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**Effective Use of Assistive Technology Tools to
Accommodate Students with Learning Disabilities**

by

Kim Hess

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Starred Paper Committee:
Bradley Kaffar, Chairperson
Michael Pickle
Christie Tamte

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Chapter 1: Introduction

Competitive participation in society requires a relatively high level of reading and writing skills. In elementary school, children spend a significant amount of time learning the skills that are important to become independent readers. In middle school and high school classrooms, the focus is no longer on learning to read but rather reading to learn. Also, in secondary settings, teachers spend less time specifically on reading instruction and strategies.

Approximately 6 million secondary students in the United States are reading significantly below grade level (Moorman, et al., 2010). The instructional content provided in most secondary settings is written at or above grade level and therefore presents a significant challenge to students who are not able to read and comprehend material at that instructional level. For students with learning disabilities, the inability to read and comprehend grade-level content can widen the gap of their educational performance compared to their peers.

The Individuals with Disabilities Education Act (IDEA) is a law that ensures that all students with disabilities receive a free and appropriate public education. School districts are responsible for identifying students with disabilities and providing special education services to meet their individual needs. The Individuals with Disabilities Act (IDEA) defines 14 categories of disabilities. They include severely multiply impaired, autism spectrum disorders, blind-visually impaired, deaf-blind, deaf, and hard of hearing, developmental cognitive disabilities, developmental delay, emotional or behavioral disorders, other health disabilities, physically impaired, specific learning disabilities, speech or language impairments, and traumatic brain injury. Almost half of all the students served under the Individuals with Disabilities Act (IDEA) are identified as having a learning disability. Eighty percent of those students have deficits in reading comprehension (Gonzales, 2014).

Reading involves several coordinated skills and processes. Students with learning disabilities often have deficits in key aspects of reading including decoding, word recognition, inferring word meanings, and using letter/sound relationships. These deficits can have a significant impact on reading comprehension.

Text-to-speech, or TTS, is an assistive technology tool that can be used to facilitate struggling readers' access to, and comprehension of print and online reading materials (Park et al., 2017). Text-to-speech allows a reader to see and hear the content in a digital format. The reading rate, tone, voice, and backlighting can be adjusted based on personal preferences.

The availability and functionality of assistive technology have improved significantly over the years. Today, text-to-speech software is commonly available as an accessibility feature on cell phones, tablets, and computers. Most curricular resources and learning management systems also have text-to-speech as an option for all students to access.

History of Assistive Technology and Accessible Educational Materials

The Individuals with Disabilities Education Act (IDEA) defines assistive technology as any item, piece of equipment, or product system, whether commercially off the shelf, modified, or customized, that is used to improve the functionalities of a child with a disability. Assistive technology, in short, is any item, software program, piece of equipment, device, or product used by individuals with disabilities to preserve or improve their individual skills and abilities (Bone & Bouck, 2017). By law, assistive technology needs to be considered for all students served under IDEA. The consideration must take place at least annually as part of their regular Individualized Education Plan (IEP) meeting.

Historically, the use of assistive technology has more often been considered for students with low-incidence disabilities. Low-incidence disabilities refer to a lower population of students

being served in a particular disability category in special education such as blind/visually impaired or developmental cognitive disability. Whereas high incidence disabilities refer to a higher population of students served in a particular disability category such as specific learning disability or other health impairments. Students with learning disabilities are the highest population of students receiving special education services at 35% (Young et al., 2019). This group is often underrepresented in their use of assistive technology tools to meet their academic needs.

Assistive technology includes a variety of tools and strategies. These tools can range from low-tech to high-tech. A low-tech assistive technology reading tool could be as simple as a reading magnifier that is used to help track words when reading, or it could be as complex as a software program that reads text aloud while also highlighting text. In the past, providing text-to-speech software was cumbersome and costly for educators. Educational agencies frequently had to provide a separate computer with specific software downloaded. Today, text-to-speech is readily available and often embedded in the software of cell phones, tablets, and computers.

Accessible Educational Materials are print and technology-based educational materials, including printed and electronic textbooks and related core materials that are designed or enhanced in a way that makes them usable across the widest range of learner variability, regardless of format. Some examples include print, digital, graphic, audio, and video. According to the Individuals with Disabilities Act of 2004 (IDEA-2004), all state and local education agencies are required to provide textbooks and other core materials in an accessible format for students with identified print disabilities.

Educational agencies are not required to use any one method to consider Assistive Technology (AT) and Accessible Educational Materials (AEM) for students. One popular tool

that is available for assistive technology consideration is called the SETT framework. SETT stands for student, environment, task, and tool. This framework can be used to guide IEP teams in deciding what type of tool to trial with students. Text-to-speech is one tool that can be considered for students who struggle with the task of reading and comprehending grade-level material.

Ultimately, reading is a complex process that involves many skills. Researchers have learned that effective literacy instruction should include phonological awareness, phonics and word recognition, fluency, vocabulary, oral language comprehension, and text comprehension. The use of assistive technology can provide effective support for struggling readers; however, it should not replace explicit reading instruction based on the science of reading.

Research Questions

This literature review focuses on two questions. First, does the use of text-to-speech software impact reading comprehension for students with learning disabilities in grades 3-12? Second, does using assistive technology tools for reading provide other benefits for students with disabilities?

Importance of the Topic

This topic is of particular interest to me as I work in my current role as a Special Education Technology Integrationist at the St. Cloud Area School District. In my role, I support students and staff in their implementation of Assistive Technology (AT) and acquisition of Accessible Educational Materials (AEM). In our district, we have dedicated resources to implement processes and systems to help students receive Accessible Educational Materials. We have invested in products that are universally designed to help support students with reading and

writing. We have purchased a product called Read & Write for Chrome. This tool includes a toolbar that is available to all students in our district. The toolbar has options for text-to-speech, dictation, highlighting, audio, and more. We also enroll students in Bookshare, an accessible eBook library for students with qualifying disabilities. In my current position, I also spend a considerable amount of time screening students to determine if they benefit from the use of text-to-speech. Professional development for staff is very important to me. I want to ensure that they have the knowledge to make appropriate considerations for their students. The fidelity of the tools and strategies that I recommend is important to me. I want to know that the tools that I recommend are research-based and help students achieve the goals on their Individualized Education Plan (IEP).

Focus of Paper

I reviewed 11 studies from the years 2010 to 2021. The subjects in the studies ranged in age from 10 to 19. All students in the studies had been identified as having some type of learning disability.

To find peer-reviewed articles related to my topic, I conducted several searches using Academic Search Premier, Google Scholar, and ERIC. I performed the following keyword searches with variations and combinations of these terms: *text-to-speech, TTS, specific learning disabilities, dyslexia, assistive technology, learning disabilities, audio-supported reading, and accessible educational materials.*

Chapter 1 provides information regarding special education law related to identifying students with disabilities and considering assistive technology. It also focuses on the historical aspects of assistive technology and accessible educational materials as well as the impact of deficits in reading comprehension for students with disabilities. Chapter 2 provides a

comprehensive review of relevant literature. In chapter 3, I will draw conclusions, provide feedback for additional research, and discuss possible implications for practice.

Definition of Terms

Assistive technology includes any item that is used to improve the functional capabilities of individuals with disabilities. There is a range of levels of assistive technology from low-tech to high-tech. Some examples may include reading pens, text-to-speech software, or a reading guide.

Accessible Educational Materials are materials designed or converted in a way that makes them usable across the widest range of student variability regardless of format.

Bookshare is an accessible online library of eBooks for people with print disabilities.

Dictation refers to the action of saying words aloud to be typed.

IDEA or Individuals with Disabilities Education Act is a law that makes available free and appropriate public education for individuals with disabilities.

Dyslexia is a neurodevelopmental condition that mainly affects the ease with which a person reads, writes, and spells. It is typically recognized as a specific learning disorder in children.

Low Incidence Disabilities is a general term used to describe disabilities that occur in low numbers, or are less common, within the general population. A few examples of low incidence disabilities include intellectual disabilities, multiple disabilities, or severe disabilities.

High Incidence Disabilities are more commonly seen in regular education classrooms. Students with high incidence disabilities typically can participate in regular education with some additional learning and support. Some examples may include communication disorders, learning disabilities or attention deficit disorder.

Read & Write for Chrome is a literacy support tool that offers help for everyday tasks like reading text aloud, understanding unfamiliar words, researching assignments, and proofing written work.

SETT Framework refers to a consideration/decision-making tool created by Joy Zabala to promote collaborative decision-making to provide assistive technology to individuals with disabilities.

Specific Learning Disability (SLD) is a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written language.

Text-to-Speech is a type of assistive technology/software that allows text to be converted into speech sounds that imitate a human voice. It often also provides text highlighting as words are read across the screen.

Chapter 2: Review of Literature

Assistive Technology, in particular the use of text-to-speech, is often used for struggling readers to access grade level material when their instructional reading level is below grade level. In this paper, I review 11 studies conducted with struggling readers in grades 3-12 to determine whether using text-to-speech improves students' reading comprehension. The first seven articles reviewed will address the first research question of whether using text-to-speech assistive technology improves reading comprehension for students with learning disabilities. The next four articles will address the second research question: does using the assistive technology tool of text-to-speech provide improvement in other functions of reading?

Literature Review-1

Park et al. conducted an experimental design study to identify the effects of text-to-speech software on reading vocabulary, reading comprehension, and reading rate. The 10 public schools in Hawaii, represented in this study, were similar in size and demographics. On average, these schools had an average student body of 1,650 students in grades nine through twelve with 45% of students receiving free and reduced lunch, 11% receiving special education services and 7% were English Language Learners. The participants consisted of ninth grade students, with an average age of 14. 30 teachers also participated in this study (9 in the control group and 21 in the intervention group). To be eligible for participation in the study, students needed to be enrolled in 9th grade, have parental consent, have a pre-referral reading level between 1.0 and 6.9, and be receiving special education services. In total, 164 students met these qualifications to participate. Of these 164 students, 44.5% of them were students with disabilities receiving services under the Individuals with Disabilities Act or Section 504. The most common disability area for these students is Specific Learning Disability.

In the experiment, 32 students participated in the control group, whereas 132 participated in the intervention group.

There are a variety of software programs available that offer text-to-speech software. For this study, a program called Kurzweil 3000 version 12, was available to all students in an intervention class, regardless of whether the students were part of the experiment. This would eliminate any stigma or impact on the student's results. The students participating were given a 45-minute training on how to utilize the text-to-speech software prior to using it. The training included: how to highlight text, extract text, copy and paste, adjust reading speed, change voices, and use annotation tools. After 2 weeks of usage, students in the intervention group were given a self-reported proficiency check to gauge their understanding of how to utilize the tools. Mastery of tool usage was achieved when students self-reported that they could utilize the software with 95% accuracy. Teachers then presented instructional materials in accessible formats so students could utilize text-to-speech for all their assignments. Students were observed by research staff on 3 occasions throughout the semester to ensure that they were using the text-to-speech software. Student usage was also captured by a usage log within the software. Students in the control group did not receive training on text-to-speech and completed their classroom assignments in a typical manner with no additional training for staff or students.

This study included 4 different measures: vocabulary & comprehension, silent reading rate, use of TTS software, and TTS software proficiency. Sub-tests from The Gates-MacGinitie Reading Tests (GMRT 7/9) were used to measure vocabulary, comprehension, and silent reading rate. A TTS software log was used to measure how often students logged in and used text-to-speech tools. A self-report checklist was used to measure students' level of mastery of the text-to-speech tools available to them. (Park et al., 2017).

On average, students in the intervention group utilized text-to-speech software 58.2 minutes per day. “There was a significant positive effect of the text-to-speech intervention on reading vocabulary. $F(1, 148) = 4.622, p < .05$, Hedges’s $g = 0.349$ ” (Park et al., 2017, p. 149). “The mean score of the reading vocabulary test for the intervention group, ($M = 15.115$), was significantly higher than the adjusted mean of the control group ($M = 12.711$)” (Park et al., 2017, p. 149). “There was also a significant positive effect of the text-to-speech intervention on reading comprehension ($F(1, 149) = 4.841, p < 0.05$, Hedges’s $g = 0.356$). The mean of the intervention group, when adjusted for initial differences ($M = 16.853$), was significantly higher than the adjusted mean of the control group ($M = 14.725$). After controlling for students’ baseline reading rate, a statistically significant difference in post-reading rate was not found” (Park et al., 2017, p. 149).

Literature Review-2

In a much smaller study, Moorman, Boone, Keller-Belle, Stagliano, and Jeffs were also interested in studying the effects of using text-to-speech software to determine effectiveness on reading comprehension for students with disabilities. In their article, “Effects of Text-to-Speech Software on Reading Rate and Comprehension Skills of High School Students with Reading Disabilities”, the authors discussed 2 other studies that had been done previously to address their research questions related to whether using text-to-speech impacted reading comprehension. Their review of a study done by Higgings and Raskind in 2004 revealed positive effects of using text-to-speech for 44 students with reading disabilities. Their second review of a study done by Lange, McPhillips, Mulhern, and Wylie also revealed positive effects on reading comprehension for 93 students with reading disabilities.

Moorman, Boone, Keller-Belle, Stagliano, and Jeffs conducted their own A-B-A-B withdrawal research design study that included 2 students. These students, from a public high school, ranged in age from 16.2 to 17.4. Their independent reading levels ranged from grade level 4.0-5.1, so both were below grade level. Both participants had a documented reading disability and no other identified disabilities. The students were given basic computer skills assessments prior to implementing the use of text-to-speech software where they both achieved 100% mastery before beginning the experiment. Both students worked individually alongside the experimenter. The students used a software program called, *Read Please*.

The main goal of this study was to determine if using *Read Please*, text-to-speech software, had an impact on students' reading rate and reading comprehension. With the experimenter sitting alongside them, the participant was presented with a reading passage to read independently either silently or aloud. The experimenter prompted them when to begin and asked them to tell them when finished, so a time could be recorded. In the next passage, the student again sat alongside the experimenter. However, this time the experimenter made available the *Read Please* software and prompted them to push the play button when ready. The experimenter also documented the time frame that the student read along with the passage. One reading passage was administered per session. The number of sessions that each student completed varied, however, each condition of the study had a minimum of 4 reading passages followed by a 20-question comprehension assessment. The study's participants participated in two to six sessions per week. The baseline for each student was determined prior to the start of the intervention using five reading passages with subsequent comprehension quizzes. Results of this study showed positive results for both students in reading comprehension and reading rate. The first participants had a more beneficial increase in their average reading rate, whereas the second

participant experienced a slight increase in their average reading comprehension with the intervention. The participants' results are indicated in table 1 below.

Table 1

Reading Rate and Reading Comprehension Accuracy for Study 2

Student	Reading Rate Baseline 1 Mean	Reading Rate Intervention 1 Mean	Reading Rate Baseline 2 Mean	Reading Rate Intervention 2 Mean	Reading Comprehension Accuracy Scores
Trey	93.75	148.32	87.12	149.64	+5.87 percentage points
Kay	96.3	148.32	101.28	149.64	+7 percentage points

The results of this study indicate that using text-to-speech may have positive benefits for students' reading comprehension and reading rate. Limitations in this study include the number of participants as well as the ethnicity of the participants. Both participants were Caucasian. Future research may include more longitudinal research to show the benefits of text-to-speech over time. Also, future research on the acquisition of vocabulary when exposed to more reading passages using text-to-speech would be warranted. (Moorman et al., 2010)

Literature Review-3

Svennson, Nordstrom Lindeblad, Gustafson, Bjorn, Sand, Almgren-Back, and Nolsson were also interested in the effects of assistive technology for students with reading and writing disabilities. Their recent study, in 2021, noted that there is still limited strong research related to assistive technology for students with learning disabilities. Also, a lot of the research on using text-to-speech is outdated using older types of text-to-speech tools. These tools have become more readily available and easier to acquire in recent years, so certainly more current research is

needed. There were three aims of their study. The first was to study whether a systematic use of assistive technologies has any effect on reading ability. The second aim was to examine the ability of students with reading and writing disabilities to assimilate and communicate text. The third aim was to determine if using assistive technology affects student motivation for literacy.

The participants in this study included 149 students (53 girls and 96 boys) in grades 4 and 8. Students were from both rural and urban schools in Sweden. All participants scored below the tenth percentile in decoding skills. Participants were administered a series of pre-tests in word recognition, sight word reading, and non-word reading. A start-test (T1), post-test (T2), and follow-up test (T3) were given to all participants. These tests measured the following: reading comprehension, listening comprehension, vocabulary, fluency, and short-term memory. In addition, after the post-test and follow-up test parents and students were given a questionnaire to answer questions related to their perceptions of using assistive technology.

The intervention consisted of 24 one-to-one sessions with 4 sessions each week during 8 weeks with a 1-week pause in the middle. Each session lasted 30 to 40 minutes. Participants also completed reading assignments at home by listening to a book with text-to-speech. Following the listening session, students were asked to write about the passages that they read to help determine if they could assimilate the text and recall the content. Results indicated the following: “In grade four, there was a significant difference in most of the tests between the two test occasions (T1 and T2) except for the sentence chain, RAN test, and the spoken vocabulary test in the intervention group. In the control group, it was only the sentence chains and the arithmetic tests that were not significant between T1 and T2 (see Table 4). The only test that had a significant difference in effect size was the listening comprehension test where the control group had a larger gain (<0.05) between the test occasions. The change between T1 and T2 on the

reading tests corresponded to effects between $d = 0.25$ and $d = 0.71$ ($M = 0.42$) for the intervention group in grade four. In grade 8 and high school, with approximately half the number of participants compared to grade 4, non-word reading, orthographic decoding, and spoken vocabulary were significant in the control group between T1 and T2. In the intervention group, all were significant (<0.05 – 0.001) except arithmetic, sentence sequence, spoken vocabulary, and written words. None of the tests had a significant difference in effect size between the groups (Table 5). The change between T1 and T2 on the reading tests corresponded to effects between $d = 0.14$ and $d = 0.77$ ($M = 0.36$) for the intervention group in grade 8 and high school” (Svensson et al., 2021, p. 202).

The third aim of the study was related to the participants’ motivation for literacy. At the end of the study, 50% felt that using the assistive technology benefited them in their schoolwork. Around 40% to 55% of the participants in the intervention group responded that they were more independent and motivated. 47% of the students had perceptions that they could do better after the intervention. 60% responded that the reading apps were good for listening and helped them understand the text better. (Svensson et al., 2021)

Literature Review-4

Young, Courtad, Douglas, and Chung completed a study in 2019 on the effects of text-to-speech on reading outcomes for secondary students with reading disabilities. Like Moorman, Boone, Keller-Belle, Stagliano, and Jeffs’ study, this study was also an A-B-A-B withdrawal design study. As cited in their article, “in the United States, roughly 6 million secondary students are reading at a level far below their grade” (Young et al., 2019, p. 80). Also noted is the fact that the gap between non-disabled students and students with learning disabilities continues to increase. The use of assistive technology can help compensate for some deficits in

reading for these students. This study aimed to answer the following questions: Does the reading comprehension of freshmen students with LD increase when using text-to-speech as measured by CBA's? Will students maintain the use of text-to-speech following the study? Does oral reading performance increase after students use text-to-speech?

Originally, there were four participants in this study in grade 9. One participant did not complete the study due to a change in his class schedule. The students attended a large public high school in the Midwest. Each of the participants had a learning disability, received special education services in a self-contained 9th-grade classroom, and had a 95% attendance rate.

These students and their classmates participated in a class with materials being presented in a digital format where students had access to Kurzweil 3000 (a text-to-speech software program) to complete all academic tasks. Each text-to-speech session lasted approximately 48 minutes, and there were 3 sessions each week. At the beginning and end of the study, all students were given the Scholastic Reading Inventory to obtain a pre and post-test Lexile score for each participant. The authors used a variety of reading passages from level A of the grade level curriculum called, *The Edge*. The authors also used an Oral Reading Fluency (ORF) pre-intervention and post-intervention to see if participants increased their words per minute after auditory and visual exposure to text. All participants received training in the text-to-speech software prior to intervention.

Students first read passages without using assistive technology to determine the baseline when reading the passages. The second baseline was determined with participants utilizing text-to-speech software. After each condition, the participants responded to a 15-question comprehension quiz. Maintenance sessions took place once a week for four weeks. (Young et al., 2019)

Results from the study indicate, “a functional relation between TTS and reading comprehension performance for all three participants who completed the study (see Figures 1 and 2)” (Young et al., 2019, p. 84). “The effects of the TTS were maintained for the three remaining participants. Furthermore, ORF outcomes indicated that all participants increased the number of words read correctly throughout the study (see Table 2). Lexile scores on the district’s universal screener, the SRI, indicated that two of the four participants increased scores between the pre and post-tests” (Young et. al, 2019, p. 84).

Literature Review-5

Students with reading disabilities often have accommodations listed in their Individualized Education Plan that allow them to participate in the general education curriculum. Some students have an accommodation to have an adult read to them, whereas others have that they can use text-to-speech software. Authors Brunow and Cullen designed a single-subject study to determine the effectiveness of a human reader and text-to-speech on reading comprehension for students with reading disabilities. Their research answered two questions: how do listening scores of students with LD using text-to-speech compare to listening comprehension using an adult reader, and which condition yields the highest listening comprehension scores (Brunow & Cullen, 2021, p. 215).

The participants in this study were four high school juniors from a south-central United States high school. All the students had a documented learning disability, an Individualized Education Plan and had regular attendance.

An online randomizer was used to determine which treatment option was applied: human reader or text-to-speech. The reading passages were selected from the novel, *To Kill a Mockingbird*, because this is a book that is used in the regular general education curriculum for

high school juniors at the school. Each reading session was followed with a 10 question, multiple choice assessment. Data was collected over 10 days. Each participant received the text-to-speech treatment 6 times and the human reader four times. Results indicate higher mean scores for all participants when using a human reader versus using text-to-speech. The results can be seen in the table below.

Table 2

Comprehension scores for both treatments for Study 5

Participant	<i>Text-to-Speech</i>				<i>Human Reader</i>			
	M	R	PSD	Mdn	M	R	PSD	Mdn
Chad	40.67*	40	14.91*	45	80	30	12.25*	75
Ivan	55	40	12.58*	60	67.5	20	12.99*	60
Nancy	70	70	28.28*	75	75	10	5	75
Priscilla	41.67*	40	15.72*	40	52.5	50	17.85*	60

Note. PSD=population standard deviation; *denotes value rounded to nearest hundredth.

Future research may include more participants to obtain a large data set. Also, giving students the option to customize their text-to-speech options such as speed, voice, and highlighting color may yield different results. Although this study yielded better results for a human reader compared to text-to-speech, text-to-speech can still be a valuable accommodation for students with disabilities. It can decrease the stigma of having to rely on an adult reader and allow individuals to be more independent in real-world settings (Brunow & Cullen, 2021)

Literature Review-6

In an article titled, *The Effects of Two Assistive Technologies in Reading Comprehension Accuracy and Rate*, Schmitt, McCallum, Hawkins, Stephenson, and Vicencio aimed to determine how continuous text-to-speech technologies compare to discontinuous text-to-speech tools as seen in their impact on reading comprehension and accuracy. Continuous text-to-speech is defined when entire passages are scanned and read aloud to students. Discontinuous text-to-speech is defined when students use technology such as a reading pen where the individual scans the text using the reading pen and then pushes play to have the text to be read back to them.

4 eighth-grade students from a Mid-Atlantic suburban school participate in this study. Each of the participants receive special education services related to their reading specific disability. All the participants also had programming goals in decoding, fluency, and comprehension.

Prior to beginning, each participant completed three curriculum-based-measures (CBM) reading probes from AIMS Web to determine a baseline of average words read per minute. The four students' oral fluency rates are listed in Table 4 below.

27 reading passages and 10 corresponding comprehension questions were selected from a fictional series titled, *Timed Readings in Literature*. The data collection took place over a 10-day period. Each participant read passages under three different conditions by reading 9 passages using a Reading Pen, 9 passages using text-to-speech with Kurzweil 3000, and 9 passages reading silently with no assistive technology or accommodations. To evaluate and compare the results of each condition, an adaptive alternating treatments design was used. Table 5 displays the results for each of the four participants.

Table 3

Mean and standard deviation of correctly answered comprehension questions for review 6.

	Mean number Correct			Mean Comprehension Rate		
	<i>Silent Reading</i>	<i>Reading Pen</i>	<i>TTS-Kurzweil</i>	<i>Silent Reading</i>	<i>Reading Pen</i>	<i>TTS-Kurzweil</i>
Christina	2.66 (1.58)	3.89 (.36)	5.44 (.74)	11.18 (0.90)	9.86 (0.43)	18.31 (.72)
Dan	3.33 (1.58)	4.56 (2.40)	6.11 (1.27)	14.03 (.80)	13.29 (0.51)	20.51 (0.54)
Kate	5.78 (1.48)	4.89 (1.83)	4.78 (1.92)	17.21 (0.75)	12.60 (0.72)	15.80 (0.73)
Valerie	4.33 (1.80)	3.67 (1.00)	5.56 (1.51)	6.38 (0.38)	5.38 (0.31)	18.45 (0.58)

These results show that text-to-speech yielded the highest results for 3 out of the 3 participants in both reading comprehension accuracy and rate as compared to silent reading and the reading pen. For all four participants, using the reading pen yielded the lowest comprehension rates across conditions. Using text-to-speech yielded better comprehension accuracy than silent reading for 3 of the four participants. (Schmitt et al., 2019)

Literature Review-7

Wood, Moxley, Tighe, and Wagner reviewed two other meta-analysis studies that looked at the effects of using text-to-speech on standardized reading and math assessments for both students with disabilities and students without. Both studies showed similar effect sizes in math and reading between students with and without learning disabilities. Students using read aloud accommodations for math did not differ significantly from students without disabilities. This prior research included students with both learning disabilities and without, and these previous

studies were done using standardized testing that were not specific to reading comprehension. Wood, Moxley, Tight, and Wagner conducted their meta-analysis study to answer three questions: what is the average weighted effect size of the use of text-to-speech on reading comprehension for students with reading disabilities; are there identifiable moderators of the effects of text-to-speech on reading comprehension; and what is the overall quantity and quality of the current research base on students with reading disabilities using text-to-speech.

To be included in this study, reading comprehension needed to be measured at the sentence, paragraph or passage level, and all students had dyslexia, a reading disability, or a learning disability in reading. Furthermore, all studies had to include oral presentation of reading material to the participants (human recorded audio, human narration, text-to-speech, reading pens or other eBooks with audio). This meta-analysis excluded qualitative studies and focused on quantitative studies. After careful selection and making exclusions, there were 22 studies examined in this meta-analysis. (Wood et al., 2017)

The results show that the use of text-to-speech tools has a significant impact on reading comprehension scores with $d = .35$, 95% confidence interval (CI) (.14, .56), $p < .01$. The effects of text-to-speech and related read-aloud tools indicate that oral presentation of text for students with disabilities helps their reading comprehension test scores. Our finding of an average weighted effect size of .35 is consistent with the other 2 previously mentioned meta-analysis studies on read-aloud accommodations for students with disabilities. Accounting for these studies, the trim and fill analysis suggested that the effect size would be $d = .24$, 95% CI (.02, .45), $p = .03$ (Wood et al., 2018, p. 79).

Literature Review-8

Michelle Gonzales was also interested in how the use of text-to-speech benefited students

with reading disabilities. Her study aimed to determine which type of book formats yield the highest rate of comprehension and oral retelling. The three types of book formats were eBooks with embedded text-to-speech, eBooks with vocabulary and pronunciation support only for selected words, and traditional print format books with no added support.

The participants in this study included 13 students in third grade and 10 students in fourth grade with documented reading disabilities. All students had an Individualized Education Plan and received special education services. All participants were reading at least one grade below grade level. The students attend elementary school in a suburban area in a mid-Atlantic state.

In the study, participants were given alternating treatments of reading using each of the three contents: eBooks with embedded text-to-speech, eBooks with vocabulary and pronunciation support only for selected words, and traditional print format books. After reading the passages, students answered comprehension questions and did an oral retell to research assistants to question prompts (Gonzales, 2014).

Results indicated that the participants had higher oral retelling scores when they read eBooks with full text-to-speech as compared to just using text-to-speech support on select words. Participants also had higher oral retelling scores when with full text-to-speech as compared to traditional print format books. Results also indicate that participants had higher accuracy of comprehension questions with full use of text-to-speech books compared to traditional print format books, however they did not yield higher comprehension results when using eBooks with only supports for pronunciation and selected words. The results are further displayed in table 6 below.

Table 4

Results of Comprehension Measures (Oral Retell & Multiple Choice) for study 8.

Book format	Measure	M	Mdn	SD	N
Format 1-eBooks with full text-to-speech	Oral-Retell	5.210	5.270	1.418	17
	Multiple Choice	72.829	76.70	18.050	17
Format 2-eBooks with select vocab text-to-speech support	Oral-Retell	4.046	4.450	1.761	17
	Multiple Choice	66.565	70.00	16.745	17
Format 3-traditional books with no supports	Oral-Retell	3.723	4.128	1.777	17
	Multiple Choice	68.018	66.70	14.595	17

Regarding other benefits of using text-to-speech, Gonzales noted, “eBooks may make reading enjoyable for students and eBooks can help decrease the decoding burden for struggling readers. eBooks can provide scaffolds to help students read books they otherwise would not be able to” (Gonzales, 2014, p. 11).

Literature Review-9

The results of the study completed by Mosito, Warnick, and Esambe also indicate additional benefits of using text-to-speech software for students with disabilities. Their study sought to analyze the effects of text-to-speech stories on the reading abilities of students with intellectual disabilities while also discovering additional benefits.

The 35 participants in this study were learners in grades 4-6 from Cape Town, Africa. They all had been diagnosed with an intellectual disability (ID). A secondary sample group

consisted of four educators of the learners. The role of the secondary group was to assess qualitative research on the use of text-to-speech for their students.

All participants were given a pre and posttest. The test was a one-minute reading passage of 34-35 words. The intervention consisted of the participants reading the same story as the pre-test 3 times using text-to-speech on a computer for 20 minutes. The learners participated in 2 sessions per week for 3 months. Following the intervention stage, a post-test was administered to obtain results.

Educator interviews were conducted for the four participating educators. The goal was to share observations that they obtained during the intervention phase. They answered 5 questions related to their students' participation. One educator noted, "the stories told and seen through the computer seemed to generate an interest level that she had not seen in learners before" (Mosito et al., 2017, p. 8). Ultimately, this study may not have had significant results in improving reading comprehension and fluency, it did demonstrate that reading using text-to-speech can increase student motivation and enhance enthusiasm to read. (Mosito et al., 2017).

Literature Review-10

Nordstrom, Nilsson, Gustafson, and Svensson developed a study that aimed to understand how assistive reading and writing applications were perceived to function regarding students' possibilities to read and write text. They were also interested in how the use of these tools affected student motivation, independence, and further use of technology. Special Education teachers, who were responsible for the students' interventions, were asked how they perceive the student and their use of assistive technology.

The participants in this study included students from 3 different age groups. These age groups included 4th grade students, 8th grade students, and 9th and 10th grade students. These

students were from 42 different public schools. All students had documented reading difficulties and reading performance on or below the tenth percentile on word-decoding tests.

The intervention sessions were carried out in a one-to-one session. The teacher taught the students how to use a specific app for text-to-speech, speech-to-text, spell check and other word processing tools. The teachers collected data two-to-three months after the intervention phase. They completed a survey comprising 16 questions related to teacher perception of student motivation, teacher perception of student learning, and how useful the technology is perceived for special education teachers' teaching practice. 54 out of the original 63 teachers were able to complete the survey following the intervention. The responses in the survey included a 5-point scale ranging from no degree, in a very small degree, in a fairly high degree, to a very high degree.

72% of the fourth-grade teachers reported positive results about the impact of assistive technology to help students assimilate text. 82% of these teachers responded that apps could compensate for their students' reading difficulties. 68% of the teachers reported that the amount of text that students assimilated had increased because of the use of the apps. A smaller percentage (46%) of the teachers felt that using text-to-speech improved reading comprehension. 54% of the teachers felt that using the apps increased student motivation for reading. 43% of the teachers perceived that traditional reading ability had improved, even though the app did not provide direct instruction on reading strategies.

Results in grades 8 and up were combined due to the smaller number of responses. Only 55% of teachers perceived that apps could compensate for their students' reading disabilities. Very few teachers (25%) responded that the students had become better readers, and 32% perceived students as being more motivated regarding traditional reading skills. 67% of the

teachers responded positively regarding their students becoming more motivated toward schoolwork. 60% of teachers responded that the apps could assist their students to assimilate text, whereas 57% responded that apps could assist students with comprehending text. 70% of all students continued to use the technology after the intervention.

Overall, the staff participating in this 6-week app usage study perceived apps to have sufficient potential to compensate for difficulties with reading and writing. One benefit noted was that students were exposed to grade level text more frequently when using text-to-speech versus when they read material independently. Another benefit noted by multiple teachers was that students were able to be more independent and autonomous when using the apps when reading versus reading in a traditional manner (Nordstrom et al., 2019).

Literature Review-11

Meyer and Bouck conducted a small multiple-baseline-across-participants study to understand the effectiveness of text-to-speech software on reading fluency, comprehension, and task completion. Their research questions included: does reading text with text-to-speech enhance fluency, comprehension, and completion time for middle school students with reading disabilities and what are students' perspectives of using text-to-speech for grade level expository texts? (Meyer & Bouck, 2014)

The participants in this study were three Midwest middle school students with a specific learning disability in reading. Karl was a 13-year-old male seventh-grade student with a learning disability in reading. He had a full-scale IQ of 109, had a 23 point and 26 point discrepancy scores of 86 and 83 for Word Recognition and Reading Comprehension. Karl self-reported that reading typically takes him longer than most students. He also reported that he does not always understand what he reads. The second participant, Chris, was a 14-year-old male in the eighth

grade who has a documented learning disability and a secondary disability of attention deficit hyperactivity disorder (ADHD). Chris's full-scale IQ was 85, with a 22-point discrepancy in reading comprehension. The third participant, Linda, was a 14-year-old eighth grade student with a learning disability in reading. Her overall IQ was 76. Her reading achievement scores were 77 for Word Identification, 49 for Word Attack, and 79 for Passage Comprehension.

The reading passages were selected from "Six-Way Paragraphs, Middle Level". Karl read 15 passages from the seventh-grade passages, and Chris and Linda read 14 and 15 passages from the eighth-grade passages. Each passage contained between 300 and 400 words and was followed by six corresponding comprehension questions related to subject matter, main idea, conclusions, supporting ideas, and vocabulary in context. In the generalization phase of the study, the three students read passages from a typical grade-level expository text. The text-to-speech software that was used was called Natural Reader. This software highlights the words as they are read and allows users to adjust the speed and voice of the reading. The technology was the independent variable in this study, whereas fluency scores, comprehension scores and time to complete the tasks were the dependent variables. An oral reading fluency probe was administered prior to intervention to obtain a baseline reading rate. After a baseline was determined for each student by reading passages without text-to-speech, the intervention phase began where they were trained in using the software and then allowed to use the software when reading grade-level passages and answering comprehension questions.

Results varied for each participant regarding reading comprehension. Karl's comprehension baseline scores ranged from 33.3 to 83.3%. His intervention scores ranged from 33.3 to 66.7%. The results indicate that the intervention was unreliable. Chris's comprehension

baseline scores ranged 33.3% to 83.3%. His intervention scores ranged from 0.0% to 83.3% indicating the intervention's effectiveness was unreliable. Linda's comprehension baseline scores ranged from 0% to 83%. Her intervention scores ranged from 16.7% to 83.3%. The results also indicate that the intervention was unreliable. Qualitative data from the study was obtained through student interviews. All three students reported that text-to-speech could help them read better than reading on their own. They were also enthusiastic about reading on the computer. They indicated that they felt like they understood more, read more fluently, and completed their reading more quickly when using text-to-speech. They also appreciated being able to see the text highlighted as it read and the ability to adjust the speed and font. Although this study did not show significant gains in reading comprehension, the students perceived other benefits regarding reading in this manner. One important benefit that was noted is that students felt more independent in their reading (Meyer & Bouck, 2014).

Summary

Chapter 2 reviewed 11 research articles related to the effects of using text-to-speech software on the reading comprehension of students with learning disabilities. The first seven articles reviewed addressed the first research question of whether using text-to-speech assistive technology impacts reading comprehension for students with learning disabilities. The last four articles addressed the second research question: does using the assistive technology tool of text-to-speech provide other benefits to struggling readers?

Overall, the articles covered the effects that using text-to-speech has on reading comprehension, and oral reading fluency. Some of the articles also revealed students' and teachers' perceptions of how this type of assistive technology impacts student confidence, independence, and motivation. Recent research on the effects of text-to-speech is limited and needs to continue,

especially, as the technology continues to advance. Students need to receive appropriate accommodations to better address their reading difficulties and help them be successful in their grade level curriculum. Reading is a complex process that requires explicit instruction in phonics, word recognition, fluency, vocabulary, and comprehension. The use of any assistive technology tool should not replace effective reading instruction for struggling readers; however, it can help remove barriers for students, particularly those who struggle with the decoding process.

Table 5*Table of Studies*

Author (s)	Study Design	Participants	Procedure	Findings
Park, H., Takahashi, K., Roberts, K., & Delise, D.	Quantitative	30 teachers, 164 ninth grade students	Experimental Design	TTS software had significant positive effect on reading vocabulary and comprehension; Significant effect on reading rate was not found
Moorman, A., Boon, R., Keller-Bell, Y., Stagliano, C., & Jeffs, T.	Quantitative	2 ranging in age from 16.2 to 17.4	Single Subject A-B-A-B withdrawal research design	Gains in reading rate & small gains in comprehension for both participants
Svensson, I., Nordstrom, T., Lindeblad, E., Gustafson, St., Bjorn, M., Sand, C., Almgren-Back, G., & Nilsson, S.	Qualitative & Quantitative, Controlled Trial	149 (53 girls, 96 boys), in grades 4 and 8	Alternating treatment design	Both groups in grade 4 had gained on all tests except for reading comprehension in the control group. Effect size did not differ significantly between groups except for listening comprehension; the control group had significantly increased ability (<0.05) compared to the intervention group. Students in grade 8 and high school had gained on all tests, but not significantly on all of them

Young, M., Courtad, C., Douglas, K., Chung, Y	Quantitative	11 ninth grade students, receiving services in LD	Alternating treatment design, Single Case A-B- A-B Withdrawal Design	Functional relation between TTS and reading comprehension performance
Brunow, D., Cullen, T.	Quantitative	4 eleventh grade students	Single-subject alternative treatment design	Students benefited from TTS, but had better comprehension with human reader
Schmitt, A., McCallum, E., Hawkins, R., Stephenson, E., & Vicencio, K.	Meta- Analysis	4 eighth grade students from a Mid-Atlantic middle school	Adapted alternating treatment design	75% of students increased comprehension accuracy and rate
Wood, S., Moxley, J., Tighe, E., Wagner, R.	Meta- Analysis	High school students	Adapted alternating treatment design	Text-to-speech/read- aloud presentation positively affects reading comprehension for individuals with reading disabilities, with average weighted effect sizes of $d = .35$ ($p < .001$).
Gonzales, M.	Quantitative	23 (13 third graders & 10 fourth graders)	Single Subject A- B-A-B withdrawal research design	Benefits: decrease burden of decoding, provide scaffolding for support, reduces reader's working memory
Mosito, C., Warnick, A., Esambe, E.	Qualitative	35 learners from 5 intermediate phase classes (grades 4-6) of the school	Action research intervention	Increased reading fluency and increased student motivation
Nordstrom, T., Nilsson, S.,	Quantitative & Qualitative	38 fourth grade students, 13 grade 8 students, 8	Explorative Study	Teachers' perceptions of using AT for reading was above 75% for all

Gustafson, S, Svensson, I.		high school students		
Meyer, N., Bouck, E.	Quantitative	3 seventh and eighth grade students	Multiple baseline Design	Students' comprehension did not improve, however student's perceived taking less time and were less frustrated

Chapter 3: Conclusions and Recommendations

This literature review examined the effects of using text-to-speech software on reading comprehension for students with learning disabilities. Chapter 1 started by addressing the importance of this topic by revealing disappointing statistics related to current reading performance of students with learning disabilities. It also discussed the laws that govern the acquisition and provision of assistive technology for students with disabilities. Historical information regarding Assistive technology and Accessible Educational Materials was discussed. This chapter also introduced an important assistive technology tool, text-to-speech software, and its potential benefit for students with disabilities. The historical perspective of the advancement of this technological tool was also discussed. Chapter 2 was a review of 11 research articles on subjects of using assistive technology, specifically text-to-speech for students with learning disabilities. Eight of these articles pertain to research question number 1 and three of them pertain to research on question number 2. Chapter 3 presents conclusions, recommendations for future research, and limitations.

Conclusions

I reviewed 11 studies that examined the impact of using text-to-speech software on reading comprehension for students with learning disabilities. 7 of these studies yielded positive

impacts on reading comprehension and 4 of these studies revealed other benefits of using text-to-speech software in regard to reading performance.

Park et al., Moorman et al., Young et al., Schmitt et al., & Wood et al. each had similar results. Although all these studies varied in the length of the intervention, number of participants, and age/grade of participants, they all had a positive effect on student reading comprehension based on the intervention. These studies were similar in design where participants were allowed to use text-to-speech for reading passages followed by comprehension assessments. All the studies used some type of pre and post-test to determine a baseline for each student's reading comprehension performance, however not all studies used the same assessment method. Park et al. used the GMRT 7/9 vocabulary and comprehension subtests for pre and posttest interventions. Moorman et al. utilized passages from the *Read Please* software for pre and post-test assessments. Young et al. utilized the Scholastic Reading Inventory (SRI) and Curriculum Based Assessments (CBAs) pre and posttest. Schmitt et al. utilized Aims Web curriculum-based assessments. Svensson et al. utilized 'LéaSt nonword reading and 'LéaSt sight-word reading assessments. Brunow and Cullen utilized reading passages from the novel, *To Kill a Mockingbird* for pre-test and post-test assessments.

Svensson et al. and Brunow and Cullen also had similar results. These studies did not show a significant improvement in reading comprehension with the use of text-to-speech software for students with disabilities. Svensson's study showed that fourth grade students made gains in all areas except reading comprehension. Students in grades 8 and high school made gains in all areas, however the results were not significant. Brunow and Cullen's study compared the results of a human reader with text-to-speech without isolating the effects of either intervention on independent reading, so the results were not relevant to the research question. It

is important to note that all students in this study showed greater gains with a human reader than with text-to speech.

The next four studies (Gonzales, 2014; Mosito et al., 2017; Nordstrom et al., 2019; Meyer & Bouck, 2014) revealed other perceived benefits to using text-to-speech software for students with disabilities. These results were often obtained with teacher and student interviews and represent qualitative data. Providing scaffolding and support, taking less time, decreased burden of decoding, reducing reader's working memory, and increased student motivation was reported throughout these studies by teachers. Students reported benefits such as reading using text-to-speech took less time, increased motivation, and increased independence.

Overall, the results of most of these studies indicate a positive relationship between reading comprehension with the use of text-to-speech. In addition, these studies also show other perceived benefits by both teachers and students. "By the end of grade 10, students are expected to read and comprehend grade-level social studies and science texts proficiently and independently" (Park et al., 2017, p. 151). Given this expectation, it is important that we continue to research and find effective accommodations to support reading comprehension for students with disabilities in our schools.

Recommendations for Future Research

Throughout the studies, several limitations were addressed. One common theme was the sample size. Many of the studies involved a small group of participants which may make it difficult to generalize the results to a larger population of students. Another common limitation is the spread of studies across grade levels. This may contribute to varying results based on the grade level of the students. Further research may include using one grade level with multiple participants.

Another limitation may be attributed to the fact that participation in the study was voluntary. Therefore, the participants who chose to participate may only represent a small portion of students in that school, grade, age. Also, teacher participation was voluntary. The level of technology expertise and comfort level may also have an impact on the results of the studies. Students participating in the studies had more access to technology, which may in turn lead to higher engagement due to the novelty of using the computer for reading versus traditional reading.

Many of the studies indicated that the study could be expanded to include other groups of students rather than just students with reading disabilities. Future research could be expanded to include students with average reading abilities or English Language Learners. Many of the sample sizes were also limited to a specific race. Future research could include more diverse groups of students.

Another limitation was due to the function of the technology. Some of the text-to-speech software mispronounced words and sentences or made errors. This led to frustration amongst the participants and could contribute to the results. Future studies could include the use of commercial, research-based instruments rather than free versions of software.

Some of the studies indicated that the timeline of the study or the time within the school year may be a limitation. For example, some of the studies occurred during the beginning of a semester when classroom routines and expectations have not yet been established. Other studies took place over a period of 10 days, however those 10 days may have spanned over long weekends and holiday breaks and therefore impacting the results.

The types of questions used to measure reading comprehension may be a limitation as well. For example, one of the studies used a six-question multiple-choice quiz. This offers

limitations in the options that students must demonstrate knowledge. Future research may include more re-tells or open-ended questions.

Finally, the classroom environment and relationship between teachers and students could impact the results of the studies. Many of the participants were in self-contained or small group classrooms with special education teachers who know them well. These classrooms often have more individualized support that may contribute to the success of the intervention and make it difficult to isolate the impact of the intervention versus the availability of support in that classroom.

Implications for Practice

In my current role, I work as a Teacher on Special Assignment/Technology Integrationist. One of my responsibilities in this role is to help staff identify appropriate accommodations and modifications for students with disabilities on an IEP or 504 plan. I want to make sure that I am recommending accommodations that are research-based and show positive outcomes for students who struggle with reading and writing. That said, the results of most of the research articles that I reviewed show a positive effect on reading comprehension as well as other functions of reading. I will continue to recommend the usage of text-to-speech for students with reading disabilities.

In my recommendations for staff, the limitations of the study will help remind me that there may be other considerations to think about when recommending accommodations. I still need to consider the students' perceptions of using assistive technology, the student's willingness to learn how to use the technology appropriately, the availability of staff to help support and train students on the usage of technology. I also need to take into consideration the technological

skills of the staff I am working with. Educating the staff is just as important as the students. They are with the students daily and know their strengths and weaknesses.

In today's classroom, there are financial constraints, staffing shortages, and other environmental concerns that can impact a student's success in the classroom. Providing assistive technology tools can often help students be more independent, confident, and successful in accessing the core curriculum. Professional development for teachers is crucial so they understand how to consider, acquire, and implement appropriate assistive technology support for their students. My current position allows me the opportunity to coach teachers, families, and students so they can use these tools effectively to reach their goals and achieve success in the classroom and beyond.

Summary

The findings in these studies varied in measurement tools, participants, length of study, and types of research. However, most of the studies revealed positive impacts on the usage of text-to-speech on reading comprehension for students with disabilities. In addition, other perceived benefits were also discovered including student motivation, independence, speed, and stamina. Ultimately, the use of text-to-speech can help students feel more successful in their mainstream courses and lead to higher comprehension rates. The use of text-to-speech is one accommodation that may help students who struggle with reading grade level text. It is not a replacement for explicit research-based reading instruction.

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