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THE ROLE OF AI-BASED TOOLS IN SUPPORTING READING DEVELOPMENT AMONG LEARNERS WITH HEARING DISABILITIES: A NARRATIVE REVIEW

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Abstract: *This narrative review examines the role of Artificial Intelligence (AI) based tools in supporting reading development among learners with hearing disabilities, focusing on their potential, limitations, and future directions (Empowering Education: The Role of Artificial Intelligence in Supporting Students with Disabilities). Reading acquisition remains a significant challenge for this population due to reduced access to phonological awareness and auditory-based language cues, yet recent AI innovations, including speech-to-text systems, adaptive learning platforms, and natural language processing, offer promising solutions by providing personalized, multimodal, and accessible learning pathways. Literature was sourced from databases such as Scopus, Web of Science, ERIC, PubMed, and Google Scholar, using targeted search terms related to AI, hearing impairment, and literacy. Peer-reviewed studies in English from 2020 to 2025 were also included for analysis. Findings highlight that AI tools can enhance literacy through personalization, immediate feedback, and visual or text-based supports, though definitional inconsistencies, reliance on small-scale studies, affordability barriers, and ethical concerns, such as algorithmic bias, limit their broader application. The evidence suggests that hybrid approaches, combining teacher expertise with AI-driven personalization, may be the most effective strategy. However, long-term and large-scale outcomes remain underexplored. This review contributes to clarifying current opportunities and challenges, while also calling for more rigorous, culturally responsive research and for policymakers and practitioners to prioritize equitable access, teacher involvement, and ethical practices in implementing AI-driven literacy solutions.*

Keywords: *Artificial intelligence, reading development, hearing impairment, literacy, inclusive education, educational technology*

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Introduction

The integration of Artificial Intelligence (AI) into education has emerged as a transformative force, offering innovative solutions to address diverse learning needs, particularly among students with disabilities (Bahroun et al., 2023). For learners with hearing impairments, reading development often presents unique challenges due to limited access to phonological awareness and auditory-based language cues, which are essential for literacy acquisition (Sibayan, 2024). Recent advances in AI-based tools such as speech-to-text systems, adaptive learning platforms, and natural language processing applications have created new opportunities to bridge these gaps by providing personalized, multimodal, and accessible pathways for reading instruction (He, 2024). While growing research highlights the potential of AI in inclusive education, there remain gaps in understanding its specific role in fostering reading proficiency among students with hearing disabilities (Nisha & Gill, 2024). Controversies also persist regarding issues of accessibility, equity, and the extent to which AI can effectively complement traditional pedagogical approaches (Bulathwela et al., 2024). The aim of this narrative review is to investigate how AI technology tools can assist reading development in readers with hearing loss, as well as the state-of-the-art applications and potential challenges that these implementations present. In synthesizing extant research, this review seeks to provide educators, policymakers, and researchers with an up-to-date map of the field that highlights the potential and pitfalls of AI in enhancing literacy results among this population.

Methods

This narrative review was undertaken to compile the existing knowledge on how AI-based tools can supplement reading development in students with hearing loss. Database The following electronic databases were searched for relevant studies: Web of Science, Scopus, PubMed, ERIC, as well as Google Scholar. By reviewing the bibliographies of relevant articles, other searches were conducted to uncover those studies not captured by the database search.

A keyword as well as a Boolean operator combination were used to facilitate a comprehensive search of the literature. The primary search terms were: *"artificial intelligence"* OR *"AI-based tools"* OR *"AI applications"* AND *"hearing impairment"* OR *"hearing loss"* OR *"deaf"* OR *"hard of hearing"* AND *"reading skills"*, OR *"reading development"*, OR *"literacy"*. Filters were imposed to include only peer-reviewed papers in English published between 2020 and 2025, encompassing the rapid developments of AI over this period.

The inclusion criteria asked for studies that: (1) participants are hearing-impaired learners, (2) the use of AI or AI-related tools in educational aspects or literacy learning, as well as (3) present research papers or discussions related to reading development. Exclusion criteria consisted of those studies that did not pertain to literacy, articles that failed to mention AI-based applications, or opinion pieces with no clear empirical evidence or theoretical foundation. This step indicated that the review was based on sound, relevant, and current evidence.

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Discussion

Synthesis Analysis

Definition and Scope of AI-Based Tools in Education

AI in education counts on technology developments such as machine learning algorithms, speech-to-text systems, adaptive learning platforms, and natural language processing applications (Wang et al., 2024). These resources are designed to help learners who have hearing loss compensate for limited auditory input through the provision of alternative means of processing, e.g., text-based versions of speech or interactive reading environments (Udbhasa et al., 2023). While most scholars agree on the potential of AI to enhance literacy outcomes, some argue that the broad definition of AI creates ambiguity in measuring its actual impact, since not all digital tools marketed as "AI-driven" rely on genuine machine learning processes. This definitional inconsistency poses a challenge for systematic evaluation.

Advantages and Opportunities

Other than that, research consistently highlights several advantages of AI-based tools for reading development. AI technologies can personalize learning experiences by adapting to individual reading levels, providing immediate feedback, and supporting multimodal learning pathways (Liu et al., 2022). For instance, speech-to-text and captioning systems help learners bridge gaps between visual and written forms of language, while AI-powered tutoring systems offer adaptive scaffolding in vocabulary and comprehension (Tripathi et al., 2024). Scholars generally agree that these affordances contribute to improved access to and inclusivity in literacy. However, some caution that overreliance on AI may risk reducing opportunities for direct teacher–student interaction, which remains vital for socio-emotional development and contextualized language learning.

Challenges and Limitations

Despite their promise, AI-based tools face significant limitations. Accessibility and affordability remain critical barriers, particularly in low-resource educational contexts where specialized hardware and software may not be available (Yadav & Vashishtha, 2024). Moreover, studies have raised concerns about algorithmic bias, where AI systems trained on majority-language corpora may not adequately reflect the linguistic needs of hearing-impaired learners, especially in multilingual settings (Tripathi et al., 2024). There is also debate on the extent to which AI can replicate the nuanced role of human educators in fostering comprehension and higher-order reading skills (Shafiee Rad, 2025). Critics argue that while AI can supplement instruction, it cannot fully address the socio-cultural dimensions of literacy development for hearing-impaired learners (Bekeš et al., 2024).

Emerging Trends and Research Gaps

Consequently, recent developments demonstrate a growing shift toward integrating AI into inclusive education frameworks, with emphasis on hybrid models that combine teacher expertise with AI-driven personalization (Song et al., 2024). Nevertheless, gaps remain in longitudinal research assessing the sustained impact of these tools on literacy outcomes. Much of the existing literature relies on short-term experimental studies, often with small sample sizes, limiting generalizability. Another unresolved issue concerns ethical considerations, such as data privacy for vulnerable student populations and equitable access across different socio-

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economic contexts. Hence, these gaps suggest the need for more rigorous, large-scale studies that evaluate both educational effectiveness and practical implementation challenges.

Implications for Practice, Policy, and Research

The synthesis of existing literature suggests that AI-based tools hold considerable potential to support reading development among learners with hearing disabilities, provided they are implemented thoughtfully (Kumar et al., 2022). For practitioners, integrating AI should be viewed as complementary rather than substitutive, with teachers playing a central role in guiding and contextualizing learning (Jeon & Lee, 2023). Policymakers should prioritize funding for accessible AI solutions while establishing guidelines to mitigate ethical risks (Li et al., 2024). Therefore, future research must move beyond proof-of-concept studies, adopting interdisciplinary approaches to assess long-term effectiveness, equity of access, and cultural adaptability (Balci et al., 2022). Addressing these issues will be crucial to ensuring that AI-driven innovations make meaningful contributions to inclusive literacy education.

Limitations

Weak points of the study and areas for improvement are addressed in this section to inform the reader about existing limitations, as no article is perfect. This may be challenging for the authors themselves, who are deeply involved in the writing process, and referring to a trusted colleague could be a possible method to determine the limitations.

Although this narrative review provides valuable insights into the role of AI-based tools in supporting reading development among learners with hearing disabilities, several limitations must be acknowledged. First, the methodological design of a narrative review is a flexible and broad-based methodology that lacks the systematic refinement of meta-analyses or scoping reviews. This constantly risks introducing selection bias where the searcher's decision to include studies may have been shaded by the database coverage, variation in keywords, and translation of relevance applied.

Second, the evidence itself has some strong limitations. Most of the work on AI in education is still exploratory, emerging from small-scale pilots, case studies, or proof-of-concept implementations. These studies are difficult to generalize from, and it is challenging in this type of evaluation to establish a clear cause-and-effect relationship between AI interventions and measurable improvements in reading. In addition, several studies do not demonstrate empirical evidence of long-term effectiveness and more specifically focus on potential technology.

Third, the heterogeneity of included studies resulted in synthesis difficulties. Differences in conceptualizing AI, the range of learner groups considered, and diverse operational measures of reading advancement hampered comparison across studies. A few studies had poorly detailed method reporting, and high quality or reliability could not be ascertained.

Lastly, potential biases should be taken into account. Publication bias would lead to positive results about AI's educational value being more likely to be reported than negative or indeterminate findings. Such searches had the potential to overlook similar non-English publications, while limiting language to English may have left out research that was pertinent and performed elsewhere.

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Thus, future reviews could mitigate these limitations by employing systematic review methodologies, expanding inclusion to non-English studies, and applying quality appraisal tools. Longitudinal and large-scale empirical research will also be essential to address current evidence gaps, allowing for stronger conclusions about the effectiveness, equity, and sustainability of AI-based tools in literacy development for learners with hearing disabilities.

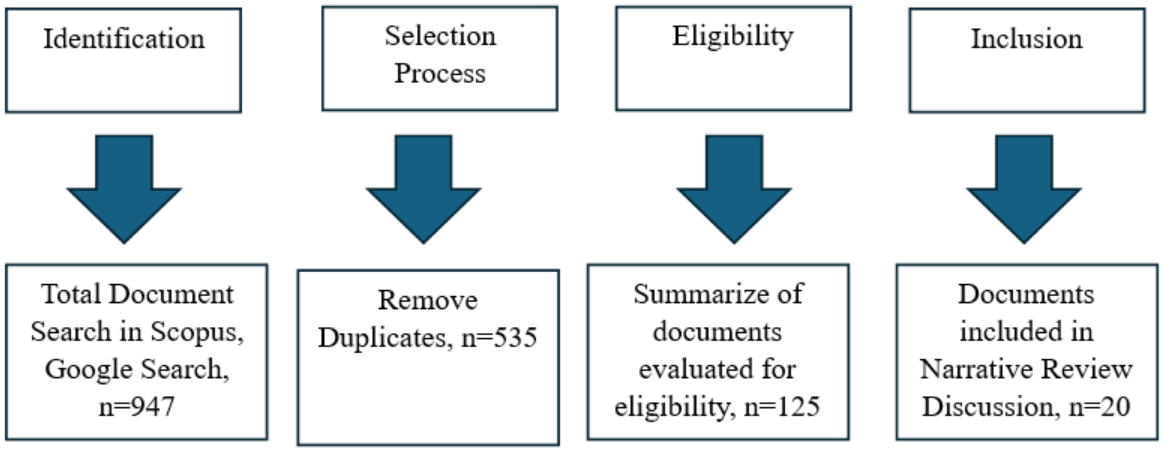

Figure 1: PRISMA-based Flow Diagram of Document Selection Process for Narrative Review

Conclusion

This narrative review examined the role of AI-based tools in supporting reading development among learners with hearing disabilities, synthesizing evidence across definitions, opportunities, challenges, and emerging trends. Findings indicate that AI holds significant promise in enhancing literacy through adaptive learning, multimodal access, and personalized feedback, particularly by compensating for reduced auditory input. However, the review also revealed critical limitations, including definitional inconsistencies, reliance on small-scale or short-term studies, and concerns regarding accessibility, affordability, and the ethical use of these methods. These insights directly address the gaps identified at the outset, demonstrating that while AI can complement traditional instruction, it cannot replace the socio-cultural and pedagogical dimensions of literacy learning. Consequently, the review highlights an emerging consensus that hybrid approaches, which combine teacher expertise with AI-driven personalization, offer the most effective model. However, rigorous empirical research is still lacking. To advance the field, future initiatives should focus on large-scale longitudinal studies, cross-cultural evaluations, and the development of AI systems trained on diverse linguistic data to reduce bias. Policymakers and practitioners should prioritize equity, accessibility, and teacher involvement when adopting AI tools. By addressing these unresolved issues, future research can ensure that AI-driven innovations meaningfully contribute to inclusive and sustainable literacy development for learners with hearing impairments.

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