Text-to-Speech Software and Reading Comprehension: The Impact for Students with Learning Disabilities

Logiciel de synthèse vocale et compréhension de la lecture : l'impact pour les étudiants avec des troubles d'apprentissage

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Abstract

This literature review examines the use of text-to-speech (TTS) software as an accommodation for students with learning disabilities and its impact on improving reading comprehension. As the development and availability of TTS tools and assistive technologies have increased over the past decade, it is significant to explore how they are used to accommodate students at all levels of education to promote a universal design of learning. Based on a review of the current literature and utilizing self-regulated learning theory as a framework, four significant themes have emerged: (a) TTS being seen as a compensatory tool; (b) improving reading abilities and comprehension; (c) increasing student motivation and self-efficacy; and (d) the need for training for students, educators, and parents. Findings of this literature review revealed that overall, TTS software is commonly used as a compensatory tool (mainly at the postsecondary level), has assisted in students improving reading speed, fluency, and content retention, resulted in increased student self-efficacy in reading abilities and independent learning, and that there is a significant need to allocate training and technological resources to support students. As there are various directions for future research, exploring this area can contribute to schools promoting inclusive and accommodating learning environments.

Keywords: text-to-speech; assistive technologies; learning disabilities; reading comprehension; universal design for learning

Résume

Cette revue de la littérature examine l'utilisation des logiciels de synthèse vocale (TTS, par ses sigles en anglais) comme mesure d'accommodement pour les étudiants ayant des troubles d'apprentissage et son impact sur l'amélioration de la compréhension de lecture. Alors que le

développement et la disponibilité des outils TTS et des technologies d'assistance ont augmenté au cours de la dernière décennie, il est important d'explorer comment ils sont utilisés pour accommoder les étudiants de tous les niveaux de l'éducation afin de promouvoir une conception universelle de l'apprentissage. À partir d'une analyse de la littérature actuelle et de l'utilisation de la théorie de l'apprentissage autorégulé comme cadre de référence, quatre thèmes importants ont émergé: a) le TTS étant considéré comme un outil compensatoire; b) amélioration des capacités de lecture et de compréhension; c) accroissement de la motivation et de l'auto-efficacité des étudiants; et d) le besoin d'une formation pour les étudiants, les éducateurs et les parents. Les résultats de cette revue de la littérature ont révélé que, dans l'ensemble, le logiciel TTS est couramment utilisé comme outil compensatoire (principalement au niveau postsecondaire), a aidé les étudiants à améliorer la vitesse de lecture, la fluidité et la rétention du contenu, a entraîné une augmentation de l'auto-efficacité des étudiants dans les capacités de lecture et l'apprentissage indépendant, et qu'il existe un besoin important d'allouer des ressources de formation et technologiques pour soutenir les étudiants. Comme il existe diverses orientations pour la recherche future, l'exploration de ce sujet peut contribuer à ce que les écoles favorisent des environnements d'apprentissage inclusifs et accommodants.

Mots-clés : synthèse vocale ; technologies d'assistance ; troubles d'apprentissage ; compréhension de lecture ; conception universelle de l'apprentissage

Introduction

Across education there is an aim to ensure that all students succeed academically and experience learning within an accessible and inclusive environment. Promoting inclusive education involves setting and supporting high standards for all students, including students with disabilities (Katz, 2013). Working within this environment can help students reach their learning goals as they move through different levels of schooling. One way in which schools and educational institutions can make learning accessible is to adopt a universal design for learning (UDL), which constitutes of a flexible and supportive instructional design for all learners, including those with learning disabilities, that is based on neuroscience and interpreted from an education perspective. This framework ensures that instructional goals, assessments, methods, and materials are usable and accessible by all (Hall et al., 2015). The main learning goals remain the same for all students, but the focus is on diversifying the ways that students learn and eventually reach these goals (Katz & Sokal, 2016). By implementing this framework into different areas such as lesson plans, assignments, and assessments, students can learn within an accessible environment that is accommodating to their learning needs.

Part of applying UDL is providing students with appropriate classroom and academic accommodations that can range from receiving extra time on assessments, extensions to complete class assignments, and accessing different forms of assistive technologies. As defined by the Individuals with Disabilities Education Act (IDEA), assistive technologies are "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain or improve functional capabilities of a child with a disability" (U.S. Department of Education, 2019, IDEA Section 1401A). Some forms of assistive technologies include the use of word

processors, dictionaries, notetaking recorders, and different computer software such as text-to-speech (TTS). Due to the greater availability of computers and technological advancements over time, options for assistive technologies have proliferated in recent years (Perelmutter et al., 2017). In order for schools and educators to keep up with these changes, there is a need for increased research and training in assistive technology (Davis et al., 2013). With these increased options available, students can access a wider range of accommodations to best support their specific learning needs.

The incorporation of different forms of assistive technologies, such as TTS software, can impact how students with learning disabilities acquire, learn, and apply new knowledge. Text-to-speech software provides synthesized speech for a computer or other electronic device to read out the text for users experiencing reading difficulties (Perelmutter et al., 2017). As approximately 80% of students with learning disabilities exhibit difficulties in the area of reading (Cortiella & Horowitz, 2014), there is an essential need for using assistive technologies to support reading comprehension. As students with a reading disability often demonstrate considerable difficulty with accurate decoding and reading fluency, presenting reading material orally can remove the need to decode and potentially help students better comprehend written texts (Wood et al., 2018). Examining the use of TTS software to accommodate students can help to determine if TTS software is an appropriate accommodation to support reading comprehension. Using the framework of Barry Zimmerman's (1986) self-regulated learning theory, the current literature was reviewed to explore the question: What is the impact of text-to-speech software on supporting reading comprehension for students with learning disabilities?

Overview of Learning Disabilities and TTS Software

When researching the use of TTS software, it is important to first explore and define what learning disabilities are to be able to accurately assess its impact. In general, learning disabilities can be defined as:

> [A] variety of disorders that affect the acquisition, retention, understanding, organisation or use of verbal and/or non-verbal information. These disorders result from impairments in one or more psychological processes related to learning, in combination with otherwise average abilities essential for thinking and reasoning (Learning Disabilities Association of Ontario, 2015, Definition of Learning Disabilities section).

Learning disabilities can affect students within the classroom in different areas related to phonological processing, working memory, processing speed, language processing, visual-spatial processing, executive functions, and visual-motor processing (Learning Disabilities Association of Ontario, 2015). The implementation of TTS software is used to help students who may be experiencing a deficit in one or more of these areas. As students with learning disabilities are the highest group of students (approximately 35%) receiving special education services (Young et al., 2019), it is important to understand how assistive technologies support their learning needs.

The main function of TTS software according to Parr (2012) is to transform print texts of varying formats, such as books, magazines, newspapers, and websites so that they can be read aloud by

a computer-synthesized voice. This differs from a student having an accommodation that involves someone reading out loud to them with different tones and expressions. When using TTS software, students need to bring their own reading strategies to experience the text with the appropriate expression and intonation to make meaning (Parr, 2012). Features within TTS programs allow students to choose the options that best suit their learning needs. These features include different voices, reading rate, document tagging (which affects reading order), dynamic highlighting, translation, dictionaries, and the ability to create notes (Wood et al., 2018).

Some examples of commonly used forms of TTS software are Microsoft Word (Meyer & Bouck, 2014), Kurzweil3000 (Parr, 2012), Google Read&Write (Wood et al., 2018), and NaturalReader (Floyd & Judge, 2012). The availability and use of free or for-purchase TTS software has continued to increase over the past decade due to wide-spread technological advancements (Davis et al., 2013). Software that requires a paid license or subscription may include more advanced features. The increase in the types of TTS software also indicates an increase in accessibility as students can utilize it on different technological devices such as computers, smart phones, and tablets.

One of the main purposes of TTS software is that it decodes for the reader, which reduces the amount of attentional capacity needed to the individual letters and sounds, remembering the sounds, putting them together, and then comprehending the words and sentences (Parr, 2012). As previously noted, the struggle to decode text is a primary difficulty experienced by students with learning disabilities (Wood et al., 2015). To address this, TTS software may be used in different ways to support students' reading comprehension based on students' level of education. Floyd and Judge (2012) detailed how in elementary and secondary school settings, the focus is on accommodating and supporting students to better access learning materials, increase their engagement, and help them demonstrate their knowledge and understanding of the curriculum. Alternatively, at the postsecondary level, the focus is on providing reasonable accommodations during assessment. Whereas elementary-level students may use TTS software directly within the classroom to engage with the text and participate in reading-based activities, postsecondary students may only utilize TTS software outside of the classroom and during assessments.

What makes this review unique beyond other studies is that it explores the impact of TTS software on reading comprehension in addition to other external factors that are influential, such as the students' learning environment, self-efficacy, and how the technology is used by students, teachers, and parents.

Methodology

In order to accurately address and answer the guiding research question, relevant articles were selected based on specific inclusion and exclusion criteria that were defined prior to the search. Articles were located through Google Scholar, ERIC, Psych Info, and Omni Academic Search Tool which searches various databases such as EBSCO, ProQuest, Scholars Portal, JSTOR, and Oxford University Press. All combinations of the following terms were used to try to yield the most relevant results: 'text-

to-speech technology', 'text-to-speech AND learning disabilities', 'learning disabilities AND assistive technologies', 'text-to-speech AND reading comprehension'.

As the number of studies using TTS tools is increasing, especially within the past 10 years, this can be viewed as a reflection of the trend of wider access to improved TTS technology (Wood et al., 2018). Only articles published within the past 10 years were included in this review as the available technology prior to this period may not have served the same purposes or included the main features of TTS software. Only articles published within North America were included in this review as there is an aim to look at the specific use of TTS software at different levels of education which may not be standard across different geographical regions. As there are various forms of assistive technologies available within classrooms, the scope of this literature review was to specifically focus on TTS tools. Taking this into consideration, articles focusing on the impact of assistive technologies in general on students with learning disabilities were also included. Finally, articles with participants from elementary, secondary, and postsecondary levels of education were included to investigate if there are different uses and aims of the technology. After applying the specific inclusion and exclusion above, 11 peer-reviewed articles were selected for this literature review. The four themes detailed in this literature review were identified and coded as either being focused on the student, environment, or behaviour based on the theoretical framework outlined below.

Theoretical Framework: Self-Regulated Learning Theory

Many concepts presented within Zimmerman's (1986) self-regulated learning theory are relevant to the area of assistive technologies, particularly TTS software. Applying self-regulated learning theory provides a theoretical background to apply the significant themes that have been identified throughout the relevant literature in this area. Through the lens of self-regulated learning, students are viewed as metacognitively (planning, organizing, self-monitoring/evaluating, etc.), motivationally (perceiving oneself as competent), and behaviourally (selecting, structuring, and creating environments that optimize learning) active participants in their learning process. Each of these three domains can be connected to the area of TTS software and its impact on supporting reading comprehension. Metacognitively, students who use TTS software can be self-monitoring their learning as they progress through a text or complete an assessment. Students can work within the TTS software to organize their thoughts and learning through making notes and highlighting text. Motivationally, if students develop a higher sense of self-efficacy, their confidence and comfort with using the software could possibly impact reading comprehension. Behaviourally, students use TTS software as an accommodation to optimize and help structure their learning environment.

In order to attain their learning goals, students who are self-regulated learners self-generate different thoughts, feelings, and actions (Zimmerman & Schunk, 2001). According to Zimmerman (1989), the interactions of the person, environment, and behaviour can lead to the idea that "self-regulated learning occurs to the degree that a student can use personal (i.e., self-) processes to strategically regulate the behaviour and the immediate learning environment" (p. 330). Also, learners need to possess and/or develop supportive motivational beliefs in order to set challenging goals for

themselves and sustain self-regulatory efforts to achieve them (Zimmerman & Kitsantas, 2014). It is essential to consider the influence of and response to the students' physical environment in which they are using the software to help determine their development of self-regulated learning. As one of the principles of the UDL framework is to provide multiple means of representation (anticipating any physical, perceptual, and cognitive barriers that might interfere with student learning in advance) (Hall et al., 2015), exploring self-regulated learning theory can possibly help in the implementation of the framework.

Zimmerman's (2002) work also details the structure and function of self-regulatory processes in terms of three cyclical phases which include the forethought phase (task analysis and self-motivation beliefs), the performance phase (self-control and self-observation), and the self-reflection phase (self-judgement and self-reaction). As students use TTS software, they move through these three phases by self-regulating their actions, performance, and levels of self-efficacy. These all can contribute to the extent that a student is functioning as a self-regulated learner. As part of the learning environment, the TTS software can influence the student's strategic planning and confidence in their abilities.

Themes from the Literature

After reviewing the selected studies, four main themes emerged throughout the literature including: (a) its use as a compensatory tool; (b) improved reading abilities; (c) increased student motivation and self-efficacy; and (d) the need for training students, educators, and parents (Table 1).

Table 1

Selected Literature by Theme

Theme	Authors (year of publication)
TTS software as a compensatory tool	Floyd & Judge. (2012) Parr. (2012) Silvestri et al. (2021) Wood et al. (2018) Young et al. (2019)
Improved reading abilities	Floyd & Judge. (2012) Meyer & Bouck. (2014 Parr. (2012) Perelmutter et al. (2017) Stodden et al. (2012) Young et al. (2019)
Increased student motivation and self-efficacy	Brunow & Cullen. (2021) Parr. (2012) Young et al. (2019)

Theme	Authors (year of publication)
Training for students, educators, and parents	Davis et al. (2013)
	Perelmutter et al. (2017)
	Silvestri et al. (2021)
	Simmons & Carpenter. (2010)
	Young et al. (2019)

Text-to-Speech Software as a Compensatory Tool

A prominent theme throughout the literature is the concept that TTS software is seen, and primarily used, as a compensatory tool. When determining the impact and effectiveness of an assistive technology accommodation, such as TTS software, it is important to examine if the tool is compensating for a deficit or is an intervention for the long-term improvement of reading skills. Wood et al.'s (2018) meta-analysis examined the use of TTS and read-aloud tools for students with reading disabilities and emphasized how TTS and read-aloud tools can be used in both compensatory and intervention settings, though using it as an intervention is theoretically and practically different. For example, if a student is using TTS software as an exam accommodation, the tool here is compensatory as it assists the student in decoding and comprehending questions so that the student can provide assessment responses. Alternatively, if a student was using TTS software to read a text that contributes to the development of reading skills, the tool can be seen as an intervention where the student progresses over time. By having the ability to alter texts and self-monitor learning and progress by participating metacognitively (Zimmerman, 1986), TTS can also be used as a tool for intervention. Although the results of this meta-analysis may not be generalizable as it was noted that 22 studies were included, and the intensities of diverse TTS interventions were unable to be measured, there is mention of the need for more research to examine its effectiveness.

Young et al.'s (2019) quantitative study examined the effects of TTS on reading outcomes for students with learning disabilities at the secondary school level. Due to the small sample size of four students at the secondary level (three completing the study), results of this study may not be generalizable to the overall student population. The authors discussed how assistive technologies in general are used as compensatory tools that permit people to complete tasks that they would be unable to perform at the expected level without them. The sample for this specific study was ninth-grade students with learning disabilities; results showed that there was a functional relationship between the use of TTS and reading comprehension. Changes in the students' reading instruction (i.e., the use of TTS software) resulted in improvements to their reading comprehension. Oral reading fluency and speed increased for all participants as a result of using the TTS software. Of note was the finding that after consistent use of TTS, students eventually read and comprehended the material without the accommodation of the software. This suggests that although TTS is commonly referred to as a compensatory tool where teachers are able to work around a reading difficulty and remove the barrier of access, it can also be viewed as a remediation tool.

In an ethnographic study on the future of TTS technology, Parr (2012) discussed how TTS tools may "assist or segment task performance in some reading tasks, whereas in others they are used to compensate for, circumvent, or 'bypass' (not remediate) reading deficits (e.g., phonemic and phonic awareness)" (p. 1420). As data were collected through various forms such as participant observation, interviews, archival documents, photographs, and conversations, results may not be generalizable to students at different levels of education outside of this research setting. The study does contribute to the concept of TTS tools being used as a compensatory tool. Through bypassing, TTS technology is seen more as a compensatory tool because reading deficits are not being directly targeted for improvement but are instead being compensated for in that instance. Based on the results of the study, Parr (2012) stated that by discussing assistive technologies as compensatory supports, interventions, or bypass strategies, there is an assumption that there is a correct and proper way for students to read and access print. Challenging these uniform reading processes and strategies can help researchers and educators promote a UDL framework.

Results from Silvestri et al.'s (2021) quantitative study on the interaction of cognitive profiles and TTS software on reading comprehension of adolescents revealed that participants classified with more severe decoding deficits, in comparison to those with marginal deficits, benefitted more from the use of TTS software. The software was seen to compensate for word decoding without a redundancy effect with participant word decoding. It was also found that using TTS software alone is not enough to foster high-level text processing as there needs to be a combination of adequate knowledge of the text, text comprehension strategies, and word decoding skills that the TTS software enables. As the study included a sample size of 94 eighth-grade students, the results are generalizable to only upper elementary school students who are struggling with reading (Silvestri et al., 2021), which was noted as a limitation. This study highlights how the use of TTS software needs to be used in combination with various reading strategies and instruction.

As previously noted, the use and aims of TTS software can vary based on the level of education within which it is being implemented. Whereas there is a focus on developing and improving reading skills and comprehension at the elementary level, within postsecondary settings, TTS software is commonly used during assessments in a compensatory manner. Floyd and Judge's (2012) mixed-methods study on the efficacy of assistive technology on reading comprehension focused specifically on postsecondary students with learning disabilities. Results from the study showed an overall improvement in students' proofreading skills by demonstrating an increase in identification of errors when using TTS. By improving proofreading skills, the use of TTS software within this instance is intervention-based as the ability to identify errors can be a determinant of overall comprehension. Floyd and Judge detailed that overall, assistive technologies can be a viable support when completing reading comprehension tasks for students with learning disabilities at the postsecondary level. Noted as one of the limitations of this study, the ability to generalize the findings to a larger population can be due to the specific deficits and learner characteristics of the participants (Floyd & Judge, 2012). As most studies of TTS software have occurred at the elementary and secondary levels, more research is needed within postsecondary settings (Meyer & Bouck, 2014). Such research may lend support to

changing current practices of using TTS software solely as a compensatory support, and restructuring it as an intervention tool.

Overall, the theme of TTS software being viewed as a compensatory support is evident throughout the literature, but there are many emerging ideas indicating a possible shift to intervention. The need for more focus on TTS technology being used as an intervention is needed throughout each grade level as students learn and apply more complex reading strategies while they progress through their education. The degree to which it is used as an intervention may vary based on different factors such as the extent of teacher assistance to use the technology, the types of reading tasks or assessments, and the ability of the TTS software to track progress. TTS software being used and considered as a compensatory support aligns with concepts presented within self-regulated learning theory. As previously noted, the performance phase is one of three phases that structure self-regulatory learning processes and contains the two major classes of self-control and self-observation (Zimmerman, 2002). Within the class of self-control, students utilize aspects such as imagery and task strategies to facilitate learning. TTS software can be seen as aiding these processes as students can use different features within the software such as annotating, highlighting, and adjusting reading speed to help progress reading comprehension. Within the class of self-observation, students self-record and self-experiment to track their personal progress. The use of TTS software aids this process in allowing the student to independently work with the text. Whether the software is being used for the purpose of intervention or as a compensatory tool, processes within self-regulated learning theory highlight how the technology can be a significant influence in students developing into self-regulated learners.

Improved Reading Abilities

A second theme that is evident throughout the literature is that the use of TTS software can contribute to students' improved reading abilities including comprehension, reading speed, and fluency. Though the results of many studies have shown overall improvements in reading comprehension as a result of TTS accommodations, the baseline or preliminary reading skill levels of participants may have impacted the results. Sampling for these studies is important to consider as not all students have the same baseline reading skills prior to participating in the study. Similarly, Perelmutter et al. (2017) argued that reading comprehension measures should be included with outcome measures and the extent of improvements should then be correlated with baseline performances. As students with the most severe reading challenges have typically tended to make the most gains in comprehension when using TTS (Meyer & Bouck, 2014), assessing students at differing levels may reveal new insights into the impact of the technology.

Young et al.'s (2019) study on the effects of TTS on reading abilities for secondary students found an increase in comprehension of print material when using TTS and students reported that they remembered more information about the text after using the accommodation. Also, students with the lowest baseline comprehension scores showed the most improvement while using TTS software and maintained this improvement. This retention can translate into increased comprehension as students are able to show their understanding of the content. Young et al. noted that by alleviating the effort needed

to decode written text, students using TTS software can put more efforts into comprehension, which can lead to improved retention.

Parr (2012) examined the future of TTS technology in relation to reading instruction. They discussed how TTS software is not doing the work for students but rather it builds upon traditional reading strategies, such as word solving, expression, and fluency allowing for more advanced reading strategies including metacognitive strategies, student dialogue, and reader response. Results of the study indicated that the TTS software allowed students to activate metacognitive strategies before beginning a reading as they were able to choose the voice type and reading speed. During their second reading, interruptions to students' metacognitive processing and comprehension were prevented because they were able to utilize features such as pausing the reading to make connections. This suggests that providing students the opportunity and environment to access different metacognitive strategies can lead to improved reading skills and comprehension as a result of using TTS tools.

When focusing on the effectiveness of TTS software on reading comprehension for postsecondary students with learning disabilities, the results of Floyd and Judge's (2012) study showed that all participants, regardless of their reading ability, performed at a higher skill level when using TTS. Participants were better able to display their comprehension abilities with TTS as opposed to without it and were better able to recall information. This finding is consistent across studies and suggests that TTS improves students' memory and retention of content. Meyer and Bouck (2014) explored the impact of TTS on reading for adolescents with learning disabilities and found that there were no major improvements in actual reading fluency, comprehension, or task completion time. Although this result does not support the use of TTS as an intervention, all of the students believed that they read more fluently, comprehended more of the learning material, and overall spent less time on the reading task when using the TTS technology. As previously noted, TTS software removes the need for students to decode written text, so this can possibly remove some of the frustration that may arise when having trouble reading a text.

In Stodden et al.'s (2012) study of TTS software with secondary school students, they found that by eliminating the need for decoding, the TTS software provided students an opportunity to focus on the content, which lead to enhanced comprehension. The students' level of reading and vocabulary scores also significantly increased. Further, by being able to adjust the speed at which the software reads aloud the text, students customized their reading experience and learned at a pace that best supports their individual learning needs. The TTS software helped students learn the accurate and correct pronunciation of terms. Overall, the results of this study indicated increased comprehension and reading speed as a result of using the TTS software.

When reviewing the impact of TTS software on improving students' reading comprehension, the literature has revealed that overall, there are improvements as a result of using the software. As self-regulated learning theory refers to students as metacognitively active participants in their own learning process (Zimmerman, 1986), the use and effectiveness of TTS software is relevant as students use the technology to aid their learning. When students move through the forethought, performance, and self-reflection phases, they are tapping into a wide variety of strategies in order to progress to the next phase.

Common within the framework of self-regulated learning theory is the feature of the 'self-oriented feedback loop' which is a cyclical process in which students monitor the effectiveness of their learning strategies and respond to this feedback in different ways such as changing behaviours and/or replacing learning strategies (Zimmerman & Schunk, 2001). Some of these learning strategies can include environmental structuring, seeking information, goal setting and planning, keeping records and monitoring (Zimmerman, 1989), and can all be applied in some format while using TTS software. Notable aspects within the above studies included students increasing their reading speed, maintaining progress after using the software, increased memory/retention of content, alleviated frustration, and the ability to tap into metacognitive strategies. By using various self-regulated learning strategies and going through the 'feedback loop', students use the technology to help aid their strategies and make adjustments as needed in order to promote increased reading comprehension.

Increased Student Motivation and Self-Efficacy

A third theme that emerged was the use of TTS software to promote increased student motivation and self-efficacy. By playing a role in alleviating some of the frustration of decoding and by allowing more room for comprehension, TTS software can contribute to students' self-confidence and self-efficacy as a reader (Parr, 2012). With the removal of this frustration, students are working within an environment that can result in more engagement and confidence in their reading abilities. Positive impacts within these areas can also possibly lead to improved levels of reading comprehension for students with learning disabilities. According to Young et al. (2019), students who use TTS understand the text better, achieve at a higher rate, and are more likely to be engaged in their learning. When focusing on student engagement with reading, it is important to consider the student's current level of reading skills. If a student struggles with aspects of reading, such as comprehension and decoding, they may have low self-efficacy or not feel motivated to engage with the text. Disengaging from the act of reading at the elementary level can have an impact on students' progress as they are initially developing reading skills and strategies.

Parr (2012) noted that it is important to "prevent the vicious cycle of withdrawal from text, lower levels of motivation, lack of confidence, and inaccessible curricula, particularly in higher grades where there is a greater emphasis on accessing content through print text" (p. 1421). This is especially important at the secondary and postsecondary level where students need to read and complete course requirements independently and outside the classroom. Parr also claimed that when students are involved and engaged in decision-making regarding TTS tools, the technology becomes a support for self-efficacy and self-advocacy. By having the chance to utilize different features within the TTS software and customize it to their learning, students can gain more independence in their learning process. When educators use TTS software as part of a comprehensive approach to instruction, it decreases the need for human supports and increases independence, self-confidence, motivation, and accessibility of grade-level curriculum. By providing the accommodation of TTS software for students with learning disabilities, this can provide differentiation in learning, increase students' independence, and motivate students to read (Meyer & Bouck, 2014). A student's overall attitude and feelings towards reading is important in maintaining engagement, and seeing positive results with the TTS software can lead to increased confidence.

It is also important to consider the impact of the use of TTS software within a students' social environment. Students who use TTS tools, or any type of assistive technology, may be subject to stigmatization. A student with a TTS accommodation may be viewed negatively by their peers as they may not fully understand the purpose and need for different accommodations to support a disability. There may be the perception by classmates that a student using TTS tools is at an advantage in completing assignments and assessments compared to the rest of the class, or that they are privileged or cheating, and this can result in the student being stigmatized (Parr, 2012). Using TTS software during lessons or assessments typically requires the student to wear headphones. Wearing headphones has the potential to change the natural class dialogue that occurs around reading books, such as through reading circles, and collaborative activities centred around the text (Parr, 2012). Taking part in reading-based activities with classmates can help students engage more with the text, develop interest in the content, and gain new insights. With the use of a TTS software, this may potentially isolate the student from peer activities and impact class participation when wearing headphones. Through the above details, the impact of using TTS software on students' social environment, the increased use of online learning, and assessments may potentially reduce this impact.

In applying self-regulated learning theory to the above, we see how students' initial levels of self-efficacy within the forethought phase impacts self-regulated learning strategies and performance in the subsequent phases (Zimmerman, 2002). Low self-efficacy within the forethought phase can potentially impact performance and self-reflection after completing a reading task. High levels of self-efficacy can be seen to promote the use of effective strategies to become a self-regulated learner. In reference to the feedback loop, students' use of learning strategies and self-monitoring have been found to be related to students' self-efficacy perceptions, where higher self-efficacy is linked with the use of better-quality learning strategies (Zimmerman, 1989). As noted above, TTS software provides students with levels of autonomy and independence in their learning, which can contribute to feelings of self-efficacy. This autonomy can possibly provide students with an environment in which they can utilize effective learning strategies in order to improve reading comprehension skills. Self-regulation theory also considers the whole learning process in terms of motivation and helps students arrive at why they are completing a task in a purposeful role (Luo et al., 2021). Overall, the literature reveals that the use of TTS software as an accommodation can positively impact students' motivation, self-efficacy, and engagement with reading. In terms of possible stigmatization from using TTS tools, the increased opportunity to use TTS software across different technological devices and in environments outside the classroom can lead to decreased stigma for students with learning disabilities in both academic and real-world situations (Brunow & Cullen, 2021). The use of the technology can provide students with an environment in which they can become more independent in their learning and have an active role in customizing their learning experience.

Training for Students, Educators, and Parents

The final theme is the need for students, educators, and parents to receive training in TTS software and assistive technologies. Though students may have greater access to different forms of TTS software through the use of mobile devices and laptops, schools have existing initiatives and technology access gaps (Brunow & Cullen, 2021). Effective communication and collaboration between

school administrators, parents, teachers, and students regarding the selection and use of TTS software is essential to students' success at school (Parr, 2012). Challenging the notion that there is one standard way of teaching and learning helps promote a UDL framework within schools. By incorporating the use of assistive technologies as part of academic and classroom accommodations, students are shown that there are different approaches to learning the same content.

Perelmutter et al.'s (2017) study on assistive technology interventions for adolescents with learning disabilities highlighted the effectiveness of assistive technologies; however, the authors emphasized that they need to be specifically customized to the student using it, and consistent technical support needs to be available. Providing a student with the wrong form of assistive technology for their specific learning needs can be detrimental to their learning progress. This can possibly lead to students disengaging from the learning environment and not being appropriately accommodated. The study revealed that students had negative emotions connected to being frustrated with technological aspects and this resulted in altered perspectives of using the technology. It was also noted that some forms of assistive technologies can be harmful to students with learning disabilities, such as synchronous online course requirements that involve rapid reading and writing. This supports the idea that accommodations vary by student and there is not a standard form of assistive technology that can be used for all students with learning disabilities.

When focusing on which form of assistive technology is needed for a student, Simmons and Carpenter (2010) stated that it is the responsibility of the team that develops the student's individual education plan (IEP). The IEP team includes the student, parent, teachers, and additional educational administrators to help determine what academic and classroom accommodations are needed to best support the student. Failure to create an effective IEP, identify the appropriate assistive technologies required, and provide technological supports needed can result in assistive technology abandonment. Providing the necessary technological accommodations such as TTS software is essential, but it is just as significant to also provide sufficient training and resources to utilize the technology to its full capability. This training needs to be provided to everyone. For example, if the student will be utilizing the technology at home, parents require training in order to support the student while they are completing homework.

Similarly, Davis et al. (2013) emphasized that the decision-making responsibility about appropriate assistive technology must be shared among multiple individuals and that there are many factors that influence the selection of specific assistive technologies. In order to access and provide sufficient assistive technology devices, appropriate funding and resources need to be allocated towards schools and students with disabilities. Another factor to strongly consider when looking at the need for training is the impact of socioeconomic status on students' and schools' ability to access funding, devices, training, and necessary maintenance and supports. This study also noted a potential lack of expertise and training among members on the decision-making team and school professionals.

Young et al.'s (2019) study on the effects of TTS on reading for secondary students with learning disabilities found that although teachers see the benefit of assistive technology for students, the teachers did not often know how to effectively implement assistive technology in the classroom, and noted difficulties with obtaining devices for students. Even as TTS is becoming more accessible,

the use of it is not increasing overall throughout classrooms. As this study revealed that teachers perceived assistive technology to be used for a certain type of disability, this suggests that there is a lack of training about the purpose of these technologies and how accommodations are specifically designed for each student. The authors also noted the importance of students with learning disabilities learning how to use the technology to increase their acquisition of content and maximize understanding. Investing time and resources into training students on how to use the technology is vital. If students are not adequately trained, then they are not fully utilizing the software or properly learning the content. This is also significant based on the level of schooling. Students at the elementary level may need more support navigating technology whereas students at the secondary and postsecondary level may be able to troubleshoot or seek assistance on their own.

Silvestri et al.'s (2021) quantitative study on the interaction of cognitive profiles and TTS software on reading comprehension for adolescents found that teachers do not need extensive assistive technology training to support their students. Participants in the study learned and used only seven basic commands when using the Kurzweil software. Though there was an increase in level improvements of student reading comprehension, it is predicted that there can be even greater progress if teachers taught various reading strategies along with the use of the TTS software. Brunow and Cullen's (2021) quantitative study on TTS software and listening comprehension involved a teacher survey. Results revealed that even with the appropriate training, "TTS does not outweigh the need for an experienced teacher in the classroom to provide support and instruction to the students they serve" (p. 228). The current literature highlights the need for teacher training, but also emphasizes that TTS software does not substitute the need for instruction.

The learning environment in which students use the TTS software plays a significant role in self-regulated learning. A self-regulated learning perspective of students' learning and achievement has implications for the way teachers interact with students and the manner in which schools can be organized. There is a shift in focus from perceiving students' learning abilities and environments as fixed entities, towards students personally initiating processes and responses to improve their abilities and learning environment (Zimmerman, 1990). This notion also challenges the concept that there is a standard method of reading instruction and learning, thus promoting a UDL framework.

Directions for Future Research

After reviewing the literature and detailing the main themes, there are areas that can be identified as possible future directions for research. Though this paper is a literature review only, an avenue for future research could involve conducting a study with a qualitative or quantitative component to survey students regarding the use of TTS software. There is a clear lack of student voice in the existing literature. As such, qualitative research focusing on the experiences of students with learning disabilities and their use of TTS software is needed. By conducting qualitative interviews with students, researchers can gain deeper insight into students' thoughts and feelings towards using TTS tools as an accommodation. Interview responses could also help to better understand and address the possible social stigmatization that students can experience as a result of using TTS software. Further,

research into parent and educator perspectives and feelings towards assistive technologies, experiences with training, and how they perceive themselves to be supporting the student is also needed. It would also be beneficial to explore the possible barriers to accessing TTS software or assistive technology devices in general. Some of the barriers that could be examined include potential costs, allocation of school funding and resources, access to up-to-date technology, training opportunities, ongoing technical support, and device maintenance. These aspects would need to be considered alongside examining other factors, such as the socioeconomic status of the student population and school district.

Another area for further study is the investigation of different TTS software's ability to track reading skills to provide a clearer picture of changes in levels of reading comprehension. Wood et al. (2018) noted how some TTS programs such as Kurzweil 3000 can track and record user actions and that this data can be combined with students' type of disability and reading level to gain insight into how students are using the software. If program-generated data is found to be a viable source to further support students' learning with the software, then adequate training for educators is needed to obtain this data on a more regular basis. Overall, the above areas can provide potential directions to move forward within this area of study and identify strategies to better support students with learning disabilities.

Conclusion

Through the selection of relevant published studies and the identification of the four main themes (TTS software as a compensatory tool, improved reading abilities, increased student motivation, and self-efficacy and the need for training for students, educators, and parents), TTS software can be seen to have a positive impact on students with learning disabilities including increased motivation for reading and independence in learning (Meyer & Bouck, 2014). Through each presented theme, the role, use, and impact of TTS software is shown to vary based on the level of schooling. Being viewed as more compensatory at the postsecondary level and intervention-based at the elementary and secondary levels, the purposes and aims of TTS software can expand beyond preconceived notions of the accommodation and supports for students with learning disabilities. The literature also highlighted how TTS software can positively impact students' reading skills such as fluency, retention, and comprehension. By examining students' levels of motivation and self-efficacy, the impact of TTS tools on the student's social environment is also noted as a significant factor. Further, the need for training and technological resources is essential for the productive use of assistive technologies. The various works by Zimmerman (1986, 1989, 1990, 2001, 2002, 2014) on self-regulated learning emphasized how students are active participants in their learning and how the proper use of TTS software can aid students in becoming self-regulated learners within a UDL framework.

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