1 to 3. The PND for David's data across baseline and intervention was 100%. David's maintenance score of 6 remained above the range of baseline data (see Figure 2).

From baseline to intervention, David increased in percentage of independent, correct responses from 18.75% to 64.71%. Across generalization probes in the general education classroom, David increased in percentage of independent, correct responses from 10% to 66.67%. David's percentage of independent, correct responses in maintenance was 60%. In baseline, across both settings, 100% of David's correct responses were "+." In intervention, 33.72% of David's responses were "+," and 69.77% of were "S+." For generalization probes that occurred during the intervention phase, 35% of David's correct responses were "+," and 65% were "S+." During maintenance, 33.33% of David's correct responses were "+," and 66.67% were "S+."

Chester independently and correctly answered 121 questions out of 290 questions across all phases. In baseline, Chester's data were moderately stable and low with no increasing trend. In intervention, Chester's data remained moderately stable. Chester's intervention data represented a clear change in level from baseline, as indicated by a median-level value of 1 in baseline and a median-level value of 6 in intervention. Chester's intervention data displayed an accelerating trend. There was an immediacy of effect from baseline to intervention, as indicated by an initial intervention score of 4, which was higher than the median baseline score of 1 and the baseline range of 0-2. The PND for Chester's data across baseline and intervention was 100%. Chester's maintenance score of 7 remained above the range of baseline data (see Figure 2).

From baseline to intervention, Chester increased in percentage of independent, correct responses from .09% to 60%. Across generalization probes in the general education classroom, Chester increased in percentage of independent, correct responses from .05% to 70%. Chester's percentage of independent, correct responses in maintenance was 70%. In baseline, across both settings, 100% of Chester's correct responses were "+." In intervention, 43.75% of Chester's responses were "+," and 56.25% of were "S+." For generalization probes that occurred during the intervention phase, 28.57% of Chester's correct responses were "+," and 71.43% were "S+." During maintenance, 42.86% of Chester's correct responses were "+," and 57.14% were "S+." Table 4 provides the percentage of "+" and "S+" responses across phases and students.

Table 4: Percentage of "+" and "S+" responses to comprehension questions

	Baseline		Gen-Base		Intervention		Gen-Inter		Maintenance	
	+	S+	+	S+	+	S+	+	S+	+	S+
Cate	100%	0%	100%	0%	40.68%	59.32%	43.48%	56.52%	58.82%	41.18%
David	100%	0%	100%	0%	33.72%	69.77%	35%	65%	33.33%	66.67%
Chester	100%	0%	100%	0%	43.75%	56.25%	28.57%	71.43%	42.86%	57.14%

Question 3. Points earned generating questions without a template. Participants could earn up to 3 points for every question they were asked to generate, for a total of 6 points each session. Participants made slight increases in mean points earned from baseline to intervention (see Table 5).

Table 5: Range and mean of points earned generating questions without an iPad2™

	Baseline	Intervention	Maintenance
Cate	m = 1.6 range = 1-2	m = 2.38 range = 2-5	m = 5.5 range = 5-6
David	m = 1 range = 0-2	m = 2.06 range = 2-3	m = 2 range = 2
Chester	m = .33 range = 0-2	m = 1.56 range = 0-3	m = 2 range = 2

Two of the three participants demonstrated a change in level (see Figure 3). In baseline, none of the participants earned all 3 points for constructing a question during any of the opportunities to form questions.

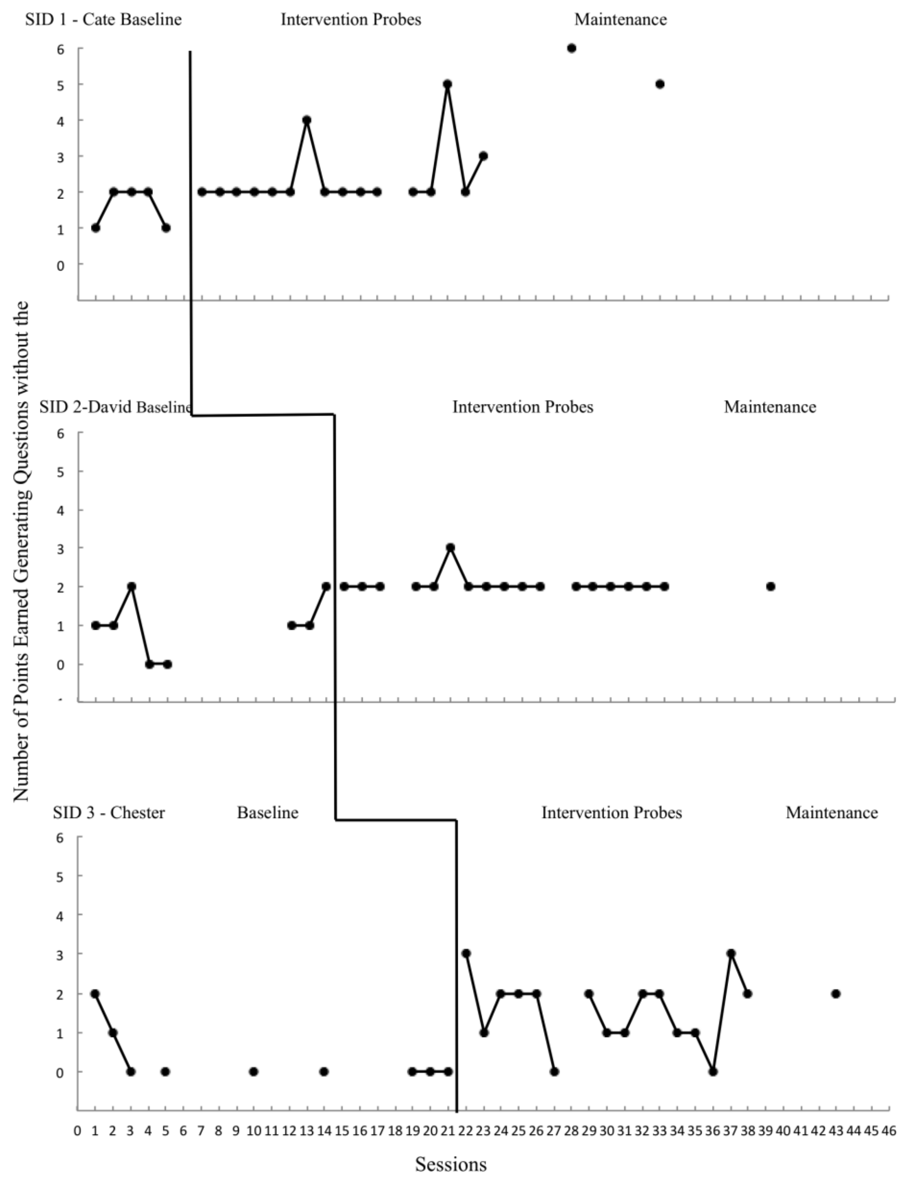

Figure 3: Multiple probe across students graph of the number of points earned generating questions each session without the use of the iPad2™ template. Students were told to "think of a question in your head," and students received points based on the novelty and accuracy of the question asked.

In baseline, Cate's points ranged from 1 to 2 (*m*=1.6). As demonstrated in Figure 3, Cate's data were low and stable in baseline with no discernable trend. In intervention, Cate's points ranged from 2 to 5 (*m*=2.38). Cate's intervention data were initially stable, but they increased in variability during the last three sessions. Due to this fluctuation in data, Cate's intervention data represented a slight ascending trend. The median scores across phases remained the same (i.e., 2), and there was no change in level. There was a high amount of overlapping data across phases; the PND for Cate's data from baseline to intervention was 18.75% (see Figure 3). Cate earned a range of 5 to 6 points for maintenance probes (*m*=5.5).

In baseline, David scored a range of 0 to 2 points (*m*=1). As demonstrated in Figure 3, David's data were low level and slightly variable in baseline with a flat trend. In intervention, David's points ranged from 2 to 3 (*m*=2.06). David's intervention data were a slightly higher level than baseline, with an increase in median scores from baseline to intervention of 1 to 2. The intervention data were stable with a flat trend. There was a high amount overlapping data across phases; the PND for David's data from baseline to intervention was 6.25%. David earned 2 points during his maintenance probe (see Figure 3).

In baseline, Chester scored a range of 0 to 2 points (*m*=.33). As demonstrated in Figure 3, Chester's data were low level and slightly variable for the first three data points and stable for the remainder of baseline. There was a slight descending trend in baseline data. In intervention, Chester's points ranged from 0 to 3 (*m*=1.56). Chester's intervention data were variable with a flat trend. These data were low level and a slightly higher level than baseline, with an increase in median scores from baseline to intervention of 0 to 2. There was a high amount overlapping data across phases; the PND for David's data from baseline to intervention was 12.5%. Chester earned 2 points during his maintenance probe.

Question 4. Generalization of question generation. All three participants demonstrated an increase in points earned across phases (baseline to intervention). Generalization probe data were recorded on the same graph used for points earned generating questions in the special education classroom (see Figure 1). Four probes were conducted in the generalization classroom. Cate and David were present for all four probes; Chester was present for two of the probes. Cate scored 0 points during the baseline probe in the general education classroom; her mean and median score for intervention probes was 8 points. David scored 0 points during the baseline probe in the general education classroom; David's mean score was 7.67, and his median score was 8 points. Chester scored 0 points during the baseline probe in the general education classroom; he scored 4 points during the intervention probe.

Question 5. Generalization of questions answering. All three participants demonstrated an increase in questions answered correctly and independently from baseline to intervention during generalization probes in the general education classroom. Generalization probe data were recorded on the same graph used for questions answered in the special education classroom (see Figure 2). Four probes were conducted in the generalization classroom. Cate and David were present for all four probes; Chester was present for two of the probes. Cate correctly and independently answered 2 questions during the baseline probe in the general education classroom; Cate's mean score was 7 questions, and her median score was 6 questions. David correctly and independently answered 1 question during the baseline probe in the general education classroom; David's mean score was 6.67 questions, and his median score was 7 questions. Chester correctly and independently answered 1 question during the baseline probe in the general education classroom; he correctly and independently answered 7 questions during the intervention probe.

Question 6. Pretest / posttest data from distal measure. The researcher administered the Listening Comprehension subtest of the WLPB™-R to the participants prior to entering intervention and after all three participants completed the intervention (7 weeks later). On the pretest, Cate received a raw score of 14 correct; with an age equivalency of 5 years, 1 month; and a grade equivalency was K.2. On the posttest, Cate's raw score was 15 correct; with an age equivalency of 5 years, 4 months; and a grade equivalency of K.4. On the pretest, David received a raw score of 11 correct; with an age equivalency of 4 years, 3 month; and a grade equivalency was K.0. On the posttest, David's raw score was 11 correct; with an age equivalency of 4 years, 3 months; and a grade equivalency of K.0. On the pretest, Chester received a raw score of 9 correct; with an age equivalency of 4 years, 0 months; and a grade equivalency was K.0. On the posttest, Chester's raw score was 10 correct; with an age equivalency of 4 years, 0 months; and a grade equivalency of K.0. See Table 6 for score summaries.

Table 6: Pretest and posttest data of WLPB™-R

	Raw Score		AE		GE	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Cate	14	15	5-1	5-4	K.2	K.4
David	11	11	4-3	4-3	K.0	K.0
Chester	9	10	4-0	4-0	K.0	K.0

AE = Age Equivalency GE = Grade Equivalency

Question 7. Ratings from stakeholders on items related to study. Social validity questionnaires were distributed to the special education teachers and families of student participants. Questionnaires were administered to student participants by both the lead researcher and Ms. Elliot. All questionnaires were voluntary and distributed after the third student completed the intervention phase of the study.

All three student participants completed the questionnaire. The student questionnaire included five items. Participants rated each statement as "I liked this" or "I didn't like this." All three participants rated the items "I asked questions about science" and "I used an iPad2™ to answer questions" as "I liked this." Two participants rated the items "I answered questions about science," "I used a computer to listen to science books," and "I asked and answered questions about science in a science classroom" as "I liked this;" one participant rated these item as "I didn't like this." Table 7 includes summary information of student ratings.

Table 7: Tally of social validity responses – Students

	"I liked this"	Did not answer	I didn't like this
1. I asked questions about science	| | |		
2. I used an iPad2™ to ask questions	| | |		
3. I answered questions about science	| | |		|
4. I used a computer to listen to science books	| |		|
5. I asked and answered questions about science in a science classroom	| |		|

Three special education teachers completed the questionnaire. Two of the teacher, Ms. Elliot and Ms. Tatum, were interventionists in the study. A third teacher, Ms. Kirk, is the special education teacher responsible for math instruction for all of the students in the Specialized Academic Curriculum program. She had direct knowledge of all three participants and had knowledge of the procedures, materials, and instruction used in the study. Table 8 includes summary information of special education teacher ratings.

Table 8: Tally of social validity responses – Teachers

	SA	A	U	D	SD
1. Students with moderate intellectual disability can learn to ask questions.	| |	|			
2. Students with moderate intellectual disability can learn to answer questions about science texts.	| | |				
3. Asking questions is a difficult skill for many students with moderate intellectual disability.	| | |				
4. Answering questions is a difficult skill for many students with moderate intellectual disability.	| |	|			
5. The science content was appropriate for my students.		| | |			
6. The materials (question template on iPad™, Discovery Education e-texts, comprehension questions) were appropriate for my students.		| | |			
7. The systematic instruction was effective for teaching question asking and answering.	| |	|			
8. My students benefited from asking and answering questions during instructional sessions.	|	| |			
9. My students benefited from asking and answering questions in the third grade science classroom.		| | |			

SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

All three teachers rated the following two items as "strongly agree": (a) "Students with moderate intellectual disability can learn to answer questions about science texts" and (b) "Asking questions is a difficult skill for many students with moderate intellectual disability." All three teachers the following three items as "agree": (a) "The science content was appropriate for my students;" (b) "The materials were appropriate for my students;" and (c) "My students benefited from asking and answering questions in the third grade science classroom." The following three items were rated "strongly agree" by two teachers and "agree" by one teacher: (a) "Students with moderate intellectual disability can learn to ask questions;" (b) "Answering questions is a difficult skill for many students with moderate intellectual disability;" and (c) "The systematic instruction was effective for teaching question asking and answering." The following item was rated as "strongly agree" by one teacher and "agree" by two teachers: "My students benefited from asking and answering questions during instructional sessions."

One of the students' families returned the questionnaire. The participating parent rated all nine items as "agree." All items mirrored the items on the teacher's questionnaire, with the exception of the words "my student" changed to "my child" for items 5 through 9. For a complete list of the items on the parents' questionnaire, see Table 4.

CHAPTER 5: DISCUSSION

Question 1: What was the effect of constant time delay on students' ability to generate questions about science e-texts?

Participants in the study were taught to form a question using an iPad2™ prior to listening to an e-text through the Discovery Education Web site. All three students demonstrated a stable, low level in baseline for points earned generating questions. A functional relationship was established due to a clear increase in level and trend across participants upon entry into the treatment phase. Two students, Cate and David, demonstrated mastery of this skill (100% accuracy across three consecutive sessions). Cate learned the skills the fastest, as she demonstrated mastery by the sixth session of treatment. David demonstrated mastery after eight sessions of treatment. Chester demonstrated a clear change in level and trend, but his data remained slightly variable throughout the treatment phase.

In a previous study by Wood et al. (2014), students were trained through a system of least prompts to generate questions given all six question words (i.e., who, what, where, when, why, how) and the topic of a section of text (a section heading) on a paper-based graphic organizer. Participants in the Wood et al. study did demonstrate an increase in points earned both asking and answering questions across phases, but the researchers were not able to parse out the difference in gains across points earned generating and answering questions. Additionally, students were able to generate any question they could think of using any question word and the provided topic. Consequently, students were able to ask questions that could not have been answered by listening to the text. In the current study, students were taught to use an iPad2™ template containing question parts (question words and topics) that would yield literal questions that could be answered in the text. Increasing the uniformity of the questions by ensuring they could all be answered, increased the likelihood that students would receive the natural reinforcer of acquiring an answer to any question they generated. Additionally, in the current study, the process of generating a question was task analyzed so the steps of forming a question could be taught as part of a clear chain. In Wood et al., the teacher modeled how to form a question using a think aloud format. In the current study, students learned to select the parts of a question in sequence by imitating the controlling prompt of the teacher pointing to and saying each part of the question in order.

Question 2: What was the effect of posing questions combined with a system of least prompts on the ability of students with moderate intellectual disability to locate answers about science e-texts?

All three participants increased in the number of comprehension questions independently and correctly answered from baseline to intervention phases. In baseline, Cate's data were variable, but there was no increasing trend. Ms. Elliot commented Cate's variation in performance might have been related to her level of interest and background knowledge of each text. For example, on several occasions, Cate expressed a dislike for texts about soil, and she expressed an interest in texts about electricity and animal habitats. Cate's data in the treatment phase represented a clear increase in level and trend. On one occasion, Cate answered only two questions correctly during an intervention session. This score was atypical and, according to her teacher, the result of "an off day." Cate learned quickly to look for answers in the text. Cate became quickly adept at using the words in the question to locate the target area of text on the page. Once she matched the question topic words (e.g., "is the Nile River") with the same words in the text ("The Nile River is"), she would highlight and replay the sentence or two containing the topic words. She listened for the answer (e.g., "Africa") and stated the answer. Initially, Cate would repeat the entire sentence or a phrase in the sentence containing the answer. The researcher instructed the interventionist to say, "Tell me the *word* that is the answer." A score of "S+" was given if Cate responded to the clarified directional cue by stating only the target answer. Initially Cate would search for every answer in the text, and she incorrectly answered some questions she may have known in her head. The researcher instructed the teacher to emphasize to Cate that she *first* tries to answer the question in her head, *then*, if needed, search for the answer in the book. The emphasis on the first / then approach to answering the question impacted Cate's question answering behavior, and she resumed answering questions without referencing the book if she knew the answer in her head. Her dual behaviors of both searching for answers and answering questions in her head were illustrated by her overall percentage of "+" and "S+" responses; only slightly more than 50% of her responses were "S+" responses.

David's baseline performance demonstrated low level, stable data. He demonstrated moderate gains in the treatment phase, and notably, David had no overlapping data. David also learned quickly to reference the book if he did not know the answer in his head. David struggled with answering questions due to his speech limitations. He had the ability to approximate any word he wanted to say, but he was selfconscious of saying a word incorrectly. Ms. Elliot encouraged David, just like the others, to answer in his head first, but to use the book if needed. For David, to augment his speech, Ms. Elliot reminded David to use the book to help his speech. Sometimes David would point to an answer in the text (sometimes the correct answer, sometimes the incorrect answer). During these instances, Ms. Elliot responded with, "Ok. Now say that answer." If David independently pointed to a correct answer and attempted to articulate the answer, he received credit for an independent correct response ("S+"). Like Cate, David quickly learned to accurately use the mouse to highlight specific portions of text and replay them. Also like Cate, David independently referenced the question topic words on the iPad2™ and scanned for the matching words in the text. Most likely due to David's difficulty articulating speech sounds, he relied more heavily on the text than the other two participants. A larger majority of his independent correct responses during intervention were "S+" compared to the other two participants.

Like David, Chester demonstrated a low level, stable baseline. Of the three participants, Chester scored the lowest mean number of independent correct responses in the baseline phase. He demonstrated a clear change in level in treatment, with no overlapping data. Chester struggled attending to the texts throughout the study, but he learned to replay the text and listen for an answer. Unlike Cate and David, Chester did not demonstrate a clear understanding of matching the question topic words on the iPad2™ to words in the text. Instead, when he indicated he needed to search back in the text, he would typically replay the entire page of text instead of a specific portion. Sometimes he would stop the text-to-speech when he heard what he perceived was the correct answer. Like Cate, Chester answered slightly more than half of the questions correctly after searching independently in the text. He still answered a large portion of the questions from his head. His ability to attend to the texts varied from session to session. Some days he would sit relatively still and remain turned toward the computer for the duration of the session. During other sessions, he would turn often in his chair, remove his shoes, or play with his fingers. Despite the differences in performance across the three participants, a functional relationship was demonstrated between the number of independent correct responses and the system of least prompts intervention. Across all three students, the majority of independent, correct responses were provided after the participants independently searched for the answers in the e-text.

A growing number of experimental studies demonstrate students with severe disabilities can improve listening comprehension skills through read-alouds and systematic instruction (e.g., Browder et al., 2011; Browder, Mims, et al., 2008; Hudson & Browder, 2014; Hudson et al., in press; Mims et al., 2009; Mims et al., 2012; Spooner et al., 2009; Wood et al., 2014). In the majority of this research, students learned to answer literal questions about narrative texts in a one-to-one or small group format with a special education teacher. The current study adds to this research by including instruction in question generation, teaching expository texts, including a generalization component in a science classroom, teaching students to access and navigate e-texts, and using an iPad2™ as assistive technology to build background knowledge and form questions. Although not previously used with students with severe disabilities, question generation is an effective comprehension strategy for students with mild disabilities and without disabilities (Berkeley, Marshak, et al., 2011; Bulgren et al., 2011; Faggella-Luby et al., 2007; Manset-Williamson et al., 2008; Rosenshine et al., 1996).

A small number of studies examined the effects of teaching expository science content to students with severe disabilities (Courtade et al., 2010; Hudson et al., in press; Jimenez et al., 2012; Knight et al., 2012; Knight, Spooner, et al., 2013; Smith, Spooner, Jimenez, et al., 2013; Smith, Spooner, & Wood, 2013). The majority of these studies taught students to comprehend the meaning of science vocabulary words and key concepts. Only one of these studies examined the effects of teaching listening comprehension of expository science texts (i.e., Hudson et al., in press).

Similar to the current study, Hudson et al. (in press) delivered a system of least prompts to teach listening comprehension of expository text. Hudson et al. described the importance of delivering prompts that do not initially provide a model prompt of the correct response for tasks such as comprehension. To comprehend text, students must understand the content, not simply memorize responses. Several studies demonstrate the effects of this modified system of least prompts on the listening comprehension of students with intellectual disability (Hudson & Browder, 2014; Hudson et al., Mims et al., 2012; Wood et al., 2014), but the current study is the first known application of this type of systematic instruction for teaching students with intellectual disability to independently reference the text to find the answer.

For example, unlike the current study, Hudson et al. (in press) did not embed instruction for finding the answers in the text (e.g., providing a question in print and teaching students to match question words to the find target areas of the text). In Hudson et al., students listened to peers read text aloud to them from adapted text materials. After hearing the question read aloud, students selected a response from an array of response options. In the current study, teachers delivered instruction and students were not given an array of response options. Instead, students were asked to answer the question from their head or find the answer in the book. In the current study, a major outcome of the procedures includes the autonomous skill of accessing and searching in texts as needed to locate an answer. When students have some emerging decoding skills, teaching them to reference the text provides an additional strategy for answering questions.

Question 3: How did the use of a question template affect students' ability to generate new questions?

All three participants demonstrated very slight gains in the number of points earned from baseline to intervention for generating new questions. However, Cate was the only participant to generate a complete and appropriate question during these probes. The data collected were points earned, not the number of questions of asked. The majority of points earned across all three students in both baseline and intervention were from an independent and correct response to the second item on the question-generating checklist: "Question contains science content related to e-text." For this item, students received one point for saying words related to the e-text topic. For example, if the students listened to a text about bodies of water, a typical response to the directional cue may have been "ocean." If a participant responded "ocean," the participant earned one point. These data represent a slight increase in the participant's behavior of stating a topic word or words related to the e-text when prompted to ask a question without the template. Ms. Elliot did not provide prompting, error correction, or praise during this probe. It is unknown why Cate spontaneously asked complete questions at the end of the study and the others did not. It is not surprising that Cate was the participant who was able to generalize this skill from the iPad2™ to her head. Cate was the most adept at correctly answering the comprehension questions, she demonstrated a high rate of on-task behaviors, and she was the fastest at acquiring the other question generating skill (generating a question with the iPad2™ template). David relied heavily on the text-to-speech and auditory cue feature of the iPad2™ due to his difficulty producing speech sounds. Chester made the smallest gains of the three participants across all of the skills, and he was not consistently providing topics when asked to think of a question without the template. The skill of generating a question in one's head likely requires further instruction than learning to build a question using an iPad2™ template through constant time delay.

The students' inability to form questions without the template may indicate the need for continued use of the template as a form of assistive technology some students may need for academic contexts. Students learned to generate questions on the iPad2™ quickly and used the iPad2™ to assist them in answering questions about the text. The iPad2™ has the capabilities with the auditory cueing and text-to-speech features to serve as a communication device that will voice questions for students without the vocal abilities to voice questions independently. The participants in the current study did not rely on the voice output feature for voicing their responses, but they did rely on the iPad2™ for the auditory cues (they could replay their target question as needed) and the text and pictures as visual referents (e.g., matching question text to target text in the book). The iPad2™ served as assistive technology to help supplement their literacy skills (none of the students could decode connected text independently).

Independent question generation may be a longer term goal for the participants in this study. The brief three to four week duration of intervention was not long enough for students to generalize the complex skill of asking questions without the support of the iPad™. Additionally, future research might include a measure of whether question asking increases in general for participants throughout the school day across various natural contexts.

Questions 4 and 5: Did the skill of generating questions about science e-texts and answering comprehension questions about the e-texts generalize to other settings?

The skills of both generating questions about science e-texts and answering comprehension questions about the e-texts did generalize to the general education classroom. All three students earned higher points generating questions from baseline to intervention while in the science classroom. Additionally, all three students answered more comprehension questions correctly in the general education setting after entering the intervention phase of the study. Many factors were different across settings, including the interventionist, the computer, the arrangement of the room, the noise level in the room, and the social climate of the general education classroom. Both interventionists, Ms. Elliot and Ms. Tatum, were special education teachers familiar to the three participants in the study. The participants did not regularly attend classes with peers from general education. The three participants did not have regular exposure to large classrooms of students (there were 22 students in the third grade class that attended the science room during the study). Despite the limited interaction the participants had with students in general education settings, they all expressed excitement about attending class with their peers.

In the current study, generalization probes were embedded in a general education context; students did not receive instruction during these probes. In other studies, instruction was embedded in general education contexts. Hudson et al. (2013) identified 17 studies in which instruction in academics or academic engagement was embedded in general education contexts for students with severe disabilities. Typically, from this body of research, students learned skills in sight word instruction through embedded constant time delay procedures (e.g., Jameson et al., 2008). Other studies embedded inquiry-based science instruction (e.g., Jimenez et al., 2012; Smith et al., 2013) and comprehension of narrative text (e.g., Hudson & Browder, 2014) and expository text (e.g., Hudson et al., in press; Wood et al., 2014). The current study embedded listening comprehension of science texts, but it is unknown if the students would have learned to generate and answer questions if instruction had been embedded in the third grade science classroom.

Question 6: Did effects of the proposed treatment package generalize to a distal measure of comprehension, as measured by the WLPB™-R)?

Changes in distal measures of comprehension were not consistent across participants. While Cate and Chester's raw scores increased by one point each from pretest to posttest, David's scores remained the same. One reason for the lack of increase in scores across all participants is the brief duration of this study. Participants received instruction in the intervention phase for an average of 16.33 sessions over a period of three to four weeks. This brief amount of time is most likely not long enough for a generalization of comprehension skills to occur. Browder et al. (2013) experienced a similar lack in generalization when all participants did not demonstrate an increase in scores on the Gates-MacGinitie Reading Tests (GMRT) from pretest to posttest. In the Browder et al. (2013) study, participants were tested using Level 1 materials, and they were administered both subtests, Word Decoding and Comprehension. While two participants increased slightly from pretest to posttest, one participant decreased slightly.

Question 7: Did stakeholders rate the procedures, materials, and outcomes favorably?

To assess the perceived value of this research study, the perceptions of three special education teachers, one parent, and the three student participants were measured using questionnaires. Each group of stakeholders represented different perspectives on disability and skill acquisition. All stakeholders rated the procedures, materials, and outcomes favorably, with the exception of three items the participants rated as “I didn’t like.” Chester indicated he did not like asking and answering questions about science in a science classroom. David indicated he did not like answering questions about science or using a computer to listen to science books. Neither Chester nor David indicated they did not like any of the materials or procedures throughout the study, so it is unknown why they rated these items as “I didn’t like.”

Contributions to the Literature

This study supports the growing body of research that indicates students with moderate intellectual disability can learn to comprehend expository text (e.g., Hudson et al., 2014; Mims et al., 2012, Shurr & Taber-Doughty, 2012; Wood et al., 2014). Spooner et al. (2011) identified 17 studies in which science content was taught to students with moderate and severe disabilities. Two recent studies (i.e., Hudson et al., 2014; & Shurr & Taber-Doughty, 2012), included instruction in comprehension of science texts. With the emphasis on comprehension across content areas urged by the developers of the CCSS and the need for increased access to all forms of literature for students with severe disabilities (Browder et al., 2009), this study contributes to this need in two ways. First, participants increased comprehension of science texts, and second, participants learned to follow cues on an iPad2™ to locate, play, and replay science e-texts. By emphasizing both content (i.e., science topics) and practices (i.e., generating questions, locating answers in text), the procedures used in this study contribute to an understanding of how to teach science to students with moderate intellectual disability. Teaching students to generate questions may help engage students in science activities. Using science e-texts during instruction can increase students' knowledge of science concepts prior to engaging in an inquiry project.

A unique contribution of this study is that participants learned a comprehension strategy (i.e., generating questions) in addition to receiving instruction in how to answer questions (i.e., "Think of it in your head or find it in the book"). Teaching students to access and navigate e-texts in order to locate answers increases students' ability to exercise autonomy in the learning process.

Additionally, this study extends the research in which a system of least prompts has been used to teach students listening comprehension (e.g., Hudson et al., in press; Hudson & Browder, 2014; Mims et al. 2012; Wood et al., 2014) by embedding explicit rules for locating answers. Specifically, inserted in the prompts was a think-aloud explanation of how to use the question on the iPad2™ to find the section of text in which the answer was contained in the text. Additionally, special education teachers delivered instruction to teach comprehension of science e-texts, a resource with supports already embedded in the design of the materials (i.e., highlighting features, pictures, text-to-speech software).

This study contributes to the limited research in which students with moderate and severe disabilities have been taught the comprehension strategy of generating questions. As described by Rosenshine et al. (1996), many studies have examined question generating for students without disabilities or students with mild disabilities. Prior to this study the only known study in which students with moderate intellectual disability were taught to generate questions was Wood et al. (2014). Across the two studies, emerging evidence suggests students with moderate intellectual disability can learn to build questions through systematic instruction. The current study introduced an iPad2™ template, on which definitions of question words could be embedded using auditory cuing. The iPad2™ template also allowed students to systematically build and voice a question containing all of the essential elements of a question (i.e., question word, question topic, and question mark). In both studies, participants were encouraged to use the question as a visual referent when listening to the text and later answering the question. In the current study, students were explicitly taught how to use the words in the question topic to locate the approximate section of text in which the answer was located. Other advantages of the iPad2™ for question building included the ability to embed pictures with each question topic. Since these participants were non-readers with varying levels of early literacy skills, the pictures and auditory cuing supported their understanding of the topics of the questions they built.

The use of the graphic organizer to form questions and support the location of answers in the text also extended the literature for this population of students. Graphic organizers have been used to teach many skills to students with disabilities (e.g., Berkeley, Marshak, Mastropieri, & Scruggs, 2011; Gardill & Jitendra, 1999; Knight, Spooner, Browder, Smith, & Wood, 2013; Ozmen, 2011), however only one study has used a graphic organizer to teach students with moderate intellectual disability to generate a question (Wood et al., 2014). The current study differed from the Wood et al. study in that students used a template on an iPad2™ to generate questions.

The use of technology to promote comprehension of and access to e-texts is another contribution to the literature. Technology can provide individuals with a means to access academic content, organize information, and respond to questions. Several studies have examined the efficacy of teaching students to use technology (e.g., iPad2s™, iPods™) to learn life skills (e.g., cleaning a room). Technology can also be used to teach students to access expository content (i.e., science e-texts) via the Internet. Technology also can be used to help students organize information to ask and answer questions related to academic content. In the current study, participants learned to use an iPad2™ as a graphic organizer for generating questions as well as to access e-texts through a Web site on a classroom computer. Similar to Zisimopoulos et al. (2011), students in the current study were taught through systematic instruction to access content using the Internet. In contrast to Zisimopoulos et al., students in the current study additionally generated and answered questions about the content they accessed online. Coyne et al. (2012) and Douglas et al. (2011) both taught students to comprehend e-text, but additional comprehension strategies were not embedded in either study (i.e., question generating).

A final contribution to the literature was the demonstration of generalization across contexts. In this study, students received instruction in question generating and question answering in the special education classroom. These skills generalized in a general education science classroom as evidenced by probes delivered by a special education teacher four times throughout the study. These probes were embedded during ongoing instructional and small group activities in which the participants with disabilities were active, engaged participants. All three participants demonstrated an ability to access e-texts, generate questions using an iPad2™, and locate and answer comprehension questions about science e-texts in the science classroom, which increased their ability to access academic content alongside their peers without disabilities. Similar to the findings of Wood et al. (2014), in which students generalized question answering skills to a fifth grade social studies class, students in the current study generalized skills across settings.

Limitations

One limitation of this study is the specificity of the materials. Both Discovery Education subscriptions and iPad2s™ are widely available to students and teachers across the country, but not all classrooms are equipped with these materials. In the school setting for the current study, Ms. Elliot did have six iPad2s™ to use with students, which she acquired through the school system and grant funding. Ms. Tatum had two iPad2s™ in her classroom, and the general education teacher had one iPad2™ in her classroom, both provided by the school system. Due to limited resources, iPad2s™ are not available to every teacher and every student in every school. The Web site, Discovery Education, is available in many large school districts, but it may not be available in smaller, rural districts. Finally, the app GoTalk NOW, which was used to create the question template and the visual and auditory cues for accessing the e-texts, costs $80. None of the teachers had this app installed on their iPad2s™, and as a result, the researcher supplied iPad2s™ equipped with the app for use in the study.

A second limitation was the amount of time required to prepare materials. Preparing the materials for the study took a substantial amount of time. The researcher prepared the materials by locating 50 e-texts, checking the topic of the e-text to ensure they matched topics covered in grades 2 through 5 (approximately 2 hours), writing and editing literal comprehension questions related to the e-texts (approximately 3 hours), and programming the GoTalk NOW communication book with question templates for each book (approximately 15 hours). However, similar to other investments of time for teachers, these materials can be used with other students once created. Additionally, recent studies on read-aloud interventions for students with severe disabilities have included texts adapted by teachers or researchers. One benefit of the current study is the texts did not require adaptations.

A third limitation is the time the special education teacher spent implementing the study in the special education classroom. Ms. Elliot spent an average of 25 min per session working one-on-one with each participant during the intervention phase of the study. These sessions were generally held first thing in the morning immediately following breakfast when the other students in the class were seated at one of two tables to complete independent morning work. Ms. Elliot’s teaching assistant managed the class when Ms. Elliot administered the intervention. This arrangement was not typically problematic, but occasionally another student in the class would have a toileting or medical need that required the collaboration of two adults. Ms. Elliot commented that she liked the one-on-one time to work with each of the students, and she believed the students were benefiting from both the attention and instruction. However, she also commented that is was sometimes stressful for both her and her teaching assistant. One possible solution may be to teach question generating and answering as part of a small group lesson. The teacher could display e-texts using a SMART Board™, similar to Smith et al. (2013). Students could still generate questions using an iPad2™ template and search in the text as needed by activating the e-text using the SMART Board™.

A fourth limitation is related to the concept of inquiry. One reason science texts were selected for this study is the assumed relationship between science inquiry, a recommended practice for teaching science content and skills, and generating questions. The connection between generating questions and inquiring about science was embedded in the procedures of the current study by the interventionist who talked to the students about "wondering" prior to asking the student to generate a question. The teacher would show a page on the iPad2™ with a picture symbol and text for "I wonder…?" and buttons with question words listed below. The teacher would explain, "Hmm… I wonder about this book. Do you wonder? Do you have a question you would like to ask? Push the question words to hear about those types of questions." The student would push the buttons to hear the definition of the question words, and then the iPad2™ app would automatically advance the page to the question-generating template related to the type of question the student selected (e.g., "What"). Including this step, in which the teacher commented on the concept of "wonder," may not have been sufficient for ensuring the student genuinely engaged in inquiry. What is known is that the student learned, through time delay, how to push buttons in a specific order to form a complete question.

A fifth and final limitation is that the intervention was not conducted in the general education classroom. The intervention (time delay and system of least prompts instructional procedures) occurred exclusively in the special education classroom. It is unknown if embedding instruction in generating and answering questions would have been effective in the general education setting. Embedding these procedures in an inclusive setting could allow students with moderate intellectual disability to receive instruction in comprehension of science content alongside their peers in general education.

Recommendations for Future Research

Future research could examine methods for combining the elements of this intervention (i.e., technology, question generating, locating answers, systematic instruction) with hands-on experiments to build inquiry skills. For example, critical elements of this study could be combined with the procedures used by Smith et al. (2013) to teach science vocabulary and concepts through an inquiry-based science lesson. Smith et al. incorporated a KWHL chart as a graphic organizer into instructional procedures. The “W” (What do you want to know?) is similar to the initial question students were asked to generate in the current study. Smith et al. used brief science texts to provide background knowledge, pique students’ interest, and build the concept of “wonder” or inquiry. Future research could examine the effects of generating questions, listening to science e-texts, and answering questions about science e-texts on the comprehension of science content following a hands-on science experiment or activity. The process of generating questions and locating answers could be used to build background knowledge. Next, students could participate in a related science experiment. Finally, the primary dependent measure, answering questions about science, could be administered. These questions would be a probe, and they would be developed to test knowledge of the concepts learned from the e-texts and participation in the experiment. Additionally, future research could examine the efficacy of embedding these procedures, both from the current study and the proposed procedures described above, in a general education setting. The current study embedded probes in a general education classroom, but future research is warranted to examine the effects of embedding instructional sessions in the general education setting as well.

Future research also could examine the efficacy of teaching the application of a self-questioning strategy to improve the comprehension of a wider range of content areas (e.g., poetry, job training manuals, leisure texts). This study extended the literature of teaching science content through science e-texts. Teaching students to ask questions and find answers in a text is a skill that may be generalizable to other types of texts, across both text content (e.g., fiction, medical brochure) and format (e.g., e-text, traditional book). Additionally, another measure for future research is the extent to which students generalize question-generating skills more broadly across contexts (e.g., Do independent and spontaneous question-generating behaviors increase across contexts following instruction in generating questions?).

Another recommendation for future research is to examine the effects of generating questions on higher-order thinking skills, such as inferential comprehension. All three participants demonstrated an ability to reference the text to find the answer, and two of the participants appeared to reference the question words to find the answer in the text. To help the participants continue to evaluate how to answer the question, the interventionist also reminded students to think of the answer “in your head.” The think-aloud procedures that were embedded in the system of least prompts were specific to helping the student find the answer in the text; there was no prompting specific to thinking of the answer without referencing the text. Hudson et al. (in press), Mims et al. 2012, and Wood et al. (2014) included think-aloud procedures in the system of least prompts procedures for answering inferential questions. These procedures have not been applied to comprehension of e-texts, and warrant further investigation.

Implications for Practice

Findings from this study suggest special education teachers can deliver systematic instruction to teach students with moderate intellectual disability to ask and answer questions about science e-texts. Students with disabilities can learn to access a wide range of expository content via the Internet if trained using systematic instruction, such as constant time delay. Additionally, through constant time delay, students with moderate intellectual disability can learn to locate, play, and replay specific portions of e-texts. The use of e-texts is a pragmatic way for students with disabilities to access academic content because these texts are premade and have supports already embedded within them, including text-to-speech, picture supports, and highlighted text. Technology, such as the iPad™, is a useful tool for facilitating the process of asking and answering questions for students with moderate intellectual disability. The embedded supports in the iPad2™ app GoTalk NOW provide students with the pictorial, organizational, auditory supports to successfully generate and answer questions. Finally, students with moderate intellectual disability can generalize skills they learn in the special education classroom to inclusive contexts.

Conclusion

Learning to comprehend or understand language is a critical outcome if one is to thrive in a literacy-rich society. The current study aimed to teach students with moderate intellectual disability skills that would improve their understanding of academic content and increase their educational autonomy. The study addressed a need for increased literacy access and instruction, as depicted in the conceptual model for literacy proposed by Browder et al. (2009). In this model, target outcomes for students with moderate and severe disabilities included both increased access to content and comprehension of content. The current study addressed the need for both outcomes by training students to locate and navigate e-texts independently. In the current climate of expansive technological innovations, teachers have an opportunity to promote access to a wealth of information across content areas and formats. In the age of multiliteracies, people have the opportunity to experience technologically supported literacy, or content that is augmented by video clips, vivid and multiple pictorial exemplars, text-to-speech technology, and an array of other related material that can provide depth and further explanation of target content. Teaching students with moderate intellectual disability to use technology to access and navigate texts may be a way to promote self-determination and positive post-school outcomes. Teaching students these skills may help them develop interests and hobbies. Teaching students to generate a question (or "wonder") may be a way to connect them to their surrounding world. The current study expands on Browder et al.'s conceptual model of literacy by emphasizing the process of learning. In addition to access and skill acquisition, students in the current study learned about learning itself. The three participants learned to generate questions, evaluate if the answer was in their head or in the book, and search for unknown answers in the book by matching the question words (topic words) to words in the text. Participants demonstrated instances of self-correcting, and they also used the text-to-speech playback feature as a tool for helping them correctly pronounce an unknown word. Learning to comprehend grade-aligned science content has great value on its own, but learning strategies to seek information independently has important implications for increasing the capacity of students with moderate intellectual disability to act as true causal agents of their own education.

REFERENCES

Adlof, S. M., Catts, H. W., & Little, T. D. (2006). Should the simple view of reading include a fluency component? *Reading and Writing*, *19*, 933-958.

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.

Ahlgrim-Delzell, L., Browder, D. M., & Wood, L. (in press). Effects of systematic instruction and an augmentative communication device on phonics skills acquisition for students with moderate intellectual disability who are nonverbal. *Education and Training in Autism and Developmental Disabilities*.

Ahlgrim-Delzell, L., Browder, D. M., Wood, L., Kemp-Inman, A., & Preston, A. (2013). *Effects of systematic instruction and an iPad on phonics skills acquisition for students with moderate intellectual disabilities*. Manuscript in preparation.

Allor, J. H., Mathes, P. G., Roberts, J. K., Jones, F. G., & Champlin, T. M. (2010). Teaching students with moderate intellectual disabilities to read: An experimental examination of a comprehensive reading intervention. *Education and Training in Autism and Developmental Disabilities*, *45*, 3-22.

Anderson-Inman, L. (2009). Supported eText: Literacy scaffolding for students with disabilities. *Journal of Special Education Technology*, *24*, 1-7.

Anderson-Inman, L., & Horney, M. (1997). Electronic books for secondary students. *Journal of Adolescent and Adult Literacy*, *40*, 486-491.

Anderson-Inman, L., & Horney, M. (1998). Transforming text for at-risk readers. In D. Reinking, L. Labbo, M. McKenna, & R. Kiefer (Eds.) *Handbook of literacy and technology: Transformations in a post-typographic world* (pp. 15-43). Mahwah, NJ: Erlbaum.

Anderson-Inman, L., & Horney, M. (2007). Supported etext: Assistive technology through text transformations. *Reading Research Quarterly*, *42*, 153-140.

Anohina, A. (2005). Analysis of the terminology used in the field of virtual learning. *Journal of Educational Technology and Society*, *8*, 91-102.

Ayres, K. M., Langone, J., Douglas, K., Mead, C., & Bell, V. (2008). *Structural analysis of video supported electronic text for learners with moderate intellectual disabilities: A pilot investigation into assistive technology supports.* Unpublished manuscript, University of Georgia, Athens.

Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis*, *1*, 91-97.

Barth, A. E., Catts, H. W., & Anthony, J. L. (2009). The component skills underlying reading fluency in adolescent readers: A latent variable analysis. *Reading and Writing*, *22*, 567-590.

Berkeley, S., Marshak, L., Mastropieri, M. A., & Scruggs, T. E. (2011). Improving student comprehension of social studies text: A self-questioning strategy for inclusive middle school classes. *Remedial and Special Education*, *32*, 105-113. doi:10.1177/0741932510361261

Berkeley, S., Mastropieri, M. A., & Scruggs, T. E. (2011). Reading comprehension strategy instruction and attribution retraining for secondary students with learning and other mild disabilities. *Journal of Learning Disabilities*, *44*, 18-32. doi:10.1177/0022219410371677

Berkeley, S., Scruggs, T. E., & Mastropieri, M. A. (2010). Reading comprehension instruction for students with learning disabilities, 1995-2006: A meta-analysis. *Remedial and Special Education*, *31*, 423-436. doi:10.1177/0741932509 355988

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

Boning, R. A. (1997). *SRA specific skills series: Getting the main idea*. Book G (5th ed.). Columbus, OH: SRA/McGraw Hill.

Boone, R., & Higgins, K. (2003). Reading, writing, and publishing digital text. *Remedial and Special Education*, *24*, 132-140.

Browder, D. M., Ahlgrim-Delzell, L., Spooner, F., Mims, P. J., & Baker, J. N. (2009). Using time delay to teach literacy to students with severe developmental disabilities. *Exceptional Children*, *75*, 343-364.

Browder, D. M., Gibbs, S., Ahlgrim-Delzell, L., Courtade, G., & Lee, A. (2007). *Early literacy skills builder*. Verona, WI: Attainment Co.

Browder, D. M., Gibbs, S., Ahlgrim-Delzell, L., Courtade, G. R., Mraz, M., & Flowers, C. (2009). Literacy for students with severe developmental disabilities: What should we teach and what should we hope to achieve. *Remedial and Special Education*, *30*, 269-282.

Browder, D. M., Hudson, M. E., & Wood, L. (in press). How do we use principles of high quality instruction in the general education classroom in providing access to the general education curriculum? In J. McLeskey, N. L. Waldron, F. Spooner, & B. Algozzine (Eds.), *Handbook of research and practice for effective inclusive schools* (pp. xx-xx). New York, NY: Routledge.

Browder, D. M., Hudson, M.E., & Wood, L. (2013). Teaching students with moderate intellectual disability who are emergent readers to comprehend text. *Exceptionality, 21*, 191-206.

Browder, D. M., Lee, A., & Mims, P. J. (2011). Using shared stories and individual response modes to promote comprehension and engagement in literacy for students with multiple, severe disabilities. *Education and Training in Autism and Developmental Disabilities*, *46*, 339-351.

Browder, D. M., Mims, P., Spooner, F., Ahlgrim-Delzell, L., & Lee, A. (2008). Teaching elementary students with multiple disabilities to participate in shared stores. *Research and Practice in Severe Disabilities*, *33*, 3-12.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A., & Wakeman, S. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities. *Exceptional Children*, *74*, 407-432.

Browder, D. M., Spooner, F., & Mims, P. J. (2011). Communication skills. In D. M. Browder & F. Spooner (Eds.) *Teaching students with moderate and severe disabilities* (pp. 262-282). New York, NY: The Guilford Press.

Browder, D. M., Trela, K., & Jimenez, B. A. (2007). Training teachers to follow a task analysis to engage middle school students with moderate and severe developmental disabilities in grade-appropriate literature. *Focus on Autism and Other Developmental Disabilities*, *22*, 206-219.

Browder, D. M., Wakeman, S. Y., Spooner, F., Ahlgrim-Delzell, L., & Algozzine, B. (2006). Research on reading instruction for individuals with significant cognitive disabilities. *Exceptional Children*, *72*, 392-408.

Bulgren, J. A., Marquis, J. G., Lenz, K., Deshler, D. D., & Schumaker, J. B. (2011). The effectiveness of a question-exploration routine for enhancing the content learning of secondary students. *Journal of Educational Psychology*, *103*, 578-593.

Catts, H., Adlof, S., & Weismer, S. (2006). Language deficits in poor comprehenders: a case for the simple view of reading. *Journal of Speech*, *Language and Hearing Research*, *49*, 278-293.

Cavanaugh, T. (2002). Ebooks and accommodations. *TEACHING Exceptional Children*, *35*(2), 56-61.

Clay, K., Zorfass, J., Brann, A., Kotula, A., & Smolkowski, K. (2009). Deepening context understanding in social studies using digital text and embedded vocabulary supports. *Journal of Special Education Technology*, *24*, 1-15.

Collins, B. C. (2012). *Systematic instruction for students with moderate and severe disabilities*. Baltimore, MD: Paul H. Brookes Publishing Co.

Common Core State Standards Initiative. (2010). *Common core state standards for English language arts & literacy in history/social studies, science, and technical subjects.* Washington, DC: CCSSO & National Governors Association.

Conley, D. (2007). *Redefining college readiness*. Eugene, OR: Educational Policy Improvement Center.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis* (2nd Ed.). Upper Saddle River, NJ: Pearson.

Courtade, G., 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 Developmental Disabilities, 45*, 378-399.

Coyne, P., Pisha, B., Dalton, B., Zeph, L. A., Smith, N. C. (2010). Literacy by design: A universal design for learning approach for students with significant intellectual disabilities. *Remedial and Special Education, 33*, 162-172. doi:10.1177/0741 932510381651

Darch, C., & Eaves, R. (1986). Visual displays to increase comprehension of high school learning-disabled students. *The Journal of Special Education*, *20*, 309–318.

Disseldorp, B., & Chambers, D. P. (2002). Independent access: Which students might benefit from a talking computer? In S. McNamara and E. Stacey (Eds.), *Untangling the Web: Establishing Learning Links.* Proceedings of the Australian Society for Educational Technology Conference 2002. Melbourne.

Douglas, K. H., Ayers, K. M., Langone, J., & Bell, V. (2009). *The effectiveness of pictorial graphic organizers for improving comprehension by students with intellectual disabilities using electronic text related to functional skills.* Manuscript submitted for publication.

Douglas, K. H., Ayres, K. M., Langone, J., & Bell, V. (2011). The effectiveness of electronic text and pictorial graphic organizers to improve comprehension related to functional skills. *Journal of Special Education Technology, 26*, 43-56.

Douglas, K. H., Ayers, K. M., Langone, J., Bell, V., & Meade, C. (2009). Expanding literacy for learners with intellectual disabilities: The role of supported eText. *Journal of Special Education Technology*, *24*, 35-43.

Downing, J. (2005). *Teaching literacy to students with significant disabilities: Strategies for the K-12 inclusive classroom*. Thousand Oaks, CA: Corwin.

Doyle, P. M., Wolery, M., Ault, M. J., & Gast, D. L. (1988). System of least prompts: A literature review of procedural parameters. *The Journal of The Association for the Severely Handicapped*, *13*, 28-40.

Elkind, J. (1998). Computer reading machines for poor readers. *Perspectives*, *24*(2) 9-13.

Elkind, J., Cohen, K., & Murray, C. (1993). Using computer-based readers to improve reading comprehension of students with dyslexia. *Annals of Dyslexia*, *42*, 238-259.

Elkind, K., & Elkind, J. (2007). Text-to-speech software for reading. *Perspectives on Language and Literacy*, *33*(3), 11-16.

Engelmann, S. & Bruner, E. (1995). *Reading Mastery I* (Rainbow ed.) (Teacher's Presentation Book, Student Material, Literature Guide and Teacher's Guide). Columbus, OH: SRA/McGraw-Hill.

Faggella-Luby, M., Schumaker, J. S., & Deshler, D. D. (2007). Embedded learning strategy instruction: Story-structure pedagogy in heterogeneous secondary literature classes. *Learning Disability Quarterly*, *30*, 131-147.

Fisher, D., Flood, J., Lapp, D., & Frey, N. (2004). Interactive read-alouds: Is there a common set of implementation practices? *Reading Teacher*, *58*, 8–17.

Fuller, P. R. (1949). Operant conditioning of a vegetative human organism. *American Journal of Psychology*, *62*, 587-590.

Gardill, M. C., & Jitendra, A. K. (1999). Advanced story map instruction: Effects on the reading comprehension of students with learning disabilities. *The Journal of Special Education*, *33*, 2-17.

Gast, D. L. (2010). *Single subject research methodology in behavioral sciences*. New York, NY: Routledge.

Gough, P. B., & Tumner, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*, 6-10.

Hall, T. E., Hughes, C. A., & Filbert, M. (2000). Computer assisted instruction in reading for students with learning disabilities: A research synthesis. *Education & Treatment of Children*, *23*, 173-194.

Hart, D., & Grigal, M. (2010). The spectrum of options current practices. In M. Grigal & D. Hart (Eds.), *Think College: Postsecondary education options for students with intellectual disabilities* (pp. 49-86). Baltimore, MD: Paul H. Brookes

Hart, J. E., & Whalon, K. J. (2012). Using video self-modeling via iPad2s™ to increase academic responding of an adolescent with autism spectrum disorder and intellectual disability. *Education and Training in Autism and Developmental Disabilities*, *47*, 438-446.

Harvey, S., & Goudvis, A. (2000). *Strategies that work: Teaching comprehension to enhance understanding*. York, ME: Stenhouse.

Hecker, L., Elkind, J., Elkind, K., & Katz, L. (2002). Benefits of assistive reading software for students with attention disorders. *Annals of Dyslexia*, *52*, 243-272.

Heward, W. L. (2003). *Exceptional children: An introduction to special education* (7th ed.). Upper Saddle River, NJ: Merrill.

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*, 127–160.

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*,165–179.

Hudson, M. E., & Browder, D. M. (2014). *Using peers and grade-level read-alouds to teach listening comprehension to students with moderate intellectual disability*. Manuscript under review.

Hudson, M. E., Browder, D. M., & Jimenez, B. (in press). Effects of a peer-delivered system of least prompts intervention and adapted science read-alouds on listening comprehension for participants with moderate intellectual disability. *Education and Training in Autism and Developmental Disabilities*.

Hudson, M. E., Browder, D. M., & Wood, L. (2013). Review of experimental research on academic learning by students with moderate and severe intellectual disability in general education. *Research and Practice for Persons with Severe Disabilities*, *38*, 17-29.

Hudson, M. E., & Test, D. W. (2011). Evaluating the evidence base for using shared story reading to promote literacy for students with extensive support needs. *Research and Practice for Persons with Severe Disabilities*, 36, 34-45.

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

Kagohara, D. M., Sigafoos, J., Achmadi, D., O'Reilly, M. F., & Lancioni, G. (2012). Teaching children with autism spectrum disorders to check the spelling of words. *Research in Autism Spectrum Disorders*, *6*, 304-310.

Kagohara, D. M., van der Meer, L., Ramdoss, S., O'Reilly, M. F., Lancioni, G. E., Davis, T. N. … & Sigafoos, J. (2013). Using iPods and iPads in teaching programs for individuals with developmental disabilities: A systematic review. *Research in Developmental Disabilities, 34*, 147-156.

Katims, D. S. (2000). Literacy instruction for people with mental retardation: Historical highlights and contemporary analysis. *Education and Training in Mental Retardation and Developmental Disabilities*, *35*, 3-15.

Kearns, J., Kleinert, H., Harrison, B., Sheppard-Jones, K., Hall, M., & Jones, M. (2011). *What does 'college and career ready' mean for students with significant cognitive disabilities?* Lexington: University of Kentucky.

Kleinert, H. L., Browder, D. M., & Towles-Reeves, E. A. (2009). Models of cognition for students with significant cognitive disabilities: Implications for assessment. *Review of Educational Research*, *79,* 301-326. doi:10.3102/0034654308326160

Kliewer, C. (1998). Citizenship in the literate community: An ethnography of children with Down syndrome and the written word. *Exceptional Children*, *64*, 167-180.

Kliewer, C., Biklen, D., & Kasa-Hendrickson, C. (2006). Who may be literate? Disability and resistance to the cultural denial of competence. *American Educational Research Journal*, *43*, 163-192. doi:10.3102/00028312043002163

Knight, V. F., McKissick, B. R., Saunders, A. (2013). A review of technology-based interventions to teach academic skills to students with autism spectrum disorder. *Journal of Autism and Developmental Disorders.* Advance online publication. doi:10.1007/s10803-013-1814-y

Knight, V. F., Smith, B. R., Spooner, F., & Browder, D. M. (2012). Using explicit instruction to teach science descriptors to students with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *42*, 378-389.

Knight, V., Spooner, F., Browder, D. M., Smith, B. R., & Wood, C. L. (2013). Using systematic instruction and graphic organizers to teach science to students with autism spectrum disorders and intellectual disability. *Focus on Autism and Other Developmental Disabilities, 28*, 115-126.

Kratochwill, T. R., Hitchcock, J. H., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2013). Single-case intervention research design standards. *Remedial and Special Education*, *34*, 26-38. doi:10.1177/07419325 12452794

Kucan, L., & Beck, I. L. (1997). Thinking aloud and reading comprehension research: Inquiry, instruction, and social interaction. *Review of Educational Research*, *67*, 271-299.

Labbo, L. D. (2000). 12 things young children can do with a talking book in a classroom computer center. *Reading Teacher*, *53*, 542.

Langone, J., Shade, J., Clees, T. C., & Day, T. (1999). Effects of multimedia instruction on teaching functional discrimination skills to students with moderate/severe intellectual disabilities. *International Journal of Disability, Development and Education*, *46*, 493-513.

Larson, L. C. (2010). Digital readers: The next chapter in e-book reading and response. *The Reading Teacher*, *64*, 15-22.

Leong, C. K. (1995). Effects of on-line reading and simultaneous DECtalk auditing in helping below-average and poor readers comprehend and summarize text. *Learning Disabilities Quarterly*, *18*, 101-115.

Manset-Williamson, G., Dunn, M., Hinshaw, R., & Nelson, J. M. (2008). The impact of self-questioning strategy use on the text-reader assisted comprehension of students with reading disabilities. *International Journal of Special Education*, *23*, 123-135.

Mastropieri, M. A., & Scruggs, T. E. (1997). Best practices in promoting reading comprehension in students with learning disabilities. *Remedial and Special Education*, *18*, 197-213.

Mastropieri, M. A., Scruggs, T. E., Bakken, J. P., & Whedon, C. (1996). Reading comprehension: A synthesis of research in learning disabilities. *Advances in Learning and Behavioral Disabilities*, *10*, 201-227.

Mechling, L. C., Gast, D. L., & Langone, J. (2002). Computer-based video instruction to teach persons with moderate intellectual disabilities to read grocery aisle signs and locate items. *The Journal of Special Education*, *35*, 224.

Miller, U. C., & Test, D. W. (1989). A comparison of constant time delay and most-to-least prompting in teaching laundry skills to students with moderate retardation. *Education and Training in Mental Retardation*, *24*, 363-370.

Mims, P. J. (2009). *The effects of the system of least prompts on teaching comprehension skills during a shared story to students with significant intellectual disabilities* (Unpublished doctoral dissertation). University of North Carolina at Charlotte, Charlotte, NC.

Mims, P., Browder, D. M., Baker, J., Lee, A., & Spooner, F. (2009). Increasing comprehension of students with significant intellectual disabilities and visual impairments during shared stories. *Education and Training in Developmental Disabilities*, *44*, 409-420.

Mims, P., Hudson, M., & Browder, D. M. (2012). Using read alouds of grade-Level biographies and systematic prompting to promote comprehension for students with moderate and severe developmental disabilities. *Focus on Autism and Developmental Disabilities, 27*, 65-*78.*

Morgan, M. F., Cuskelly, M., & Moni, K. B. (2011). Broadening the conceptualization of literacy in the lives of adults with intellectual disability. *Research and Practice for Persons With Severe Disabilities*, *36,* 112-120.

More, C. M., & Travers, J. C. (2012). What's app with that? Selecting educational apps for young children with disabilities. *Young Exceptional Children.* Advance online publication. doi: 10.1177/1096250612464763

Morse, T. E., & Schuster, J. W. (2004). Simultaneous prompting: A review of literature. *Education and Training in Developmental Disabilities*, *39,* 153-168.

Montoli, J., & Lewandowski, L. (1996). Bimodal reading: Benefits of a talking computer for average and less skilled readers. *Journal of Learning Disabilities*, *29*, 271-279.

Mulligan, S. A. (2003). Assistive technology: Supporting the participation of children with disabilities. *Beyond the journal: Young children on the Web*. Retrieved from http://www.naeyc.org/files/tyc/file/MulliganVol2No2NEXT.pdf

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*.

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction.* (NIH Publication No. 00-4754). Washington, DC: US Department of Health and Human Services.

Okolo, C. M., Englert, C. S., Bouck, E. C., & Heutsche, A. M. (2011). Web-based history learning environments: Helping all students learn and like history. *Intervention in School and Clinic*, *43*, 3-11.

Ozmen, R. G. (2011). Comparison of two different presentations of graphic organizers in recalling information in expository texts with intellectually disabled students. *Educational Sciences: Theory & Practice*, *11*, 785-793.

Palincsar, A., & Brown, A. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*, 117-175.

Papay, C. K., & Bambara, L. M. (2011). Postsecondary education for transition-age students with intellectual and other developmental disabilities: A national survey. *Education and Training in Autism and Developmental Disabilities*, *46*, 78-93.

Pearson, P. D., & Gallagher, M. C. (1983). The instruction of reading comprehension. *Contemporary Educational Psychology*, *8*, 317-344.

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*, *25*, 239–248.

Raphael, T. (1982). Question-answering strategies for children. *The Reading Teacher*, *36*, 186-190.

Raskind, M., & Higgins, E. (1995). Effects of speech synthesis on the proofreading efficiency of postsecondary students with learning disabilities. *Learning Disabilities Quarterly*, *18*, 141-158.

Reis, E. M. (1986). Advance organizers and listening comprehension in retarded and nonretarded individuals. *Education and Training of the Mentally Retarded*, *21*, 245-251.

Rhodes, J. A., & Milby, T. M. (2007). Teacher-created electronic books: Integrating technology to support readers with disabilities. *The Reading Teacher*, *61*, 255-259.

Rose, D. H., Hasselbring, T. S., Stahl, S., & Zabala, J. (2005). Assistive technology and universal design for learning: Two sides of the same coin. In D. Edyburn, K. Higgins, & R. Boone (Eds.), *Handbook of special education technology research and practice* (pp. 507-518). Whitefish Bay, WI: Knowledge by Design.

Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research, 66*, 181-121.

Rowling, J. K. (1998). *Harry Potter and the Sorcerer's Stone*. New York, NY: Scholastic.

Schuster, J. W., Morse, T., Ault, M. J., Doyle, P. M., Crawford, M. R., & Wolery, M. (1998). Constant time delay and chained tasks: A review of literature. *Education & Treatment of Children*, *21*, 74-106.

Scruggs, T. E., & Mastropieri, M. A. (1998). Summarizing single subject research: Issues and applications. *Behavior Modification*, *22*, 221-242.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Shurr, J., & Taber-Doughty, T. (2012). Increasing comprehension for middle school students with moderate intellectual disability on age-appropriate texts. *Education and Training in Autism and Developmental Disabilities, 47*, 359-372.

Smith, B. R., Spooner, F., Jimenez, B., & Browder, D. M. (2013). Using an early science curriculum to teach science vocabulary and concepts to students with severe developmental disabilities. *Education & Treatment of Children*, *36*, 1-31. doi: 10.1353/etc.2013.0002

Smith, B. R., Spooner, F., & Wood, C. L. (2013). Using embedded computer-assisted explicit instruction to teach science to students with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *7,* 433-443. doi: 10.1016/j.rasd. 2012.10.01010

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

Spooner, F., Browder, D. M., & Mims, P. J. (2011). Evidence-based practice. In D. M. Browder & F. Spooner (Eds.), *Teaching students with moderate and severe disabilities* (pp. 92-124). New York, NY: Guilford.

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

Spooner, F., Knight, V. F., Browder, D. M., & Smith, B. R. (2012). Evidence-based practices for teaching academic skills to students with severe developmental disabilities. *Remedial and Special Education, 33*, 374-387. doi: 10.1177/ 0741932511421634

Spooner, F., Rivera, C. J., Browder, D. M., Baker, J. N., & Salas, S. (2009). Teaching emergent literacy skills using cultural contextual story-based lessons. *Research and Practice for Persons with Severe Disabilities, 34*, 102-112.

Vacca, J. L., Vacca, R. T., Gove, M. K., Burkey, L. C., Lenhart, L. A., & McKeon, C. A. (2006). *Reading and learning to read* (6th ed.). Boston, MA: Pearson.

Vacca, R. T., Vacca, J. L., & Mraz, M. (2011). *Content area reading: Literacy and learning across the curriculum* (10th ed.). Boston, MA: Pearson.

Wehmeyer, M. L., Smith, S. J., Palmer, S. B., & Davies, D. K. (2004). Technology use by students with intellectual disabilities: An overview. *Journal of Special Education Technology, 19*, 7-21.

Wolery, M., Ault, M. J., & Doyle, P. M. (1992). *Teaching students with moderate to severe disabilities: Use of response prompting strategies.* New York, NY: Longman.

Wood, L., Browder, D. M., & Mraz, M. (2014). Passage comprehension and read-alouds. In D. M. Browder & F. Spooner (Eds.) *MORE language arts, math, and science for students with severe disabilities* (pp. 63-84). Baltimore, MD: Paul H. Brookes.

Wood, L., Browder, D. M., & Flynn, L. (2014). Teaching students with intellectual disabilities to use a self-questioning strategy to comprehend social studies text. *Manuscript in preparation*.

Woodcock, R. W. (1991). *Woodcock Language Proficiency Battery—Revised*. Itasca, IL: Riverside.

Zisimopoulos, D., Sigafoos, J., & Koutromanos, G. (2011). Using video prompting and constant time delay to teach an Internet search basic skill to students with intellectual disabilities. *Education and Training in Autism and Developmental Disabilities*, *46*, 238–250.

APPENDIX A: DATA SHEET FOR ASKING AND ANSWERING QUESTINOS WITH PROMPTING

Student ID: ___ Teacher ID:___ Date:_____ eBooks # ___ & ___ IOA: Y or N

I. Points Earned Generating Questions

	First text	Second text
1. First touched a green button to select a question starter		
2. Second touched a yellow button to select a question topic		
3. Third touched a red button to add a question mark		
4. Fourth touched the white bar to listen to the complete, logical question		
TOTAL Points earned =		

Key: 1 = correct, independent 0 = incorrect
M = model prompt (no points) NR = no response (no points)

II. Number of Questions Answered

	First text		Second text	
	Response	Score	Response	Score
Question 1 (generated question)				
Question 2				
Question 3				
Question 4				
Question 5				
Total Correct, independent responses				
TOTAL Questions answered =				

Key: + = correct, independent
+S = correct after student search - = incorrect
R1 = reread of 3 sentences NR = no response
R2 = reread of 1 sentence
M = model prompt

III. Points Earned Generating Question without Template

	First text	Second text
1. Question contains question starter		
2. Question contains science content related to e-text		
3. 1, 2 met AND Logical question has not been previously asked		
TOTAL Points earned without template =		

Key: 1 = correct, independent NR = no response (no points) 0 = incorrect

APPENDIX B: DATA SHEET FOR ASKING AND ANSWERING QUESTIONS WITHOUT PROMPTING

Student ID: ___ Teacher ID:___ Date:____ eBook #s ___ & ___ IOA: Y or N

Condition (circle one): baseline / generalization probes / maintenance

I. Points Earned Generating Questions

	First text	Second text
1. First touched a green button to select a question starter		
2. Second touched a yellow button to select a question topic		
3. Third touched a red button to add a question mark		
4. Fourth touched the white bar to listen to the complete, logical question		
TOTAL Points earned =		

Key: 1 = correct, independent 0 = incorrect
NR = no response (no points)

II. Number of Questions Answered

	First text		Second text	
	Response	Score	Response	Score
Question 1 (generated question)				
Question 2				
Question 3				
Question 4				
Question 5				
Total Correct, independent responses				
TOTAL Questions answered =				

Key: + = correct, independent - = incorrect
+S = correct after student search NR = no response

III. Generate Question without Template

	First text	Second text
1. Question contains question starter		
2. Question contains science content related to e-text		
3. 1, 2 met AND Logical question has not been previously asked		
TOTAL Points earned without template =		

Key: 1 = correct NR = no response (no points)
0 = incorrect

APPENDIX C: SOCIAL VALIDITY QUESTIONSNAIRES FOR TEACHERS, PARENTS, AND STUDENTS

Social Validity Questionnaire for Teachers

Please rate your opinions concerning comprehension of science texts on the scale:

1. Students with moderate intellectual disability can learn to ask questions.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

2. Students with moderate intellectual disability can learn to answer questions about science texts.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

3. Asking questions is a difficult skill for many students with moderate intellectual disability.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

4. Answering question is a difficult skill for many students with moderate intellectual disability.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

5. The science content was appropriate for my students.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

6. The materials (question template on iPad2™, Discovery Education e-texts, comprehension questions) were appropriate for my students.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

7. The systematic instruction was effective for teaching question asking and answering.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

8. My students benefited from asking and answering questions during instructional sessions.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

9. My students benefited from asking and answering questions in the third grade science classroom.

   Strongly agree / Agree / Undecided / Disagree / Strongly disagree

Social Validity Questionnaire for Parents

Please rate your opinions concerning comprehension of science texts on the scale:

1. Students with moderate intellectual disability can learn to ask questions.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

2. Students with moderate intellectual disability can learn to answer questions about science texts.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

3. Asking questions is a difficult skill for many students with moderate intellectual disability.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

4. Answering question is a difficult skill for many students with moderate intellectual disability.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

5. Learning science content (e.g., habitats, solar system, plants, soil) is appropriate for my child.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

6. My child can benefit from using technology (iPad2s™, computers, the Internet).

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

7. My child can benefit from learning new skills in a structured, systematic way.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

8. My child can benefit from asking and answering questions during instructional sessions.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

9. My child can benefit from asking and answering questions in a third grade science classroom.

Strongly agree / Agree / Undecided / Disagree / Strongly disagree

<u>Social Validity Student Participant Questionnaire</u>

Statements and responses are read aloud to the student.

1. I asked questions about science.

I liked this.	Did not answer	I didn’t like this.
		

2. I used an iPad2™ to ask questions.

I liked this.	Did not answer	I didn’t like this.
		

3. I answered questions about science.

I liked this.	Did not answer	I didn’t like this.
		

4. I used a computer to listen to science books.

I liked this.	Did not answer	I didn’t like this.
		

5. I asked and answered questions about science in a science classroom.

I liked this.	Did not answer	I didn’t like this.
		

APPENDIX D: DATASHEET FOR PRETRAINING PARTICPIANTS TO ACCESS e-TEXTS

Student ID: ____

Date								
(a) Click the Windows button on the bottom left of the screen								
(b) Click “All Programs” at the bottom of the list								
(c) Click “Discovery Education”								
(d) Type “germelman” in the login box								
(e) Type “cortez” in the password box								
(f) Click “login”								
(g) Type search words from friend or teacher								
(h) Click K-2 for “grades,”								
(i) Click “science” for subjects								
(j) Click “e-book” for media types								
(k) Click “submit”								
(l) Find title on the screen and click it								
TOTAL								

Key: + = correct, independent response - = incorrect
P = prompted correct NR = no response

APPENDIX E: FIDELITY CHECKLIST

Teacher ID: _______ Date: _____________ Observers: ______________________

Condition (circle one): baseline / treatment / generalization / maintenance probes

Note: Items in **bold** are only to occur during treatment sessions

I. Accessing e-texts (does not occur during generalization probes)	
Presented participant with iPad2™ cued to pictures for accessing e-texts	
Provided model prompts for each step only as needed after a 4 s wait time	
II. Use of GoTalk Now application	
Used correct question templates to match e-texts in session	
III. Systematic instruction (procedures repeat to accommodate two e-texts / session)	
First e-text	
Asked participant to ask a question	
Presented participant with iPad2™ cued to the question template	
Provided model response prompt as needed	
Recorded student question asking data (across 4 points)	
Directed student to play e-text	
Asked student comprehension questions	
Provided correct system of least prompts as needed	
Recorded student question answering data	
Asked student to ask one more question without the template	
Withheld prompting for final question	
Recorded student question asking data without template (across 3 points)	
Second e-text	
Asked participant to ask a question	
Presented participant with iPad2™ cued to the question template	
Provided correct model response prompt as needed	
Recorded student question asking data (across 4 points)	
Directed student to play e-text	
Asked student comprehension questions	
Provided correct system of least prompts as needed	
Recorded student question answering data	
Asked student to ask one more question without the template	
Withheld prompting for final question	
Recorded student question asking data without template (across 3 points)	
TOTAL CORRECT	

Key: + = performed correctly
- = performed incorrectly
X = did not perform

Fidelity: Total # of correct steps / total # of steps X 100 = _____________