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The Effects of Text-to-Speech on Reading Comprehension of Students with Learning Disabilities

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THE EFFECTS OF TEXT-TO-SPEECH ON READING

COMPREHENSION OF STUDENTS

WITH LEARNING DISABILITIES

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126 Pages

In this study, I implemented the use of technology to investigate the effectiveness of text-to-speech (TTS) on the reading comprehension of students with learning disabilities (LD). In a freshman self-contained classroom, I used the classroom-based text and TTS on four participants during a 48-min English class period for 16 weeks. An A-B-A-B withdrawal design evaluated the effectiveness of TTS on reading comprehension, the dependent variable, measured through accuracy of participants' responses to reading comprehension questions from curriculum-based measures (CBMs). Following intervention, I assessed maintenance of the effect of TTS on reading comprehension for 4 weeks. Additionally, I measured participants' perspectives on the use of TTS when reading using a researcher-developed social validation survey. After visual analysis of the data, results showed a functional relation between the independent variable and participants' increased reading comprehension accuracy as measured by CBMs. All participants scored higher on reading comprehension using TTS as the intervention when reading instructional passages. Results on participants' oral reading fluency (ORF) also indicated an increased level of words read per min at the end of each condition. Comparison of pre- and posttest achievement on the universal screener (i.e., Lexile) showed that two of four participants increased their reading scores. Maintenance results showed continued increase in reading comprehension accuracy on CBMs with TTS compared to baseline performance. Social validation questionnaires revealed participants enjoyed using TTS to acquire information from literature. Lastly, major findings are discussed with implications for practice and recommendations for future research needed to increase the use of TTS in the classroom.

KEYWORDS: Assistive technology, Learning disabilities, Legislation, Secondary, Special education, Text-to-speech

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CONTENTS

TABLES

FIGURES

CHAPTER I

THE PROBLEM AND ITS BACKGROUND

The No Child Left Behind (NCLB) Act of 2001 created standards for educating all students, including individuals with disabilities. More specifically, students with disabilities are required to make progress in general education curriculum with interventions from scientifically based research (Parette & Peterson-Karlan, 2007). Since NCLB, researchers have implemented and tested several instructional designs for reading interventions. Current research focuses on teaching interventions to elementary-aged students to improve reading skills (i.e., phonics, phonemic awareness, and alphabetic awareness) (Flynn & Swanson, 2012). As students progress in school, reading shifts from learning to read to reading to learn (Kim, Linan-Thompson, & Misquitta, 2012) and becomes more difficult for students with reading disabilities (Flynn & Swanson, 2012). Additionally, formal reading instruction in secondary schools rarely exists (Saenz & Fuchs, 2001). With changes in reading instruction and minimal experimental methodological research for secondary reading interventions using technology, additional research to compensate for students' reading deficits is an urgent priority (Anderson-Inman & Horney, 1997).

Reading is a necessary skill required to learn and affects educational outcomes, possible employment, and personal growth (Strangman & Dalton, 2005). Roughly 6 million secondary students are reading far below grade average and nearly 3,000 students drop out of high school daily (Slavin, Cheung, Groff, & Lake, 2008). Struggling readers who do not learn to read in school are more likely to be unemployed, earn low incomes, and exhibit poor health as adults (National Center for Educational Statistics [NCES], 2013).

In the past decade, national reading research agendas included quality reading instruction for adolescents in the United States (Hauptli & Cohen-Vogel, 2013). Even with these agendas, data indicate that adolescents do not have the required skills to be proficient readers in high school (Vaughn & Wanzek, 2014). Recent National Assessment of Educational Progress (NAEP) data on adolescent readers indicates that 69% of eighth graders and 64% of twelfth graders do not meet proficient-level reading skills, and 26% and 27%, respectively, do not meet basic-level skills (NAEP, 2009).

Although several legislative actions have focused on evidence-based practice and inclusion of students with disabilities in the general education curriculum, reading scores are not improving. Results on national assessments of secondary students with disabilities' reading show only 31% scored at or above a basic level on the eighth-grade reading assessment (NCES, 2013). More startling is that between the years of 2002 and 2011, students with disabilities' reading scores decreased but the scores of students without disabilities increased (NCES, 2013). In addition to the regression of reading scores, the number of students with disabilities included in general education classes has increased (Vaughn & Wanzek, 2014). Students in one of the largest groups receiving special education services have learning disabilities (LD) (Wanzek, Otaiba, & Petscher, 2014) and approximately 80% exhibit reading disabilities (Hudson, High, & Otaiba, 2007). Additional research shows that 90% of students with LD are not able to read material independently (Vaughn, Levy, & Coleman, 2002) and do not spend time in or out of class reading from print (Vaughn & Wanzek, 2014).

Reading Difficulties for Students with Learning Disabilities

Students with LD show increased outcomes after reading interventions that address their cognitive deficits (Vaughn & Wanzek, 2014). Whereas good readers have the cognition to identify and understand text structure, vocabulary, and conceptual density (Saenz & Fuchs, 2002), students with LD exhibit poor decoding, fluency (Elkind & Elkind, 2007), understanding of semantics (Nation, 2005), and an inability to access working memory (Roberts, Torgesen, Boardman, & Scammacca, 2008). Thus, students with LD require compensatory support (e.g., technology) to learn curriculum (Edmonds & Li, 2005; Tian & Okolo, 2007).

Research indicates secondary teachers typically instruct using whole-class instruction (Salisbury, Brookfield, & Odom, 2005) even with students with disabilities in the same class. With whole-class instruction, students rarely apply concepts independently (Salisbury et al., 2005). As a result, students with LD rely on teacher-directed instruction and are left without independent reading skills required to handle the literacy demands of adulthood (Flynn & Swanson, 2012). Without strong literacy skills, students with LD lack motivation to read and fall further behind their peers in learning content (Cardon, 2000; Slavin et al., 2008).

Accessing Information through Technology

While students with LD have been able to access information through technology for the previous three decades, this has not always played out in the classroom. In the 1980s, individuals with disabilities gained access to devices (i.e., technology) that were necessary to participate in their communities (Wallace, Flippo, Barcus, & Behrmann, 1995). Subsequently, the Center for Applied Special Technology (CAST) developed digital tools to build literacy skills for students with disabilities for whom regular curriculum did not work (Hall, Cohen, Vue, & Ganley, 2015; Hitchcock & Stahl, 2003). In 1986, the Education for All Handicapped Children Act (EHA; P.L. 95-142) provided $4.7 million in research and development tools to investigate the use of Assistive Technology (AT) in meeting educational goals (Malouf & Hauser, 2005).

In 1988, the Technology-Related Assistance Act ("Tech Act", P.L. 100-407), an important law on the use of AT in educational settings for students with disabilities, was enacted (Bailey, Meidenbauer, Fein, & Mollica, 2005). For the first time in American history, the Tech Act defined AT devices and services (Bailey et al., 2005). An AT device is defined as "any piece of equipment or product system, whether acquired commercially, off the shelf, modified, or customized, that is used to increase, maintain or improve the functional capabilities of individuals with disabilities" (20 U.S.C. & 1401[1]). AT service is defined as "any service that directly assists an individual with a disability in the selection, acquisition, or use of an AT device" (20 U.S.C. & 1401[2]). AT definitions were later put into the 1997 and 2004 reauthorizations of the Individual with Disabilities Education Act (IDEA). IDEA 2004 changed the language the involved the use of AT in the Individualized Education Plan (IEP) from *requiring* AT devices and services to *mandating the consideration* of AT. In 2008, IDEA's revision required states to adopt the National Instructional Materials Accessibility Standards (NIMAS) to provide instructional materials outside of traditional print (i.e., paper based) to individuals who are blind and those with specific learning disabilities who have print disabilities

(Berkeley & Lindstrom, 2011). Partly due to NIMAS, schools now have better access to digital text and can provide curricular access to students with disabilities through AT.

The prevalence of AT has increased with legislation from the Tech Act of 1998. In the 1970s, there were 100 AT devices commercially available and today, there are more than 29,000 AT devices available for individuals with disabilities (Poel, 2007). Despite this increase in the number of AT devices available, teachers are not typically using AT in the classroom. Many teachers lack trouble-shooting skills to appropriately use AT on a regular basis to compensate for reading deficits (Okolo & Diedrich, 2014). Although data showing that 67% of teachers reported that they believed AT increased access to curriculum and outcomes, only 33% of respondents could make print accessible on the computer (Okolo & Diedrich, 2014). Even with knowledge that AT has educational benefits, teachers do not have time to manipulate text for students with disabilities to access curriculum (Vaughn, Reiss, Rothlein, & Hughes, 1999).

Text-to-Speech (TTS) Technology

To assist secondary students in accessing curriculum, students with reading disabilities need compensatory tools (e.g., text-to-speech, TTS). TTS is a compensatory tool that can provide students with reading support while allowing them access to text (Stodden, Roberts, Takahashi, Park, & Stodden, 2012). Furthermore, researchers found that technology promotes independence, increases self-worth, and increases productivity in students with LD (Edyburn, Higgins, & Boone, 2005) which can increase motivation and learning (Cardon, 2000). Researchers found reading intervention strategies using technological speech-synthesized tools (Lange, McPhillips, Mulhen, & Wylie, 2006) that were implemented at least once per week (Stodden et al., 2012), and allowed for repeated reading of text resulted in reading gains for students with LD (Moorman, Boon, Keller-Bell, Stagliano, & Jeffs, 2010). More specifically, the use of TTS resulted in increased time spent reading, better outcomes on comprehension measures (Hecker, Burns, Elkind, Elkind, & Katz, 2002), and increased reading rates (Elkind, 1998). Research has found the lowest readers actually benefitted the most in comprehension (Moorman et al., 2010) and reading rates (Elkind, 1998) after using TTS.

Research indicates that when students with LD individualize TTS (e.g., rate of speed, voice selection, size of font), they exhibit educational benefits (Moorman et al., 2010, Tian & Okolo, 2007). By pronouncing the words aloud while simultaneously highlighting words, TTS allows readers to increase their reading speed to minimize the cognitive task of decoding, creating more energy to comprehend material (Elkind, Black & Murray, 1996). When computerized reading speed is set at a moderately faster rate (i.e., a 25% increase) than struggling readers' present oral reading fluency, students increase comprehension (Coleman, Carter, & Kildare, 2011). Additionally, the readers' voice selection and adjustment of the font size can increase readers' focus when reading on the computer (Hecker et al., 2002). With previous research indicating positive outcomes, researchers need to conduct more reading interventions with technology for secondary students with reading disabilities to investigate the compensatory benefits of TTS when acquiring content in classroom settings.

Significance of the Problem

Students with LD experience several years of reading difficulties that involve deficits in making meaning from text. Achieving success in school requires using good reading skills to understand all content areas (Vaughn & Wanzek, 2014). When secondary reading instruction wanes or no longer exists, students with LD still struggle to gain information from text (Saenz & Fuchs, 2002). To prevent the achievement gap from widening between special and general education students, additional types of reading interventions need to occur to facilitate learning. Reading interventions that involve technology have been known to increase academic outcomes for secondary students with LD (Stetter & Hughes, 2011).

The NCLB Act and IDEA mandate that educators learn to use technology relevant to their students' needs (Dyal, Carpenter, & Wright, 2009). The National Educational Technology Standards (NETS) and the Council for Exceptional Children (CEC) Technology Specialist Standards established standards to train teachers on the use of AT when instructing students with disabilities (Parette & Peterson-Karlan, 2010; Smith & Allsopp, 2005). Even with these mandates and guidelines, teachers are not using technology to make content accessible (Okolo & Diederich, 2014). Adding to this dilemma is the fact that classroom curricula are still primarily based in print (Rose, Meyer, & Hitchcock, 2011). Teachers end up teaching to students who are able to read the text and do not meet the needs of those who can't read the text (i.e., students with disabilities). This creates a *Matthew Effect* which causes the word-rich to get richer, and the word-poor to get poorer (Stanovich, 1986). To address this effect, teachers need to maximize students with disabilities' motivation to read content. Technology is highly motivating to secondary students with LD and can potentially increase the amount of content they learn (Anderson-Inman, 2009; Bouck, Flanagan, Miller, & Bassette, 2012).

The current study is based on conclusions from my pilot study conducted in 2014. My pilot study investigated the effects of TTS on four students with LD in a freshman cotaught English class. I found that the lowest readers benefitted the most from the TTS, which is similar to previous studies (Brown & Augustine, 2000; Dolan, Hall, Banerjee, Chun, & Strangman, 2005; Moorman et al., 2010). In addition, my pilot study results indicated that the participants with the lowest reading abilities outperformed peers whose reading abilities were not as low. With research suggesting that longer studies (e.g., one semester) and increased exposure to TTS (e.g., more than once per week) resulted in increased reading outcomes (Stodden et al., 2012), the current study implemented the use of TTS for one semester with increased intensity. My pilot study's social validation questionnaire indicated that participants perceived TTS as helping them read to learn and were more likely to use TTS in the future. Students with LD minimally increased their oral reading fluency (ORF) and significantly increased their comprehension. With these findings, research needs to continue to investigate the effects of increased intensity of TTS on the lowest readers with disabilities.

Summary

TTS used as a reading intervention may increase the ability of students with LD to compensate for their reading deficits and, in turn, gain information from text (Tian & Okolo, 2007). Because secondary curriculum is primarily presented using traditional text (Rose et al., 2011), students with LD are not successful readers when learning secondary curriculum. Practitioners need to present curriculum differently to meet the cognitive learning needs of students with LD.

Purpose

This study aimed to extend previous research on the effects of reading interventions with technology on reading comprehension. More specifically, this study evaluated the effectiveness of TTS on the reading comprehension of high school freshman students with LD in a self-contained class. The reading intervention used TTS, *Kurzweil 3000*, to provide reading material to students with LD through auditory and visual support. The researcher monitored participants' performance in reading comprehension through curriculum-based measurements (CBMs) to ensure improvement before measuring the effects on outcomes maintenance. The results provide additional empirical evidence on how to improve reading comprehension for students with LD while advancing the effects of TTS on reading outcomes.

Research Questions

The following research questions were addressed in this study:

1. Does Text-to-speech (TTS) increase the reading comprehension of freshman students with learning disabilities (LD) as measured by curriculum-based measures (CBMs) from the classroom text in a self-contained classroom?
2. Does oral reading fluency (ORF) increase after participants use TTS?
3. To what extent are participants able to maintain reading comprehension outcomes as measured by CBMs?
4. To what extent are participants able to generalize reading comprehension on universal screening assessments (e.g., Lexile)?
5. How is the use of TTS perceived by the participants when acquiring information from classroom text after increased intensity of TTS?

Definitions of Terms

Assistive Technology: Any product system, device, or equipment, whether acquired commercially, modified or customized, that is used to maintain, increase, or improve the functional capabilities of individuals with disabilities (Assistive Technology Act of 1998).

Bimodal Presentation: Refers to information that is presented with synchronous audio and visual formats. Bimodal reading is when someone reads the text while hearing the words at the same time (www.readspeaker.com).

Individuals with Disabilities Education Improvement Act (IDEIA): Passed in 2004, IDEIA refers to the refinement of IDEA to provide more seamless procedures and paperwork in special education; it mandates that all students with disabilities must participate in assessments conducted in school districts, and that special education teachers must be *highly qualified* to teach core subjects (Friend & Bursuck, 2012).

Kurzweil 3000: A technology software program that converts print into an electronic format that can be read aloud to the user and contains various features (e.g., highlighting, font size, voice selection, rate of speed) to help students acquire content (Moorman et al., 2010).

National Instructional Materials Accessibility Standard (NIMAS): A national electronic file standard that requires states to prepare material used solely for efficient conversion into specialized formats (IDEA, Section 674€(3)(B)).

No Child Left Behind (NCLB) Act: As the reauthorization of the Elementary and Secondary Education Act of 1965, NCLB mandates that all students be given equal access to a high-quality education by increasing academic standards and accountability for students to make adequate yearly progress, regardless of their income or disability (Friend & Bursuck, 2012).

Oral Reading Fluency (ORF): Reading fluency is accurate, rapid, oral word recognition skills using proper punctuations that allow readers to make meaning of text (Harris & Hodges, 1995).

Reading Comprehension: A process that involves the reader's previous learned knowledge about the world and involves strategies such as predicting, summarizing, identifying meanings of vocabulary, and reflecting on one's comprehension skills (Bartoli & Botel, 1998).

Optical Character Recognition (OCR): The ability of a computer to recognize the characters in written or printed text.

Screen Reader. The use of software that reads text on a computer screen to a user.

The "Tech Act" of 1988. The first law to define AT devices and services and increased availability of AT to all persons and their families in the United States (Behrmann & Jerome, 2002).

Text-to-Speech (TTS). A computer software program that can convert printed text (e.g., worksheets, tests, notes, and textbooks) into digital format and then read the whole text from the beginning to the end or anywhere the user selects (Tian & Okolo, 2007).

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter includes an overview of the current literature on students with LD with reading disabilities in Grades 6 to 12 related to reading outcomes. The first section describes characteristics of secondary students with LD in reading. The second section describes how technology, when used as a reading intervention, can provide compensatory assistance to students with LD when accessing secondary curriculum. Next, findings from major reviews for reading comprehension intervention studies without technology are discussed. The next section presents findings from major reviews of reading comprehension intervention studies with technology. The chapter concludes with a discussion regarding conclusions made from synthesizing the studies' results on secondary students with LD in reading.

Literature Search Procedures

I conducted a comprehensive search of the literature using four methods: (a) keyword searches in subject indexes, (b) searches in refereed journals, (c) reference searches in previously published literature, and (d) consultation**.** First, I conducted computer searches of key electronic databases: *Education Full Text, Educational Resources Information Center (ERIC), CINAHL, MEDLINE, PsycINFO,* and *SAGE Journals*. I used the following descriptors and keywords, in both abbreviated and varied versions, to identify studies in peer-reviewed journals that focused on reading interventions for secondary students with LD: *learning disability, reading, reading comprehension, reading disability, reading interventions, secondary, secondary education,* and *struggling reader.* I used truncation of the following terms: *comprehend*, learning disab*,* and *reading disab** to locate the greatest possible number of empirical studies. Second, to locate the most recent literature, I conducted a hand-search of 10 refereed journals from 2011 through 2015. I examined the following journals: *Annals of Dyslexia, Exceptional Children, Journal of Learning Disabilities, Journal of Special Education, Journal of Special Education Technology, Learning Disability Quarterly, Learning Disabilities Research and Practice, Reading Research Quarterly, Reading and Writing Quarterly,* and *Remedial and Special Education.* I selected these journals because reading interventions both with and without technology have been published in the journals. I searched within each journal from the years 2011 through 2015 using the key terms. I chose these years based on the latest literature review on secondary students with reading difficulties (Wanzek et al., 2013). Third, I conducted a reference search which involved reviewing the reference lists and footnotes from pertinent studies and previous literature reviews (Ciullo & Reutebuch, 2013; Swanson et al., 2014; Wanzek et al., 2013) to locate articles that were not found using the previous search methods. Fourth, I sent an electronic message to a prominent author in the field of reading interventions asking if there were any articles in press that focused on reading interventions for secondary students with disabilities.

Inclusion Criteria

I established criteria to determine which studies to include in this review. The selected studies were based on the following criteria: (a) published in a peer-reviewed journal in English, (b) included participants with LD or reading disabilities (i.e., scored below expected grade level in reading achievement or below 30% on standardized reading tests) or included additional participants if data were disaggregated for participants with LD or reading disabilities, (c) included an intervention in a middle or high school (i.e., Grades 6 through 12) or when more than 50% of the participants were in Grades 6 through 12, (d) had an experimental, quasi-experimental, single-group, or single-case research design, (e) was conducted in the United States, and (f) had a dependent measure of reading outcomes. If a study did not clearly report the reading outcomes of students with disabilities or LD, the study was not included. I selected the single-case and group design research to broaden my search on reading interventions for students with LD in Grades 6 through 12.

This process yielded 15 articles relevant to reading interventions for students with disabilities in secondary schools. I adapted the quality indicators of rigorous research by using Horner et al.'s (2005) and Gersten et al.'s (2005) guidelines for single-case and group designs, respectively. I used quality indicators to determine the methodological strengths and weaknesses of the studies. Quality indicators can assist practitioners with information to advance research through replicating studies with different groups in different settings (Jitendra, Burgess, & Gajria, 2011).

Article Coding

Researchers code articles to compare essential information and findings among studies in a literature review (Wilson, 2009). I coded the studies based on three different factors: (a) essential information in each study, (b) dependent variables, and (c) reading interventions with and without technology. First, the essential information from each study was coded and included the following categories: (a) participants, (b) independent and dependent variables, (c) design, (d) findings, and (e) generalization. I used essential information based on a previous synthesis (Chung, Carter, & Sisco, 2012). Second, I coded studies by dependent variables (i.e., vocabulary, comprehension, fluency, and phonics) in each study to make accurate comparisons among outcomes. Furthermore, I organized the studies according to the presence or absence of technology used as a reading intervention. By doing this, I focused on the effects of reading interventions without technology (see Table 1) and with technology (see Table 2) for students with LD in Grades 6 through 12.

Table 1

Key Information from Reading Intervention Studies without Technology for Secondary Students with Disabilities

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Reading Comprehension Intervention (*n* = 1)						
Vaughn et al. (2015)	77 (51 M, 26 F) 74 with LD 3 with ED *High*	Supplemental REWARDS Plus program; collaborative strategic reading strategy for 50 min per day for 160 days over 2 years; three treatment groups: T1 Reading without DOP T2 Reading with DOP T3 DOP without reading	Scores on Gates-MacGinitie reading comprehension; student engagement using enrollment status	Randomized control trial with pre- and posttest	Increase was significant for SWD in treatment groups compared to comparison group on Gates – MacGinitie reading comprehension	Not reported

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Vocabulary Intervention (n = 1)						
Harris, Schumaker, & Deshler (2011)	230 (16 M, 8 F) 16 with LD 2 with ED 1 with ID 4 with OHI 1 with AU *High*	Word Mapping (WM), LINCing (VL), and Test only (TO) less than 1 semester	Scores on Morphological Analysis Test for Vocabulary	Randomly assigned SWD and NSWD in a comparison-group	Increase was significant for SWD in VL group on the Word Knowledge Test and significant for SWD in the WM group on the Morphological Analysis Test; No difference for TO group	Not reported

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Fluency and Reading Comprehension Interventions (*n* = 2)						
Vaughn et al. (2011)	182 64 SWD *Middle*	T1 REWARDS word study, fluency, vocabulary, comprehension T2 Word study, fluency, vocabulary, comprehension specific to students' needs C Typical school-based interventions for 1 year	Scores on WJIII (letter word identification and reading passage comprehension); TOWRE for word reading efficiency; and TAKS	Random assignment to two treatment or one comparison group with pre- and posttest	No significant increase existed between SWD in the treatment conditions and the comparison group	Not reported

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Vaughn et al. (2012)	41 (29 M, 12 F) 9 with LD *Middle*	T Individual intervention in small group for 50 min per day for 1 year during an elective period C Participated in an elective (i.e., art, music, physical education)	Scores on WJIII word reading and comprehension; TOWRE; AIMSweb fluency; Gates-MacGinitie comprehension; TOSREC silent reading	Longitudinal, randomized trial with two treatment students for one comparison student with pre- and posttest	Increase was significant for students with LD in the treatment group on Gates-MacGinitie, WJIII Letter-Word, and on TOWRE Phonemic Decoding	Not reported

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Fluency, Reading Comprehension, and Vocabulary Interventions (*n* = 2)						
Seifert & Espin (2012)	20 with LD (11 M, 9 F) *High*	Reading interventions of text reading, vocabulary learning, and a combination of text and vocabulary in short-term study	Scores on reading fluency, vocabulary, and comprehension	Within-subject	Increase was significant for students with LD in vocabulary and reading fluency; no significant increase in comprehension	Not reported

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Wanzek, Vaughn, Roberts, & Fletcher (2011)	135 with LD *Middle*	Supplemental reading intervention for 50 min per day for 1 year with 10 to 15 students per class; T REWARDS Plus Program in place of an elective C Typical school-based interventions	Scores from WJIII word identification, word attack, and reading passage comprehension; TOWRE on decoding efficiency; TAKS for comprehension	Randomized treatment and control groups with pre- and posttest	Increase in scores on sight word reading fluency, and small increases on phonemic decoding, fluency, and passage comprehension	Over time; four months after posttest

Note. AU = autism; C = control group; DOP = dropout prevention; ED = emotionally disturbed; F = female; ID = intellectual disability; LD = learning disability; M = male; MBL = multiple baseline design; NSWD = non students with disabilities; RTI = response to intervention; SWD = students with disabilities; T = treatment group; TAKS = Texas Assessment of Knowledge and Skills; TOSREC = Test of Silent Reading Efficiency and Comprehension; TOWRE = Test of Word Reading Efficiency; OHI = other health impaired; WJIII = Woodcock-Johnson III Tests of Achievement.

[a] A total of six studies were summarized.

Table 2

Key Information from Reading Intervention Studies with Technology for Secondary Students with Disabilities

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Reading Comprehension Interventions (n = 2)						
Marino et al. (2014)	341 (174 M, 167 F) 57 with LD *Middle*	14 sessions of four blocks; Pretest score; sum of UDL game features; completed levels; LD with UDL features and level completion	Scores on researcher- created science unit pre-posttests; survey	Mixed methods using pre- and posttest with between and within subject factors	Increase for SWD in posttest scores but not significant; no increase of science knowledge after using UDL game enhancements; SWD felt skillsimproved	Over time

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Stetter & Hughes (2011)	9 with LD (4 M, 5 F) *High*	Story mapping (CAI) for 8 weeks; three treatment groups: TI – Story Map Intervention T2-Delayed Story Map Intervention T3-Baseline	Scores on daily Story map comprehension quizzes and on Gates-MacGinitie comprehension	MBL with survey	Increase in scores on Gates-MacGinitie at posttest for all three treatment conditions; no increase on daily quiz scores	Over time with maintenance

(Table Continues)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Vocabulary Interventions (n = 2)						
Kennedy, Deshler, & Lloyd (2015)	278 (133 M, 145 F) 30 with LD *High*	Content Area Podcasts (CAPs) with EI; CAPs with KMS; CAPs with EI + KMS; and instructional videos as EI without visual (VM) for 3 weeks	Scores on researcher created vocabulary tests using MC and OE questions; satisfaction survey	Random assignment treatment and control using pre- and posttest design with between-subject factors for SWD	Increase was significant on posttest scores from LD in EI + KMS group with explicit instruction	Over time with maintenance
Wood, Mustian, & Cooke (2012)	8 (5 M, 3 F) 4 with OHI 1 with ED 3 with LD *Middle*	Peer Tutoring (CAI) for 14 weeks	Scores on acquisition of vocabulary and generalization of vocabulary	Experimental simultaneous treatments	Increase in vocabulary scores on researcher-created measures	Over time

(*Table Continues*)

Study[a]	Participants/School Level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Fluency and Reading Comprehension Interventions (*n* = 3)						
Fitzgerald, Miller, Higgins, Pierce, & Tandy (2012)	5 with LD (3 M, 2 F) *Middle*	*Word IdentificationStrategy* online lessons to improve reading decoding skills for 4 months	Scores on WJIII comprehension and fluency	Multiple probe across participants	Increase in WJIII fluency and comprehension and WIS-CBM in oral reading, comprehension, and CBT	Over time with maintenance
Hall, Cohen, Vue, & Ganley (2015)	73 (144 M, 140 F) 64 with LD *Middle*	*Strategic Reader* (SR) with online CBM for 11 to 12 weeks	Scores on Gates-MacGinitie; CBM in fluency and comprehension; survey	Mixed methods using pre- and posttests with qualitative design	Increase was significant for SWD on the Gates-MacGinitie using SR online; significantly more engaged	Not reported
Meyer & Bouck (2014)	3 with LD (2 M, 1F) *Middle*	*Natural Reader*, TTS for 15 sessions; less than 1 semester	Scores on fluency, comprehension, and time to complete tasks; survey	MBL across participants	No difference in fluency, comprehension, or task completion; felt TTS made reading efficient	Over time

(Table Continues)

Study[a]	Participants/School level	Independent Variable	Dependent Variable	Design	Findings	Generalize Skills
Fluency, Vocabulary, and Reading Comprehension Interventions (*n* = 2)						
Retter, Anderson, & Kieran (2013)	13 with RD (11 M, 2 F) *High*	iPad2 applications with *Second Chance Reading Program* for 12 weeks	Scores on SRDT for vocabulary and comprehension;Jamestown Test for fluency	Pre- and postxperimental	Increase in comprehension and vocabulary with iPad; no difference between iPad and fluency	Not reported
Stodden, Roberts, Takahashi, Park, & Stodden (2012)	104 with LD Study 1 (n=35) Study 2 (n=69) *High*	*Kurzweil 3000* TTS for 30 min per week for 1 semester	Study 1-Scores on WJIII comprehension and vocabulary; Study 2-Scores on Nelson Denny Test in comprehension, vocabulary, and fluency	Mixed methods, repeated measures design	1-Increase in vocabulary; no difference in reading comprehension; 2-Increase was significant in vocabulary, comprehension and reading rate	Not reported

Note. CAI = computer assisted instruction; CBM = curriculum-based measurement; CBT = curriculum-based test; ED = emotionally disturbed; EI = explicit instruction; F = female; KMS = mnemonic strategy; LD = learning disability; M = male; MBL = multiple baseline design; MC = multiple choice; OE = open-ended questions; OHI = other health impaired; SRDT = Stanford Reading Diagnostic Test; TTS = text-to-speech; UDL = universal design for learning; WIS-CBM = Word Identification Strategy Curriculum-based Measurement

[a] A total of nine studies were summarized.

Intervention Components

The studies in this review included at least one of the following reading intervention components: vocabulary, phonics, fluency, and comprehension. Vocabulary interventions create semantic representations that interact with orthographic information contributing to visual word recognition (Harris et al., 2011) and phonics interventions stress letter-sound correspondences to help read and spell words (Harris & Hodges, 1995). Fluency interventions help readers read a text rapidly and accurately without word identification problems (Harris & Hodges). Reading comprehension interventions ask students to interact with text using prior knowledge and strategies such as predicting, questioning, summarizing, reflecting, and identifying vocabulary in context (Bartoli & Botel, 1988). In this review, studies were categorized by reading interventions with or without technology and grouped according to these dependent variables.

Methodological Features

In addition to coding the articles, I reviewed the studies' evidence of quality indicators established by Horner et al. (2005) and Gersten et al. (2005) for single-case and group design studies, respectively. Single-case studies were considered based on 21 components in the following areas: (a) participant and setting descriptions, (b) dependent variables, (c) independent variables, (d) baseline phase, (e) experimental control, (f) external validity, and (g) social validity (see Table 3). Group designs were considered based on 10 components in the following areas: (a) description of participants, (b) description and implementation of intervention and comparison conditions, (c) outcome measures, and (d) data analysis (see Table 4).

Table 3

Definitions of Horner et al.'s (2005) Quality Indicators

Participants and settings
Participants were described based on their ages/grades, genders, race/ethnicity, specific disabilities, and diagnoses to allow for replication.
Methods existed for specifically stating the selection of the participants.
Physical settings were clearly described for precise replication.

Dependent variable (DV)
Reading outcomes were operationally defined in quantifiable terms.
Each reading outcome was quantifiably measured.
Each measurement of reading outcomes was valid and accurately described to permit replication.
Reading outcomes were repeatedly measured throughout the duration of the study.
Data collection occurred on the reliability or interobserver agreement (IOA) of the DVs, and IOA calculations qualified as meeting the minimum standard (i.e., 80%).

Independent variable (IV)
The description of the IVs was provided in exact detail to allow for replication.
The experimenters systematically introduced the IV instead of allowing the IV to occur by itself.
The fidelity of implementation for the IV was conspicuously measured.

Baseline phase
Baseline phase included at least three data points showing repeated measures to help determine future performance.
Baseline conditions were described in exact detail to be replicated.

Internal validity/experimental control
Design provided at least three demonstrations of the effects gathered from three different data points.
Design provided information on threats to internal validity.
Results documented a pattern that exhibits experimental control.

External validity
Intervention effects on reading outcomes were replicated across participants or settings.

Social validity
Reading outcomes were established as socially valid.
Reading outcomes that resulted from the IVs were important.
Implementing the IVs were practical and cost efficient.
Implementation of the intervention occurred in natural settings with typical personnel.

Note. Definitions were adapted from Chung et al. (2012, p. 279) and Horner et al. (2005, p. 174).

Table 4

Definitions of Gersten et al.'s (2005) Quality Indicators

Essential Qualities

Participants

Researchers provided enough information to determine the participants had learning or reading difficulties.

Researches used appropriate procedures to increase the chances that characteristics of participants were similar across conditions.

Researchers gave enough information characterizing the interventionists and indicated that the characteristics were similar across conditions.

Intervention and Comparison Conditions

Researchers clearly described and specified the types of interventions.

Researchers clearly described and assessed the fidelity of implementation.

Researchers described the nature and type of instruction provided in comparison conditions.

Outcome Measures

Researchers used multiple measures to evenly align measures with interventions and generalization.

Researchers measured outcomes on the effect of interventions at appropriate times.

Data Analysis

Researchers analyzed data with techniques that matched research questions and the limit of analysis.

Researchers used inferential statistics and calculated effect sizes to report on the studies.

Desirable Qualities

Researchers provided data on attrition rates among intervention samples and documented severe attrition.

Researchers provided internal consistency, test-retest, and inter-rater reliability for outcome measures. Data collectors were blind to study conditions and equally familiar to examinees across study conditions.

Researchers provided for extended measures on outcomes after the posttest.

Researchers provided evidence on criterion-related and construct validity on measures provided.

Research team assessed features of fidelity implementation and examined the quality of implementation.

Researchers documented the nature of instruction provided in comparison conditions.

Researchers reported on the nature of the intervention through an audio or videotape excerpt.

Researchers presented results in a coherent way.

Note. Definitions were adapted from Gersten et al. (2005, p. 152).

Results

Students with Disabilities in the Intervention Studies

The total sample of students involved in these 15 studies was 1,731 who met the criteria for participating in reading interventions. There were 583 males and 520 females described in 80% (*n* = 12) of the studies. The remaining 20% of the studies (*n* = 3) did not specify whether the participants were male or female. This group of students ranged in age from 10.2 years to Grade 12 and were enrolled in either middle (*n* = 999) or high (*n* = 732) schools. Students with disabilities (*n* = 567; 35%) were dispersed across the 15 studies. Students with disabilities were identified as having LD (*n* = 423; 75%), ED (*n* = 10; 2%), OHI (*n* = 16; 3%), MR (*n* = 1; .1%), ADHD/ADD (*n* = 7; 1%), TBI (*n* = 2; .3%), LEP (*n* = 40; 7%), HI (*n* = 1; .1%), AU (*n* = 2; .3%), and SL (*n* = 1; 1%), or were reported as having disabilities without specifying the categories within special education (*n* = 64; 11%). Race/ethnicity was reported for 1,166 students (67%) or nearly all studies (*n* = 13; 87%), of whom 620 were Caucasian, 372 were African-American, 163 were Hispanic, 9 were Asian, 1 was American Indian, and 1 was Bi-racial. Free and reduced lunch was reported for nearly all studies (*n* = 11; 73%). Participants had a reading level at least one or more grade level below their nondisabled peers and/or performed in the bottom 30% on standardized tests in reading.

Reading Interventions without Technology

Two groups of reading interventions were included in this review: one group without technology and one with technology. The reading intervention studies without technology are presented in Table 1 which shows six (40%) reviewed studies by reading intervention focus without the use of technology and includes descriptive information. I organized the studies according to their dependent variables which focused on one, some, or all of the following: vocabulary, phonics, fluency, and comprehension. Out of these six studies, one study had a dependent variable of comprehension, one of vocabulary, two of fluency and comprehension, and two of fluency, comprehension, and vocabulary.

Reading comprehension intervention. One study (Vaughn et al., 2015) focused on reading comprehension without technology as an intervention. The researchers studied the effects of reading interventions and assessed drop-out rates among students with LD in Grades 9 and 10. They used interventions focused on comprehension and engagement over 2 years and assessed reading comprehension and student engagement. Results showed that students with disabilities exhibited a significant increase on the Gates-MacGinitie reading comprehension test after treatment.

Vocabulary intervention. In Harris et al. (2011), the first author taught high school students with and without LD a morphemic analysis strategy for analyzing the meanings of words. Vocabulary interventions focused on teaching two different vocabulary strategies to derive meaning from words. Results indicated that the students using Word Mapping exhibited higher scores on morphological analysis tests and created meanings for new words, a crucial skill when learning new material.

Fluency and reading comprehension intervention. Two studies focused on fluency and reading comprehension as interventions without technology. Vaughn et al. (2011) hired six reading intervention teachers to teach Tier 3 reading interventions to students in Grades 7 and 8 for 1 year of 50-min daily interventions. Trained teachers explicitly instructed reading using standardized and individualized interventions with narrative and expository text. Individualized procedures relied on students' mastery of content to adjust the pace of the curriculum. Results indicated that both treatment groups performed higher on decoding, fluency, and comprehension compared to the control group. Vaughn et al. (2012) hired two interventionists who implemented a 1-year intensive reading intervention in small groups focusing on fluency and comprehension. The researchers used data to inform decision making for the groups of two to four students. Teachers created and adjusted lessons based on individualized needs obtained from diagnostic assessments and CBMs. Findings showed that participants exhibited moderate increases in word reading skills and significant increases in comprehension.

Fluency, vocabulary and reading comprehension intervention. The last group used fluency, vocabulary, and reading comprehension as interventions. Seifert and Espin (2012) provided instruction to 20 high school students with LD on three types of reading interventions using a high school Biology textbook. The researchers investigated if there was an immediate effect on the ability of students with LD to improve comprehension. Results indicated that the reading of the text and combined interventions had a positive effect on fluency and vocabulary. Wanzek et al. (2011) implemented a 1-year supplemental reading intervention for 50 min per day to middle school students with LD. Reading groups were composed of 10 to 15 students engaged in multicomponent reading interventions. Results indicated significant improvements in participants' word fluency and small effects for decoding fluency and comprehension. The literature on reading interventions without technology contained evidence that students made greater reading gains when taught in small groups, received explicit instruction, and given frequent feedback on coursework. Additionally, reading interventions administered daily over the course of at least one semester indicated students increased reading outcomes. In addition to reviewing literature on reading interventions without technology, I reviewed studies that implemented reading interventions with technology.

Reading Interventions Using Technology

Reading interventions with technology include essential information to allow the researcher to draw conclusions among the studies. In nine (60%) studies, a total of 1,046 students were involved in research using technology to increase reading skills. I categorized the studies based on the dependent variables used to measure reading outcomes.

Reading comprehension intervention with technology. There were two studies that used technology as a reading intervention to assess reading comprehension. Marino et al. (2014) examined how science material, when using computerized game features, could assist middle school students with LD in learning curriculum. Results indicated an increase for students with disabilities in posttest scores but no increase of science knowledge after using Universal Design for Learning (UDL) game enhancements. Stetter and Hughes (2011) examined whether computer-assisted instruction (CAI) using *Story Mapping* could effectively teach reading skills to high school students with LD. Participants in all three treatment conditions increased scores on Gates-MacGinitie comprehension at posttest. The current study used a multiple baseline design that staggered the introduction of the intervention resulting in greater reading outcomes as compared to Marino et al.'s study which used a mixed-methods design using pre- and posttests, resulting in minimal gains.

Vocabulary intervention with technology. Two studies targeted vocabulary as a dependent variable. Kennedy et al. (2015) used content area podcasts (CAPs) and explicit instruction to improve high school students' vocabulary. Using a random assignment treatment and control design, the researchers showed that participants increased vocabulary significantly on posttest scores. Wood et al. (2012) used peer tutors to help middle school students with disabilities acquire vocabulary. Findings showed that participants increased vocabulary scores on researcher-created measures.

Fluency and reading comprehension with technology. Three studies used fluency and reading comprehension as dependent variables. Fitzgerald et al. (2012) used online modules to teach *The Word Identification Strategy* to middle school students with LD who were enrolled in an online charter school. Participants increased fluency and comprehension as shown on the Woodcock Johnson III and CBMs. Hall et al. (2015) used *Strategic Reader*, UDL strategies, and CBMs to evaluate the effectiveness of reading interventions on middle school students with LD. Results indicated that participants significantly increased their fluency and comprehension on the Gates-MacGinitie after using *Strategic Reader* online. Meyer and Bouck (2014) used *Natural Reader***,** a TTS software program, with middle school students with LD to access grade-level expository text. Results indicated no difference in fluency, comprehension, or task completion after using TTS for 15 sessions.

Fluency, vocabulary, and reading comprehension with technology. Two studies used fluency, vocabulary, and reading comprehension as dependent variables. Retter et al. (2013) used a combined instructional approach with iPad2 applications and the *Second Chance Reading Program* to instruct high school students in vocabulary, fluency, and comprehension skills. Participants increased comprehension and vocabulary with the iPad2 but there was no correlation between iPad2 use and fluency. Stodden et al. (2012) conducted a two-part study using *Kurzweil 3000*, a TTS intervention, to teach high school social studies content for 30 min weekly to increase fluency, vocabulary, and comprehension. The first study indicated an increase in participants' use of vocabulary but there was no difference in comprehension. Results showed significant increases in vocabulary, comprehension and reading rate in the second study.

Methodological Elements of the Intervention Studies

In literature reviews, examining the methodological elements of empirical studies allows researchers to compare studies. Additionally, I used quality indicators to evaluate studies in this review. Four single-subject and eleven group design studies are discussed in relation to Horner et al.'s (2005) and Gersten et al.'s (2005) quality indicators, respectively.

Quality Indicators for Single-Subject Research

Since NCLB (2002), students with disabilities are required to be taught using evidence-based practice. Reviews must be conducted to determine if existing research meets methodological rigor to be able to provide practitioners with quality instruction to improve student outcomes. Horner et al. (2005) developed quality indicators to guide reviewers' consideration of methodological strengths and weaknesses present in single-subject studies. The following categories include information on the four single-subject studies presented in this review.

Participants and settings. All four single-subject design studies (100%) reported participant descriptions that included age/grade, gender, specific disabilities, and race/ethnicity. Researchers from three of four studies (75%) specifically stated the instruments and procedures used to determine students' diagnoses. In addition, researchers from all four studies (100%) specifically stated the inclusion and exclusion criteria for participation in their studies.

Researchers provided information on the types of settings in which the reading interventions would occur (e.g., special or general education settings, computer lab, and/or community settings) in all identified studies (100%). The researchers provided information on the class size (*n* = 3 studies; 75%) and physical features or instructional models (*n* = 3 studies; 75%). One of four studies (25%) was conducted in the school's computer lab, two of four studies (50%) took place in a special education setting (e.g., resource room), and one of four studies (25%) occurred through the charter school's Internet platform either in the child's home or local library. The specific class subject (e.g., science or social studies) was mentioned in all four studies (100%).

Dependent variables. The four single-subject studies showed many different dependent variables to measure students' progress. Measurement of dependent variables assessed participants' behavior after receiving interventions. Measurements assessed one of these areas or a combination them: phonics, fluency, comprehension, and/or vocabulary skills through the use of pre- and posttest measurements and/or researcher-created questions. All studies (100%) operationally defined the measurements and procedures. Three of four (75%) studies presented interobserver agreement (IOA) data for reading interventions that were above the standard criterion (i.e., 80%) on 20% to 30% of the probes. Mean IOA scores ranged from 97% to 100%.

Independent variables. In the included studies, researchers used independent variables to provide treatment to students with disabilities to cause a change in their reading skills. Four out of four studies (100%) provided adequate descriptions of the procedures, content, and the length of the study to allow replication. The researchers in three of four studies (75%) reported an acceptable range of 96% to 100% in treatment fidelity levels. Stetter and Hughes (2011) did not provide information on treatment fidelity in their study.

Baseline phase. Baseline data demonstrate participants' pre-intervention knowledge through repeated measurements. By establishing baseline-level performance before introducing interventions, researchers can easily identify whether the interventions caused changes in participants' behavior. Three of four studies (75%) exhibited stability in baseline levels with at least three or more baseline data points before moving into the intervention phase (Fitzgerald et al., 2012; Meyer & Bouck, 2014; Stetter & Hughes, 2011). Fitzgerald et al. used a multiple probe across participants design with quick probes, rather than repeatedly measuring behavior. Wood et al. (2012) used a simultaneous treatments design which did not show baseline measures. Stetter and Hughes used a multiple baseline design with maintenance data; however, not all students exhibited stability in baseline performance before the intervention was implemented. All the researchers provided detailed information on settings, personnel, and activities to describe their baseline conditions for future replication.

Internal and external validity. Quality research establishes strong internal and external validity by controlling threats that may interfere with the effect of the intervention. Not all threats can be controlled; however, addressing possible threats proactively in the design validates the findings (Gast, 2010). All four single-subject studies provided baseline or comparison data to control for threats to internal validity. Wood et al. (2012) used a simultaneous treatments design that counterbalanced treatments within sessions. Fitzgerald et al. (2012) and Meyer and Bouck (2014) used a multiple baseline across participants design that demonstrated internal validity through intersubject replication and external generality of findings. Stetter and Hughes (2011) used a multiple baseline design that showed each participant's transition from baseline to intervention conditions.

Researchers visually document single-subject research data to indicate the presence of a functional relation. Four of four studies (100%) visually displayed results with interventions and conditions clearly defined. After visual analysis, Wood et al.'s (2012), Fitzgerald et al.'s (2012), and Stetter and Hughes's (2011) data documented a functional relation between the intervention and the participants' reading outcomes. Internal validity threats of history and maturation were controlled due to having short studies and staggering the introduction of the intervention across participants (Gast, 2010).

External validity is displayed when the single-subject designs' effects can be replicated with different participants and in settings that exist outside the study (Horner et al., 2005). Although all four of these single-subject design studies had at least three participants, not all the studies replicated the effects to the same extent as other studies. Meyer and Bouck's (2014) multiple baseline study only had three participants which made it difficult to increase the generality of findings or to identify exceptions (Gast, 2010). On the other hand, Stetter and Hughes's (2011) multiple baseline design involved nine participants which increased the generality of findings. With more participants with different ages and disabilities, it is easier for the researcher to identify exceptions to the rule which, in turn, increases our understanding of behavior (Gast, 2010).

Generalization. Researchers measure participants' ability to generalize skills in different settings to increase confidence in the findings. The researchers showed the students' generalization in reading skills learned in three of four studies (75%). Researchers documented generalization in either the same setting as intervention but using different material (e.g., narrative verses expository text) or by placing generalization into probes in three of four studies (75%). Stetter and Hughes (2011) examined students' daily scores in relation to their own progress and in relation to other students in the group. Meyer and Bouck (2014) included a generalization phase in their study to match grade-level readability. Fitzgerald et al. (2012) collected data on mean generalization percentage scores (M = 95.93%) and on maintenance percentage scores (M = 95.80%).

Social validity. Identifying participants' perceptions after exiting intervention documents the social significance of the intervention (Horner et al., 2005). The researchers reported on social validity in four of four studies (100%) on the objectives, procedures, and results of the interventions, and on the contexts of the interventions. Social validity was assessed using a survey (n = 2; 50%) or interview (n = 2; 50%). Researchers identified participants' perceptions and noted positive responses from students and teachers on their use of reading interventions. All the interventions occurred in natural settings (i.e., schools, homes, or libraries). In three of four studies (75%), the interventions were administered by the researchers. One of four studies (25%) used peer tutors and one of four studies (25%) used a special education facilitator to administer the intervention.

Summary

Overall, the single-subject designs contained quality indicators that exhibited methodological rigor in several areas. All the single-subject studies exhibited at least one component in each of the seven categories (i.e., participants, dependent and independent variables, baseline phase, and internal, external, and social validity). Studies that contain methodological rigor can inform practitioners on improving reading instruction for secondary students with disabilities.

Quality Indicators for Group Studies

Group designs have quality indicators that differ from single-subject designs. Quality indicators identify components that exhibit methodological strengths and weaknesses. Researchers accurately identify quality indicators in group designs to determine the methodological strengths and weaknesses found in the studies. In this review, I found 11 group design studies that addressed reading interventions for middle and high school. I used Gersten et al.'s (2005) quality indicators with the descriptions in Table 2 to identify whether each of the 11 studies met the criteria for "high quality" or "acceptable" research studies. A study was considered high quality if it contained all but one of the Essential quality indicators and demonstrated at least four of the Desirable quality indicators. A study was determined to be acceptable if it contained all but one of the Essential quality indicators and demonstrated at least one of the Desirable quality indicators (Jitendra et al., 2011).

Essential Quality Indicators

Essential quality indicators provide minimum standards for identifying quality research for group designs (Gersten et al., 2005). Group design quality indicators are labeled as Essential and Desirable and contain different components for consideration of acceptable or high-quality research.

Description of participants. Eleven studies (100%) provided sufficient information on participants' disabilities or learning difficulties. Over half of the studies (*n* = 8; 73%) demonstrated equal groups across conditions. Methodological weaknesses were present in some studies. Hall et al. (2015) indicated that the pretest scores were not equal for the two groups which may have skewed the posttest results. Stodden et al. (2012) did not indicate the presence of a control group in the study. Over half of the studies (*n* = 6; 55%) provided information on the intervention agents to allow for future replication of the studies. Fewer than half of the studies (*n* = 5; 45%) included all three components of the quality indicators when describing participants.

Intervention/comparison conditions. Defining intervention and comparison conditions is essential in developing quality group studies. Eleven studies (100%) clearly described reading intervention to improve reading skills. Nearly all the studies (*n* = 10; 91%) described and measured procedural fidelity; however, Retter et al. (2013) did not provide this information. Nearly all the studies (*n* = 9; 82%) provided descriptive instructions in the comparison groups except for Kennedy et al. (2015) and Stodden et al. (2012).

Outcome measures. Multiple measures are used in studies to provide reliability in the findings. Eleven of the studies (100%) used multiple measures for assessing reading skills for students in secondary schools. All the studies (100%) measured students' reading skills at appropriate times which helped obtain accurate assessment data.

Data analysis. Proper data analysis is crucial when seeking answers to research questions. Eleven of the studies (100%) analyzed the data using techniques that were associated with the research questions. Almost all the studies (n = 10; 91%) included effect sizes in the results section of the articles; however, Hall et al. (2015) lacked this information.

In applying the Essential quality indicators, 7 of 11 studies (64%) met the criteria for rigorous research which included 9 of 10 (90%) components of Essential quality indicators (Harris et al., 2011; Marino et al., 2014; Seifert & Espin, 2012; Vaughn et al., 2011; Vaughn et al., 2012; Vaughn et al., 2015; Wanzek et al., 2011). After studies were identified as having Essential quality indicators, they could then be considered as exhibiting Desirable quality indicators if they met more rigorous standards.

Desirable Quality Indicators

The Desirable quality indicators have additional components that exhibit more rigor than the Essential quality indicators. I evaluated the seven studies that met the criteria for rigorous research with the Essential quality indicators to determine the presence of eight Desirable quality indicators. These seven studies exhibited differences when I investigated the other components of the Desirable quality indicators. For example, Harris et al. (2011), Seifert and Espin (2012), and Vaughn et al. (2015) documented that interraters were blind to the conditions when conducting reliability measures. More than half of the studies (n = 5; 71%) documented the presence of a team assessing the quality of fidelity implementation. Vaughn et al. (2015) was the only study to document attrition rates among participants. All the studies documented results clearly and coherently.

For a study to be considered high quality, the study had to meet all but one of the 10 components of the Essential quality indicators and at least four of the Desirable quality indicators. An acceptable study had to document all but one of the 10 components and at least one of the Desirable quality indicators. When I evaluated the seven studies, five studies met the criteria for high-quality studies (Harris et al. 2011; Seifert & Espin, 2012; Vaughn et al., 2012; Vaughn et al., 2015; Wanzek et al., 2011) as compared to two studies that met the criteria as having acceptable quality (Marino et al. 2014; Vaughn et al., 2011).

Summary

Since the passage of NCLB (2002), the need for empirical studies to exhibit methodological rigor has become more prominent. After obtaining information on the presence of the quality indicators in the related literature, methodological strengths and weaknesses were found that can guide reading instruction for students with disabilities. The integration of using technology as a reading intervention has shown increases in the reading skills of students with LD. When reviewing the literature on reading interventions, I found nine studies without technology and six studies with technology. Evidence from all studies exhibited shared conclusions. Some common conclusions were that longer studies are needed (i.e., close to one semester) and reading interventions tailored to meet students' individualized deficits should occur more often in secondary school.

When addressing reading deficits of secondary students with LD, effective reading interventions include the use of TTS. More specifically, when TTS is used by students with LD to read passages, they can implement features that are individualized to meet their needs (i.e., rate of speed, bi-modal presentation, and highlighting). TTS used as a reading intervention increases motivation for students to engage in reading longer than without the use of TTS (Hecker et al., 2002). To meet the needs of secondary students with LD, TTS used as a reading intervention can increase reading skills and when used over time, create more efficient readers.

Synthesis and Conclusions

I have presented information that shows the qualities of single-subject and group design research along with the effects of reading interventions with and without technology for secondary students with disabilities. Evidence from the related literature indicates interventions seek to improve reading in the following areas: vocabulary, comprehension, fluency, and phonics. This review of the literature found that reading interventions with technology benefit high school students with disabilities more than middle school students. The evidence indicates explicit reading interventions with technology result in reading gains. The current research base for reading intervention using technology is scant and needs to continue to address the needs of secondary students with reading disabilities.

I found 15 studies during my extensive research to identify related literature on reading interventions for secondary students with disabilities. Researchers in these studies used reading interventions with or without technology. Overall, they found that reading outcomes for secondary students with disabilities provide ideas on how to improve reading instruction. From this literature review, three conclusions for reading interventions remained prominent: (a) reading interventions with technology and explicit instruction need to occur more often, (b) reading interventions conducted for longer periods of time should be expanded, and (c) reading interventions tailored to students' specific reading deficits should continue in high school. These three conclusions aim to inform practitioners on ideas for improving reading instruction for secondary students with disabilities.

The first finding in this review concluded that reading interventions with technology using explicit instruction showed increased reading outcomes. More specifically, all four studies using reading interventions with technology reported increases in comprehension, vocabulary, or fluency (Kennedy et al., 2015; Retter et al., 2013; Stetter & Hughes, 2011; Stodden et al., 2012). Kennedy et al. used researcher-created science comprehension questions and found significant increases in students with disabilities' vocabulary after using CAPs with explicit instruction. Retter et al. found significant increases in students with disabilities' comprehension and vocabulary after learning content using an iPad. Interestingly, the Stetter and Hughes (2010) and Ciullo and Reutebuch (2013) syntheses on technology and reading outcomes found that high school students with disabilities exhibited greater reading gains than middle school students after receiving reading interventions with technology. This contradicts Scammacca et al.'s (2007) research indicating students with reading disabilities in middle school exhibited higher outcomes than high school students without technology. Thus, more research on using technology as a reading intervention should be conducted with high school students with LD to increase reading outcomes.

Along with implementing reading interventions using technology with explicit instruction, a second finding emerged. This finding indicated that reading interventions using technology consistently over time increased reading outcomes. Reading intervention studies with technology when used at least once per week and conducted for nearly a semester exhibited greater reading outcomes for students with LD, particularly in the pre- and posttest gains on assessments (Fitzgerald et al., 2012; Hall et al., 2015; Stetter & Hughes, 2011; Stodden et al., 2012). More specifically, studies found that using digital text increased oral reading and comprehension with technology used more than a minimum of 30 min per week (Stodden et al., 2012) and 3 to 4 days per week (Hall et al., 2015). Fitzgerald et al. (2012) implemented 40 sessions of online learning using a decoding reading strategy, resulting in significant reading comprehension gains on standardized and curriculum-based tests. Consistent gains in all three studies were attributed to the increase in the exposure the students had to the digital text (Fitzgerald et al., 2012; Hall et al., 2015; Stodden et al., 2012). Students with LD need additional online instruction to learn the same content as their peers without disabilities (Fitzgerald et al., 2012). Along with additional exposure to digital text, evidence suggests that immediate teacher or computer feedback improves reading outcomes (Hall et al., 2015). When researchers provided feedback at the start of class, students were not able to implement changes and did not learn from their mistakes (Stetter & Hughes, 2011). Researchers suggested that immediate feedback along with additional exposure to digital text may increase reading outcomes (Hall et al., 2015; Stetter & Hughes, 2011) and more efficient learning (Hall et al., 2000).

The third conclusion was that when researchers individualized reading interventions tailored to students with disabilities' reading deficits, significant reading gains occurred (Vaughn et al., 2012; Vaughn et al., 2015). Vaughn et al. (2012) provided intensive, small-group reading instruction to freshman students with disabilities for 50 min per day using assessment data to guide instruction (i.e., comprehension, fluency, phonics, and vocabulary). Using a randomized controlled trial group design, Vaughn et al. (2015) found that individualized reading interventions increased reading outcomes. Both Vaughn et al. (2012) and Vaughn et al. (2015) showed increased results; however, it was not enough to close the achievement gap. Researchers found that technology used as an additional reading intervention resulted in positive reading outcomes. Hall et al. (2015) tailored reading interventions using *Strategic Reader*, an online software program, and found increases in reading comprehension outcomes and engagement. Although the use of technology has established itself as a critical factor in improving reading deficits for students with disabilities, there is some criticism and doubt. Many teachers are still unaware of how to use technology when instructing students with disabilities (Okolo & Diedrich, 2014). With rampant personal use of technology among adolescents (Stetter & Hughes, 2011), practitioners should use technology to teach to specific needs of struggling readers (Hall et al., 2015). Discussions regarding the use of technology to teach literacy state that if technology is motivating and provides practitioners' instant student feedback, it should be used more often (Edyburn, 2014).

Implications for Future Research

After reviewing the relevant literature, three gaps emerged regarding reading interventions for secondary students with disabilities. First, this research indicates that technology can effectively instruct students with disabilities without relying on reading specialists. Using trained reading specialists to implement reading interventions is costly, especially when administered to small groups of students (Vaughn et al., 2015). After technology software is installed and updated, the cost is minimal when looking at what technology provides. Furthermore, technology software for literacy includes reading skill instruction with drills, practice, error correction and components of reading (i.e., vocabulary, fluency, comprehension, and vocabulary). Research shows that secondary students with disabilities spend minimal time reading in class (Vaughn & Wanzek, 2014) but become motivated to learn using technology (Cardon, 2000). In addition to replacing reading specialists with technology to increase reading skills, a second gap emerged.

There is minimal evidence of experimental research for high school students with disabilities (Vaughn et al., 2015; Wanzek et al., 2013). This review identified only one single-subject design study that used reading interventions with technology for high school students with disabilities (Stetter & Hughes, 2011). Single-subject research should be used when using technology as a reading intervention to identify the existence of a functional relation between technology and reading (Gast, 2010). Single-subject designs provide repeated measures and quick assessments which is ideal when teaching reading to secondary students with disabilities (Kim et al., 2012). Since each participant acts as his/her own control, this design can address students' individualized reading deficits. With the prevalence of personal use of technology among students with disabilities in high school (e.g., iPhones, iPads, Internet, and computers), assessing the benefits of technological interventions on reading outcomes is crucial. If more single-subject design studies are conducted using reading interventions with technology, additional research will guide practitioners on how to implement technological reading interventions targeting students' reading needs.

In addition to using technology as a cost-efficient reading intervention, and the lack of single-subject research, another gap emerged. Technology when used alone without teacher-led instruction is not enough to increase student outcomes. Students with disabilities exhibited significant reading gains when they used technology and teacher-led instruction to learn curriculum (Stetter & Hughes, 2011). Secondary students with disabilities can rely on features of technology (e.g., TTS and self-selected reading rates) to increase efficient comprehension of material. Reading intervention studies with technology should include consistent exposure (i.e., at least once weekly) to technology (i.e., TTS) that occurs for a semester when instructing reading to high school students with disabilities.

Conclusions

This review contains the most current literature on reading interventions for students with reading disabilities in Grades 6 through 12 and indicates there is room for improvement. The identified gaps in the literature indicate that research should include more single-subject studies that use reading interventions with technology in high school to address students with disabilities' deficits. More specifically, when reading interventions use individualized technological interventions consistently over time, students with disabilities can improve reading skills. If more research on effective reading interventions for secondary students with disabilities exists, practitioners will be able to implement new research to increase outcomes. Increasing reading outcomes continues to be a priority when secondary students with disabilities need to learn to not only graduate from high school, but attend postsecondary school and gain competitive employment.

CHAPTER III

METHOD

This chapter contains the methods for the current study including information on the research design, criteria for selecting participants, setting in which the study occurred, information on instructional materials, and descriptions of the dependent measures. The end of the chapter includes information on the instructional, testing, and scoring procedures and the assessment of treatment fidelity.

Research Design

A single-subject withdrawal design evaluated the effects of TTS on reading comprehension performance. The A-B-A-B withdrawal design used repeated measures of behaviors (i.e., reading comprehension measures) obtained from the classroom text, the *Edge*. Replication of effects across conditions occurred to document a functional relation between the independent variable (i.e., TTS) and the dependent variable (i.e., reading comprehension). Experimental control is exhibited when the level and trend of the dependent measure improve with exposure to the intervention and then diminish during baseline conditions (Gast, 2010).

Threats to Internal Validity

Single-subject designs may contain threats to internal validity when conducting research. These threats cause difficulty in documenting the presence of a functional relation between the independent and dependent variables. Researchers can proactively address threats when designing studies. The participants were familiar with me, the researcher, and the research setting before beginning the study. This familiarity made students feel comfortable when reading from the computer and completing CBMs to avoid Hawthorne Effects. Hawthorne Effects is when participants' outcomes are different due to the researcher being new to them (Gast, 2010). Furthermore, only one variable, the TTS, was changed when participants entered the conditions. When moving from the baseline to the intervention conditions, there were immediate and abrupt changes in data documenting an immediacy of effect. Next, an observer completed interobserver agreement (IOA) sheets that documented the implementation of procedures to guard against instrumentation threats. Additionally, each reading comprehension CBM was a new passage to control for the threat of instrumentation. The CBMs were all at the same readability level to control the threat of testing. Another threat, cyclical variability, was controlled by the experimental conditions including different numbers of sessions.

Threats to External Validity

This study's design, A-B-A-B, allowed for inter-subject generalization. There were more than three students (i.e., four) in the study to show generalization. With inter-subject replication, it can be assumed that if the TTS was effective with this group, it will also be effective with other participants with similar disabilities.

Criteria for Changing Conditions

Participants exited a condition after they completed a pre-determined number of CBMs (i.e., five in the first baseline condition, seven in the first intervention condition, six in the second baseline condition, and seven in the second intervention condition). When participants completed five CBMs in the baseline condition, the intervention began. The participants remained in the TTS intervention condition for seven sessions. After seven sessions, participants revisited baseline condition without TTS for five sessions. Once again, participants entered intervention and remained in the condition for seven sessions. After completing the intervention, participants began the maintenance condition during which CBMs were given once per week for up to 4 weeks.

Participants

The participants in this study were selected based on purposive and convenience sampling. The study aimed at using participants who had LD in reading as determined through state and district regulations. The participants were between the ages of 14 and 15 and were enrolled in a freshman self-contained English class.

The criteria for students with LD to be placed in self-contained classes are based on Lexile scores in the bottom 25% locally (i.e., below 900), teacher recommendations, the inclusion of reading comprehension goals on their Individualized Education Plans (IEPs), and having good attendance. Good attendance was defined as having a 95% attendance rate. As standard practice, the school district's special education administrators also place students based on middle school teachers' recommendations for courses that will best meet the students' needs.

Parents and potential participants were given information regarding the study in language they understood. I sent a parental permission form home to the enrolled students' parents. I informed parents of my availability to answer any questions about participation in the study and provided them with enough time (i.e., 1 week) to make an informed decision.

I gained parental permission and verbal informed assent from four participants at the start of first semester in August 2016. I reviewed participants' IEPs and identified when each participant initially became eligible to receive special education services under the LD category and documented the presence of a secondary characteristic, if available. Furthermore, I documented the amount of time the participant spent in the general education setting and their social-economic status (SES). Next, I collected information about whether or not each participant had previously used TTS software to access reading passages. I reviewed the IEP reading goal of each participant to identify how the goal targeted comprehension. I documented initial 9th grade Lexile scores taken in August when entering high school. Finally, I obtained survey data indicating each participant's ethnicity and age (see Table 5).

Table 5

Participant Characteristics

Name Gender	Age	Initial Eligibility; Primary and Secondary Characteristic	Ethnicity and SES	Used TTS Previously	Initial Lexile Scores	% in General Education
Vincent (M)	15	5/2011 SLD	African-American Low SES	No	864	40-79%
Jack (M)	14	12/2009 SLD/AU	African-American Low SES	No	186	Less than 40%
Dianna (F)	15	11/2012 SLD/ADHD	African-American Low SES	No	772	40-79%
Donald (M)	14	4/2008 SLD	African-American Low SES	No	872	40-79%

Note. ADHD = Attention Deficit/Hyperactivity Disorder; AU = Autism.

Four participants were included in the study. The results and findings were based on the data collected from the four participants who had a special education eligibility based on specific LD and who were involved in the study for the entire semester.

Setting

The study occurred in a large, Midwest public high school with an overall student enrollment of 3,317 as of 2015-2016. Out of the 3,317 students, about 16% (i.e., 528 students) received special education services. Forty percent of the students receiving special education services did so under the LD category. Twenty percent of the overall student population received free and reduced lunch.

Research activities occurred in a computer lab close to the freshman students' self-contained classroom. The computer lab had at least 15 desktop computers and had TTS, *Kurzweil 3000*, installed on each computer. All participants in the class used TTS to access and read fiction passages; however, data were only collected for those students whose informed assent and parent permission were received. Each session where participants read from the computer with and without TTS lasted no more than 48 min (i.e., one class period). Participants engaged in this activity three times per week on Mondays, Wednesdays and Fridays during the regularly scheduled English class.

When participants read passages on the computers, they were placed at least one seat away from their peers to minimize distractions. All participants read the passages during the same time per day (i.e., 8:00 am until 8:48 am) on Mondays, Wednesdays and Fridays. When participants finished reading, they remained seated to complete the CBMs until the end of the period. To manage behavior when participants were in the computer lab, classroom rules were reviewed and maintained. Classroom behavior expectations were posted on the wall of the computer lab to remind students of desired behavior.

A teaching assistant accompanied the students along the teacher/researcher, into the computer lab. The teaching assistant provided support to students logging into the computers, accessing the fiction stories, and maintaining appropriate behavior.

As the researcher, I identify as a Caucasian female special education teacher with Learning Behavior Specialist I credentials. I had taught for a total of 22 years at the start of the study, all of which were dedicated to teaching students in special education. I have taught 13 years in the district in which the study occurred. Currently, I teach English to students with LD in the special education department.

Materials

Classroom Textbook

Before the study began, I selected 29 fiction stories from the *Edge* classroom textbook. The *Edge* textbook contains fiction stories written at the participants' readability level. I used the *Edge* CBM assessments for each fiction story that consisted of 15 multiple-choice questions. These CBMs had the same number of questions in each component (i.e., eight vocabulary, four literary analysis, and three reading comprehension) for each passage. An example of a vocabulary question found in the Edge curriculum is "to *affect* something is to: (a) sell it, (b) change it, (c) produce it, and (d) connect it" (Hampton-Brown, 2007, p. 1c). An example of a literary analysis question from the *Edge* is "The climax of the story occurs when: (a) Mr. Sanchez invites Rey to his house, (b) Hernando tries to bend the basketball rim, (c) Rey's mother asks him to pick up his brother, and (d) Rey stops to help Mr. Sanchez change his tire" (Hampton-Brown, 2007, p. 1c). The last component of each CBM focused on comprehension. An example of a comprehension question is "Which life lesson does Rey learn from the events of the story? (a) Give people a chance to change, (b) Forgive people who have let you down, (c) Do not expect people to help others in need, and (d) Do not rely upon people who cannot be trusted" (Hampton-Brown, 2007, p. 1d). The overall mean percentage scores were based on accuracy of the 15 multiple-choice reading comprehension questions (i.e., CBMs) shown in Table 8. Additional analysis involved documenting mean scores of each component in all conditions shown in Table 9.

Text-to-Speech (TTS)

The TTS software used to access reading material was *Kurzweil 3000.* This software was available on desktop computers that were available for student use in the school. Prior to beginning the study, participants attended a training session during which they preselected settings in *Kurzweil 3000* (i.e., highlighting, rate of speed, voice selection). These settings became the default each time a participant logged into *Kurzweil 3000* to access passages.

Dependent Measures

Reading Comprehension Measures

Reading comprehension measures entailed using CBMs from the *Edge* assessments after participants read each fiction story. The textbook was selected for the class after investigating effective curricula for struggling readers in a self-contained setting. In this study, I refer to reading comprehension questions broadly as the entire 15 multiple-choice reading comprehension questions (i.e., CBMs). When I further analyze CBMs based on questions in each component (i.e., eight vocabulary, four literary analysis, and three comprehension), the term comprehension refers to three comprehension questions in each CBM.

The CBMs were scored by grading the percentage of correctly answered questions out of 15 in total. The mean accuracy percentage of correct responses for each participant is documented in Table 8. Table 9 documents the mean performance score percentages on CBMs by component. Additionally, the SRI assessment was used to obtain a pre- and two posttest Lexile scores.

Oral Reading Fluency (ORF)

The paper-based ORF measure is a reading fluency assessment that involves students reading eighth grade passages aloud to the teacher without stopping for 1 min. Each participant reads three 1-min passages while the teacher documents the errors and number of words read correctly. After participants read three passages in one session, the teacher averages the scores to determine ORF scores for that date and time. The ORF assessment was conducted at six different times throughout the study (i.e., pre-baseline, after each condition, and after the maintenance condition). Each ORF passage contained a different topic so participants did not repeatedly read the same passage. The ORF was used to determine if participants increased their words read per min after auditory and visual exposure to text.

Typical ORF rates for eighth grade students reading in the 50th percentile is 150 words per min (Hasbrouk &Tindal, 2006). Average weekly improvement in ORF for eighth grade students is .5 words per min per week (Hasbrouck & Tindal, 2006) which over a period of one semester (i.e., 16 weeks), equals eight words per min. Thus, in one school year the average ORF growth is 16 words.

Pre-baseline ORF data for each participant was used to calculate the TTS reading rate of speed. The TTS reading rate of speed was calculated by multiplying the initial

ORF score by 25%. Research shows that students who used TTS at a reading rate of 25% faster than their ORF increased reading comprehension (Coleman, Carter, & Kildare, 2011; Young, 2013). The calculated rate was manually entered into each participant's TTS account in *Kurzweil 3000* before baseline and remained the default when using TTS.

Scholastic Reading Inventory (SRI)

The SRI is a computerized reading comprehension assessment used to obtain a reader's Lexile score. This assessment is used by school administrators as a universal screener to determine students' placement in English courses. The SRI assessment adjusts the difficulty of the questions based on the initial questions answered, and, upon completion, provides a numerical score (i.e., Lexile) ranging from 0 to 1500. The readers' scores are placed into categories which directs course placement. The SRI recommends placing students into categories to identify their reading needs. For example, a ninth grade reader with a Lexile score of 649 and below is considered to be in the *Below Basic* level or performing in the bottom 10% locally. *Below Basic* level means that students with Lexile scores in this range do not have the minimal skills to read grade-level text and are significantly below grade level (Scholastic, 2007). The *Basic* level is a category where students exhibit a Lexile range from 650 to 999 or 11% to 35% performance locally. These students exhibit minimal competency when reading grade-level text but are still reading slightly below grade level. Students with Lexile scores ranging from 1000 to 1200 or 35% to 80% locally are considered *Proficient* readers and exhibit competency reading appropriate grade-level text. *Advanced* students score above a Lexile of 1201 or above 80% locally and are considered to read above grade level (Scholastic, 2007).

A typical growth rate for eighth grade students performing in the *Below Basic and Basic* level is approximately 140 Lexile points per year or 70 points per semester (Scholastic, 2007). This approximation is based on students' growth in a full school year who were exposed to intensive reading instruction. Initially, all four participants in this study placed into the *Below Basic* and *Basic* categories or 1% to 25% performance on local norms.

Scholastic recommends taking pre- and posttest measures in fall and spring; however, additional SRI measures should be taken throughout the year for progress monitoring. In this study, I took three SRI measures in one semester, one in August, another one after the second intervention (B2) in November, and the last one after the maintenance condition in late December.

Participants' Perceptions of the Intervention

An 8-item Likert scale survey using a 1 to 5-point scale was administered to gather social validity information on the procedures and outcomes of the TTS intervention. The participants' perceptions were obtained by comparing their degree of agreement with each statement in the survey (i.e., 1=strongly disagree; 5=strongly agree). The survey items asked participants to rate their levels of satisfaction on each item when using TTS to read curriculum (see Appendix A-Social Validation Survey).

Procedures

Generalization

After participants gave their informed assent, I gathered information on participants' reading levels and reading achievement by looking at previously obtained data (i.e., Lexile score and IEPs). The SRI assessment used to obtain a current Lexile score was obtained on all freshmen in August during the first week of school. I administered the ORF test to all participants in my self-contained English class in a separate setting other than the classroom (e.g., office or computer lab). Data from the ORF tests, the Lexile scores, and IEP reading goals were recorded for each participant on a pre- and postintervention data recording form (see Appendix B-Pre-Baseline and Post-Intervention Data Recording Form).

Training

Before the baseline condition began, participants engaged in a 48-min training session on the use of TTS in the computer lab in which the study took place. I instructed participants on how to log on to the computer, access fiction reading passages, and individualize preferences (e.g., rate of speed, highlighting words or phrases, and voice selection). Participants practiced using headphones to hear the audio readings, turned pages with an example of a reading passage, and logged off when they had completed the readings. Training ended when all participants could independently log in, access passages, and use TTS features for one session at 100% accuracy. An independent observer used a Training Fidelity Checklist to verify that the researcher/trainer followed the training steps and participants met the criteria in IOA (see Appendix C-Pre-Baseline Training on Use of TTS).

Baseline Condition

The baseline condition (i.e., A1) began after the researcher obtained participants' pre-intervention data and after participants completed their training on the use of TTS. During the baseline phase, participants read the fiction stories in the computer lab on the computer without using any TTS features. Participants accessed the fiction passages on the computer monitor while using only the page-turning icon to progress when finished reading each page. No other features of TTS were used (i.e., auditory support and highlighting) when reading during A1. I did not provide explicit instruction on the reading material or on the use of TTS. Additionally, I did not provide any specific feedback to the participants when engaging in the reading or when answering the reading comprehension questions.

Participants read fiction passages on the computer without TTS for five sessions in the baseline condition. When participants were finished reading, they logged off the computer. Participants answered the reading comprehension CBMs (i.e., 15 reading questions) from the *Edge* assessments in writing (i.e., pencil and paper format) immediately following independent reading of the passages without looking back at the text. Subsequently, I administered an ORF test to measure each participant's words read correctly. I collected the baseline data for reading comprehension scores and ORF and recorded participants' performance data on a data recording form (see Appendix D-Reading Comprehension and ORF Accuracy Recording Form).

Intervention Condition

Immediately after the participants completed the baseline phase at the same time, all participants began using TTS to read fiction passages on the computer in the intervention condition (i.e., B1). Participants accessed the reading passages in the same way as in A1, but this time, enabled the TTS features to provide auditory and visual support while reading. Participants enabled the voice, highlighting, and rate of speed features previously customized from the training session. After finishing the reading passages, each participant logged off TTS and then took the written portion of the reading comprehension assessment while remaining seated at the computer. All participants did this activity for seven sessions at the same time. I did not provide any feedback to the participants when engaging in the reading or when answering the reading comprehension questions. I administered the ORF test to each participant individually in a separate setting (i.e., office) following completion of B1.

I conducted a between condition analysis of the baseline and intervention conditions. The objective of between condition analyses is to determine what effect a change in condition has on the dependent variable. At the end of A1 and B1, I obtained the absolute and relative level change to document the immediacy of effect. I calculated the absolute level change by taking the last ordinate data point of A1 and the first ordinate data point of B1, and subtracting the larger number from the smaller one. The difference was the absolute level change (Gast, 2010). To obtain the relative level change, I took the last half (median) of A1 and subtracted that from the first half (median) of B1. The result was the relative level change. This information indicates if there is experimental control between the baseline condition and the intervention condition (Gast, 2010).

Second Baseline Condition

Participants began the second baseline condition (i.e., A2) in the computer lab immediately following B1. Participants read a new fiction reading passage while seated at the computers with the text shown on the monitors, without enabling any TTS features. Upon completion of reading the passage, participants logged off the computer, and began answering the written portion of the reading comprehension assessment while remaining seated at the computers. Participants continued reading passages and answering reading questions for six sessions, one session less than in the first intervention to avoid cyclical variation. I did not provide any feedback to the participants when reading or answering the reading questions. I administered the ORF test to each participant individually after the participants completed all six sessions.

Second Intervention Condition

Immediately following A2, participants enabled the TTS features on desktop computers to read new fiction passages in the second intervention condition (i.e., B2). I did not provide any feedback to the participants when engaging in the reading or when answering the reading comprehension assessment. Upon completion of reading a passage, participants logged off TTS and took the written reading comprehension assessment. Participants continued to access and read fiction passages for seven sessions, one session more than in the second baseline condition. At the end of B2, each participant took the ORF administered by the researcher. These procedures were the same as B1.

As stated previously, I obtained the absolute level change and the relative level change between A2 and B2. This provided information about the effect of TTS on the dependent variable (i.e., reading comprehension).

Maintenance Condition

After the second intervention condition, postintervention data were obtained and the participants started the phase in which maintenance data were collected. Collecting maintenance data documented the effect of the intervention over time. Maintenance data collection included participants' accuracy on reading comprehension questions after using TTS. I used the same procedures and instructions as were included in the baseline condition. No new instructions were provided to the participants during the maintenance phase. I did not provide any feedback to the participants when engaging in the reading or when answering the reading comprehension questions. I administered four reading comprehension CBMs, once per week, during the maintenance condition. Participants remained in maintenance condition for 4 weeks following B2.

Postintervention Data

I administered a postintervention assessment, the SRI, to all the participants after they exited B2. The SRI provided a Lexile score for comparison with the initial Lexile score obtained in August 2016. The SRI was administered in the same computer lab the participants used for reading fiction passages from the *Edge* text. The pre- and postintervention Lexile scores were used to assess participants' ability to generalize reading comprehension.

In addition to obtaining a Lexile score, I administered a postintervention assessment, the ORF, to all participants. The ORF provided information on participants' words read per min for comparison with the pre-baseline ORF score. The ORF was administered in the same computer lab in which students used TTS to read passages. The ORF data were used to determine if the additional exposure to text through TTS resulted in an increase in words read per min.

Reliability

Procedural Reliability

Procedural reliability data were collected in 30% of the sessions for each participant, at least once per condition, to measure treatment fidelity. Two independent scorers used a researcher-created checklist of procedures to indicate whether the teacher-directed activities occurred or not (see Appendix E-Procedural Reliability Checklist for

Baseline, Intervention, and Maintenance Conditions). The checklist entailed activities used for the baseline, intervention, and maintenance conditions. The procedural reliability data were collected and based on the presence of the teacher-directed activities and reliability percentages were calculated using the point-by-point agreement method. Reliability percentages were based on the calculation of the observed components divided by the number of possible components and then multiplied by 100 (Gast, 2010). The resulting calculations determined the mean procedural reliability for each participant.

Interobserver Reliability

I used interobserver agreement (IOA) to protect against threats to instrumentation. I used the point-by-point agreement method to calculate IOA) data on participants' CBMs completed after each reading passage. IOA data were collected during 30% of all sessions or at least once per condition for each student, whichever was greater (Horner et al., 2005). I copied each participant's CBMs before giving them to the independent observer for grading. The independent observer and I, the researcher, each graded the CBMs independent of one another.

After the independent observer had completed her IOA task, I calculated the IOA by dividing the total number of agreements by the number of agreements plus disagreements and multiplying that number by 100 (Gast, 2010). This calculation resulted in a mean IOA percentage.

Prior to the start of the study, the teaching assistant, who served as the independent observer, was trained by me, the researcher, on how to collect IOA data. If IOA was calculated to be low (i.e., below 90%), I retrained the independent observer on accurately evaluating behaviors.

Data Analysis

The analysis of single subject research contains general guidelines when evaluating line graphed data (Gast, 2010). Researchers need to analyze the level, trend, mean, immediacy of effect, and percentage of non-overlapping data (PND) to indicate the presence of a functional relationship between the dependent variable, the reading comprehension CBMs, and the independent variable, TTS. Furthermore, researchers should address the following three comparisons when conducting visual analysis of data; within conditions, between adjacent conditions, and similar conditions (e.g., non-adjacent, A1 to A2) to further support the existence of a functional relationship. Lastly, social validity is conducted to determine if the dependent variable, reading comprehension CBMs, is socially feasible and that the independent variable, TTS, is practical and cost effective (Gast, 2010).

Level Within Conditions

Researchers analyze data by identifying the level change within conditions. When looking at the level within conditions, the absolute and relative level change indicates the direction of the data. The researcher calculates the direction of the data by taking the first data point minus the last data point, resulting in an absolute value. The direction indicates if the data is improving (i.e., therapeutic) or deteriorating (i.e., contra-therapeutic). The relative level change is calculated by splitting the data set in half and organizing the data in the first half of the set to determine the median value. Then, the second half of the data set is calculated the same way, resulting in a median of the second half. The researcher subtracts the median of the first half minus the median of the second half. This calculation presents a clear picture of the direction of the data.

Level Between Conditions

When analyzing data between adjacent conditions, the researcher determines how many variables changed to indicate a difference between the baseline (i.e., A1 and A2) and the intervention (i.e., B1 and B2). This analysis shows if experimental control was present. Similar to the level within conditions, the absolute and relative level changes are calculated. The absolute level change is calculated by taking the last data point in the first condition minus the first data point in the next condition. The larger number of the two indicates the extent of the change. Relative level changes result from taking the median of the last half of the first condition (i.e., baseline) and subtracting it from the median of the first half of the second condition (i.e., intervention). Larger numbers indicate the presence of a strong experimental control in single subject research.

Trend Within Conditions

Calculating the trend identifies the slope of the data within a condition. The quarter intersect and split middle are two ways to identify the trend within a condition. The quarter intersect is determined by identifying the median value using the numerical values for each half of the data within in the condition. Thus, two marks are identified, one for each half of the condition. Then, the researcher draws a line to connect the two intersects. This line is used to identify a trend (e.g., accelerating or increasing, decelerating or decreasing, or zero-celerating or no change). The split middle is not calculated; rather, is determined by drawing a line so that exactly half of the data points fall above and half fall below the line (Gast, 2010).

Mean

The mean score is used to identify the average reading comprehension CBMs of each participant in each condition. The researcher calculated the mean accuracy on reading comprehension CBMs by adding up the data point values (i.e., percentages on each CBM) divided by the number of data points in each condition. To identify the mean level change between adjacent conditions (e.g., A1 and B1), the researcher calculated the mean value of B1 or B2 and subtracted that score from the mean value of A1 or A2 to identify the mean level change. This answer identified if the participants increased their reading comprehension CBMs after the implementation of the intervention, TTS. Mean scores were also compared among similar conditions (e.g., A1 and A2; B1 and B2) to show a replication of effect among conditions.

Immediacy of Effect

A researcher can identify if the dependent variable, the reading comprehension CBMs, was immediately effected by the independent variable, TTS, if the data points abruptly change moving from one condition to another. The immediacy of effect is determined by using the end data point of one condition (i.e., baseline) and the first data point of another condition (i.e., intervention). The change in the two data points indicate if an immediacy of effect was present. The immediacy of effect can also document the demonstration of effect. If there are three demonstrations of effect within an A-B-A-B study, strong intra-subject replication is present (Gast, 2010).

Percentage of Non-Overlapping Data (PND)

According to Gast (2010), calculating the percentage of non-overlapping data (PND) is a way to compare participants' data between adjacent conditions. Visually analyzing graphic data has shown that overlapping data between baseline and intervention is an important step for evaluating outcomes (Scruggs & Mastropieri, 1998). To determine whether an intervention is effective, performance in the intervention condition should not overlap with previous performance percentages from the baseline condition. Furthermore, PND scores where 90% of the data do not overlap with the highest baseline point are regarded as *very effective*. PND scores of 70-90% are considered *effective* and scores of 50-70% are *questionable*. Lastly, PND scores below 50% are considered *ineffective* (Scruggs & Mastropieri, 1998). I calculated PND using the following method: (a) finding the range of values in the baseline condition, (b) adding up the number of data points in the intervention condition, (c) adding up the number of data points in the intervention condition that exist outside the range of data points in the baseline condition, (d) dividing the total number of data points in the intervention condition, and (e) multiplying this answer by 100 (Gast, 2010).

Social Validity

Participants were asked their perceptions of the procedures and outcomes of the intervention. At the end of the second intervention phase and before entering the maintenance condition, I provided an 8-item Likert scale survey to the participants in a pencil and paper format (see Appendix A-Social Validation Survey). The social validity survey used a 1-5-point scale in which 1 represented “strongly disagree” and 5 represented “strongly agree”. Participants read on their own and checked boxes independently. Surveys were created in Microsoft Word at the participants’ readability levels and administered to each participant with a pen/pencil for completion during a class session in a private area in the back of the classroom. The researcher reported data by calculating the participants' averages in each category of the survey.

CHAPTER IV

ANALYSIS OF THE DATA

This chapter presents the results of this research study which investigated the effects of text-to-speech (TTS) on reading comprehension performance of ninth-grade students with learning disabilities (LD) in a self-contained classroom. An A-B-A-B single-subject design was used to determine if there was a functional relation between the dependent variable, reading comprehension and the independent variable, TTS. The design evaluated a direct replication of effect with each participant (Gast, 2010). This chapter displays the results in the areas of interobserver and procedural reliability assessments, accuracy on CBMs, ORF (i.e., words read correctly per min), pre- and posttest Lexile scores, and social validity. The results are discussed through the presentation of mean scores, percentage of non-overlapping data (PND), trend, and level changes from the baseline conditions to the intervention conditions.

Reliability

Interobserver Reliability

Interobserver reliability data were collected during 30% of the sessions for all participants. I calculated the interobserver agreement (IOA) on the dependent measure, reading comprehension, from the *Edge* textbook. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. IOA was collected on nine sessions (i.e., two in each baseline and intervention condition and one in the maintenance condition) for Jack, Dianna, and Donald and seven for Vincent due to his exiting early from the study half way through the second intervention condition. Only three participants completed the study in its entirety, including the maintenance condition. The IOAs were on the CBMs from the *Edge* textbook. Vincent's IOA was 99% on his CBMs with a range of 96-100%. Jack, Dianna, and Donald's IOA scores were 100% on all CBMs. Each participant's IOA is displayed in Table 6.

Table 6

Interobserver Agreement Data

Participant	Range	Mean of CBMs
Vincent	96-100%	99%
Jack	100%	100%
Dianna	100%	100%
Donald	100%	100%

The observer ensured that the passages were easily accessible on the computer via TTS in *Kurzweil 3000*. Additionally, the observer made sure the participants had simultaneous auditory and visual reading of the passages. Finally, the observer verified that the headphones and volume were working on each computer.

Procedural Reliability

Procedural reliability data were collected during 30% of the sessions for all students. Within the A-B-A-B design, procedural reliability data were collected twice in each session and once in the maintenance condition, to total nine sessions, for Jack, Dianna, and Donald. Procedural reliability assessment on Vincent was completed during seven sessions as he did not participate in the maintenance phase and left partway through the second intervention, B2. The procedural reliability data indicated 96% for Vincent and Jack, 98% for Dianna, and 97% for Donald. The calculation method for determining procedural reliability was the number of observed behaviors divided the number of expected behaviors multiplied by 100. When the observers collected data on the procedural reliability of each task on all four students, the mean total equaled 97%. Additionally, there were some glitches in the technology that delayed participants' ability to proceed with reading passages using TTS. There was an instance where Jack's computer would not turn on after several attempts and he had to switch to a new computer. Additionally, one of Vincent's sessions was disrupted when his monitor stopped working after a student stepped on the power cord while he was reading a passage. Once Vincent resumed reading using TTS, he completed the CBM in the allotted time. Table 8 displays the procedural reliability results for all four participants.

Table 7

Procedural Fidelity Data

Participant	Sessions	Range	Mean Procedural Fidelity
Vincent	7	86-100%	96%
Jack	9	86-100%	96%
Dianna	9	90-100%	98%
Donald	9	86-100%	97%

Reading Comprehension Performance

After the participants read passages from the classroom text on the computers with or without TTS, they were assessed using written CBMs that contained vocabulary, literary analysis, and comprehension questions. Responses to questions were assessed by using the *Edge* curriculum's answer key which indicated correct answers on the CBMs. The overall percentage of correct reading comprehension questions was obtained by adding the number of correct answers divided by 15 (i.e., the total number of reading comprehension questions per CBMs) then multiplying by 100 to yield a percentage. This section answers the research question does TTS increase the reading comprehension of freshman students with LD as measured by CBMs from the classroom text in a self-contained classroom? Figure 1 and 2 graphically display participants' reading comprehension performance results in baseline and intervention conditions and in the maintenance condition. Absolute and relative level change, mean, immediacy of effect, and PND are discussed for each participant. Each CBM contained three components (i.e., vocabulary, literary analysis, and comprehension) related to the passage. I further analyzed each participants' reading performance by component. This analysis would identify if a functional relationship and replication of effect existed among the components. Participants' results on each component with and without TTS may add documentation on the effect of TTS on specific areas in reading.

Participants' Performance on CBMs

Research question 1: Does TTS increase the reading comprehension of freshman students with LD as measured by CBMs from the classroom text in a self-contained classroom?

Vincent. Figure 1 displays Vincent's accuracy on the CBMs across the baseline conditions (i.e., A1 and A2) and the intervention conditions (i.e., B1 and B2). There are no data for Vincent in the maintenance condition due to his exiting from the study in the middle of B2. Vincent's performance during A1 exhibited data at a low level of accuracy with scores ranging from 53% to 73% and 80% of data falling within the stability envelope. Vincent's data moving from A1 to B1 did not show an immediacy of effect; however, once in B1, there was an abrupt increase. Data within B1 ranged from 53% to 100% with the second half showing data moving in a therapeutic direction. PND between adjacent conditions (i.e., A1 and B1) was 43%. Between conditions analysis for Vincent in A1 and B1 revealed no change and a relative level change of 6% (i.e., 67% to 73%). Showing intrasubject replication, Vincent's three data points in A2 moved in a decelerating trend as shown in A1. Once Vincent moved from A2 to B2 there was an abrupt increase replicating the effect from A1 to B1. The PND of adjacent conditions for A2 and B2 was 67%. Additionally, visual analysis between A2 and B2 conditions showed an absolute level of 13% and a relative level of 11% (i.e., 60% to 71%). Overall, Vincent's data showed three demonstrations of effect from A1 to B1, B1 to A2, and from A2 to B2; however, these demonstrations were not as significant as shown in other participants' data.

Further analysis yielded Vincent's variable mean scores in components across similar conditions (i.e., A1 to A2 and B1 to B2). Review of vocabulary scores between A1 to B1 (i.e., 83% to 91%) and A2 to B2 (i.e., 65% to 96%) in Table 9 showed an 8% and 31% increase respectively. However, comparison of vocabulary mean scores in similar conditions (i.e., B1 to B2) showed a slight increase from 91% to 96%. Vincent's scores on vocabulary when in the intervention conditions showed increases over the baseline conditions, further supporting that TTS affected outcomes.

Additionally, Vincent's mean performances in the literary analysis component when answering questions on the CBMs indicated gains as well. When comparing mean scores for both sets of adjacent conditions (i.e., A1 to B1; A2 to B2), there was a 15% increase in mean scores. When comparing Vincent's results among similar conditions, there was an 18% decrease in both mean performances from A1 to A2 (i.e., 45% to 27%) and from B1 to B2 (i.e., 60% to 42%).

Minimal gains were made when comparing mean comprehension component results among adjacent conditions for Vincent. Vincent's mean performance scores in A1 and A2 (i.e., 47% and 44%) and B1 to B2 (i.e., 52% to 44%) both show decreases in the comprehension component. While there was a slight increase in mean comprehension component data from A1 to B1 (i.e., 5%), there was no increase from A2 to B2.

Jack. Jack's accuracy on CBMs during A1 were very low with 60% of data falling within the stability envelope. His performance in A1 indicated a stable trend in a contratherapeutic direction with his scores ranging from 33% to 46%. An immediacy of effect occurred when Jack moved from A1 to B1 with an absolute level change of 47% (i.e., 33% to 80%) and a relative change of 27% (i.e., 33% to 60%), showing significant reading gains with TTS. Once in B1, Jack's accuracy in reading comprehension scores ranged from 53% to 80% with data moving in an accelerating and therapeutic direction when using TTS. Jack's data moving from A2 to B2 indicated a change of 20% (i.e., 40% to 60%) and 100% PND. Jack's trend in data moved in an accelerating and therapeutic direction in B2. Similar reading comprehension CBM scores and PND were repeated in A2 and B2, documenting intrasubject replication. Jack's data displayed three demonstrations of effect from A1 to B1, B1 to A2, and A2 to B2.

Further descriptive analysis showed Jack scored highest in the vocabulary component in all conditions. As shown in Table 9, Jack increased his mean vocabulary scores when using TTS by 20% and 36% from A1 to B1 and A2 to B2 respectively. Jack's mean vocabulary scores for B1 to B2 were 75% to 85% respectively and 94% in maintenance documenting significant gains with TTS.

Jack continued to increase mean performance scores when answering literary analysis questions on the CBMs. Although Jack's increases were not as great as in the vocabulary component, data showed 6% increase in B1 and 14% increase in B2 when using TTS. Additional analysis among similar conditions (i.e., B1 to B2) indicated a slight decrease (7%). However, in maintenance, Jack increased his mean performance to 50%, the highest mean performance compared to previous intervention scores.

Jack continued to show increases in mean performance scores in the comprehension component as shown in Table 9. Jack's mean comprehension performance remained low in A1 to A2 (i.e., 27% to 28%) but abruptly increased when using TTS. Jack's data in comprehension showed 30% increase when comparing A1 to B1 mean scores and 15% increase between A2 to B2 mean scores. Between condition analysis revealed that Jack increased his reading comprehension CBM performance in all components from A1 to B1 and A2 to B2 with 100% PND exhibiting intrasubject replication of effect. Jack's maintenance data on mean reading comprehension CBMs displayed consistent high scores indicating that Jack maintained reading skills when using TTS. High maintenance scores further documented a functional relation between TTS and reading outcomes.

Dianna. During A1, Dianna's data was consistently low with sores ranging from 53% to 66% and 100% of data falling within the stability envelope. When Dianna moved from A1 to B1 with TTS, there was a significant increase showing immediate effects with an absolute level change of 34% (i.e., 53% to 87%), a relative change of 27% (i.e., 60% to 87%). While in B1, Dianna's accuracy on reading comprehension CBMs ranged from 73% to 93% indicating an accelerating trend with 100% PND. After moving from B1 to A2, Dianna's data abruptly decreased from 80% to 53% (i.e., -27%). While in A2, Dianna's mean scores were the same as in A1 (i.e., 63%), displaying repeated lower levels. Similarly, data movement from A2 to B2 indicated an abrupt increase with an absolute and relative level change of 20% (i.e., 60% to 80%) and 71% PND documenting that TTS showed increased outcomes. Even though Dianna's B2 data was higher than in A2, data moved in a decelerating trend direction. Furthermore, B1 and B2 results exhibited similar trends and levels showing intrasubject replication. Overall, Dianna's data showed the presence of a functional relation between TTS and reading comprehension. Overall, Dianna showed three demonstrations of effect between all three conditions.

After reviewing Dianna's performance in each component (i.e., vocabulary, literary analysis, and comprehension), she performed highest on vocabulary in B1 and B2 (i.e., 98%; 88%) as shown in Table 9. Dianna performed the same (i.e., 98%) on vocabulary in B1 as in maintenance indicating TTS had an effect on vocabulary outcomes.

Furthermore, Dianna's mean accuracy on the literary analysis component showed mixed results among the baseline, intervention, and maintenance conditions. Dianna's data showed a decelerating trend (mean -4%) from A1 to B1 but mean scores remained constant from B1 to B2 (i.e., 61%). In maintenance, Dianna did not show an increase in the literary analysis component making it unclear if the TTS had an overall effect.

Additionally, of all the participants, Dianna performed the highest in the comprehension component for both B1 and B2 (i.e., 71%) displaying abrupt increases from A1 and A2 (i.e., 38% and 32%). This same trend in similar conditions reveals TTS effectively increased comprehension outcomes.

While in the 4-week maintenance condition, Dianna consistently maintained high reading scores with a mean score of 77%. Her maintenance performance data documents the ability of TTS to improve reading comprehension.

Donald. Donald's performance on reading comprehension CBMs during A1 exhibited scores ranging from 33% to 53% with decelerating data moving in a contratherapeutic direction. An abrupt increase (i.e., 20%) occurred when Donald moved from A1 to B1 with a relative level change of 26% (i.e., 47% to 73%). In B1, Donald's accuracy ranged from 60% to 80% with data moving in a therapeutic and accelerating direction. PND was 100% documenting TTS effectively increased outcomes. Donald showed an abrupt increase of 26% and a relative level change of 20% in A2 and B2 repeating the same effects as in A1 and B1. PND between A2 and B2 was 86%. Donald's data showed intrasubject replication and three demonstrations of effect proving that TTS was effective in increasing reading outcomes.

Further analysis of each component showed that Donald scored the highest on the vocabulary component. Donald's scores ranged from 55% and 54% in baseline, 82% and 75% in intervention and 88% in maintenance. Data when using TTS was significantly higher than data without TTS.

Donald's scores in the literary analysis component showed gains when using TTS. Comparisons among A1 and A2 and B1 and B2 indicated similar mean performances (i.e., 35% and 29%; 57% and 50% respectively). Literary analysis in the maintenance condition was highest with 67% mean performance, indicating TTS was effective in increasing outcomes.

The comprehension component data on the CBMs for Donald reveal low levels in A1 and A2 (i.e., 27% and 28%) and increases when using TTS in B1 and B2 (i.e., 67% and 52%). In maintenance, Donald's data in the comprehension component decreased but remained above baseline levels, further supporting that TTS effectively increased reading outcomes.

After participating in maintenance for 4 weeks, Donald's mean score on the 15 question multiple-choice reading comprehension CBMs in maintenance (i.e., 68%) was slightly higher compared to B2 (i.e., 64%). However, compared to A1 and A2, Donald consistently increased and maintained his reading when using TTS. Donald's overall performance on his CBMs was maintained, further supporting the existence of a functional relation between TTS and reading outcomes.

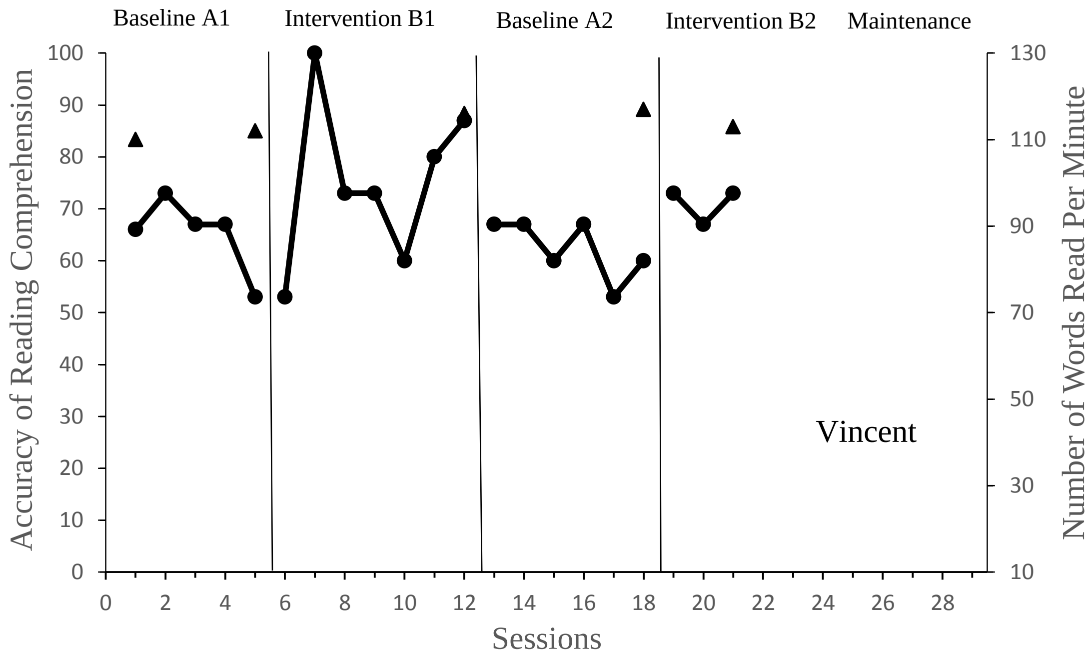

Figure 1. Vincent's Reading Comprehension (●) and ORF (▲) data.

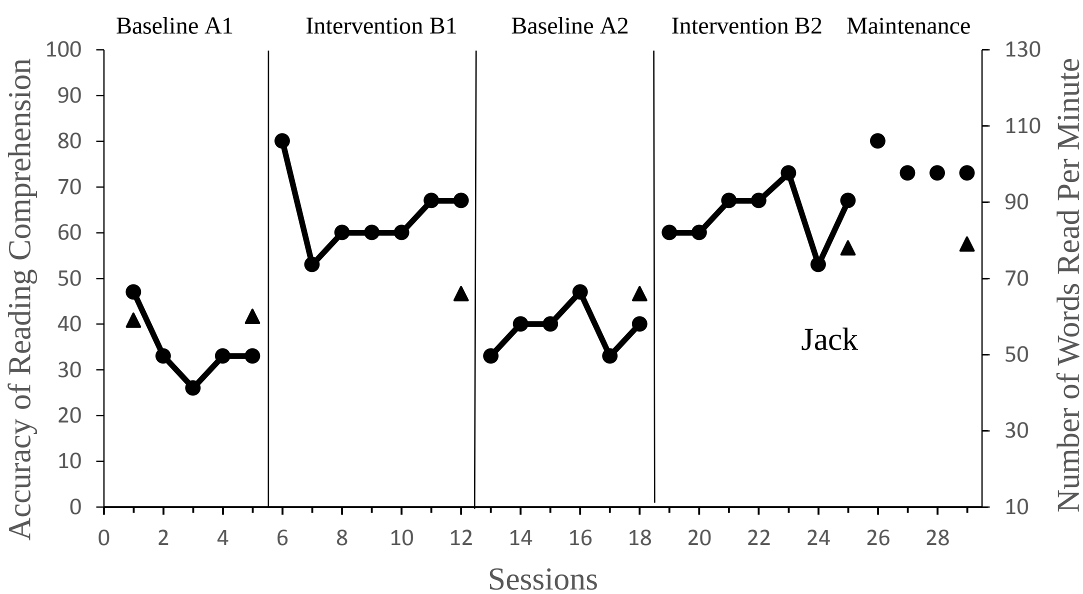

Figure 2. Jack's Reading Comprehension (●) and ORF (▲) data.

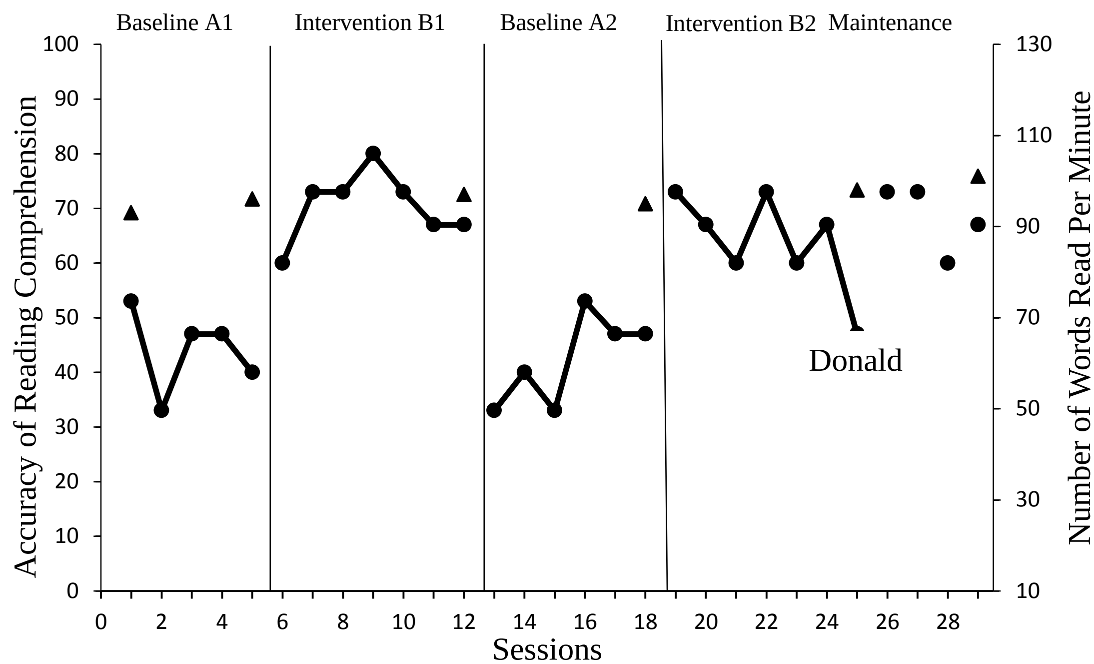

Figure 3. Donald's Reading Comprehension (●) and ORF (▲) data.

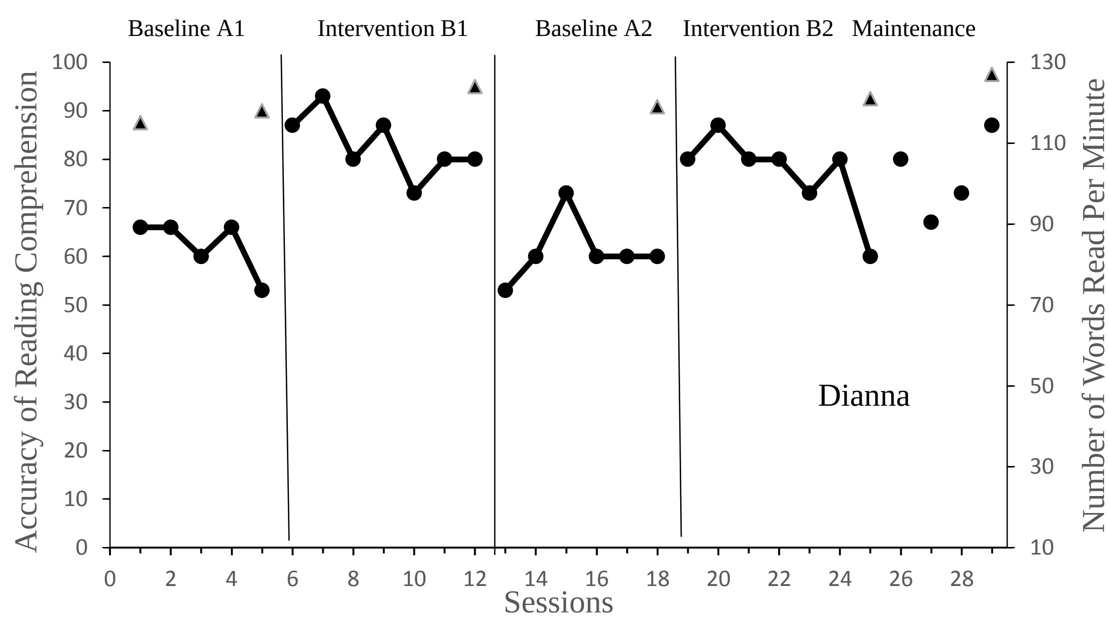

Figure 4. Dianna's Reading Comprehension (●) and ORF (▲) data.

Table 8

Accuracy Percentages on Reading Comprehension CBMs

Participant		Baseline A1	Intervention B1	Baseline A2	Intervention B2	Maintenance
Vincent	*M*	65%	76%	62%	71%	
	MD	67%	73%	64%	73%	
	R	53-73%	53-100%	53-67%	67-73%	
Jack	*M*	34%	64%	39%	64%	75%
	MD	33%	60%	40%	67%	73%
	R	26-47%	53-80%	33-47%	53-73%	73-80%
Dianna	*M*	63%	83%	63%	77%	77%
	MD	67%	80%	60%	80%	77%
	R	53-67%	73-93%	60-73%	60-87%	67-87%
Donald	*M*	44%	70%	42%	64%	68%
	MD	47%	73%	43%	67%	70%
	R	33-53%	60-80%	33-53%	47-73%	60-73%

Note. *M*= mean; *MD*= median; *R*= range

Table 9

Mean Performance Score Percentages on CBMs by Component

Participants and Component	Baseline *M*=	Intervention *M*=	Baseline *M*=	Intervention *M*=	Maintenance *M*=
Vincent					
Vocabulary	83%	91%	65%	96%	
Literary Analysis	45%	60%	27%	42%	
Comprehension	47%	52%	44%	44%	
Jack					
Vocabulary	55%	75%	50%	86%	94%
Literary Analysis	40%	46%	25%	39%	50%
Comprehension	27%	57%	28%	43%	58%
Dianna					
Vocabulary	72%	98%	79%	88%	98%
Literary Analysis	65%	61%	42%	61%	44%
Comprehension	33%	71%	39%	71%	67%
Donald					
Vocabulary	55%	82%	54%	75%	88%
Literary Analysis	35%	57%	29%	50%	67%
Comprehension	27%	67%	28%	52%	42%

Note. M= Mean percentage score on components within CBMs

Oral Reading Fluency

Participants' ORF performance is shown by closed triangle data points in Figures 1 and 2. Participants were assessed on their ORF at the end of each condition to determine if the intervention affected their fluency. Throughout this study, participants took the ORF test six times (i.e., pre-baseline A1, after baseline conditions, after intervention conditions, and after the maintenance condition). Overall, the participants' ORF scores indicated a mean increase from pre- to posttest scores. Table 10 displays participants' ORF scores at the end of each condition.

Participants' Performance on ORF

Research question 2: Does ORF increase after participants use TTS?

Vincent. Vincent's ORF performance indicates improvement in his words read per min after five sessions. From pre-baseline, Vincent's highest ORF increase was seven words per min at the end of A2 and only three words per min at the end of B2. Vincent's overall increase in ORF of three words per min indicate below average ORF growth rate for his age. Due to Vincent's early exit from this study, there is no ORF score after the maintenance condition. Figure 1 shows five ORF performance scores for Vincent.

Jack. After taking the ORF test six times, Jack displayed the greatest gains in words read per min (i.e., 20). Jack's pre-baseline ORF was the lowest of all the participants (i.e., 59). Jack's ORF scores showed increases of two to three words per min across all conditions except for the last intervention score increasing 12 words per min, the highest increase in one condition of all three participants. Overall, Jack showed a 20 words per min ORF growth rate in 16 weeks. As stated previously, average ORF rate of growth is eight words per min in 16 weeks. Jack increased his ORF 20 words per min in 16 weeks, more than doubling the average growth rate of similar aged peers. Additionally, Jack maintained his ORF performance in the postintervention maintenance condition. Jack's significant increase in his ORF words per min indicate that TTS may have assisted in his ability to read more efficiently.

Dianna. Dianna improved her ORF scores by a total of 12 words read per min from pre-baseline to postintervention which is more than the average rate of growth for same age peers. Showing steady increases in four of six ORF assessments, Dianna repeatedly increased her ORF in B1 and B2, documenting that the intervention may have caused an increase in ORF. Comparing Dianna's pre-baseline ORF score to her score in B2, Dianna increased nine words per min. However, comparing her B1 ORF score (i.e., 124) to her B2 ORF score (i.e., 121), Dianna decreased her ORF performance (i.e., -3). Although some variability exists, Dianna's overall ORF increase shows support for the claim that TTS improves reading efficiency.

Donald. Donald's ORF data showed steady gains over six sessions. Additionally, Donald's three highest ORF scores were at the end of the intervention conditions and at post-intervention (i.e., 97, 98, 101). Donald's ORF increased a total of eight words per min, an average ORF growth rate compared to same age peers.

Table 10

ORF Scores in Pre-Baseline, Each Condition, and Postintervention

	Pre-Baseline	Baseline A1	Intervention B1	Baseline A2	Intervention B2	Post-Intervention
Vincent	110	112	116	117	113	
Jack	59	60	66	66	78	79
Dianna	115	118	124	119	121	127
Donald	93	96	97	95	98	101

Pre-/Postintervention Reading Achievement Data

Before the baseline condition began, all participants were assessed on their reading achievement using the SRI assessment. The SRI yields a Lexile score ranging in value from 0 to 1500. This value equates to a national reading percentile. The time that lapsed from the first Lexile test (i.e., pre-test) to the final posttest was approximately 16 weeks. Participants took a pre-test in late August 2016 and two posttest scores were taken: one at the end of the second intervention and one at the end of maintenance (i.e., 4 weeks after the second intervention condition). Three participants in this study exhibited scores that fell in the below-average range and one participant's score fell in the beginning reader/intensive range. Participants' scores for pre- and posttests are presented in Figure 3.

Participants' Reading Achievement Data

Research question 4: To what extent are participants able to generalize reading comprehension on universal screening assessments (e.g., Lexile)?

Vincent. Vincent's initial pretest Lexile score was 864 or 23% national percentile. When Vincent exited the study in the middle of the second intervention condition, Vincent scored lower than his initial baseline, an 810 Lexile, or 17% national percentile. No Lexile score for Vincent was obtained after maintenance.

Jack. In August 2016, Jack's initial Lexile score of 186 placed him in the beginning reader range or 1% national percentile. At the end of the second intervention, Jack's score increased 34 Lexile points, to 221, or 2% national percentile. A third Lexile score was obtained (i.e., 245) after maintenance, keeping Jack in the 2% national percentile. Jack's overall increase was 59 Lexile points from pre-baseline to post-intervention.

Dianna. Pretest Lexile data for Dianna showed a 772 or 17% national percentile. At the end of the second intervention, Dianna increased her Lexile score by 107 points to 879, increasing her national percentile from 8% to 25%. At the end of maintenance, Dianna scored a 902 or 29% national percentile, a 130 Lexile score increase, the highest gain of all participants.

Donald. Donald's pretest Lexile score was an 872 or 24% national percentile. At the end of the second intervention, Donald scored an 887 or 26% national percentile, a 15-point increase from his pretest score. However, Donald's posttest Lexile score after maintenance was an 832, a 55-point decrease from his second intervention score and a 40-point decrease from his pretest score.

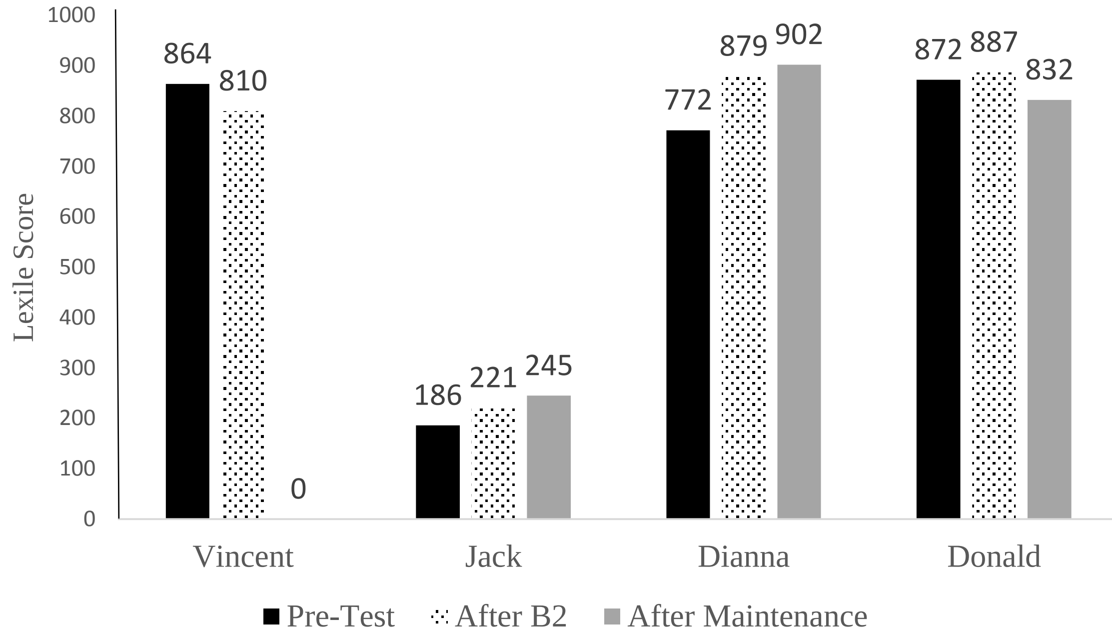

Figure 5. Reading Comprehension Scores on Universal Screeners (i.e., Lexile).

Social Validity Results

Three of four participants in this study completed the eight-item Likert-scale social validation survey with selections ranging from 1=strongly disagree to 5-strongly agree. Participants completed the surveys anonymously at the end of the study. The classroom teaching assistant administered and collected the surveys in the instructional classroom.

Participants' Perceptions of TTS

Research question 5: How is the use of TTS perceived by the participants when acquiring information from classroom text after increased intensity of TTS?

Results averages for each statement indicate that two of three participants had positive views regarding the use of TTS when acquiring information from the computer.

While some participants felt stronger than others, they all felt that TTS was easy to use. Participants' highest level of satisfaction on the survey related to their enjoyment of the visual and auditory support TTS provided. Two participants did not feel one way or the other about using TTS for enjoyment in the future whereas one felt s/he would use TTS for fun.

With regards to participant views on the procedures, all three participants said they enjoyed using the visual and auditory support of TTS ($M = 4.0$) on a scale of one to five. Additionally, the questions regarding the use of the highlighting and voice selection features were rated close to neutral ($M = 2.7$, 3.0, respectively). All three participants stated they liked the rate of speed feature in TTS ($M = 3.7$). The results from the social validity surveys made it difficult to tell which participants felt TTS provided the amount of support needed to improve their reading comprehension.

With regards to the participant outcomes**,** all three participants agreed that they remembered more information after using TTS ($M = 3.7$). However, three participants indicated they were less likely to use TTS in the future for class assignments ($M = 2.7$) because they felt it was difficult to access the lab on their own. Lastly, one of three participants agreed that s/he would use TTS in the future for fun when reading ($M = 2.7$). Table 11 includes the mean responses in each category as stated by the participants.

Table 11

Mean Social Validity Scores for Each Statement

Social Validity Statements	Mean Score (out of possible 5)
TTS was easy to use	3.7
I enjoyed the synchronous visual and auditory support of TTS	4.0
I liked following the words with the highlighting feature in TTS	2.7
I liked using the rate of speed feature in TTS	3.7
I liked listening to my voice selection in TTS	3.0
I remembered more information after using TTS	3.7
I will use TTS in the future for class assignments	2.7
I will use TTS in the future for fun	2.7

Summary

This chapter contained a report of the results of the dependent measure of reading comprehension with and without TTS. Visual analysis of the data indicated a functional relation between the use of the intervention, TTS, and the dependent measure, reading comprehension for the participants. The dependent measure remained high throughout the intervention conditions and during the 4-week maintenance condition. Universal screener reading achievement (i.e., Lexile) increased for two out of four participants after using TTS for one semester. Finally, results of the social validation survey demonstrate participants' satisfaction with using TTS to comprehend reading material

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains a discussion of the pertinent findings from the current study. The purpose of this study was to investigate the effectiveness of TTS on the reading comprehension of freshman students with LD. An A-B-A-B withdrawal design was used to evaluate if the intervention, TTS, affected the dependent measure, reading comprehension. CBMs were used to assess reading comprehension after participants accessed fiction passages via the computer with and without TTS. Results showed that there was a functional relation between TTS and reading comprehension performance for all participants. Additionally, experimental control was exhibited with each student acting as her/his own control. Furthermore, ORF was assessed to evaluate if exposure to the TTS affected the participants' fluency. The ORF outcomes indicate that all participants increased the number of words read correctly. Lexile scores on the district's universal screener, the SRI, indicate two out of four participants increased scores after continued exposure to TTS. The effects of the TTS were maintained by three participants after the conclusion of the intervention. Finally, the social validation survey results document participants' satisfaction with the use of TTS when reading classroom literature.

The results from this study are similar to previous studies conducted by Stetter and Hughes (2011) and Stodden et al. (2012) on the use of technology when reading for secondary students with LD with increases in comprehension, vocabulary, and reading fluency. This chapter proceeds with a discussion of the major findings, limitations, suggestions for future research and implications on the use of TTS when used as a reading intervention.

Major Findings

The major findings in this study are discussed in relation to the research questions.

Reading Comprehension Performance with Text-to-Speech

The first research question investigated if TTS increased the reading comprehension of students with LD as measured by CBMs from the classroom text. Reading comprehension gains were determined by assessing the participants' accuracy on the CBMs after reading passages on the computer with or without TTS. The participants' positive results are similar to previous findings by Stetter and Hughes (2011) and Stodden et al. (2012) with findings showing an increase in reading comprehension after exposure to TTS. The current findings provide additional information on the use of TTS when reading. The participants in this study had increased intensity of TTS (i.e., two to three times per week) for a longer time period (i.e., one semester), fluency data points collected at the end of each condition, and pre-/postintervention reading achievement data collected. These additions resulted in more data points to be examined over a longer time period. All participants' reading comprehension increased with the use of TTS indicating a functional relation between the intervention and the dependent variable.

All participants increased their reading comprehension during the study's intervention conditions; however, some displayed higher gains than others. Dianna's vocabulary and comprehension component data showed much higher gains compared to the other participants when reviewing her performance in the intervention conditions. Dianna could have made significant growth in vocabulary with TTS because she was already higher in her ORF and Lexile scores from pre-baseline. Dianna's higher initial scores compared to the other participants may have given her an advantage in her performance when using TTS. With Dianna's primary characteristic of specific LD and a secondary characteristic of ADHD, TTS could have provided the support she needed to remain on task when reading passages. Dianna's ADHD as a secondary characteristic required the auditory and visual support embedded in TTS to remain on task. Dianna's results can lead to an assumption that participants with a specific LD and ADHD will improve their reading comprehension when using TTS.

Of all of the participants, Jack showed the most significant gains on his reading comprehension CBMs. Jack began the study with very low reading comprehension CBMs in both baseline conditions and had the lowest initial ORF and Lexile scores. With TTS, Jack showed significant and immediate gains on his reading comprehension CBMs that were maintained over time. Additionally, Jack's secondary label of AU indicated a need for learning curriculum through multi-modal support (e.g., visual and auditory). With Jack having the lowest baseline reading abilities of all of the participants and his results showing the greatest gains, it can be assumed that TTS benefits the lowest readers the most. Previous research shows that the lowest readers benefitted the most in comprehension from TTS (Moorman et al., 2010).

Another participant, Vincent, did not exhibit the same reading comprehension gains as Dianna or Jack. Vincent began the study in baseline with higher scores on his reading comprehension CBMs and Lexile compared to the other participants in this study. While Vincent showed some gains on reading comprehension CBMs when using TTS, he also had the most overlapping data making it difficult to conclude that TTS solely effected his reading outcomes. Without a secondary characteristic of ADHD or AU and with a higher initial Lexile achievement score, TTS may not have been as effective for Vincent as it was for Dianna and Jack who began the study with low CBMs Vincent started the study with higher scores on CBMs concluding that participants who begin with higher baseline scores do not make as much gains using TTS.

Lastly, Donald's data showed gains on his reading comprehension CBMs with TTS. Donald began both baseline conditions with low scores on the reading comprehension CBMs. Donald's consistently higher scores on reading comprehension CBMs and in maintenance showed TTS effectively increased reading outcomes for the participants who began the study with low scores. Initially, Donald scored the highest on his Lexile data of all of the participants yet over time, his Lexile decreased which may be due to some factors. TTS contains the bimodal input of auditory and visual support embedded in the software. The SRI assessment used to provide the Lexile score did not have the auditory and visual support to assist with learning the material. The lack of features could have effected Donald's results on the Lexile scores over time.

Oral Reading Fluency after Text-to-Speech

The second research question investigated if participants' ORF increased after using TTS. ORF was evaluated using eighth grade reading assessments six times during the study: once in pre-baseline, at the end of each of the four conditions, and at postintervention at the end of the maintenance condition. All participants made gains in their ORF from their initial score to their final score in the maintenance condition.

This study contributes to the existing research in that ORF was assessed at the end of each condition. Two studies that used ORF as a measure after participants accessed information on the computer (Coleman, Carter, & Kildare, 2011; Fitzgerald et al., 2012) found that participants' reading comprehension and ORF increased. This study's results revealed similar findings after continued exposure to the TTS over time.

In the pre-baseline condition, participants' ORF scores were below average. This initial ORF score was used to calculate the rate of speed in the TTS software and was used as the default for future reading passages. Research shows that when TTS is individualized at a rate faster than readers' initial ORF (i.e., increased by 25%), students with LD read more words in less time (Coleman et al., 2011; Young, 2013), minimizing the cognitive task of decoding and leaving more energy for comprehending material (Elkind et al., 1996). Replicating previous research, the participants' ORF continued to grow throughout the study. The second ORF score indicated participants' ORF scores increased one to three words per min. However, at the end of the intervention condition, two participants increased their ORF more significantly (i.e., six words per min) whereas one participant increased his ORF one word per min. At the end of the second intervention, three participants increased ORF scores and the participant with the lowest score showed the highest gains. In particular, Dianna and Jack increased their ORF scores more than the average rate of growth (i.e., eight words per min) in 16 weeks. Jack more than doubled the average ORF rate with 20 words per min and Dianna surpassed the average rate of ORF growth by four words per min, totally 12 words per min. With TTS set at a faster rate, participants showed significant increases in their ORF read which, over time, can greatly increase the amount of material learned in less time. If more material is acquired by students with LD during the school day with technology, they will learn more content which will improve overall academic success.

Maintaining Reading Comprehension Performance

The third research question investigated the extent to which participants maintained their reading comprehension performance as measured by CBMs. Most of the studies in the literature review on which this study was based did not provide maintenance data (Hall et al., 2015; Retter et al., 2013; Stodden et al., 2012). However, some research regarding using technology as a reading intervention used maintenance to assess reading comprehension (Fitzgerald et al., 2012; Kennedy et al., 2015; Stetter & Hughes, 2011). Stetter and Hughes found that participants increased in reading comprehension on maintenance probes begun two weeks after exiting the study. In another study, Kennedy et al. (2015) found participants significantly increased accuracy on reading comprehension at three probes in a maintenance phase following the intervention condition. The uniqueness of the current study is that it included four data points, each taken once weekly showing higher mean performance scores on CBMs than in previous intervention conditions.

While the current maintenance data revealed positive results, there remains a need to continue to investigate if TTS improves reading comprehension. My results showed that all participants with LD who accessed TTS consistently over time (i.e., three times per week) increased reading outcomes. Results were more pronounced for the participants, Dianna and Jack, who had secondary labels of ADHD and AU respectively, proving that TTS may have assisted in increasing time on task and engagement. Although not directly measured, student engagement may increase when students use

TTS. Secondary practitioners should include technology that uses bimodal support (i.e., auditory and visual) when delivering curriculum to struggling readers to see the effects on student engagement. My study is similar to previous research which revealed that participants felt TTS helped them read longer and be more engaged (Meyer & Bouck, 2014). As shown with Dianna and Jack, if students use TTS to increase reading comprehension, they may learn better and more efficiently. Struggling readers experiencing success in the classroom when using technology to read, may increase learning on their own. Furthermore, if practitioners make TTS available on all school and personal devices for students to freely use in school, overall use of technology will increase. It can be assumed that the more students with LD use technology to read, their reading outcomes will increase, greatly affecting their opportunities for postsecondary and career success.

Generalization of Reading Comprehension Performance

The fourth research question investigated the extent to which participants generalized reading comprehension on universal screening assessments (i.e., Lexile). The SRI assessment was the universal screener administered to all participants at three different times; in the pre-baseline condition, after the intervention condition, and after the maintenance condition. The SRI is a multiple-choice computerized reading comprehension assessment that lasts approximately 30 min.

Participants showed some variability in their Lexile scores during the study. Dianna and Jack increased their Lexile scores from pre- to posttest scores by 130 and 59 points respectively. According to the Lexile growth standards, raising Lexile scores an average of 70 points in one semester is considered average growth (Scholastic, 2007).

Dianna more than doubled her average Lexile growth in one semester with the use of TTS and Jack exhibited average Lexile growth. It can be assumed that students who use TTS to acquire information will generalize their increased reading skills on other assessments, resulting in increased outcomes. These increases in reading may be a result of consistent exposure to TTS and the incidental effect of reading more words in less time, increasing overall achievement. Additionally, Dianna and Jack each had secondary characteristics of ADHD and AU, perhaps concluding that participants with these secondary characteristics may achieve greater increases in achievement on reading. Dianna and Jack's results on reading comprehension CBMs is similar to the increases in Lexile, documenting that TTS assisted in overall growth in reading achievement data. With these results, it can be assumed that TTS not only increases reading comprehension on CBMs but may raise achievement data for those learners who have secondary characteristics of ADHD and AU.

The other two participants Vincent and Donald had specific LD as their primary characteristic and no other secondary characteristic and did not show similar gains to Dianna and Jack. Donald and Vincent did not increase their Lexile scores from pre- to posttest, raising questions regarding if TTS effectively increases performance on achievement data for students with LD. Additionally, Vincent and Donald began the study with the two highest Lexile scores (i.e., 864 and 872 respectively). Beginning the study with higher Lexile scores may indicate that TTS is not as effective for these students because they are not the lowest readers and may not require the support of TTS. The readers with the lowest Lexile scores, Jack and Dianna (i.e., 186 and 772), showed the greatest growth with TTS. Not only did Jack and Dianna exhibit secondary characteristics that as learners, may have benefitted more from the TTS, but their low data initially gave them more to gain from the bimodal support of the TTS. Future research should assess the effects of TTS on achievement when using participants with secondary characteristics such as ADHD/AU or with very low achievement scores to investigate for whom TTS is most effective.

Limitations

This study focused on the effectiveness of TTS on reading comprehension for freshman students with LD. The participants' results revealed that there was a functional relation between the intervention, TTS, and the outcome, reading comprehension. Even with positive results, limitations were identified. Discussing the current study's limitations can provide practitioners with insight when conducting future research using technology as a reading intervention.

One limitation resulted from the participants' motivation and attitudes regarding reading. The participants had little interest in reading when the study began. After showing gains with TTS, answers to the social validation questionnaire indicated that participants would not likely use TTS for enjoyment or future assignments. Participants expressed difficulty in accessing TTS because it was limited to computer labs which teachers must reserve in advance. The reliance on teachers to implement TTS limits the potential for participants to use TTS on their own. With the participants not interested in reading on their own and the difficulty it takes to use TTS, the potential of documenting the effects of technology when used over time poses challenges. Thus, it is important to provide feasible access to TTS through software available on participants' own school devices (e.g., Read and Write on Chromebooks) to have participants use TTS consistently.

The use of TTS had some technological limitations. There were some issues with the computers not working properly and consistently in all sessions. The computer malfunctions delayed participants' timely completion of the written CBMs during the 48-min class period. Additionally, participants lost some instructional time when unable to log in quickly which could have affected reading comprehension outcomes.

Another limitation was that the participants had difficulty maintaining their focus on reading for the entire 48 min period. Two participants each had secondary labels. One participant had a secondary label of ADHD and another participant had a secondary label of Autism. These students needed continual prompts to stay on task. Furthermore, the fiction passages varied in topic and could have appealed to some participants more than others which could have caused fluctuating scores. The participants already struggle in reading and if a topic is boring, they may exhibit limited interest compared to reading interesting passages. I controlled for this by preselecting a variety of reading topics and maintaining appropriate, on task behavior when participants were actively reading in the lab. Additional information should be obtained on the results of readers with LD reading non-fiction or high-interest stories to determine if the outcomes were the same.

The familiarity with the researcher, the teacher, may have influenced participants' outcomes. The researcher was the classroom teacher and established relationships with participants as the semester progressed. The researcher was extensively trained in teaching students with LD. The student-teacher relationships may have affected the participants' responses to the reading comprehension questions. If a researcher investigated this study without knowing the participants, there may have been different reading outcomes. Additional research should investigate whether participants' reading outcomes are similar when the participants do not know the researchers.

This study used a single-subject design, A-B-A-B, to investigate the effects of TTS on participants' reading comprehension. This design requires a small number of participants included in the study (i.e., four). This low number limits the potential for external validity, making it difficult to assume that all participants with LD in reading would experience the same outcomes. Quality research is able to show that results can be generalized in a variety of settings with other participants. With technology becoming more prevalent and accessible in everyday life, it remains a priority to document the generalizability of the results.

Implications for Future Research

Previous research indicates that the use of TTS has the ability to increase secondary students' reading comprehension which can later assist in achieving vocational and professional success (Hecker et al., 2002). Much of the previous research on the use of technology as a reading intervention has primarily focused on using TTS to gain knowledge of core content. Future research is needed to increase generalization on the effectiveness of TTS for secondary students with LD as they prepare for postsecondary education and careers.

With the rapid development of new technologies, it can be assumed that TTS will continue to improve. TTS may have additional features available when students use it to acquire information from print. Future research should include instructing struggling readers to use all features available in TTS (e.g., font size, reading rate, highlighting, and outlining) on personal devices to assist in their acquisition of material. Additionally, as students increase their knowledge of TTS's capabilities, additional technology skills may be learned that can improve their use of technology for engaging in recreational, vocational, and social activities.

As literacy skills are crucial when learning content, it is important that students with reading disabilities learn to use technology to increase their reading ability. With literature readily available through technology (e.g., ebooks and Learning Ally), students should continue to practice using technology to maximize their ability to understand material. Encouraging students to learn and use technology for academic, recreational, and vocational purposes may assist in reducing the achievement gap.

The stories used in this study were short in length to accommodate for 48-min class periods. High school curriculum usually requires students to spend more time reading content. Thus, it would be beneficial to conduct a study with assessments containing more than 15 reading comprehension questions to see if TTS effectively increased reading comprehension with longer passages.

The results of the current study indicate that students with reading disabilities became more efficient readers after using TTS. As these students increase their reading efficiency with TTS when set at a faster rate than their present level of ORF, they should be able to read curricular material in less time. This effect will allow them to gain content more quickly and accurately, which may result in increased academic outcomes. A result of increased academic outcomes can lead to greater success in all areas of life.

This study's findings imply suggestions for teachers and administrators to consider when planning instruction to increase student outcomes. Teachers and administrators should promote the use of TTS as an available option for all students to use when acquiring information. School administrators should increase professional development to faculty and staff on the use of TTS when acquiring content. As a result of increased professional development, teachers could inform students on how to use TTS for a variety of purposes. With learned technological skills, students could improve confidence and independence when reading curriculum in a self-contained or general education classroom.

Practitioners should expand the use of technology in high school when delivering core content to students with LD. Using technology during instruction for SLD is a win-win. Teachers can access student outcomes immediately from technology. With faster results on student progress, teachers can more quickly adjust curricular decisions. Students are more likely to become more engaged and self-correct when using technology because of their daily reliance on technology in general (e.g., iPhones, computers, video games) (Marino et al., 2015). As technology becomes more prevalent in education, using it more in the classroom will assist the teacher in customizing lessons to meet students' needs which in turn, can result in increased student outcomes.

Conclusions

The purpose of this study was to further research on the use of TTS when reading literature to address reading deficits among freshman students with LD. The intervention, TTS, was primarily used to increase reading comprehension skills among participants who read below grade level and require intensive reading instruction. The goal of the research was to not only to increase reading comprehension but to provide participants with knowledge of TTS features in an attempt to increase accessibility to high school content, more specifically English literature.

Results showed positive outcomes and a functional relation between TTS and reading comprehension scores for the participants. As shown in previous studies, students with reading disabilities increased reading comprehension when using TTS consistently over time (Retter et al., 2012; Stetter & Hughes, 2011; Stodden et al., 2012). Additionally, like this study's findings, previous studies reported increased engagement and efficiency among students with LD when using TTS (Fitzgerald et al., 2012; Meyer & Bouck, 2014).

When looking at the overall reading outcomes of the participants, results confirmed that the lowest readers with LD in high school benefitted the most from TTS. Low readers with LD who continue to use TTS over time may increase reading outcomes enough to reduce the achievement gap among students with disabilities. Additionally, if students with LD in reading can learn material more efficiently and thoroughly with TTS, perhaps more students will be able to handle higher level curriculum. This may increase students' opportunities to participate in the general education curriculum. Furthermore, TTS used as a compensatory tool for struggling readers may increase independence, resulting in successful learning not only with high school content but material learned for vocational and post-secondary success.

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APPENDIX A

SOCIAL VALIDATION SURVEY LIKERT SCALE

ASKING PARTICIPANTS QUESTIONS

REGARDING THE USE OF TTS

Question	1-strongly disagree	2-disagree	3-neutral	4-agree	5-strongly agree
TTS was easy to use					
I enjoyed the synchronous visual and auditory reading support of TTS					
I liked following the words with the highlighting feature in TTS					
I liked using the rate of speed feature in TTS					
I liked listening to my voice selection in TTS					
I remembered more information after using TTS					
I will use TTS in the future for class assignments					
I will use TTS in the future for fun					

APPENDIX B

PRE-BASELINE AND POSTINTERVENTION DATA RECORDING FORM

Participant Identification Number (no real names):______________________________

IEP Goal in Reading:____

Lexile Score from August 2016:__________________________________

SED Eligibility:____

Lexile Score from December 2016:________________________________

Oral Reading Fluency (ORF) from August 2016:_____________________

ORF from December 2016:______________________________________

APPENDIX C

PRE-BASELINE TRAINING ON THE USE OF TTS

Tasks	Vincent	Jack	Dianna	Donald
Participant will select a computer and log on using a TTS password				
Trainer will inform the participant which fiction passage to access				
Participants will open the designated fiction reading passage				
Participant will select their reading rate				
Participant will select their preferred voice				
Participant will select the font size of the text				
Participant will learn how to enable highlighting preferences (i.e., word, phrases, or paragraphs)				
Participants will practice using headphones to access audio and visual input of TTS				
Participants will practice turning the pages forward and backwards				
Trainer will verify that participants' selected TTS features are working properly				
Participants will practice logging off				
Participants will stop training when they can independently complete these steps at 100% accuracy				

APPENDIX D

READING COMPREHENSION AND ORF ACCURACY RECORDING FORM

Participant: Date: Name of Reading Passage:	Oral Reading Fluency (AIMSWeb)
Condition: _____Baseline (A1) _____Intervention (B1) _____Baseline (A2) _____Intervention (B2) _____Maintenance CBM Reading Score: _____Vocabulary _____Literary Analysis _____Comprehension _____Total Percentage (out of 15 questions)	Condition: _____Baseline (A1) _____Intervention (B1) _____Baseline (A2) _____Intervention (B2) ORF Score ____________WRC ____________Errors

APPENDIX E

PROCEDURAL RELIABILITY CHECKLIST FOR BASELINE, INTERVENTION, AND MAINTENANCE CONDITIONS

Participant: Observer: Date: Text:______________________________ Teacher and Participants Activities		
Baseline Conditions	Yes	No
Teacher asks participants to log into *Kurzweil 3000* and access "XX" reading passage		
Teacher asks participants to read the passage on the computer without using any TTS features		
Participants completely read the passage on their own		
Once teacher sees participants are finished reading, teacher asks participants to log off the computer and begin the written multiple-choice assessment (i.e., CBM)		
Teacher passes out written assessment to participants when ready		
When participants are finished with the CBM assessment, teacher picks up the written assessment and tells the participants they are finished		
Teacher provides general praise such as, "Nice job" during activities but no specific prompts are provided		
Intervention Conditions		
Teacher asks participants to log into *Kurzweil 3000* and access "XX" reading passage		
Teacher asks participants to enable TTS features before reading the passage on the computer		
Teacher asks participants to put on earbuds or headphones and to check for sound		
Participants indicate to the teacher that they hear sound via TTS		
Participants completely read the passage on their own with TTS support		
Once each participant is finished with the reading, teacher asks the participant to log off the computer and begin the written assessment (i.e., CBM)		
Teacher passes out written assessment to participant		

Participant completes the reading comprehension CBMs on his/her own		
When participants are finished with the assessment, the teacher picks up the written assessment (i.e., CBM)		
Teacher provides general praise such as, "Nice job" during activities but no specific prompts are provided		
Maintenance Condition		
Teacher asks participants to log into *Kurzweil 3000* and access "XX" reading passage		
Teacher asks participants to put on earbuds or headphones and to check for sound		
Participants indicate to the teacher that they hear sound via TTS		
Participants completely read the passage on their own with TTS support		
Once each participant is finished with the reading, the teacher asks the participant to log off the computer and begin the written assessment (i.e., CBM)		
Teacher passes out written assessment to participant when ready		
When participants are finished with the assessment, the teacher picks up the written assessment (i.e., CBM)		
Teacher only provides general praise such as, "Nice job" during activities but no specific prompts are provided		