Original Research Article

Feature Level Impacts of TTS and STT on Literacy Outcomes in Students with Dyslexia

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ABSTRACT

This study examines how assistive technologies, specifically text-to-speech (TTS) and speech-to-text (STT), influence literacy outcomes in students with dyslexia. A sequential explanatory mixed methods design combined a systematic literature review with descriptive feature-level coding of published intervention studies and qualitative interviews with experienced educators. The quantitative phase coded 16 published studies involving elementary through high school students who used TTS, STT, or related assistive technology tools. Studies were analyzed by tool type, literacy outcome, intervention duration, major features, reported outcome direction, and other key metrics. The qualitative phase included semi-structured interviews with three teachers experienced in supporting students with reading disabilities, with responses coded for tool use, perceived benefits, implementation conditions, and barriers. Across the coded literature, TTS appeared most frequently and was commonly associated with improved reading comprehension and fluency while STT was more often linked to increased writing productivity and reduced spelling barriers. Features such as synchronized highlighting, pacing control, and error correction appeared repeatedly across studies reporting positive outcomes. The teacher interviews reflected similar patterns, with educators describing increased student confidence, stronger task completion, and improved access to grade level content when assistive technologies were implemented. Reported barriers include limited device access, inconsistent training, and concerns about overreliance on technology. These findings suggest that assistive technology can improve literacy access and performance when paired with targeted instruction and supportive implementation conditions.

Keywords: Assistive Technology (AT); Dyslexia; Text-to-Speech (TTS); Speech-to-Text (STT); Literacy Outcomes; Mixed Methods Research; Synchronized Highlighting; Multimodal Learning

INTRODUCTION

Dyslexia involves chronic issues with reading decoding, reading comprehension, and written expression that put students at a significant disadvantage when compared to their peers who experience success in traditional learning contexts. According to Wood *et al.* (1), these factors lead to limited reading volume and slow growth toward grade-level expectations. Structured remediation protocols, such as Orton-Gillingham, were designed to address reading difficulties. Technology serves as a compensatory approach that enables students to access and produce content more efficiently without directly remediating dyslexia. Text-to-speech (TTS) and speech-to-text (STT) are examples of this compensatory method of learning. These technologies improve two of the most time-consuming aspects of literacy, decoding

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and handwriting, allowing students to focus their cognitive resources on comprehension and written organization rather than the mechanics of reading and writing (2).

The possible benefits of these technologies have garnered the interest of researchers and school districts alike. Early studies by researchers such as Elkind, Cohen, and Murray (3) revealed that computer-based readers improved comprehension, while the work of Raskind and Higgins (4) showed that speech recognition increased writing productivity. Together, the studies showed that TTS and STT offered the possibility of improved educational outcomes otherwise blocked by the problems of decoding a text or transcribing your own record. However, while there is a general agreement that these forms of technology work, the bigger questions still remain: which specific features of TTS and STT technologies yield the most significant learning gains, and how do school infrastructure and administrative support systems facilitate the sustained, effective use of these tools?

The school and district context also complicates the understanding of these specific features. The tool's accessibility through devices, access to professional development (PD) time for teachers, and ease of login mechanism can determine whether the tool feels fully integrated or if it is somewhat disconnected and can go underutilized (5). Moreover, the speed of implementation can lag behind the field's understanding of the research, temporarily creating a gap between research knowledge of what is an effective practice, and the practice that is happening in classrooms. Thus, the purpose of this literature review is to analyze the TTS and STT tools with respect to the most important specific features or characteristics in the relevant literature that offer literacy and writing gains, specifically for students with dyslexia. Additionally, this literature review will examine the extent and impact of district infrastructure on sustainable outcomes and how it shapes tool characteristics. This study is among the first to isolate specific assistive technology features rather than treating TTS/STT as uniform interventions.

LITERATURE REVIEW

Cornerstone Works

Early research provided evidence to understand the implications of TTS and STT for learning. MacArthur (2) discussed a capture-revise approach in which students dictated with STT and then used TTS to read their text for revisions. This cycle recognized word prediction, error detection, and auditory feedback as necessary scaffolds. Elkind *et al.* (3) provided evidence that TTS facilitated comprehension in experimental situations, especially when the students controlled the features such as the color highlighting, the speed, and rewinding of the text. Their findings are enduring and relevant because almost all TTS platforms today utilize these same features.

Raskind and Higgins (4) explored STT in the context of spelling and word recognition when they shared that students with learning disabilities wrote down more words with higher accuracy when they needed to handwrite as opposed to dictating. This data suggested that dictation was not just a transcription tool but a productivity tool. Finally, Wood *et al.* (1) conducted a meta-analysis about the research over the past several decades, which showed that students' comprehension has improved across populations that used TTS. Wood *et al.* (1) also provided mean estimates for educators on the effect size to expect with using TTS. All of this foundational work encompassed the key idea that technology can serve as a compensatory vehicle for students who wish to access grade level information and communicate their ideas more easily.

Current Perspectives

In more recent research, the focus of the studies has evolved from evidence of efficacy to exploration of which features matter the most and in what context. For instance, Bonifacci *et al.* (6) showed that TTS is associated with reduced mind wandering that ultimately leads to greater comprehension when paired with synchronized highlighting and the ability to personalize the pace of TTS.

In writing, Levine *et al.* (7) found that students in high school wrote longer and more coherent drafts using STT. Moreover, they found that anxiety lessened, and fluency in writing increased as the cognitive load was reduced from transcription to idea generation. Kambouri *et al.* (8) showed how STT could help young writers reduce their errors with mechanics, freeing them up to revise with more meaningful content. The authors were particularly intrigued by the combination of dictation for drafting and TTS for read-back. Alternative perspectives also place an emphasis on the ecosystem surrounding the use of these tools. Alqahtani (5) found that insufficient professional development time, teacher discomfort, and incompatible devices can create barriers to adoption. A comprehensive and feature-rich technology will not have the desired impact when students are rarely engaged.

Almgren Bäck *et al*. (9) reiterated this sentiment by saying districts often overlook the importance of a simplified login process; when students are required to log in with multiple passwords, student engagement is minimal. Similar implementation concerns have been reported in under-resourced school settings, where limited infrastructure can reduce the effectiveness of assistive technology. School-level implementation examples suggest that simplified single sign-on (SSO) and teacher training may improve fidelity of assistive technology use. Case studies suggest that the design of a technology tool and decisions made at the district level cannot be considered independently from one another. The effectiveness of a tool's design depends on the context in which the tool is used.

These perspectives together emphasize the multi-faceted scope of issues associated with the use of education technologies. Design features matter, and some features like highlighting text, playback speeds, and correction features create measurable impacts on learning outcomes. However, if a supportive context is not provided through adequate PD, uncomplicated and secure login, and appropriate access devices, the tools do not have the capacity to deliver.

Gaps

Despite significant research, several gaps remain in the literature. Many studies ask whether TTS or STT lead to better outcomes, but don't isolate precisely which feature or features are responsible for gains—such as Bonifacci *et al*. (6)—which identified highlighting and pace control as important features but did not determine the independent effects of these features on comprehension. Experimental designs have not varied features in a factorial way to systematically evaluate the effects of different features on comprehension in TTS or STT studies.

Likewise, little research uses local district conditions in any kind of quantitative modeling. Although Alqahtani (5) recognized that infrastructure was important, no study has tried to quantitatively predict adoption as a function of variables like either SSO integration, professional development hours, or device-to-student ratios. Longitudinal studies that will follow students over years of exposure to the technologies would also be a valuable addition to the field.

Equity issues are also under-researched. The majority of the research examines dyslexic students as a homogenous group and has not examined subgroups of dyslexia students based on English learner (EL) status, and rural districts where access to reliable internet and devices may be limited. Knowing how technology interacts with language background and access to resources will add important understanding to the field.

Lastly, limited research has examined how assistive technology works when combined with direct literacy instruction. Many studies evaluate TTS or STT as accommodations that help students access text or produce writing, but fewer studies examine how these tools function alongside structured reading interventions, phonics instruction, vocabulary support, or writing strategy instruction. This creates an important gap because assistive technology may be most effective when it is used as a scaffold rather than as a replacement for reading and writing instruction. Future research should examine whether combining TTS or STT with explicit literacy instruction produces stronger long-term outcomes than either approach used alone.

METHODS AND MATERIALS

Research Design

The study used sequential explanatory mixed-methods design. The first phase consisted of a systematic literature review with descriptive coding of 16 published studies on text-to-speech, speech-to-text, and related assistive technology interventions for students with dyslexia or reading and writing difficulties. Because the included studies varied widely in research design, sample size, outcome measures, intervention duration, and effect-size reporting, the quantitative phase was not treated as a formal pooled meta-analysis. Instead, studies were coded descriptively by tool type, participant population, study design, literacy outcome, intervention duration, reported outcome direction, available effect-size information, and specific assistive technology features. The second phase consisted of semi-structured educator interviews designed to explain and contextualize the patterns found in the literature.

The study synthesized descriptively coded findings from existing literature with original qualitative interview data. The dependent variables include literacy outcomes such as reading fluency, comprehension, and writing productivity. The independent variables include the type of assistive technology used (TTS vs. STT) as well as specific tool features, including synchronized highlighting, voice prediction, and adjustable dictation rate (1). Quantitative synthesis from Alqahtani (5) establishes baseline effect sizes for technology interventions. Qualitative data from Almgren Bäck *et*

al. (9) show how confidence, agency, and sustained use can develop over time, helping identify the conditions that allow positive effects to last. Moreover, this study was reviewed and determined to be exempt from IRB oversight by Jordan High School because it involved educator interviews with no student data.

Literature Search Strategy

A structured search was conducted across MEDLINE, ScienceDirect, and Google Scholar to identify studies published between 2010 and 2025 examining TTS, STT, and related assistive technology tools for students with dyslexia, reading disabilities, writing disabilities, or broader literacy difficulties. Searches were limited to English-language sources and prioritized peer-reviewed journal articles, systematic reviews, meta-analyses, intervention studies, single-case studies, and studies involving elementary, middle, or high school students.

The literature search was conducted using MEDLINE, ScienceDirect, and Google Scholar. Search strategies combined terms related to learning disabilities/dyslexia, assistive technologies (e.g., text-to-speech, speech-to-text, speech synthesis, dictation software, synchronized highlighting, predictive text, and error correction), and literacy outcomes such as reading comprehension, reading fluency, writing productivity, spelling, composition, and writing performance. Searches targeted studies involving students, children, and adolescents with dyslexia, reading disabilities, writing disabilities, or related learning disabilities. Boolean operators (AND/OR) were used to combine synonymous terms and construct database-specific search queries tailored to reading- and writing-related assistive technology outcomes. Titles and abstracts were screened first, followed by full-text review of sources that appeared relevant. Studies were retained only if they met the inclusion criteria described below. After screening and full-text review, 16 studies met the criteria and were included in the descriptive literature synthesis.

Inclusion and Exclusion Criteria

Studies were included if they m*et al*l of the following criteria: 1) the study examined text-to-speech (TTS), speech-to-text (STT), digital read-aloud, reading-while-listening, dictation, spellcheck, predictive text, or another related assistive technology tool; 2) the participants included elementary, middle, or high school students, or the study focused on school-age learners with dyslexia, reading disabilities, writing disabilities, learning disabilities, or broader literacy difficulties; 3) the study reported at least one literacy-related outcome, such as reading comprehension, reading fluency, spelling, writing productivity, writing quality, academic achievement, attention, motivation, or access to grade-level text; 4) the source was published in English between 2010 and 2025; and 5) the source was a peer-reviewed article, systematic review, meta-analysis, intervention study, single-case study, or other scholarly source relevant to assistive technology and literacy outcomes.

Studies were excluded if they focused only on adult workplace use, medical speech disorders without a literacy outcome, general educational technology without a specific assistive technology tool, non-literacy outcomes only, or interventions unrelated to reading or writing. Studies were also excluded if the full text was not available or if the source did not provide enough information to code tool type, population, outcome category, or outcome direction. After screening, 16 studies met the inclusion criteria and were included in the descriptive literature synthesis.

Participants

Participants in the qualitative phase included three educators with experience supporting students with dyslexia and other reading difficulties across middle and high school settings. These teachers were selected based on their familiarity with assistive technologies such as text-to-speech and speech-to-text in classroom or intervention contexts. No students were directly interviewed for this study. All teacher responses were anonymized prior to analysis.

Procedure

In the first phase, studies were identified through database searches, title and abstract screening, and full-text review. Each included source was entered into an assistive technology coding sheet. The coding sheet recorded the author and year, tool type, participant population, study design, primary literacy outcome, intervention duration, outcome direction, available effect-size information, and notable tool features. Tool type was coded as TTS, STT, mixed assistive technology, or digital text/read-aloud support. Literacy outcomes were coded as reading comprehension, reading fluency, spelling, writing productivity, academic achievement, attention, motivation, or mixed literacy outcomes.

Outcome direction was coded descriptively as positive, mixed, neutral/descriptive, or not reported. A study was coded as positive when the authors reported improvement

in at least one literacy related outcome, such as reading comprehension, reading fluency, spelling, writing productivity, writing quality, attention, motivation, or access to grade-level text. A study was coded as mixed when results varied across outcomes, participants, or measures, such as when one literacy outcome improved but another showed no clear improvement. A study was coded as neutral when the study primarily described tool use, reported no clear improvement, or presented findings without a clear positive or negative outcome direction. A study was coded as not reported when the source did not provide enough information to determine the direction of the outcome. Effect sizes were recorded only when the original study reported a standardized value such as Cohen's d, Hedges' g, standardized mean difference, partial eta squared, nonoverlap metric, or a comparable statistical result. Because many included studies did not report standardized effect sizes and because the studies differed substantially in design, outcome measures, and duration, pooled effect sizes, combined means, and confidence intervals were not calculated. The quantitative phase should therefore be understood as a descriptive synthesis rather than a formal statistical meta-analysis.

In the second phase, semi-structured online interviews were conducted with three educators who had experience supporting students with dyslexia or reading difficulties. The interviews followed a consistent interview protocol but allowed follow-up questions when teachers provided relevant examples about tool use, benefits, barriers, or implementation conditions. This approach allowed the interviews to remain comparable across participants while still giving teachers space to explain their experiences in detail. Interview responses were coded for repeated themes, including tool use, perceived benefits, helpful features, effective tasks, barriers, training needs, student confidence, and concerns about overreliance. The qualitative themes were then compared with the descriptive literature coding to identify areas of alignment and tension between published findings and classroom experience.

RESULTS

Descriptive Literature Synthesis Findings

The 16 included studies varied substantially in design, sample size, intervention length, and outcome reporting. Coded designs included meta-analyses, quasi-experimental intervention studies, within-subject designs, single-case studies, and descriptive or narrative reviews. Sample sizes ranged from single-case designs to larger review-level samples. Intervention duration ranged from one session to several weeks or months, and some studies included follow-up periods. Because of this heterogeneity, the results are presented as a descriptive synthesis rather than as a pooled statistical meta-analysis (Table 1).

Table 1. *Descriptive Assistive Technology Study Summary Table. This table summarizes each study included in the descriptive literature synthesis by citation, assistive technology tool type, primary literacy outcome category, intervention duration, outcome direction, and reported effect-size information. TTS refers to text-to-speech, STT refers to speech-to-text, AT refers to assistive technology, SMD refers to standardized mean difference, NR means not reported, NS means not significant, and NAP refers to nonoverlap of all pairs. The table shows that TTS was most commonly associated with reading comprehension and fluency outcomes, while STT was more commonly linked to writing productivity. Outcome direction was coded as positive, mixed, neutral/descriptive, or not reported using the criteria described in the Procedure section. Note. The most frequently reported outcome categories included reading comprehension, reading fluency, and accuracy.*

Study	Tool Type	Primary Outcome Category	Duration	Outcome Direction	Effect Size
Wood *et al*. (1)	TTS	Reading comprehension	8 weeks	Positive	SMD = 0.35
Levine *et al*. (7)	STT	Writing performance	6 weeks	Positive	0.64
Alqahtani (5)	TTS-based tech	Reading fluency & comprehension	10 weeks	Positive	SMD = 0.87
Kambouri *et al*. (8)	Mixed AT	Reading & spelling	~7 weeks	Positive	d = 0.44–0.69
Tan *et al*. (10)	Mobile AT app	Reading & psychosocial	6 weeks	Mixed	NR
Schiavo *et al*. (11)	TTS/read-aloud	Reading comprehension	Single session	Positive	24% gain
Bhola (12)	TTS	Academic achievement	4 months	Positive	NR

Continued Table 1. *Descriptive Assistive Technology Study Summary Table. This table summarizes each study included in the descriptive literature synthesis by citation, assistive technology tool type, primary literacy outcome category, intervention duration, outcome direction, and reported effect-size information. TTS refers to text-to-speech, STT refers to speech-to-text, AT refers to assistive technology, SMD refers to standardized mean difference, NR means not reported, NS means not significant, and NAP refers to nonoverlap of all pairs. The table shows that TTS was most commonly associated with reading comprehension and fluency outcomes, while STT was more commonly linked to writing productivity. Outcome direction was coded as positive, mixed, neutral/descriptive, or not reported using the criteria described in the Procedure section. Note. The most frequently reported outcome categories included reading comprehension, reading fluency, and accuracy.*

Study	Tool Type	Primary Outcome Category	Duration	Outcome Direction	Effect Size
Verlaan & Ortlieb (13)	Digital texts	Reading comprehension	3 days	Neutral/Descriptive	d = 0.36
Keelor *et al*. (14)	TTS	Reading comprehension	One session	Positive	d ≈ 0.71
Bonifacci *et al*. (6)	TTS	Comprehension & attention	One session	Positive	Partial η^2
Nordström *et al*. (15)	TTS + STT	Reading/writing & motivation	6 weeks	Mixed	NR
Svensson *et al*. (16)	Multi-app AT	Reading & motivation	8 weeks + follow-up	Neutral/Descriptive	Cohen's d (NS)
Lindeblad *et al*. (17)	Multi-app AT	Reading & motivation	5 weeks	Positive	NR
Clinton-Lisell (18)	Reading-while-listening	Reading comprehension	Varies	Positive	g = 0.18
Almgren Bäck *et al*. (9)	STT	Writing productivity	7 weeks	Positive	NAP (med–large)
Svensson *et al*. (19)	TTS	Comprehension	~12 sessions	Positive	Visual analysis

Across the coded studies, TTS tools appeared most frequently. These tools were primarily associated with reading comprehension and fluency outcomes. STT tools were more commonly associated with writing related outcomes such as word count, spelling accuracy, and text length. Multi-app assistive technology packages combined reading and writing support.

Figure 1 shows that TTS was the most frequently represented tool type across the 16 included studies. This supports the finding that existing literature focuses more heavily on reading-support technologies than on writing-only STT interventions. Reported outcome directions were categorized as positive, mixed, or descriptive/neutral. Many studies reported positive outcomes for at least one measured variable. Some studies reported mixed results across different outcome measures or participant groups. Several studies did not report standardized effect sizes and instead provided descriptive findings.

Figure 2 shows that most studies reported positive or mixed-positive outcome directions. This supports the overall finding that assistive technology was generally associated with improved literacy access or performance,

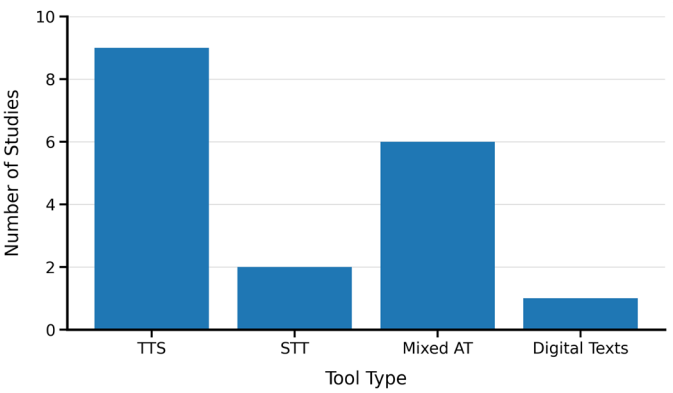

Figure 1. *Frequency of assistive technology tool types across the 16 included studies. This figure shows how often each assistive technology category appeared in the descriptive literature synthesis. Tool categories included text-to-speech (TTS), speech-to-text (STT), mixed assistive technology (mixed AT), mobile assistive technology applications, and digital text/read-aloud tools. The figure shows that TTS appeared most frequently across the reviewed studies, suggesting that reading-support tools were more commonly represented in literature than writing-only STT tools.*

although the variation in outcomes confirms that the evidence should be interpreted descriptively rather than as a pooled statistical effect.

Effect-size information was recorded when it was available in the original studies. Reported metrics included standardized mean differences, Cohen's d, Hedges' g, partial eta squared, nonoverlap metrics, statistical significance tests, and percentage gains. However, several studies did not report standardized effect sizes, which limited direct statistical comparison across studies. Therefore, effect-size values were not pooled; instead, they were used descriptively to support interpretation of outcome direction (Table 2).

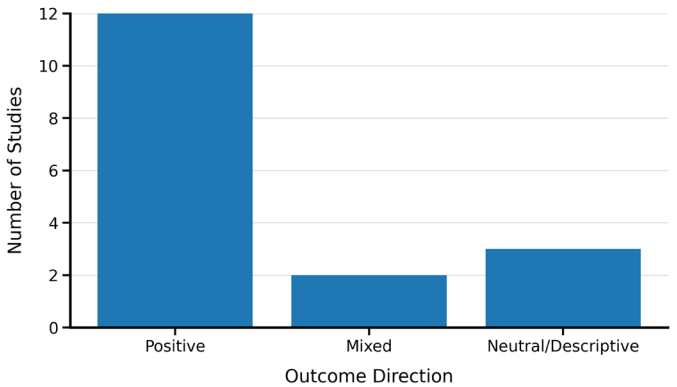

Figure 2. *Distribution of reported outcome directions across the 16 included studies. Outcome direction was coded as positive, mixed, neutral/descriptive, or not reported based on each study's reported literacy-related findings. "Positive" indicates improvement in at least one measured outcome, "mixed" indicates both positive and neutral or inconsistent findings, and "neutral/descriptive" indicates no clear improvement or primarily descriptive reporting. The figure shows that most studies reported positive or mixed-positive outcomes, although variation in study design and effect-size reporting limited direct statistical comparison.*

Interview Findings

Teacher interview responses were coded into thematic categories. All three educators reported experience working with students diagnosed with dyslexia or other reading difficulties across multiple grade levels. The most commonly reported tools included text-to-speech, speech-to-text, audiobooks, digital highlighting, spellcheck, and graphic organizers (Table 3).

Table 2*. Feature Frequency Chart. This table shows how often specific TTS and STT features appeared across the reviewed studies. Features included highlighting, pacing control, predictive text, and error correction/spellcheck. Values represent the number of studies in which each feature was identified. Highlighting and pacing control appeared most frequently, suggesting that multimodal reading support and adjustable reading speed were common design features in the literature.*

Feature	Number of Studies
Highlighting	11
Pacing Control	10
Predictive Text	3
Error Correction / Spellcheck	7

Table 3*. Interview Theme Matrix. This table summarizes coded responses from three anonymized educators, labeled Teacher A, Teacher B, and Teacher C, who had experience supporting students with dyslexia or other reading difficulties. Themes include experience with reading disabilities, common tools used, observed student improvements, helpful features, effective tasks, challenges or limits, support and training needs, and overall value. TTS refers to text-to-speech, STT refers to speech-to-text, and EL refers to English learner. The table shows that educators consistently described TTS/read-aloud tools, highlighting, spelling supports, training, and device access as important factors in effective assistive technology use.*

Theme	Teacher A	Teacher B	Teacher C	Overall Pattern
Experience with reading disabilities	Worked with diagnosed dyslexia and decoding/ comprehension issues	Taught multiple grades; extensive reading-acquisition support	16+ years with dyslexia in general ed	All have substantial experience with struggling readers
Common tools used	TTS, STT, audiobooks, digital annotation	Read-aloud, highlighting, graphic organizers, translation tools	TTS on devices, read-aloud during tests, spelling accommodations	TTS/read-aloud and writing supports most common

Continued Table 3. *Interview Theme Matrix. This table summarizes coded responses from three anonymized educators, labeled Teacher A, Teacher B, and Teacher C, who had experience supporting students with dyslexia or other reading difficulties. Themes include experience with reading disabilities, common tools used, observed student improvements, helpful features, effective tasks, challenges or limits, support and training needs, and overall value. TTS refers to text-to-speech, STT refers to speech-to-text, and EL refers to English learner. The table shows that educators consistently described TTS/read-aloud tools, highlighting, spelling supports, training, and device access as important factors in effective assistive technology use.*

Theme	Teacher A	Teacher B	Teacher C	Overall Pattern
Observed improvements	Better assessment performance and comprehension	Increased focus and confidence	Better comprehension, motivation, endurance	All report improved comprehension and confidence
Helpful features	Highlighting, spellcheck	Highlighting, pacing, spellcheck	Highlighting, STT, reduced spelling penalties	Highlighting and error correction mentioned most
Most effective tasks	Writing process tasks; long texts via audiobooks	Listening for reading; models for writing	Long/complex reading and writing tasks	Best for longer or cognitively demanding tasks
Challenges/limits	Tech access and over-dependence	STT struggles for English learner (EL) students	Risk of overreliance limiting skill growth	Training and balanced use are key concerns
Role of support/ training	Training critical for effectiveness	Teacher knowledge improves outcomes	Staff training and device access matter	Implementation quality strongly affects benefit
Overall value	Meaningful access and confidence	Helpful scaffold but not permanent crutch	Improves confidence and access when balanced	All agree AT is beneficial when used strategically

Teachers described observed changes when students used assistive technology. These included improved comprehension, increased word production in writing, greater confidence, and higher task completion rates. Teachers also reported that some students demonstrated stronger listening comprehension than reading comprehension.

Figure 3 shows that educators most often identified highlighting and error correction/spellcheck as helpful features. This supports the study's feature-level finding that tools helping students maintain attention to text and reduce writing barriers were especially valued in classroom use.

Tasks where tools were frequently used included longer reading assignments, multi-step writing tasks, and assessments requiring sustained attention. Audiobooks and read-aloud features were noted for longer texts.

Figure 4 shows that implementation challenges were not limited to the technology itself but also included access, training, student familiarity, STT accuracy, and concerns about overreliance. This supports the finding that assistive technology outcomes depend on implementation conditions, not just tool availability.

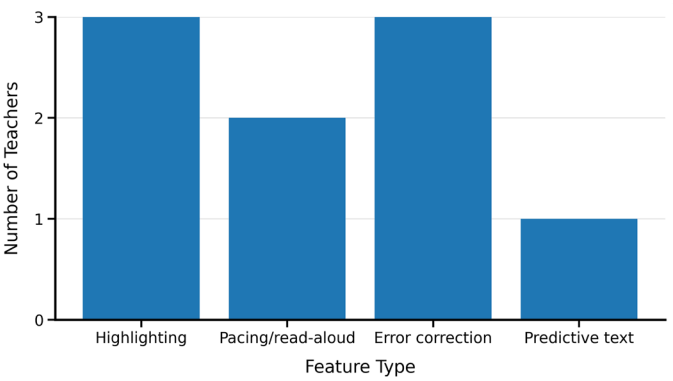

Figure 3. *Assistive technology features identified as helpful by interviewed educators. This figure summarizes the number of educators who identified specific TTS or STT features as helpful for students with dyslexia or reading difficulties. Features included highlighting, pacing/read-aloud control, predictive text, and error correction/ spellcheck. The figure shows that highlighting and error correction/spellcheck were the most frequently identified helpful features, suggesting that educators valued tools that support attention to text and reduce writing-related barriers.*

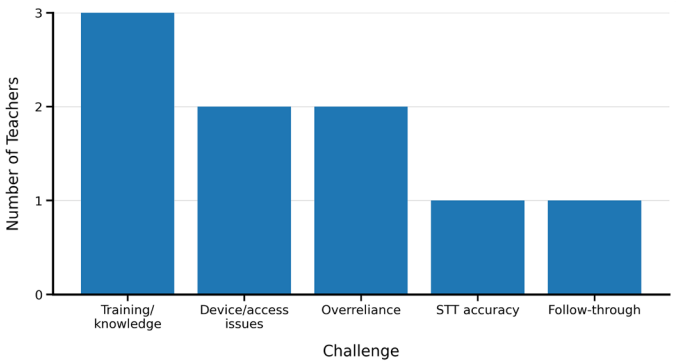

Figure 4. *Implementation challenges reported by interviewed educators. This figure summarizes the main barriers teachers reported when students used TTS, STT, or related assistive technology tools. Challenges included limited device access, technology malfunctions, student unfamiliarity with tools, speech-to-text pronunciation issues, and concerns about overreliance on technology. The figure shows that successful implementation depends not only on tool availability but also on training, access, and balanced instructional use.*

The reported challenges included limited device access, technology malfunctions, student unfamiliarity with tools, pronunciation issues with speech-to-text, and concerns about overreliance on technology. Teachers also mentioned that training and teacher familiarity influenced how effectively students used assistive tools. Access to devices and school support structures were referenced in multiple responses.

Both datasets documented the presence of features such as highlighting and pacing control. TTS appeared frequently in both research literature and teacher reports. Writing supports such as STT and spellcheck were also documented in both datasets. These similarities were presented as descriptive observations of coded categories.

DISCUSSION

Summary of Findings

The aim of this study is to evaluate the impact of assistive technology on students with reading disabilities. This was accomplished through analysis of existing research on the use of TTS and STT technologies and their effects on reading comprehension and writing productivity. In addition, qualitative data from teacher interviews were analyzed to provide contextual insight. Through this mixed-methods approach, which included a descriptive literature synthesis and interviews with educators, consistent trends were identified in both outcome patterns and effective implementation practices.

Across the descriptive literature synthesis, most studies reported positive outcome directions for at least one literacy-related measure, although the strength of evidence varied because not all studies reported standardized effect sizes. More specifically, there was a clear trend of reading comprehension and writing production improving when students were allowed to use TTS and STT software. Two prior meta-analyses included in this review reported small-to-moderate average effect sizes (1, 18). Other studies with more tightly controlled conditions produced larger effect sizes (14, 11). Interestingly, some studies that used longitudinal designs (16, 17) did not find significantly greater improvements over control groups but did find that assistive technology provided consistent opportunities for students to access materials, maintain motivation, and work independently. These were benefits that may not be realized on traditional reading assessments but could translate to reading engagement outside of testing environments.

Interpretation of Results

As mentioned above, there were multiple patterns that occurred within the studies across both reading and writing. The first notable trend was how AT was used and made a larger impact than whether students had access to it. This pattern can be explained by cognitive load theory, as features such as synchronized highlighting and pacing control reduce the mental effort required for decoding and allow students to allocate more attention to comprehension. By minimizing split attention between reading and processing text, these features support more efficient information processing and sustained focus (11, 14). Schiavo *et al*. (11) found that comprehension increased by 24% when students were allowed to use attention- driven pacing and had the text highlighted as it was read aloud. Keelor *et al*. (14) also found a significant improvement in comprehension when text-to-speech was accompanied by highlighting and attention-driven pacing, with an effect size of around d = 0.71.

While some studies showed improvements in reading comprehension when students used TTS or related read-aloud tools, others demonstrated that students with reading disabilities were better able to comprehend information when listening to text rather than reading it on their own (16, 19). This may further support that text-to-speech allows students to access information at their grade level despite deficits in their ability to decode

words. Across studies that implemented STT to support writing, students wrote more words and demonstrated increased fluency, especially if their spelling difficulties were impeding their ability to write (7, 9). Similar to the TTS studies, the biggest improvements were seen when students were taught how to use STT to compose essays by learning how to punctuate and revise as they dictated.

Qualitative feedback from teachers was largely consistent with the quantitative data and provided useful context to interpret the findings. All teachers interviewed reinforced that students have stronger listening comprehension than reading comprehension and gain access to material when extraneous decoding or spelling demands were minimized. Interviews repeatedly highlighted the benefits of highlighting text, controlling the pace of reading, and correcting errors – this preference aligns with the frequency of features identified in the descriptive literature synthesis.

Qualitative feedback also highlighted concerns less-apparent from experimental data. Many teachers expressed concern that students may become reliant on assistive technology as a "crutch" if provided without instruction on how to apply reading strategies independently. Teachers also identified lack of device access, inconsistent training, and variable teacher familiarity as barriers to implementation. These factors may account for some null or mixed trials despite positive qualitative findings.

Implications

This research can help teachers, special education teams, administrators, and policymakers. Schools should interpret these findings as evidence that assistive technology has the capacity to support students with reading disabilities in meaningful ways if coupled with training, intentionality with features, and instructional scaffolding. TTS or STT should not be seen as a way to take the reading part out of learning for students. Instead schools can view these accommodations as ways to allow students to access content on grade-level cognitive demand while working on reading skills.

The results can also be used to argue for more professional development as teacher input was found to impact student outcomes. Students did not benefit from these tools if teachers did not know how to implement them properly.

This review can be replicated if given the transparent coding procedures, inclusion criteria, and feature-level variables reported across studies. Researchers can replicate or expand this descriptive synthesis by coding more studies with the same coding frame or by interviewing more teachers using the same interview protocol. Using both a quantitative synthesis and qualitative validation of results adds to confidence in these findings.

Future Research

This research builds upon past literature by approaching the effectiveness of assistive technology at a feature level rather than making all technology fit into one intervention category. Additionally, this research creates connections between experimental results and real classroom application by demonstrating the gap between research settings and student experiences in the classroom.

Future studies should explore what long-term effects occur when students were taught how to use assistive technology features deliberately. Other studies should look at which students see the most benefit from certain features. Because assistive technology does not teach reading skills explicitly, future research should explore how to best teach these tools in conjunction with explicit reading instructions instead of being used as a replacement. Finally, although motivation, autonomy, and engagement were valuable outcomes in several studies, more research should include standardized effect sizes to allow clearer comparison across interventions.

Limitations

A major limitation of this study is that the quantitative phase was a descriptive synthesis rather than a formal pooled meta-analysis. Because many included studies did not report standardized effect sizes and because the studies differed in design, duration, and outcome measures, it was not appropriate to calculate a single combined effect size or confidence interval. There are several limitations to consider when interpreting these findings. First, significant heterogeneity existed across study design, outcome measures, and participant characteristics, precluding comparison of effect sizes across studies. Many studies did not compute or report standardized effect sizes and relied on descriptive outcomes.

Second, many studies looked at short-term outcomes of interventions. The long-term impacts of assistive technology for reading on growth towards independence is still unknown. Investigators were able to show that motivation and access improved for students who used assistive technology, however, less studies demonstrated long-term improvements in decoding or fluency in the

absence of support. Third, interviewed teachers were geographically limited to one state and sampled from a pool of self-selected individuals who were familiar with assistive technology.

Together these limitations mean that these findings should be interpreted as support for functional benefit and access, not evidence that assistive technology can remediate reading disabilities.

CONCLUSION

The purpose of this study is to understand how assistive technology impacted student literacy outcomes when working with students with dyslexia or other reading disabilities. Through a sequential explanatory mixed-methods design using descriptive literature coding and teacher interviews, this study establishes a holistic understanding of assistive technology in both experimental studies and real-world classrooms. Assistive technology was not found to treat or "fix" students with reading disabilities. However, the findings demonstrate that assistive technology allows students functional access to grade level materials, increases reading comprehension when paired with decreased decoding demand, increases writing productivity, and overall boosts student confidence. When combined, the datasets consistently show that positive outcomes were associated with features such as highlighting, pacing, and error correction. Furthermore, the interviewed teachers conveyed how these features were most regularly used.

As a community of practice, there were several takeaways for all involved in the process of selecting and implementing assistive technology. Teachers and special education teams should understand that just because a student has been provided with a tool doesn't mean they should use it independently or solely rely on it all of the time. Systematic instruction in features and when to use them should be taught alongside other methods. If teachers do not know how to use or teach the features, students will not fully benefit from the intervention. Administrators and district level leaders should understand that not all tools are created equal and thus, funding decisions should lean toward tools that have evidence backed features. Investments should be made in both technology and teacher training. Assistive technology should not replace high-quality reading instruction but should be used as a scaffold while students continue developing reading and writing skills.

Researchers should conduct longer studies with larger samples to measure the impact of consistent assistive technology use over time and to determine whether these findings remain consistent across different student populations. By focusing not just on the extent of access to these tools but how they were used at the specific feature level and the quality of teacher training, future works on this subject would fill the gaps that surfaced from the study and provide a deeper and more cohesive understanding of the best optimized application of the assistive technologies.

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this work.

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