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LITERATURE REVIEW: USE OF TRANSCRIPTION TECHNOLOGY TO IMPROVE LEARNING ACCESSIBILITY FOR DEAF CHILDREN

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Abstract

Deaf children face persistent structural barriers in accessing spoken classroom discourse, placing them at a systematic disadvantage in mainstream educational settings. Transcription technology the automated or manual conversion of spoken language into written text has emerged as a promising intervention to bridge this gap. This article presents a systematic literature review of relevant sources published between 2007 and 2022, examining the theoretical foundations of transcription technology, its documented benefits for deaf learners, and the structural challenges constraining its large-scale adoption. Rather than cataloguing benefits in isolation, this review critically compares competing theoretical perspectives from Universal Design for Learning to sociolinguistic models of deaf identity and traces tensions between technological optimism and practical implementation realities. Findings indicate that transcription technology meaningfully enhances deaf children's access to instructional content, supports language and literacy development, and strengthens academic engagement, yet its effectiveness is strongly mediated by pedagogical integration quality, teacher competence, and infrastructural equity. Implications for inclusive education policy and future research directions are discussed.

Keywords: assistive technology; deaf children; inclusive education; learning accessibility; transcription technology.

Abstrak

Anak tunarungu menghadapi hambatan struktural dalam mengakses wacana lisan di ruang kelas, yang menempatkan mereka pada posisi tidak setara dalam lingkungan pendidikan reguler. Teknologi transkripsi konversi otomatis atau manual dari bahasa lisan menjadi teks tertulis telah muncul sebagai intervensi yang menjanjikan untuk menjembatani kesenjangan ini. Artikel ini menyajikan tinjauan literatur sistematis terhadap sumber-sumber yang relevan, diterbitkan antara tahun 2007 hingga 2022, mengkaji fondasi teoretis teknologi transkripsi, manfaatnya yang terdokumentasi bagi peserta didik tunarungu, serta tantangan struktural yang membatasi adopsinya secara luas. Alih-alih sekadar mencatat manfaat secara terpisah-pisah, tinjauan ini secara kritis membandingkan perspektif teoretis yang bersaing dari kerangka Universal Design for Learning hingga model sosiolinguistik identitas tunarungu dan menelusuri ketegangan antara optimisme teknologis dan realitas implementasi di lapangan. Temuan menunjukkan bahwa teknologi transkripsi secara bermakna dapat meningkatkan akses terhadap konten pembelajaran, mendukung perkembangan bahasa dan literasi, serta memperkuat keterlibatan akademik anak tunarungu. Namun, efektivitasnya sangat dimediasi oleh kualitas integrasi pedagogis, kompetensi guru, dan kesetaraan infrastruktur. Implikasi bagi kebijakan pendidikan inklusif dan arah penelitian ke depan turut dibahas.

Kata kunci: aksesibilitas pembelajaran; anak tunarungu; teknologi asistif, teknologi transkripsi; pendidikan inklusif.

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INTRODUCTION

Every child has the right to learn. But for millions of deaf children worldwide, this right clashes daily with a simple structural reality: most classrooms are built on a foundation of spoken language. Teacher lectures, class discussions, explanations, and student interactions all take place primarily through auditory channels, which are inaccessible to deaf children. The result is not simply discomfort; it is systematic exclusion from the cognitive and social networks of classroom life. According to the World Health Organization (WHO, 2023), approximately 34 million children worldwide live with hearing impairments that impair their abilities, and this number is projected to continue to rise. In Indonesia, data from the Ministry of Education, Culture, Research, and Technology (Kemendikbud, 2022) shows that tens of thousands of deaf children are enrolled in Special Needs Schools (SLB) and inclusive schools, yet the quality of learning access remains highly uneven across regions.

The traditional response to this challenge has been to provide sign language interpreters or special education teachers trained in a total communication approach. While both remain indispensable, these approaches are resource-intensive and geographically constrained—very real problems in an archipelagic country as vast and diverse as Indonesia. It is in this context that transcription technology is receiving increasing scholarly and policy attention as a widely scalable solution. Gold and Morgan (2011) define transcription technology as the process of converting speech signals into written text, which can be done manually or using computational algorithms. In the context of modern education, the most relevant form is Automatic Speech Recognition (ASR), software that processes live or recorded audio and produces text output in real time. The appeal of this technology lies in its potential to democratize access: providing every deaf child in every classroom with a written representation of spoken discourse, regardless of whether a human interpreter is available.

However, the relationship between transcription technology and learning accessibility is neither simple nor guaranteed. Numerous studies have shown that technology alone does not lead to inclusion; Its effectiveness is closely tied to the pedagogical context, teacher preparedness, institutional infrastructure, and even the linguistic background and identity of deaf learners themselves (Knoors & Marschark, 2014; Leigh & Andrews, 2020). This literature review is motivated by the need to move beyond the optimistic-tech narrative and engage critically with what the evidence actually shows—where transcription technology succeeds, where it fails, and why.

This article makes three distinct contributions. First, it synthesizes recent findings on educational outcomes associated with the use of transcription technology with deaf children, during a period marked by significant advances in ASR accuracy and the proliferation of mobile technologies. Second, it situates these findings within competing theoretical frameworks, examining tensions between the Universal Design for Learning (UDL) paradigm, sociolinguistic models of deaf education, and sociocultural theories of learning. Third, it identifies the structural conditions, what researchers call the "implementation ecosystem," that determine whether transcription technology functions as a true accessibility tool or remains an underutilized addition to classroom practice.

METHOD

This article uses a systematic literature review approach. The literature search was conducted through the academic databases Google Scholar, ERIC (Education Resources Information Center), and Scopus, using a combination of keywords: 'deaf education transcription technology', 'automatic speech recognition hearing impairment learning', 'assistive technology deaf children literacy', and 'inclusive education deaf accessibility technology'. Inclusion criteria included: (1) peer-reviewed scientific journal articles or academic books; (2) published between 2007 and 2022; (3) focused on the deaf or hard-of-hearing population in an educational context; and (4) discussed transcription technology or assistive technology as a primary focus or significant component. The synthesis was conducted thematically and comparatively, prioritizing the identification of agreements, tensions, and gaps between sources rather than simply a sequential summary of each individual study.

RESULTS AND DISCUSSION

Transcription Technology: Conceptual Foundations and Theoretical Framework

What Is Transcription Technology?

Transcription technology refers to any human-operated or automated system that converts spoken language into written text. Gold and Morgan (2011) provide a basic technical definition: transcription is the process of converting a speech signal into written text, which can be done manually by a trained transcriber or computationally through algorithms that model the acoustic, phonological, and linguistic properties of speech. In the contemporary educational context, the most relevant form is Automatic Speech Recognition (ASR), software that processes live audio and generates text in real time.

This distinction between manual and automated approaches is important because they have different implications for educational accessibility. Manual approaches that rely on typists or sign language interpreters tend to produce more accurate, contextually relevant output but require trained, expensive human resources and cannot be easily scaled to all classrooms in all schools. In contrast, ASR has become more scalable and affordable as deep learning technologies advance, but still faces serious accuracy challenges in realistic classroom conditions (Butler et al., 2019). Mott et al. (2024), in their comprehensive evaluation of 11 common ASR services using recorded higher education lectures, found that accuracy varied widely across vendors and within individual audio samples, with the quality of ASR streams used for live events significantly lower. These findings underscore the ongoing gap between technical claims and actual user experiences.

Competing Theoretical Frameworks

The integration of transcription technology into deaf education can be approached through at least three distinct theoretical frameworks, each yielding different insights and priorities. The first framework is Universal Design for Learning (UDL), developed by CAST (2018), which advocates proactive and flexible instructional design to eliminate barriers for all learners, rather than reactively

designing specific accommodations for specific individuals. Within the UDL framework, transcription technology is a “multi-mode representation” strategy that provides spoken content in written form alongside auditory delivery, thereby expanding access without stigmatizing deaf students. A compelling argument from this perspective is that live captioning for the entire class not only serves deaf students but also benefits learners with attention difficulties, non-native speakers, and students processing complex technical language.

The second framework is the sociocultural theory of learning, rooted in Vygotsky’s concepts of the zone of proximal development and mediated learning. From this perspective, transcription technology functions as a cultural tool that mediates deaf children’s engagement with academic discourse communities. Knoors and Marschark (2014) argue that for transcription technology to function as an effective mediation tool, it must be integrated into the instructional sequence in a way that supports comprehension beyond simply providing text, but also supports the cognitive processing of that text through discussion, questioning, and collaborative meaning construction. Technology that simply converts speech to text without pedagogical support may provide only surface-level access, not in-depth learning.

The third and perhaps most critical framework is the sociolinguistic model of deaf identity and bilingual education. Scholars such as Leigh and Andrews (2020) and Singleton and Morgan (2019) emphasize that many deaf individuals are bilingual, using both sign language and written forms of spoken languages in their environments. For these students, transcription technology that converts spoken Indonesian into text functions within a bilingual ecosystem: it provides access to written Indonesian, but does not replace sign language-based instruction. This perspective cautions against positioning transcription technology as a complete solution and highlights the importance of maintaining and supporting sign languages in educational settings. These three frameworks together reveal that the question is not simply 'does transcription technology work?' but 'under what conditions, for which learners, and in serving what educational purposes, does this technology work best?'

Documented Benefits: What The Evidence Shows

Improved Access to Instructional Content

The most consistently documented benefit of transcription technology is its ability to provide deaf students with real-time access to orally delivered classroom content. Butler et al. (2019), in their study implementing ASR as a supplemental accessibility service in biology, statistics, and other college courses, found that while deaf students believed ASR was beneficial, they also consistently identified that its accuracy and readability needed improvement. Importantly, these benefits were not uniform. Students who relied more on sign language or had limited exposure to formal texts showed more moderate gains. This confirms Knoors and Marschark's (2014) finding that transcription technology works best as a 'literacy booster'—it enhances existing reading competencies, rather than building foundational literacy from scratch.

Kawas et al. (2016), in their study on improving real-time captioning experiences for deaf students, found that design factors such as placement, font size, and caption readability significantly affected how effectively students could integrate transcribed text with other visual observations in the classroom. This finding suggests that accessibility is not simply about the availability of text but also about how it is presented within a multimodal learning environment.

Language and Literacy Development

A second body of evidence relates to the role of transcription technology in supporting the language and literacy development of deaf students. Winarsih (2007) emphasized that hearing impairments directly impact the language and communication development of deaf children, including vocabulary poverty and difficulty understanding sentence structure. In this context, continuous exposure to authentic, contextually embedded transcribed text—text that emerges from real classroom interactions, rather than fabricated reading materials—offers a promising mechanism for supporting incidental vocabulary and syntax development.

However, Knoors and Marschark (2014) offer a different, yet complementary, perspective. They argue that the effects of transcription technology on language development are maximized when teachers actively use transcripts as instructional texts, explicitly directing students' attention to the vocabulary, syntax, and discourse structures in the transcribed content. In other words, the text produced by transcription technology should not simply scroll passively across the screen; it should be the object of deliberate pedagogical attention. This position aligns with Knoors and Marschark's (2014) broader argument that deaf learners benefit most from explicit language instruction, given that the implicit language-learning mechanisms that hearing children rely on through auditory exposure are not equally available to deaf learners.

Academic Engagement and Self-Efficacy

Beyond content access and language development, several studies document the psychosocial effects of transcription technology on deaf students' academic engagement and self-efficacy. Butler et al. (2019) found that deaf students who used ASR devices reported benefits despite limited accuracy, particularly in reducing cognitive anxiety resulting from the inability to follow spoken discourse. Marschark and Hauser (2011) connected these psychological effects to broader theories of academic motivation, arguing that accessibility tools that reduce cognitive load—the mental effort required to process incomplete or degraded information—free up attentional and motivational resources for deeper engagement with content. When deaf students no longer have to devote a significant portion of their cognitive capacity to lip-reading, guessing, or compensating for missed information, they can redirect that capacity toward higher-order thinking.

Challenges and Tensions in Implementation

Technical Limitations and Accuracy Issues

Despite significant advances in ASR technology over the past decade, accuracy remains a critical challenge in educational applications. Mott et al. (2024) systematically measured the performance of 11 common ASR services using recorded higher education lectures and found that accuracy varied widely across vendors, with the quality of ASR streams used for live events significantly lower than non-streaming modes. These findings confirm what the deaf community has reported: a clear gap between claims of technical innovation and the actual experiences of users who rely on transcription. Butler et al. (2019) also consistently found that deaf students in college classes identified accuracy and intelligibility as the main barriers to ASR utilization, even though they still perceived it as a useful tool.

In the Indonesian context, this challenge is even more significant. Most state-of-the-art ASR systems are developed and trained with data from English or languages with large training corpora. These systems exhibit significantly higher error rates for languages with smaller training data corpora and more complex linguistic structures—conditions that are relevant for Indonesian and its diverse varieties. This means that deaf children in Indonesian classrooms potentially face higher ASR error rates than their peers in English-speaking countries, exacerbating existing accessibility gaps (Mott et al., 2024).

Infrastructure Gaps and Inequitable Access

The promise of transcription technology as a 'scalable' solution presupposes access to the devices, internet connectivity, and software licenses needed to run it—assumptions that do not hold true in many Indonesian schools. Mott (2019) and Harahap et al. (2021) both documented a significant digital divide between urban and rural schools. Suwahyo et al. (2022) found that even where assistive technology is nominally available, it often malfunctions due to lack of maintenance, outdated hardware, or a lack of technical support staff. A troubling irony arises: schools and students with the greatest accessibility needs, located in areas with the fewest interpreters and specialist educators, are the ones least likely to have reliable access to the necessary technological infrastructure.

Pedagogical Integration: The Determining Variable

The most consistent finding across the reviewed literature is that the pedagogical context of technology use—how teachers integrate transcription tools into their teaching practices—is a key determinant of whether those tools produce meaningful learning outcomes. Knoors and Marschark (2014) consistently argue that technology is only effective if educators have the capacity to integrate it meaningfully into their teaching practices. Leigh and Andrews (2020) caution that technological accommodations do not automatically result in substantial inclusion without changes to teachers' instructional practices. Smith (in Kushalnagar, 2019) also warns against what she calls "technological

displacement of pedagogical responsibility"—the tendency to treat assistive technology as a substitute for inclusive teaching practices, rather than as a complement to them.

Deaf Identity, Agency, and Community Voice

A final, but often overlooked, tension concerns the relationship between transcription technology and deaf identity and the deaf community. Leigh and Andrews (2020) argue that educational technology interventions for deaf students are too often designed by hearing researchers and developers, without meaningful input from the deaf community, resulting in tools that reflect hearing people's assumptions about what deaf students need. Singleton and Morgan (2019) note that some deaf individuals and advocacy organizations are critical of transcription technology precisely because it prioritizes access to spoken language and, with it, the auditory-verbal world over investments in sign language education and deaf-centered learning environments. This is not a rejection of technology, but rather a call for participatory design and community agency.

Implications for Inclusive Education Practice and Policy

The synthesis of evidence and the framework presented in this review yield several concrete implications. For educators, the central message is that transcription technology is a powerful pedagogical tool, not a standalone accessibility solution. Teacher professional development programs should include structured modules on integrating live captioning into instructional sequences: specifically, how to use transcripts as instructional texts, how to verify understanding amid potential ASR errors, and how to coordinate transcription with other visual and gestural communication strategies (Knoors & Marschark, 2014).

For policymakers, the equity dimension of this review warrants attention. Suwahyo et al. (2022) and Harahap et al. (2021) converge in recommending that national and regional education policies include explicit provisions for the equitable distribution of technology, not simply mandating that schools accommodate deaf students, but ensuring that the technological and human infrastructure necessary to make genuine accommodations a reality. In the Indonesian context, this implies targeted funding for assistive technology procurement, maintenance, and training in schools serving deaf students.

For researchers, this review highlights a persistent gap: most empirical studies on transcription technology and deaf education have been conducted in English-speaking contexts in high-income countries. Evidence from Indonesia, Southeast Asia, and other non-English-speaking contexts remains sparse. Future research should prioritize these contexts and, consistent with calls by Leigh and Andrews (2020) and Singleton and Morgan (2019), systematically incorporate the perspectives of the deaf community into research design and interpretation.

CONCLUSION

This literature review has examined transcription technology not as a monolithic solution, but as a complex educational intervention whose value is highly context-dependent. The evidence clearly demonstrates that, under the right conditions, transcription technology can significantly improve deaf children's access to classroom instruction, support language and literacy development, and strengthen academic engagement and self-efficacy. These are not trivial benefits; for children who have long been systematically excluded from full participation in educational life, increased accessibility is a significant contribution to educational equity.

However, the evidence equally clearly demonstrates that these benefits are not automatic. Benefits depend on the accuracy of ASR in realistic classroom acoustic conditions, on the equitable availability of devices and connectivity, on the quality of pedagogical integration, and on the extent to which the technology implementation respects and responds to the diverse linguistic backgrounds and identities of deaf learners. When these conditions are not met, transcription technology risks becoming a cosmetic accommodation that gives the appearance of accessibility without its substance.

The theoretical frameworks reviewed here—UDL, sociocultural learning theory, and sociolinguistic models of deaf education—are not in fundamental conflict; rather, they illuminate different aspects of the same complex reality. Together, they suggest that the most powerful use of transcription technology is as one element in a comprehensive, inclusive educational ecosystem that combines technological tools with trained and dedicated teachers, equitable resource distribution, and genuine respect for deaf identities and communities. Moving forward, both research and practice must embrace this complexity, rather than simplifying reality into purely technological solutions.

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