The Impact of Assistive Technologies in Enhancing English Learning Outcomes for Students with Disabilities: A Meta-Narrative Analysis

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Abstract

Integrating assistive technologies in education is crucial for enhancing English learning outcomes among students with disabilities. This meta-narrative analysis aims to synthesize existing research on the impact of assistive technologies in improving English language skills in this population. We conducted a comprehensive search across databases, including Taylor and Francis and Scopus, identifying relevant studies published from 2020 to 2023. Eleven peer-reviewed articles met the inclusion criteria, focusing on empirical studies that evaluated tools such as EducaPlay, Rosetta Stone, PECS, AR applications, inclusive videos, LEA tools, VAS and multimedia tools, web-based drill programs, the AMALL application, and various assistive technologies like JAWS, MELDICT, OCR scanners, and Braille devices. Data collection involved extracting critical information on the effectiveness of the learning tools, types of disabilities, and educational outcomes related to language skills in using technology learning tools to study the English language for disabled students. The analysis revealed significant improvements in vocabulary, reading comprehension, and writing skills, demonstrating the positive impact of assistive technologies on English learning. The findings suggest that these technologies enhance engagement and motivation, offering personalized support that addresses individual needs. The discussion highlights the variability in effectiveness across different technologies and the importance of proper implementation and training for educators.

Keywords: Assistive technology, educational outcome, English language learning, students with disabilities, meta-narrative analysis

1. Introduction

Technology integration into educational settings has evolved significantly over the past few decades, transforming traditional teaching and learning methodologies. Initially, educational technology was limited to computers and basic software in classrooms (Kalita & Kumar, 2020). Over time, advancements in digital technologies, including the internet, interactive whiteboards (Vogt & Westerlin, 2021), and more recently, mobile devices, have revolutionized the educational landscape (Yan, 2021). Fan et al. (2023) highlighted the advantages of mobile apps in learning language, noting their effectiveness in improving language skills and learning motivation. Kruchinin and Bagrova (2021) also pointed out that mobile apps are helpful for language learning and best used as supplementary learning tools. Nehe et al. (2023) explored learners' experiences using mobile language learning applications, finding that these tools significantly supported self-paced learning and accessibility. Tu (2021) demonstrated that mobile apps could improve learning outcomes in intelligent environments, highlighting their potential to enhance educational accessibility. These innovations have made education more accessible, tailored, and engaging by offering a wide array of tools that accommodate various learning preferences and needs (Fernández-Sánchez et al., 2022; Malicay, 2023; Viberg et al., 2020). This adaptability also empowered students to learn more effectively by providing resources that suit their learning styles. Furthermore, incorporating technologies has demonstrated immense potential in improving educational outcomes for students with disabilities, ensuring inclusivity and better learning experiences (Bouck & Long, 2021; Viner et al., 2020). In light of these technological advancements, it is crucial to examine how they can be further optimized to support diverse learner needs, particularly for students with disabilities in language acquisition.

Assistive technologies (AT), any product, device, or service designed to support individuals with disabilities (Jurišić et al., 2022), have become essential in modern educational systems, particularly for enhancing learning experiences for students with disabilities. These tools, including text-to-speech applications, mobile learning apps, and interactive technologies, have demonstrated significant potential in enabling students with visual, auditory, and cognitive impairments to overcome barriers to traditional learning environments (Svensson et al., 2019; Klimova & Zamborova, 2023). As the use of AT continues to expand, its role in fostering academic engagement, improving performance, and promoting autonomy for disabled learners is increasingly recognized. These technologies offer personalized learning experiences and flexible access to educational materials, which are crucial for students with special needs (Park et al., 2022; McNicholl et al., 2020).

However, challenges remain in ensuring these technologies are inclusive and effectively meet the diverse needs of disability learners in learning English as their foreign language (Alghamdi, 2022; Atanga et al., 2020). Learning English is essential for students with

disabilities as it plays a critical role in their academic success and enhances their communication skills, providing them with better access to educational resources and future career opportunities (Rapti et al., 2022). Additionally, proficiency in English helps these students interact more effectively in social and academic settings, which is crucial for their inclusion in both educational environments and society (Khasawneh, 2021).

Disabilities such as dyslexia, visual impairments, and hearing impairments can significantly hinder this acquisition (Price et al., 2021; Howard, 2023) since they face unique challenges in learning English as a foreign language (Rustamovna, 2021; Javed et al., 2020). Dyslexic learners, for instance, face difficulties with reading and sensory motor skills, which severely impact their ability to engage with English language content (Vizhi & Rathnasabapathy, 2023; Fazio et al., 2020). Similarly, visual impairments affect English phonemic awareness, as visually impaired students struggle with identifying certain vowel and consonant sounds critical to language comprehension (Arum et al., 2021). Furthermore, students with hearing impairments also face barriers in English learning, with methods like the Verbotonal method proving useful in enhancing their language skills by adapting to their specific auditory challenges (Autayeva & Seitimbetova, 2020). Students with disabilities face significant challenges in learning English as a foreign language. However, inclusive technologies and tailored teaching methods can enhance language acquisition, improve academic and social success, and expand future career opportunities.

Despite these challenges, proficiency in English is critical as it often serves as the primary medium of instruction and communication in many educational contexts (Le Menestrel, 2020; Jassim, 2021; Shenoy et al., 2022). Assistive technologies can play a vital role in mitigating these challenges, enabling students with disabilities to achieve their full potential in language learning (Klimova & Zamborova, 2023). The proliferation of mobile applications has added a new dimension to educational technologies (Oliveira et al., 2022). These applications, accessible via smartphones and tablets (Kumar et al., 2020), offer versatile (Jaramillo et al., 2020) on-the-go learning opportunities (Booton et al., 2021). Mobile apps designed for educational purposes can include features like interactive lessons (Paramartha et al., 2022), gamified learning experiences (Hidayat et al., 2021), and personalized learning tracks (Alkhawalde & Khasawneh, 2024), which are particularly beneficial for students with disabilities (Türel & Davudova, 2022). These tools provide immediate feedback, are highly customizable, and can be adapted to meet the specific needs of each learner, thus enhancing their engagement and motivation (Xodobande & Atai, 2020). These assistive technologies, particularly mobile applications, are essential in helping students with disabilities overcome learning challenges by providing personalized, adaptable, and engaging tools that enhance their English language proficiency.

Current research emphasizes the effectiveness of various tools, such as text-to-speech applications, mobile learning apps, and interactive technologies, which foster autonomy, improve academic performance, and enhance engagement among disabled learners (Svensson et al., 2019; Klimova & Zamborova, 2023). Previous studies have also shown mixed results regarding the impact of these technologies on educational outcomes such as improved academic engagement (McNicholl et al., 2021), positive psychosocial Impact (McNicholl et al., 2020), enhanced learning for hearing impairment (Bell & Foiret, 2020), increased competence and social interaction (Kirboyun, 2020), impact on cognitive and psychomotor performance (Kalyani & Taj, 2021), and teacher preparedness and implementation (Jones et al., 2020). Moreover, AT has been shown to benefit students with learning disabilities in digital environments, helping them reduce reading and writing errors (El Kah et al., 2021). These researches tend to focus on broader educational outcomes, leaving a critical gap in understanding how these technologies can be customized to address specific learning challenges in foreign language acquisition.

Despite the extensive research, significant gaps remain in understanding assistive technologies' full potential and limitations for students with disabilities in learning English. To address the identified research gap, this study extends the existing body of literature by exploring the specific impact of assistive technologies on students with disabilities in the context of English language learning. It aims to determine the overall impact of assistive technologies on English learning outcomes for students with disabilities. This question is crucial for understanding the general effectiveness of various assistive technologies in improving English proficiency among students with disabilities. By determining the overall impact and identifying the most effective technologies, this study can guide educational policymakers and practitioners worldwide in making informed decisions about integrating assistive technologies into English learning curricula. This review seeks to bridge this gap by providing a meta-narrative analytic approach to synthesize findings across various studies and identify areas for future research.

2. Literature Review

2.1 The Role of Assistive Technologies in Enhancing English Learning Outcomes for Students with Disabilities

Integrating assistive technologies (AT) in education has become critical in enhancing the learning outcomes of students with disabilities, particularly in English language acquisition. AT tools, such as text-to-speech software, mobile applications, and augmented reality (AR), address challenges these students face due to impairments in vision, hearing, or cognition (Svensson et al., 2019). These technologies are designed to enhance engagement, comprehension, and learning outcomes, providing crucial support to students with disabilities. However, the effectiveness of these tools is contingent upon various factors, including the context in which they are used, the support provided to educators, and the nature of the impairments being addressed.

One of the core areas in which assistive technologies have demonstrated significant benefits is enhancing vocabulary acquisition and reading comprehension for students with disabilities (Alsalem & Alzahrani, 2023). Studies have demonstrated the benefits of tools such as text-to-speech (TTS) applications, which provide auditory support for students with reading disabilities (Raffoul & Jaber, 2023). In

particular, TTS software like JAWS has been shown to significantly improve reading comprehension and vocabulary acquisition for students with visual impairments (McNicholl et al., 2021). This positive impact is particularly evident when these tools are combined with comprehensive training for teachers and students.

A systematic review by Svensson et al. (2019) highlighted the transfer effects of assistive technology on reading abilities in students with severe learning disabilities. The study demonstrated that TTS technology, combined with digital reading tools, improves reading comprehension and increases motivation for schoolwork among students with disabilities (Svensson et al., 2019). These findings are corroborated by other studies showing that assistive technologies such as Kurzweil 3000 software immediately and significantly impact students' vocabulary recognition and comprehension (Chiang & Liu, 2011).

Building on the positive effects of traditional assistive technologies, Augmented Reality (AR) applications are emerging as valuable tools in enhancing English language learning for students with intellectual disabilities. AR-based tools such as EduAr have significantly improved vocabulary retention and comprehension among students with cognitive impairments. These tools use interactive visual aids and gamified learning environments to facilitate learning (Rapti et al., 2023). The immersive nature of AR enhances engagement and makes language learning more accessible for students who struggle with traditional learning methods.

Mobile applications also offer versatile and accessible learning platforms. According to research by Gul, Noor, and Chaudhary (2021), mobile game-based learning applications significantly improved the vocabulary acquisition of intellectually disabled students. The study demonstrated that students in the experimental group who used mobile technology outperformed those who followed traditional learning methods in vocabulary tests.

In addition to AR and mobile applications, speech recognition technologies are increasingly playing an important role in helping students with learning disabilities improve their writing and reading skills. Raskind and Higgins (1999) found that speech recognition technology significantly improved spelling and word recognition for children with special needs. The study emphasized that while speech recognition was initially designed to assist writing, it provides substantial remedial benefits for reading and spelling skills (Raskind & Higgins, 1999).

Additionally, Svensson et al. (2019) noted that assistive technologies such as speech recognition and TTS support, when integrated with proper pedagogical methods, have transfer effects that boost overall school performance for students with severe reading disabilities (Svensson et al., 2019). Assistive technologies, including TTS applications, AR tools, and mobile applications, have improved English learning outcomes for students with disabilities. These tools enhance vocabulary acquisition, reading comprehension, and overall engagement. This meta-narrative analysis focuses on the impact of these tools and explores ways to make them more accessible in diverse educational settings.

2.2 Barriers to Effective Use of Assistive Technologies

Despite the demonstrated benefits of assistive technologies, several barriers hinder their effective implementation. One of the most significant challenges is inadequate teacher training in using these tools. McNicholl et al. (2021) identified that insufficient teacher training and lack of access to the necessary tools can limit the benefits of AT for students with disabilities (McNicholl et al., 2021). Another challenge is the variability in the quality of assistive technology across different educational settings, which can affect learning outcomes. Underfunded schools often lack access to the latest tools, leading to disparities in learning outcomes. Addressing these infrastructural barriers is crucial to ensuring that students with disabilities can benefit equally from the advancements in assistive technology.

This meta narrative analysis tracks the progression of AT innovations and provides a lens through which to analyze the effectiveness and limitations of those innovations. In the case of assistive technologies, this meta-narrative analysis provides a structured way to assess both the transformative potential and the barriers that need to be addressed to enhance the educational experience of students with disabilities.

3. Method

The methodology of meta-narrative analysis, devised by Greenhalgh et al. (2005), serves as a powerful approach to conducting systematic literature reviews, particularly in research fields that are still evolving or lack clear, universally accepted definitions. This method is distinctive in offering a comprehensive perspective on the primary concepts that shape a specific research domain or sub-domain, thus providing clarity where ambiguity previously prevailed. Table 1 in the study by Greenhalgh et al. (2005) meticulously outlines this process, providing a clear framework or applying meta-narrative analysis. This approach not only enhances the depth and breadth of understanding in complex research fields but also helps pinpoint gaps in existing literature and suggest new pathways for inquiry.

Table 1. Phases in meta-narrative analysis, according to Greenhalgh et al. (2005)

(1) Planning phase	- Outline the initial research questions.
(2) Search phase	- Electronically search for papers in key databases, - Search for seminal papers by tracking citations of references. - Evaluate these according to comprehensiveness and contribution to work within the tradition.
(3) Mapping phase	- The key elements of the research paradigm (conceptual, theoretical, methodological), - The main findings of the research - The prevailing language used to describe and define the concept.
(4) Appraisal phase	- Evaluate each study for its validity and relevance to the research questions - Extract and collate the key results

(5) Synthesis phase	- Identify the key dimensions of the concept that has been researched. - Analyse conceptual and descriptive concepts using different definitions. - Consider the dimensions in turn and give a narrative account of the contributions.

For the search phase of the meta-narrative analysis, a comprehensive database search was performed using the keyword "assistive and adaptive technologies in English language learning for students with disabilities." The databases utilized for this research were Taylor and Francis and Scopus. The search aimed to capture a broad spectrum of relevant literature to ensure a thorough analysis.

For the meta-narrative mapping phase, 4,227 search results were reviewed according to specific inclusion criteria. These criteria included determining whether the article was within the field of assistive and adaptive technologies in English language learning for students with disabilities, ensuring the publication date was within the last 5 years to maintain relevance, verifying that the articles were peer-reviewed to ensure credibility, confirming that the articles were published in English for consistency, and ensuring full-text availability for comprehensive analysis. The result was a collection of 393 research articles that met these criteria. To ensure a focused and relevant meta-narrative analysis, additional criteria were established for including studies on the effectiveness of various assistive and adaptive technologies in enhancing English language learning outcomes. These criteria required that studies focus on students with disabilities, such as those with learning disabilities, physical disabilities, speech impairments, and autism spectrum disorders. Additionally, the research needed to evaluate the impact of specific assistive technologies, including EducaPlay, Rosetta Stone, PECS, AR applications, inclusive videos, LEA tools, VAS and multimedia tools, web-based drill programs, the AMALL application, and various assistive technologies like JAWS, MELDICT, OCR scanners, and Braille devices. This thorough selection process aimed to provide a robust and comprehensive dataset for the meta-narrative analysis.

This process yielded 40 research articles. These articles were then more rigorously filtered by examining the full text and verifying whether the article had been cited by other researchers in the field of assistive and adaptive technologies in English language learning. The final result was 11 articles used to conduct a meta-narrative analysis. The articles are presented based on the year of publication, beginning with the oldest period of time (2020) to the most recent period of time (2024).

By employing a meta-narrative analysis research method, this study aims to provide a systematic synthesis of existing research on the influence of public administration on the development of sustainable tourism pathways in Eastern Indonesia. It seeks to identify the role of public administration in facilitating or impeding sustainable tourism, incorporating diverse perspectives and methodologies to provide a comprehensive overview of the current landscape.

4. Results

This meta-narrative analysis synthesizes findings from various studies exploring the effectiveness of assistive technologies and educational interventions for students with different types of disabilities. The key themes identified include the effectiveness of assistive technologies in enhancing educational outcomes, the role of inclusive and multimedia tools in supporting learning, and the impact of specialized interventions on motivation and engagement. This table summarizes various studies investigating assistive technology's impact on educational outcomes for students with different kinds of disabilities. Each entry details the type of disability, the specific assistive technology used, its effectiveness, and the educational outcomes measured. This comprehensive overview highlights the diversity of assistive tools and their significant role in improving the learning experience and performance of students with disabilities across various educational settings.

Table 2. The summary of various studies investigating the impact of assistive technology on educational outcomes for students with various disabilities

	Author(s)	Kind of Disability	Assistive Technology	Effectiveness	Educational Outcomes Measured
1	Martínez-Hernán and Bellés-Fortuño (2021)	Visual impairment	JAWS (Job Access with Speech)	JAWS TTS software was essential for visually impaired students' exam success, requiring format adjustments for optimal use.	Reading Comprehension; Vocabulary Acquisition; Motivation; Engagement
2	Jozwik and Mustian (2020).	English learners with developmental delays, speech-language impairments, or at-risk status	A combination of technology-supported Language Experience Approach (LEA) tools	Participants showed slight improvements in reading accuracy and comprehension with fewer meaning-change errors.	Number of words read correctly per minute from connected text; Number of words read correctly from learner-dictated passages; Percentage of meaning-change miscues during oral reading; Participant satisfaction with the technology-supported LEA

3	Ortogero and Ray (2021)	Speech/language impairments	Vocabulary acquisition strategies (VAS) and multimedia tools	Strategies and tools like L1 use, CLIL, culturally relevant activities, multimedia tools, and self-regulation techniques improved vocabulary acquisition and English proficiency.	Vocabulary acquisition; Reading comprehension; Motivation; Engagement; Self-regulation skills
4	Kamali et al. (2021)	Visual impairment	Web-based English vocabulary	The web-based drill program significantly enhanced spelling and semantics knowledge, with sustained learning and retention.	Spelling accuracy; Semantics knowledge (understanding and meaning of vocabulary); Retention of learned vocabulary over time; Overall vocabulary achievement
5	Zohoorian et al. (2021)	Children with Autism Spectrum Disorders (ASD)	Picture Exchange Communication System (PECS)	The PECS was highly effective in teaching English vocabulary to children with autism, significantly improving their vocabulary learning and communication skills.	English vocabulary acquisition; Ability to recognize and use pictures related to vocabulary words; Communication skills, including making requests and responding to questions
6	Andujar and Nadif (2022)	Students with hyperacusis (hearing loss), ADHD, Borderline Intellectual Functioning, Semantic-Pragmatic Disorder, and Asperger's Syndrome.	Inclusive videos	Flipped learning with inclusive videos enhanced engagement, comprehension, and retention, particularly benefiting students with hearing impairments.	Motivation; Effectiveness; Engagement; Overall satisfaction
7	Yulian et al. (2022)	Slow learner	Android-based application designed for authentic multimedia-assi sted language learning (AMALL)	The AMALL application improved speaking performance, fluency, structure, and vocabulary in EFL slow learners.	Speaking performance (accuracy and fluency); Vocabulary acquisition; Motivation; Engagement; Structure (use of grammar and sentence formation)
8	Hamid and Setiawan (2022)	Visual impairment	JAWS (Job Access with Speech), MELDICT (Mitra Netra Electronic Dictionary)	Assistive technology increased independence, enhanced learning outcomes, improved motivation and confidence, and facilitated better communication.	Listening: Improved comprehension through optimal use of JAWS; Reading: Effective reading and understanding of the material with JAWS; Speaking: Enhanced pronunciation and speaking skills; Writing: Improved writing accuracy and vocabulary through the use of MELDICT.
9	Khan and Mahmood (2022)	Blindness and visual impairments (BVI).	JAWS (Job Access with Speech), Scanners and OCR (Optical Character Recognition), Braille devices, Magnifying tools	Assistive technology increased independence, enhanced learning outcomes, improved motivation and confidence, and facilitated better communication.	Reading Comprehension; Vocabulary Acquisition; Motivation; Engagement; Pronunciation and Grammar
10	Rapti et al. (2023)	Intellectual disability (ID)	Augmented Reality (AR) named “EduAr"	AR significantly improved vocabulary acquisition and retention in students with intellectual disabilities.	Vocabulary acquisition (number of correct vocabulary items identified); Retention of vocabulary knowledge over time; Students' ability to comprehend, produce, and correctly spell vocabulary items in English

11	Arroyo-Cedeño et al. (2024)	Deaf individuals with hearing disabilities.	EducaPlay, General translation and communication tools such as Google Translate, Microsoft Translator, and SayHi.	EducaPlay enhances English language skills, motivation, and class performance in students with hearing disabilities, but teachers' lack of training limits its effectiveness.	Reading comprehension; Vocabulary acquisition; Writing skills

4.1 Overall Effectiveness

Various assistive technologies have shown significant positive impacts on the English language learning outcomes for students with disabilities across different contexts. The data indicates diverse assistive technologies used to support English language learning among students with various disabilities. EducaPlay and Rosetta Stone are utilized for enhancing reading and writing skills through interactive online environments and language learning platforms, respectively, supplemented by general translation tools like Google Translate, Microsoft Translator, and SayHi (Arroyo-Cedeño et al., 2024). The Picture Exchange Communication System (PECS) is employed to teach vocabulary to children with autism through visual aids (Zohoorian et al., 2021). A combination of technology-supported Language Experience Approach (LEA) tools, including voice typing, word prediction, and screen reading tools, aids reading comprehension and writing accuracy (Jozwik & Mustian, 2020). Augmented Reality (AR) applications like EduAr enhance vocabulary instruction through interactive markers, videos, and games (Rapti et al., 2023). Inclusive videos, featuring captions and embedded interpreting, create accessible learning environments for students with disabilities (Andujar & Nadif, 2022). Vocabulary acquisition strategies (VAS) and multimedia tools, such as captioned videos, accessible reading materials, video conferencing services, and online dictionaries, improve vocabulary retention and learning efficiency (Ortogero & Ray, 2021). A web-based English vocabulary drill program designed for visually impaired students demonstrates progress in spelling and semantics (Kamali et al., 2021). The AMALL application supports multimedia-assisted language learning for EFL slow learners, enhancing speaking skills and vocabulary (Yulian et al., 2022). For visually impaired students, JAWS screen reader, MELDICT electronic dictionary, OCR scanners, smartphone applications like Seeing AI, Braille devices, and magnifying tools facilitate comprehensive learning experiences (Hamid & Setiawan, 2022; Khan & Mahmood, 2022; Martínez-Hernández & Bellés-Fortuño, 2021). These findings collectively highlight the critical role of tailored assistive technologies in enhancing educational outcomes for students with diverse learning needs.

Across various studies, assistive technologies like JAWS and PECS consistently show significant positive effects on specific educational outcomes such as reading comprehension, vocabulary acquisition, and communication skills. Inclusive and multimedia tools, including flipped learning videos and AMALL applications, enhance engagement and learning across different disabilities, indicating a broader applicability of these tools. Using assistive technology increases students' independence and motivation, while specialized interventions and inclusive tools enhance specific learning outcomes and overall engagement. There is a clear trend towards the effectiveness of multimedia and interactive tools in improving learning experiences for students with disabilities.

The findings support the theory that assistive technologies and inclusive tools can significantly bridge the educational gap for students with disabilities, aligning with inclusive education principles (Viner et al., 2020). The success of specialized interventions underscores the importance of customized educational approaches in special education. Educators and policymakers should consider integrating assistive technologies and multimedia tools into the curriculum to enhance learning outcomes for students with disabilities. Training for teachers on the effective use of these technologies and tools is crucial for maximizing their potential benefits (Sharma & Mullick, 2020).

The studies reviewed vary methodologies and scopes, which may affect the generalizability of the findings. More longitudinal studies are needed to assess the long-term impact of these interventions. Further research should explore the integration of emerging technologies like augmented reality and artificial intelligence in special education. Studies should also investigate the scalability of successful interventions across different educational settings and populations. Future research and continued innovation in this field are essential to enhance educational opportunities for all students.

4.2 Specific Tools and Technologies

The data indicates diverse assistive technologies used to support English language learning among students with various disabilities. EducaPlay and Rosetta Stone are utilized for enhancing reading and writing skills through interactive online environments and language learning platforms, respectively, supplemented by general translation tools like Google Translate, Microsoft Translator, and SayHi (Arroyo-Cedeño et al., 2024). The Picture Exchange Communication System (PECS) is employed to teach vocabulary to children with autism through visual aids (Zohoorian et al., 2021). A combination of technology-supported Language Experience Approach (LEA) tools, including voice typing, word prediction, and screen reading tools, aids in reading comprehension and writing accuracy (Jozwik & Mustian, 2020). Augmented Reality (AR) applications like EduAr enhance vocabulary instruction through interactive markers, videos, and games (Rapti et al., 2023). Inclusive videos, featuring captions and embedded interpreting, create accessible learning environments for students with disabilities (Andujar & Nadif, 2022). Vocabulary acquisition strategies (VAS) and multimedia tools, such as captioned videos, accessible reading materials, video conferencing services, and online dictionaries, improve vocabulary retention and learning efficiency (Ortogero & Ray, 2021). A web-based English vocabulary drill program designed for visually impaired students demonstrates progress in

spelling and semantics (Kamali Arslantas et al., 2021).

The AMALL application supports multimedia-assisted language learning for EFL slow learners, enhancing speaking skills and vocabulary (Yulian et al., 2022). For visually impaired students, JAWS screen reader, MELDICT electronic dictionary, OCR scanners, smartphone applications like Seeing AI, Braille devices, and magnifying tools facilitate comprehensive learning experiences (Martínez-Hernández & Bellés-Fortuño, 2021; Hamid & Setiawan, 2022; Khan & Mahmood, 2022). Across various studies, assistive technologies like JAWS and PECS consistently show significant positive effects on specific educational outcomes such as reading comprehension, vocabulary acquisition, and communication skills. Inclusive and multimedia tools, including flipped learning videos and AMALL applications, enhance engagement and learning across different disabilities, indicating a broader applicability of these tools. The use of assistive technology leads to increased independence and motivation among students, while specialized interventions and inclusive tools enhance specific learning outcomes and overall engagement. There is a clear trend towards the effectiveness of multimedia and interactive tools in improving learning experiences for students with disabilities. These technologies collectively foster an inclusive and effective learning environment for students with diverse needs.

4.3 Types of Disabilities

The studies reviewed highlight the significant role of assistive technologies in supporting English language learning among students with various disabilities. Specific tools and technologies include a variety of interventions tailored to meet the unique needs of these learners. These disabilities include hearing disabilities, specifically for deaf students, as outlined by Arroyo-Cedeño et al. (2024). For instance, deaf students can benefit significantly from specialized tools that cater to their unique needs, facilitating better integration into standard educational settings.

Children with Autism Spectrum Disorders (ASD) are supported by interventions like the Picture Exchange Communication System (PECS), which helps in improving their communication skills (Zohoorian et al., 2021). PECS is particularly effective in fostering meaningful interactions, enabling ASD students to express themselves more clearly. English learners with developmental delays, speech-language impairments, or at-risk status are addressed by technology-supported Language Experience Approach (LEA) tools, which provide a structured way of learning through personal experiences (Jozwik & Mustian, 2020). Students with intellectual disabilities (ID) benefit from augmented reality applications for vocabulary instruction (Rapti et al., 2023). These applications create immersive learning experiences that can significantly enhance vocabulary retention and understanding. Additionally, various disabilities such as hyperacusis (hearing loss), ADHD, Borderline Intellectual Functioning, Semantic-Pragmatic Disorder, and Asperger's Syndrome are accommodated through inclusive videos (Andujar & Nadif, 2022). These videos are designed to cater to the specific learning needs of these students, making the learning process more inclusive and effective.

Learning disabilities or speech/language impairments are tackled with vocabulary acquisition strategies and multimedia tools, providing a multimodal approach to learning (Ortogero & Ray, 2021). Visual impairments are specifically addressed by web-based vocabulary drills and screen reader programs (Kamali Arslantas et al., 2021; Hamid & Setiawan, 2022; Khan & Mahmood, 2022; Martínez-Hernández & Bellés-Fortuño, 2021). These tools ensure that visually impaired students can easily access educational content, promoting equal learning opportunities. Slow learners improve their language skills through multimedia-assisted language learning applications (Yulian et al., 2022). These applications provide interactive and engaging learning experiences that cater to the slower pace of these learners. The varied disabilities and corresponding technological interventions highlighted in these studies underscore the need for tailored approaches to effectively support diverse learning needs. By leveraging these technologies, educators can create more inclusive and supportive learning environments for all students.

The integration and synthesis of these technologies into educational settings underscore their significance in fostering inclusive learning environments. However, there are limitations to consider. The effectiveness of these interventions can vary based on individual needs and the quality of the technology itself. Future research should explore how these tools can be optimized for diverse learning profiles and investigate the long-term impacts on language acquisition. Additionally, developing new technologies and refining existing ones could further enhance support for students with disabilities. In conclusion, the varied disabilities among students necessitate tailored technological solutions to effectively address their specific learning needs. The ongoing evolution of assistive technologies promises to enhance language learning outcomes and ensure that all students have the opportunity to succeed.

4.4 Educational Outcomes

The studies reviewed highlight the outcomes of assistive technologies in supporting English language learning among students with various disabilities. These specific tools and technologies encompass various interventions tailored to meet the unique needs of these learners. For example, deaf students benefit significantly from specialized tools that cater to their needs, facilitating better integration into standard educational settings (Arroyo-Cedeño et al., 2024). Children with Autism Spectrum Disorders (ASD) are supported by interventions like the Picture Exchange Communication System (PECS), which enhances their communication skills by fostering meaningful interactions and enabling them to express themselves more clearly (Zohoorian et al., 2021). English learners with developmental delays, speech-language impairments, or at-risk status benefit from technology-supported Language Experience Approach (LEA) tools, which provide a structured way of learning through personal experiences (Jozwik & Mustian, 2020).

Students with intellectual disabilities (ID) experience significant improvements in vocabulary retention and understanding through augmented reality applications for vocabulary instruction (Rapti et al., 2023). Additionally, inclusive videos cater to the learning needs of

students with hyperacusis (hearing loss), ADHD, Borderline Intellectual Functioning, Semantic-Pragmatic Disorder, and Asperger's Syndrome, making the learning process more inclusive and effective (Andujar & Nadif, 2022). For students with learning disabilities or speech/language impairments, vocabulary acquisition strategies and multimedia tools provide a multimodal approach to learning (Ortogero & Ray, 2021). Visual impairments are addressed through web-based vocabulary drills and screen reader programs, ensuring that visually impaired students can access educational content with ease, promoting equal learning opportunities (Kamali et al., 2021; Hamid & Setiawan, 2022; Khan & Mahmood, 2022; Martínez-Hernández & Bellés-Fortuño, 2021). Slow learners improve their language skills through multimedia-assisted language learning applications, enhancing their speaking performance, fluency, and vocabulary (Yulian et al., 2022).

These findings underscore the critical role of assistive technologies in enhancing educational outcomes for students with diverse learning needs. These applications provide interactive and engaging learning experiences that cater to the slower pace of these learners. The varied disabilities and corresponding technological interventions highlighted in these studies underscore the need for tailored approaches to effectively support diverse learning needs. By leveraging these technologies, educators can create more inclusive and supportive learning environments for all students. These findings emphasize the vital role of assistive technologies in fostering educational success for students with varied learning needs. The integration of these technologies not only enhances academic performance but also supports broader aspects of student engagement and satisfaction. As educational practices continue to evolve, ongoing research and development of assistive technologies will be crucial in addressing the unique challenges faced by students with disabilities and ensuring their academic growth and development.

5. Discussion

The integration of assistive technologies in English language learning for students with disabilities presents a promising yet complex landscape, as evidenced by the reviewed studies. The overall effectiveness of these technologies is unequivocal, showing significant improvements in various educational outcomes. For instance, EducaPlay has been beneficial for students with hearing disabilities, enhancing their motivation and class performance despite the limitation posed by insufficient teacher training (Arroyo-Cedeño et al., 2024). Similarly, the Picture Exchange Communication System (PECS) has proven highly effective in improving vocabulary acquisition and communication skills in children with autism, highlighting the system's capacity to facilitate meaningful learning interactions (Zohoorian et al., 2021).

Augmented Reality (AR) tools, such as EduAr, have effectively enhanced vocabulary acquisition among students with intellectual disabilities, with measurable improvements in vocabulary retention and spelling accuracy (Rapti et al., 2023). The use of inclusive videos has also shown to create engaging and accessible learning environments, particularly for students with hearing impairments, thus improving motivation and comprehension (Andujar & Nadif, 2022). Moreover, multimedia tools and vocabulary acquisition strategies (VAS) have been instrumental in boosting vocabulary retention, self-regulation skills, and overall learning efficiency for English learners (Ortogero & Ray, 2021).

Specific tools and technologies reviewed include a range of platforms and applications tailored to diverse disabilities. Tools like EducaPlay and Rosetta Stone cater to students with hearing disabilities by providing interactive language learning environments. PECS is tailored for children with autism, while AR applications like EduAr are designed for students with intellectual disabilities, offering interactive and immersive learning experiences. For visually impaired students, tools such as JAWS, MELDICT, OCR scanners, and Braille devices play a critical role in supporting comprehensive language learning (Hamid & Setiawan, 2022; Martínez-Hernández & Bellés-Fortuño, 2021). These tools collectively cater to a broad spectrum of disabilities, from hearing impairments to autism, intellectual disabilities, and visual impairments, underscoring the necessity for tailored technological interventions.

The educational outcomes observed in these studies are multifaceted, reflecting improvements across key areas such as reading comprehension, vocabulary acquisition, and writing skills. Enhanced vocabulary learning and communication skills, as facilitated by PECS, underscore the system's role in enabling children with autism to engage meaningfully with language learning (Zohoorian et al., 2021). The positive impacts of AR applications on vocabulary retention and spelling further highlight the potential of immersive technologies in supporting intellectual development (Rapti et al., 2023). Additionally, tools like JAWS and MELDICT have fostered improvements in listening, reading, writing, and speaking skills among visually impaired students, promoting greater independence and effective communication (Hamid & Setiawan, 2022; Martínez-Hernández & Bellés-Fortuño, 2021).

However, the implementation of these technologies is not without challenges and barriers. A significant challenge is the lack of teacher training on technological tools, which hampers the effective use of resources like EducaPlay and PECS, leading to poor vocabulary acquisition and pronunciation issues (Arroyo-Cedeño et al., 2024; Zohoorian et al., 2021). Students also show variability in baseline proficiency and cognitive capacity, necessitating individualized support that can be demanding in diverse classroom settings (Jozwik & Mustian, 2020; Yulian et al., 2022). Technical issues, such as Wi-Fi connectivity problems and the need for specific formats for TTS software, complicate the integration of these tools (Andujar & Nadif, 2022; Martínez-Hernández & Bellés-Fortuño, 2021).

While the positive impacts of assistive technologies on English language learning for students with disabilities are clear, addressing the challenges and barriers is crucial for their successful integration. Ensuring adequate teacher training, technological resources, and support systems will enhance the effectiveness of these tools, ultimately leading to more inclusive and effective educational environments. The integration of assistive technologies in English language learning holds significant potential for improving educational outcomes for

students with disabilities. Stakeholders, including educators, policymakers, and technology developers, must prioritize comprehensive teacher training programs that equip educators with the skills and knowledge to effectively use these tools. Additionally, investing in technological infrastructure and ensuring reliable access to necessary devices and software are critical steps.

Future research should focus on longitudinal studies to assess the long-term impact of assistive technologies on language acquisition and other educational outcomes. Investigating the specific needs of different disability groups can inform the development of more tailored interventions. Moreover, exploring the role of student feedback in the design and implementation of these technologies can lead to more user-centered solutions. Collaboration among researchers, educators, and technology developers is essential to address the technical and pedagogical challenges associated with assistive technologies. By fostering an inclusive research and development environment, stakeholders can contribute to creating effective, accessible, and sustainable educational tools that cater to the diverse needs of students with disabilities. This collaborative effort will ultimately promote equity and enhance learning experiences for all students.

6. Conclusion

The primary aim of this meta-narrative analysis was to evaluate the effectiveness of various assistive technologies in enhancing English language learning outcomes for students with diverse disabilities. The analysis revealed that these technologies significantly improve educational outcomes, such as reading, writing, vocabulary acquisition, and communication skills across a wide range of disabilities, including hearing impairments, autism, intellectual disabilities, and visual impairments. Tools like EducaPlay, PECS, AR applications, inclusive videos, and multimedia tools have shown substantial benefits, enhancing motivation, engagement, and self-confidence among students. However, several limitations were identified, including inadequate teacher training, variability in student proficiency and cognitive capacities, technical issues, and the high cost of advanced assistive technologies, which limit accessibility, particularly in developing countries. The findings underscore the importance of tailored assistive technologies in creating inclusive and effective educational environments. Future research should focus on developing comprehensive teacher training programs, exploring cost-effective solutions, and conducting longitudinal studies to assess the long-term impacts of these technologies. Addressing these challenges will maximize the potential benefits of assistive technologies, ensuring that students with disabilities can achieve their full academic potential.

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Authors' contributions

Each author contributed significantly to the development and completion of this research, bringing specialized expertise and collaborative support throughout the process. Nostalgianti Citra Prystiananta led the conceptualization, project administration, and supervision, guiding the research's direction while drafting and meticulously refining the manuscript. Ade Irma Noviyanti and Khusna Yulinda Udhiyanasari played a pivotal role in the formal analysis and methodological design, establishing a rigorous framework and conducting thorough data analysis, in addition to their contributions to drafting and revising the manuscript. Khusna Yulinda Udhiyanasari provided vital resources and engaged actively in the writing, review, and editing stages, ensuring the final manuscript's scholarly rigor and quality. Each author's dedicated contributions, from initial planning to finalization, were essential to the study's successful execution.

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Competing interests

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