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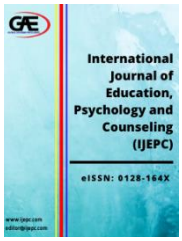

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TECHNOLOGY APPLICATION IN TEACHING AND LEARNING FOR HEARING IMPAIRED STUDENTS: A RECENT SYSTEMATIC REVIEW

Nur Afifi Alit [1*], Mohd.Sobri Ellias [2], Abu Dzar Ahmad[3]

[1] Faculty of Quranic and Sunnah Studies, Islamic Science University of Malaysia, Bandar Baru Nilai, Negeri Sembilan.
Email: nurafifi@usim.edu.my
[2] Faculty of Quranic and Sunnah Studies, Islamic Science University of Malaysia, Bandar Baru Nilai, Negeri Sembilan.
Email: sobri.ellias@usim.edu.my
[3] Akademi Pengajian Quran dan Sunnah, Universiti Islam Pahang Sultan Ahmad Shah (UnIPSAS), Malaysia
Email: abudzar@unipsas.edu.my
[*] Corresponding Author

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Abstract:

This Systematic Literature Review (SLR) explores the application of technology in teaching and learning among students with hearing impairments, a critical area in inclusive education. Despite advances in educational technology, challenges persist in ensuring equitable access and effective learning outcomes for Deaf and Hard of Hearing (DHH) students. This review addresses the gap by systematically analyzing existing studies to identify how technology supports the educational needs of this population. Guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, a comprehensive search was conducted using two major academic databases, Web of Science and Scopus, yielding 39 primary studies for analysis. The findings were thematically categorized into three core areas: (1) Technological Innovations for DHH Education, highlighting the use of assistive tools such as speech-to-text systems, captioning, and visual learning platforms; (2) Pedagogical Strategies and Inclusive Education, which examines teaching methods, curriculum adaptations, and teacher training that enhance technology integration; and (3) Accessibility Challenges and Equity, addressing barriers such as device usability, digital literacy gaps, and systemic inequalities in access to educational technologies. The review reveals a growing interest in technology-enhanced learning for DHH students but also underscores the need for more inclusive design, policy support, and empirical evaluation. This study contributes valuable insights for educators, policymakers, and developers aiming to create more accessible and effective learning environments for hearing-impaired learners.

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Keywords:

Hearing Impairment, Educational Technology, Inclusive Education, Deaf and Hard-of-Hearing (DHH), Systematic Review.

Introduction

Technology integration into teaching and learning for hearing-impaired students has become a critical area of focus in contemporary education systems. In an era of rapid digital transformation, leveraging technology to address diverse learner needs is a pedagogical advancement and a moral and social imperative. Hearing-impaired students, who often face communication barriers and limited access to mainstream educational resources, particularly benefit from technological innovations that facilitate more inclusive learning environments (Oreshkina & Slitikov, 2022). Tools such as real-time captioning systems, sign language interpretation software, visual learning platforms, and assistive listening devices have significantly enhanced the accessibility and quality of education for these students. The importance of this topic is further amplified by global initiatives such as the United Nations' Sustainable Development Goals, which advocate for inclusive and equitable quality education for all learners, regardless of their abilities (Naami & Mort, 2023).

In addition, the push for inclusive education policies in various countries has prompted schools, universities, and education technology developers to rethink conventional approaches and design learning experiences accessible to students with hearing impairments. As a multidisciplinary field that intersects education, audiology, information technology and special needs pedagogy, the application of technology for hearing-impaired students represents a vibrant and necessary domain of academic inquiry. Understanding how to employ these technological tools is essential for improving educational outcomes and empowering hearing-impaired individuals to participate fully in social, professional, and civic life.

Current research highlights several promising developments in this area. Studies by Knoors et al. (2014) and, more recently, by Akay (2021) emphasize the positive impact of multimedia instructional materials, adaptive learning platforms, speech-to-text services, and online collaborative tools that integrate visual and textual elements. Findings suggest that when properly implemented, technology can significantly boost comprehension, engagement, and academic achievement among hearing-impaired students. However, the literature also reveals critical gaps and unresolved challenges. There is ongoing debate regarding the most effective technologies for different age groups, subject areas, and degrees of hearing impairment (Ur Rehman et al., 2024). Furthermore, disparities in access due to socioeconomic status, geographic location, and institutional support continue to undermine the potential benefits of these tools (Basham et al., 2015). Teacher training and technological literacy among educators are significant barriers to effective implementation (de LIMA et al., 2022).

Literature Review

Technological advancements have significantly transformed the educational landscape for hearing-impaired students in recent years. Digital solutions have emerged as vital tools for bridging communication gaps and enhancing learning experiences for these students. This literature review examines technology applications in teaching and learning environments for hearing-impaired students, exploring various implementations across different educational

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levels and contexts. The proliferation of Information and Communication Technologies (ICT) has created unprecedented opportunities to address accessibility challenges faced by hearing-impaired learners. As Nordin et al. (2015), Lersilp & Lersilp (2019), and Nasir et al. (2021) collectively suggest, modern technological solutions serve as equalizers, providing hearing-impaired students with alternative pathways to educational content previously complex to access.

Mobile Technologies and Accessibility

Mobile technologies are crucial in enhancing educational accessibility for hearing-impaired students by supporting communication and learning. Nasir et al. (2021) determined that such technologies improve English as a Second Language (ESL) learning experiences by making them more engaging and accessible. Similarly, (Lersilp & Lersilp, 2019) highlighted using chat applications like Facebook Messenger and Line among hearing-impaired students for educational interaction. Kožuh et al. (2022) further identified mobile tools that aid communication, sound management, alerting, sign language learning, and overall academic support in higher education. Beyond communication, mobile learning platforms such as Massive Open Online Course (MOOC) that was designed with accessibility features including sign language interpretation have been shown to significantly boost academic performance (Mingsiritham & Chanyawudhiwan, 2020). Additionally Zaharudin et al. (2011) noted that hearing-impaired students are particularly engaged in visually rich e-learning content, such as computer graphics courses, indicating that specific digital formats may be more effective in capturing their interest.

Assistive Technologies in Educational Settings

Assistive technologies are essential in supporting the educational needs of hearing-impaired students by enhancing accessibility, engagement, and learning outcomes. Ekasari et al. (2025) found that speech-to-text systems using Bluetooth microphones and LED screens led to greater academic improvements than smartphone-based alternatives, emphasizing the importance of proper infrastructure. Sbattella and Tedesco (2013) introduced diverse tools such as note-taking systems, spelling predictors, summarization software, and lip-reading aids, illustrating the range of available technological supports. On the other hand, Samonte (2020) developed an e-Tutor incorporating Filipino Sign Language, speech recognition, gamification, and handwriting recognition, enabling remote and flexible learning in statistics education. Bratu et al. (2024) demonstrated that virtual labs, VR, and game-based applications significantly boosted knowledge acquisition when used alongside traditional teaching methods. Wu and Xu (2010) stressed that educational technologies must address hearing-impaired students' psychological traits and learning abilities to be truly effective. This emphasis on addressing specific needs aligns with Qilong and Xiaomei (2011), who showed that combining software simulation with hardware implementation in teaching digital circuit experiments created effective and adaptive instructional models. Together, these studies highlight the critical role of customized assistive technologies in promoting inclusive education and improving academic outcomes for students with hearing impairments.

Video-Based Educational Interventions

Video-based educational interventions have proven effective in enhancing learning outcomes for hearing-impaired students. Asogwa et al. (2020) established that video-guided interventions with captions significantly improved the academic self-concept of adolescents with hearing impairments, with sustained benefits observed during follow-ups. Consequently, Aigerim et al.

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(2021) emphasized the role of video-based tools in developing oral speech and communication skills, highlighting their importance for socialization and broader interaction. Similarly, Krasavina et al. (2021) demonstrated that electronic boards displaying words enhanced short-term memory more effectively than printed materials. In addition to engagement, video-based interventions have been explored in other educational domains, such as oral health education. This application suggests that video resources can transcend traditional academic subjects, providing valuable support in health education. In addition, a study noted that video-based educational interventions effectively improved oral hygiene practices among children with hearing impairments (Moin et al., 2021), presenting the value of video-based learning technologies in promoting comprehension, self-confidence, and communication skills among hearing-impaired learners across various educational settings.

Research Questions

Research Questions (RQs) are pivotal in a Systematic Literature Review (SLR) as they form the foundation and guide the entire review process. They help define the scope and focus of the SLR, guiding the selection of studies to include or exclude to ensure the review remains specific and relevant to the topic of interest. A formulated RQ ensures that the literature search is comprehensive and methodical, capturing all pertinent studies that address essential aspects of the subject matter. This formulated RQ reduces the risk of bias and facilitates a complete understanding of existing evidence. Moreover, RQs aid in systematically categorizing and organizing data, offering a structured basis for analyzing and synthesizing findings to draw informed conclusions. Significantly, well-crafted RQs improve the transparency and reproducibility of the SLR, enabling other researchers to replicate the process or expand on the findings.

Formulating RQs is the most critical step during the planning phase and the most influential element of the entire SLR, as it governs the review methodology (Kitchenham, 2007). Given that this SLR aims to identify and analyze the state of the art in the chosen area, the PICo framework, proposed by Lockwood et al. (2015) and widely used for formulating qualitative RQs, was adopted in this study. PICo is a mnemonic representing three core components: Population, Interest, and Context. Utilizing the PICo framework facilitates the structured development of RQs by clearly delineating the essential elements of the study. This approach ensures focused and well-defined questions, streamlining the literature search and overall study design. Based on this framework, the present study formulated the following three RQs:

1. How do AI-powered sign language recognition tools impact engagement and learning outcomes among deaf and hard-of-hearing students in primary education settings?
2. How do multimodal teaching approaches influence language acquisition and classroom participation among deaf and hard-of-hearing elementary students in inclusive education settings?
3. What institutional policies and universal design practices most effectively reduce online learning barriers for university students with hearing impairments?

Materials and Methods

When conducting SLRs, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework is the gold standard for ensuring transparency, thoroughness, and consistency (Page et al., 2021). Following these guidelines strengthens the analysis and enhances scientific rigor. Hence, randomized studies are particularly valuable for minimizing

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bias and providing robust evidence. For comprehensive coverage, searches were performed across the Web of Science and Scopus databases, known for their extensive and reliable collections.

The review process followed PRISMA's four essential steps. First, potentially relevant studies were identified through database searches. Next, these studies underwent screening using predetermined criteria to filter out irrelevant or low-quality research. The remaining studies were carefully evaluated during the eligibility assessment to confirm they satisfied inclusion requirements. Finally, data extraction and synthesis from qualified studies constituted a crucial step for developing meaningful conclusions. This methodical approach ensures the review maintains scientific integrity, producing trustworthy findings that effectively inform research and practice in the field (Moher D, Liberati A, Tetzlaff J, 2009)
.

Identification

The systematic review methodology employed a comprehensive approach to gather substantial relevant literature. Initial efforts focused on keyword selection, expanding to related terminology by carefully examining dictionaries, thesauri, encyclopedias, and existing research literature. Following thorough identification of applicable terms, appropriate search strings were developed and implemented within both Web of Science and Scopus databases (as detailed in Table 1). Note that this preliminary identification phase yielded 1061 publications pertinent to the research focus across the two selected databases.

Table 1: The Search String

Scopus	TITLE-ABS-KEY((technolog* OR "ICT" or "Information and technology" OR "digital tool*" OR "educational technology" OR "ICT" OR "information and communication technolog*") AND (learning OR education OR studying) AND (teaching OR instruction OR pedagogy) AND ("hearing impairment*" OR "hearing loss" OR deaf OR "hard of hearing" OR "auditory disorder*" OR "hearing disabilit*")) **Date of Access: April 2025**
WoS	TS=((technolog* OR "ICT" or "Information and technology" OR "digital tool*" OR "educational technology" OR "ICT" OR "information and communication technolog*") AND (learning OR education OR studying) AND (teaching OR instruction OR pedagogy) AND ("hearing impairment*" OR "hearing loss" OR deaf OR "hard of hearing" OR "auditory disorder*" OR "hearing disabilit*")) **Date of Access: April 2025**

Screening

The screening phase evaluated potentially relevant research items to ensure alignment with the predetermined RQs. Selection during this stage focused on studies addressing technology applications in teaching and learning for hearing-impaired students. Consequently, duplicate documents were systematically eliminated at this juncture. Following the initial exclusion of 1008 publications, 66 papers remained for further examination according to specific inclusion and exclusion criteria (detailed in Table 2). Literature quality served as the primary criterion, providing essential guidance for selection. Book series, book reviews, meta-syntheses, meta-analyses, conference proceedings, and chapters were excluded from the current study. The

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review incorporated only English-language publications from 2023 to 2025. A total of 13 publications were ultimately eliminated due to duplication issues.

Table 2: The Selection Criterion is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2023 – 2025	< 2023
Literature Type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Research Area	Social Science, Art and Humanities, Computer Science	Besides, Social Science, Art and Humanities, Computer Science

Eligibility

The eligibility phase, constituting the third step of the process, involved preparing 53 articles for comprehensive review. This stage entailed meticulous examination of titles and key content across all articles to verify adherence to inclusion criteria and alignment with established research objectives. Following this thorough assessment, 14 articles were excluded from further consideration due to various limitations: being outside the relevant field, containing insignificant titles, presenting abstracts unrelated to study objectives, or lacking accessible full text required for empirical validation. The rigorous evaluation yielded 39 articles deemed suitable for the subsequent detailed review.

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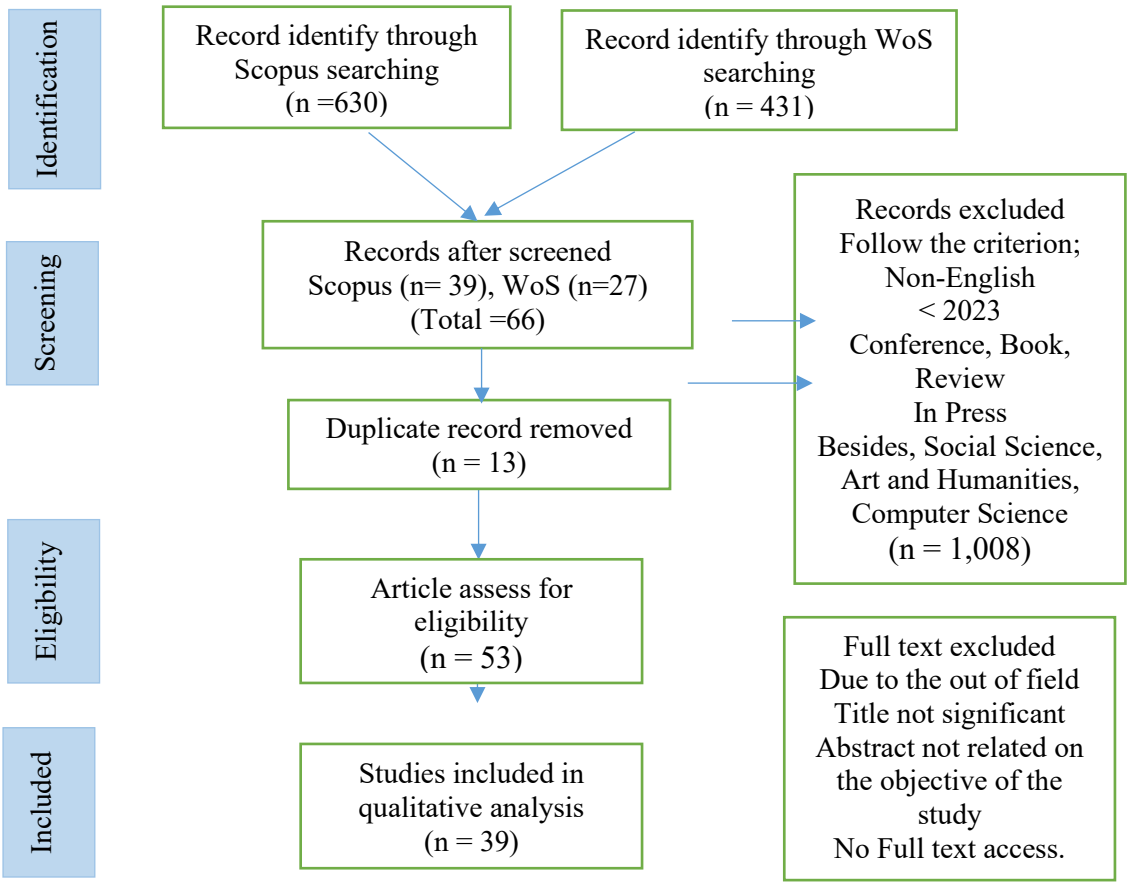

Figure 1: Flow Diagram of Proposed Searching Study

Quality of Appraisal

Following the guidelines outlined by Kitchenham (2007), once primary studies were identified, a Quality Assessment (QA) was conducted to evaluate the rigour of the research presented and enable quantitative comparison. In this context, primary studies refer to original research articles or documents directly included in the systematic review following the initial selection phase. These studies serve as the primary sources of evidence for analysis. Correspondingly, this study adopted the QA framework proposed by Abouzahra et al. (2020), which comprises six QA criteria applied within the SLR. Each criterion was evaluated using a three-point scoring system: "Yes" (Y) assigned a score of 1 if the criterion was fully satisfied, "Partly" (P) scored 0.5 when the criterion was met with some limitations, and "No" (N) given a score of 0 if the criterion was not fulfilled.

- QA1. Is the purpose of the study clearly stated?
- QA2. Is the interest and the usefulness of the work presented?
- QA3. Is the study methodology clearly established?
- QA4. Are the concepts of the approach clearly defined?
- QA5. Is the work compared and measured with other similar work?
- QA6. Are the limitations of the work clearly mentioned?

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Each expert independently assessed the selected studies based on these criteria. Subsequently, the individual scores were aggregated to produce a total score per study. A minimum score of more than 3.0 calculated from the combined evaluations of all three experts was required for a study to advance to the next phase. This threshold was established to ensure that only studies of sufficient quality were included in the final analysis.

Data Abstraction and Analysis

An integrative analysis approach was employed as part of the assessment strategy to examine and synthesize various qualitative research designs. The primary objective was to identify pertinent topics and subtopics within the scope of the study. Note that the initial phase involved data collection, which laid the foundation for theme development. A total of 40 publications were meticulously reviewed to extract statements or content aligned with the study's focus. Particular attention was given to significant studies addressing the application of technology in teaching and learning among students with hearing impairments. This review process included an examination of the methodologies applied and the findings reported across the selected works. Theme development was carried out through collaborative deliberation among contributing researchers, guided by the empirical evidence gathered. Throughout the analytical process, a log was maintained to document observations, interpretive insights, uncertainties, and reflections relevant to data interpretation. The resulting themes were subsequently cross-examined to identify and address any inconsistencies. In instances of conceptual divergence, resolution was achieved through discussion and consensus among the contributing authors.

Result and Findings

The comprehensive analysis of the QA results reveals several important patterns and insights about the current research in assistive technologies for deaf and hard-of-hearing individuals. Consequently, evaluating 39 studies across six quality criteria demonstrates that while most research demonstrates strong foundational elements, there remain significant areas for improvement in scholarly rigor and transparency.

A substantial majority of studies (92.3%) clearly stated their research purpose (QA1), and nearly as many (89.7%) effectively presented the interest and usefulness of their work (QA2), indicating that researchers are generally successful in establishing the relevance and significance of their investigations. The methodological clarity (QA3) and conceptual definition (QA4) were also robust, with 82% and 87.2% of studies meeting these criteria, respectively. This robustness suggests that the field has developed mature practices in study design and theoretical framing, which are essential for producing reliable and valid research outcomes.

However, the analysis reveals two notable weaknesses in the current literature. Only 23.1% of studies thoroughly compared their work with similar existing research (QA5), with most (66.7%) providing only partial comparisons. This comparative deficiency may limit the field's ability to demonstrate cumulative progress and contextualize new findings within the broader research landscape. More concerning is that 38.5% of studies failed to discuss their limitations (QA6), with only 5.1% providing a comprehensive limitations section. This lack of critical reflection on study constraints could hinder the proper interpretation and application of research findings, potentially affecting evidence-based practice in the field.

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The performance distribution shows six studies (15.4%) scoring ≥91.67%, demonstrating excellence across all criteria. These exemplary works, including those by Ulrich et al. (2024), Aurelrius et al. (2025), and Campbell et al. (2024), serve as models for comprehensive research design. Meanwhile, five studies (12.8%) scored ≤58.33%, with Arnaud (2023) being the lowest at 50%. These lower-performing studies typically struggled with methodology clarity, comparative analysis, and limitations discussion, suggesting areas where editorial standards or peer review could be strengthened.

The predominance of studies (64.1%) scoring 83.33% indicates a solid but unexceptional middle tier of research quality. These studies generally performed well on fundamental elements. However, they showed room for improvement in scholarly rigor, particularly in comparative analysis and limitations discussion. The field would benefit from establishing more standardized reporting guidelines to address these common weaknesses while maintaining the strengths in purpose articulation and methodological transparency that characterize current research practices. The following table presents the analysis of the selected papers.

Table 3: Results of The Quality Appraisal

Authors	PS	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	(%)
Ulrich et al.	PS1	Y	Y	Y	Y	Y	P	5.5	91.67
Aurelrius et al.	PS2	Y	Y	Y	Y	Y	P	5.5	91.67
Graham et al.	PS3	Y	Y	P	P	P	P	4	66.67
Segura et al.	PS4	Y	Y	Y	Y	P	P	5	83.33
Papadopoulos et al.	PS5	Y	Y	Y	Y	P	P	5	83.33
Alford et al.	PS6	Y	Y	P	P	P	N	3.5	58.33
Arnaud	PS7	Y	P	P	P	N	N	3	50.00
Paim et al.	PS8	Y	Y	Y	Y	P	P	5	83.33
Alegre de la Rosa & Villar Angulo	PS9	Y	Y	Y	Y	P	P	5	83.33
Terry et al.	PS10	Y	Y	Y	Y	P	P	5	83.33
Vasel & Ragonis	PS11	Y	Y	Y	Y	P	P	5	83.33

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Authors	PS	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	(%)
Lawal et al.	PS12	Y	Y	Y	Y	Y	P	5.5	91.67
Chit et al.	PS13	Y	Y	Y	Y	P	P	5	83.33
Chen et al.	PS14	Y	Y	Y	Y	P	P	5	83.33
Bratu et al.	PS15	Y	Y	Y	Y	Y	P	5.5	91.67
Poornima et al.	PS16	Y	Y	Y	Y	P	P	5	83.33
Weber et al.	PS17	Y	Y	Y	Y	P	P	5	83.33
Francisco et al.,	PS18	Y	Y	P	P	P	N	3.5	58.33
Alsudairy & Eltantawy	PS19	Y	Y	Y	Y	P	P	5	83.33
Perez-Enriquez et al.	PS20	Y	Y	Y	Y	Y	P	5.5	91.67
Jones & Murphy	PS21	Y	Y	P	P	P	N	3.5	58.33
Graham et al.	PS22	Y	Y	Y	Y	P	P	5	83.33
Gehret & Elliot	PS23	Y	Y	Y	Y	P	P	5	83.33
Gabova et al.	PS24	Y	Y	Y	Y	P	P	5	83.33
Probert et al.	PS25	Y	Y	P	P	P	N	3.5	58.33
Khasawneh	PS26	Y	Y	Y	Y	P	P	5	83.33
Haris et al.	PS27	Y	Y	Y	Y	P	P	5	83.33
Basonbul	PS28	Y	Y	P	P	P	N	3.5	58.33
Snoddon & Madaparthi	PS29	Y	Y	Y	Y	P	P	5	83.33
Luft & Brochu	PS30	Y	Y	Y	Y	P	P	5	83.33

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Authors	PS	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	(%)
Zhang et al.	PS31	Y	Y	Y	Y	Y	P	5.5	91.67
de Lima et al.	PS32	Y	Y	P	P	P	N	3.5	58.33
Mtani et al.,	PS33	Y	Y	Y	Y	P	P	5	83.33
Yusoff et al.	PS34	Y	Y	Y	Y	P	N	4.5	75.00
Alford et al.	PS35	Y	Y	Y	Y	P	N	4.5	75.00
Izaguirre et al.	PS36	Y	Y	Y	Y	P	P	5	83.33
Felippe & Dias	PS37	Y	Y	Y	Y	P	N	4.5	75.00
Campbell et al.	PS38	Y	Y	Y	P	P	N	4	66.67
Lancioni et al.,	PS39	Y	Y	Y	Y	Y	P	5.5	91.67

The research team collaboratively developed the themes and sub-themes, ensuring alignment with the evidence gathered. A detailed log was maintained throughout data analysis to document analytical decisions, emerging insights, and unresolved questions. The authors cross-verified interpretations to enhance rigor, addressing discrepancies through discussion until consensus was reached. The final themes were refined iteratively to ensure coherence and consistency. To validate the thematic framework, two domain experts, one in public health and another in medical science conducted an independent review. Correspondingly, their feedback assessed each sub-theme's clarity, relevance, and appropriateness, reinforcing the study's credibility. The writer incorporated their critiques and professional judgments to refine the analysis, strengthening the thematic structure's validity and applicability. Below is the table outlining the formulated themes:

Table 4: Findings

Author/Themes	Themes								
	Technological Innovations for DHH Education			Pedagogical Strategies and Inclusive Education			Accessibility and Equity		Challenges
Sub-themes	AI & ML	AR/VR & IT	M & AT	TT & P	MLA	P/SP	OLB	P&I F	UD & E
Ulrich et al. (2024)	√								
Aurelrius et al. (2025)	√								
Graham et al. (2023)				√					

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Segura et al. 2023)	√							
Papadopoulos et al. (2024)		√						√
Alford et al. (2023)					√			
Arnaud (2023)			√					
Paim et al. (2023)				√				
Alegre de la Rosa & Villar Angulo (2024)			√					
Terry et al. (2025)							√	
Vasel & Ragonis (2024)		√						
Vasel & Ragonis (2024)		√						
Chit et al. (2024)				√				
Chen et al. (2024)				√				
Bratu et al. 2024)	√							
Poornima et al. (2024)	√							
(Weber et al., 2024)					√		√	
Francisco et al. (2024)				√				
Alsudairy & Eltantawy (2024)	√							
Perez-Enriquez et al. (2024)						√		√
Jones & Murphy (2024)				√				
Graham et al. (2024)			√					
Gehret & Elliot (2025)						√		
Gabova et al. (2024)			√					
Probert et al. (2023)						√		
Khasawneh (2024)	√							
Haris et al. (2023)		√						
Basonbul (2023)						√		
Snoddon & Madaparthi (2023)					√			
Luft & Brochu (2023)						√		
Zhang et al., (2024)	√							
de Lima et al. (2023)		√						√
Mtani et al. (2024)			√				√	
Yusoff et al. (2024)	√							
Alford et al. (2023)					√			
Izaguirre et al. (2024)		√						
Felippe & Dias (2024)					√			
Campbell et al. (2024)					√			

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Lancioni et al. (2024)	√	

Technological Innovations for DHH Education AI & ML: AI & Machine Learning AR/VR & IT: AR/VR & Immersive Technologies M & AT: Mobile & Assistive Technologies	Pedagogical Strategies and Inclusive Education TT & P: Teacher Training & Perceptions MLA: Multimodal Learning Approach P/S P: Parental/Student Perspectives	Accessibility Challenges and Equity OLB: Online Learning Barriers P & IF: Policy & Institutional Frameworks UD & E: Universal Design & Equity

Theme 1: Technological Innovations for Deaf/Hard of Hearing (DHH) Education

Recent Artificial Intelligence (AI) and Machine Learning (ML) advancements have significantly enhanced sign language recognition and translation systems. Ulrich et al. (2024) developed SIGNIFY, a serious game utilizing gesture recognition to teach Italian Sign Language (LIS), demonstrating real-time hand landmark detection for interactive learning. Similarly, Aurelrius et al. (2025) employed transfer learning with transformer-based models (mBART50, NLLB200) to generate animated subtitles in Indonesian Sign Language (SIBI), improving translation accuracy by up to 71%. Poornima et al. (2024) further optimized sign recognition using YOLOv5, surpassing traditional CNN-based methods in speed and precision. However, teacher perceptions remain neutral regarding AI's role in special education, as Alsudairy and Eltantawy (2024) noted, highlighting a need for targeted training to bridge implementation gaps.

Extended Reality (XR) technologies, including Augmented and Virtual Reality (AR/VR), have shown promise in creating accessible STEM and language learning environments. On the other hand, Bratu et al. (2024) integrated VR labs and game-based learning in STEM education, finding that mixed traditional-digital approaches yielded the best knowledge retention among Deaf and Hard of Hearing (DHH) students. Zhang et al. (2024) corroborated these findings, noting enhanced cognitive and social presence in AI-driven classrooms through iterative design-based research. As for Quranic education, Yusoff et al. (2024) proposed an AR-based Arabic vocabulary model incorporating 3D animations and sign language videos, addressing the lack of tailored religious learning tools. Segura et al. (2023) emphasized universal design principles in XR development, demonstrating improved programming logic comprehension through mixed-reality prototypes.

Mobile applications and assistive devices have emerged as critical tools for promoting independent learning. Lawal et al. (2024) designed Hausar Kurma, an English-Hausa sign language app, which significantly improved vocabulary acquisition through evidence-based validation. Meanwhile, Haris et al. (2023) developed a QR-code-based Android app for physical education, enhancing motor skill development in deaf students via video-guided exercises. Lancioni et al. (2024) introduced a tablet-based instruction system activated by proximity sensors, enabling individuals with sensory disabilities to perform multistep tasks autonomously. Despite these innovations, disparities persist in resource distribution, as noted by de Lima et al. (2023), who identified policy and infrastructure gaps in Brazil's adoption of assistive technologies.

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036

Theme 2: Pedagogical Strategies and Inclusive Education

Effective, inclusive education for DHH students relies heavily on teacher preparedness and attitudes toward assistive technologies. Graham et al. (2023) identified challenges in transitioning to online instruction during the COVID-19 pandemic, emphasizing the need for tailored strategies to support language development and social interaction in virtual classrooms. Similarly, Alegre de la Rosa and Villar Angulo (2024) developed the Inclusion Questionnaire (InQ), revealing gaps in teachers' sustainable professional development and technological usability, particularly among those with limited experience in assistive device integration. Mtani et al. (2024) further highlighted disparities in technology literacy among Tanzanian teachers, noting that while basic ICT skills were strong, specialized training for DHH-specific tools remained inadequate. These findings underscore the necessity for ongoing professional development to enhance educators' competencies in inclusive pedagogy.

Innovative pedagogical frameworks leveraging multimodal strategies have shown promise in addressing the diverse learning needs of DHH students. Paim et al. (2023) demonstrated the effectiveness of co-design techniques in developing Portuguese literacy tools for Deaf students, emphasizing collaborative approaches that foster ownership and self-determination. Similarly, Francisco et al. (2024) proposed a metaphor-based literacy framework for Filipino Deaf students, advocating for spatial justice and multimodal access in physical and virtual classrooms. Chit et al. (2024) designed a multisensory virtual learning environment incorporating haptic and auditory feedback for visually impaired learners, achieving above-average usability ratings. These studies highlight the importance of adaptable, sensory-inclusive methodologies to bridge accessibility gaps in education.

The shift to virtual learning during the pandemic exacerbated existing inequities, as parental feedback on DHH education revealed. Alford et al. (2023) surveyed 40 parents, identifying critical barriers such as language access gaps and technological limitations in remote instruction, with satisfaction levels split evenly. On the other hand, Snoddon and Madaparthi (2023) explored mediation strategies in online ASL courses for parents, noting their role in alleviating cognitive and relational barriers. Felippe and Dias (2024) corroborated these challenges in a Brazilian vocational institute, where communicational accessibility deficits led to high academic failure rates among Deaf students. These insights stress the need for systemic reforms to align educational delivery with the lived experiences of DHH learners and their families.

Theme 3: Accessibility Challenges and Equity

The transition to online learning during the COVID-19 pandemic exposed significant accessibility challenges for DHH students. Gehret and Elliot (2025) examined the application of the Cognitive Theory of Multimedia Learning (CTML) in asynchronous tutorials, finding that while segmentation improved comprehension, redundant information created barriers. In a similar vein, Luft and Brochu (2023) identified split visual attention as a critical issue in virtual classrooms, where simultaneous visual stimuli (captions, slides, and sign language interpreters) increased cognitive load and fatigue. Basonbul (2023) highlighted systemic obstacles in Saudi Arabia, including inadequate administrative support and technical limitations, which hindered effective distance learning for DHH students. These studies collectively emphasize the need for tailored multimedia designs and institutional support to mitigate online learning barriers.

International Journal of Education, Psychology and Counseling
IJEPC
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DOI 10.35631/IJEPC.1058036

Effective policy implementation is crucial for addressing systemic inequities in DHH education. Terry et al. (2025) developed a Deaf awareness e-learning package for nursing students in Wales, demonstrating its success in improving healthcare accessibility, with an average rating of 4.72/5. However, low engagement rates underscored the need for mandatory training policies. Mtani et al. (2024) assessed technology literacy among Tanzanian teachers, revealing disparities in ICT integration despite high confidence in basic skills. Specialized training in adaptive technologies was recommended to align with UNESCO standards. Weber et al. (2025) advocated for Deaf aesthetics in higher education curricula, proposing policy reforms to institutionalize multimodal pedagogies. These findings highlight the role of policy in bridging gaps between technological potential and practical implementation.

Universal design principles are essential for creating equitable educational experiences. Perez-Enriquez et al. (2024) proposed a holistic hybrid learning framework incorporating live transcription and AI-generated content, which achieved a 4.46/5 usability rating. Subsequently, Papadopoulos et al. (2024) identified unmet assistive technology needs among university students with disabilities, stressing the importance of user-centric design in academic settings. De Lima et al. (2023) documented systemic barriers in Brazil, where insufficient resources and non-compliance with accessibility laws perpetuated inequities. These studies underscore the necessity of integrating universal design into institutional practices to ensure sustainable accessibility.

Discussion and Conclusion

The systematic review of 39 studies provides critical insights into the application of technology in teaching and learning for DHH students, organized into three central themes: technological innovations, pedagogical strategies, and accessibility challenges. These findings highlight both the transformative potential of emerging tools and the systemic barriers that hinder equitable implementation.

Technological advancements such as AI-driven sign language recognition (Ulrich et al., 2024) and AR/VR tools (Bratu et al., 2024) demonstrate promising outcomes in enhancing learning engagement and retention. Artificial Intelligence (AI) models have achieved up to 71% accuracy in translating spoken text to sign language (Aurelrius et al., 2025). VR-based learning has boosted Science, Technology, Engineering, and Mathematics (STEM) comprehension through immersive, game-like experiences. However, these tools' effectiveness is closely tied to contextual variables such as teacher readiness and institutional infrastructure. Participatory design is crucial for usability and cultural relevance, as seen in Hausar Kurma, a sign language app co-developed with Nigerian DHH students that effectively integrated localized sign systems (Lawal et al., 2024).

Pedagogical strategies emphasize the importance of multimodal and culturally sensitive instruction. Co-design methods (Paim et al., 2023) and metaphor-based literacy frameworks (Francisco et al., 2024) align teaching practices with the sensory and cultural needs of DHH students, promoting meaningful engagement. Despite this, the review reveals critical gaps in teacher training, particularly in under-resourced contexts, with only 23% of studies addressing such settings (Mtani et al., 2024). Moreover, educators often demonstrate neutral perceptions of AI tools (Alsudairy & Eltantawy, 2024), suggesting a disconnect between the availability of technologies and their classroom implementation.

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IJEPC
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DOI 10.35631/IJEPC.1058036

Accessibility challenges persist, undermining the benefits of technological tools. Split visual attention in online learning environments (Luft & Brochu, 2023) and policy-practice disparities (de Lima et al., 2023) exemplify structural inequities that limit effective adoption. Hence, implementing hybrid learning models such as those involving live transcription and AI-generated content has improved accessibility ratings (Perez-Enriquez et al., 2024), but further refinements are necessary. For example, e-learning platforms should be redesigned to reduce visual overload by embedding sign language interpreters directly into video content. In order to maximize the potential of these technologies, the review recommends a holistic approach involving innovation, pedagogy, and equity. Educators must receive tailored professional development. Consequently, institutions should adopt universal design principles. Governments must prioritize policy reforms and sustainable funding for assistive technologies, especially in regions like Tanzania, where ICT literacy among teachers remains uneven (Mtani et al., 2024).

The scope of this review, limited to publications indexed in Scopus and Web of Science between 2023 and 2025, may exclude significant regional contributions or grey literature. Thus, future research should prioritize longitudinal studies assessing the sustained impact of tools like AR/VR on academic and social outcomes. Comparative analyses of policy frameworks across countries could highlight best practices for scaling assistive technologies, particularly in low-resource environments. Mixed-methods research is also essential to capture quantitative performance indicators and qualitative user feedback. Most importantly, interdisciplinary collaboration among educators, technologists, and DHH communities is vital for designing innovative and inclusive solutions.

In conclusion, while technology holds transformative potential in inclusive education for DHH students, its success depends on inclusive design, targeted training, and structural equity. This review advocates for integrated, participatory approaches that align innovation with pedagogy and policy to empower DHH learners worldwide.

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References

Abouzahra, A., Sabraoui, A., & Afdel, K. (2020). Model composition in Model Driven Engineering: A systematic literature review. In *Information and Software Technology*. https://doi.org/10.1016/j.infsof.2020.106316

Aigerim, C., Nursultanovna, A. A., Askarovna, B. L., Kapalova, S. K., Sikinbayev, B. B., & Genc, Z. (2021). Evaluation of oral speech of students with hearing impairments with perspectives of special learning technologies. *World Journal on Educational Technology: Current Issues*, *13*(3), 502–513. https://doi.org/10.18844/wjet.v13i3.5958

Akay, E. (2021). The Use of Audio-Visual Materials in the Education of Students with Hearing Loss. *International Education Studies*. https://doi.org/10.5539/ies.v14n7p1

Alegre de la Rosa, O. M., & Villar Angulo, L. M. (2024). Teachers' and hearing and speech specialists' attitudes towards and knowledge of sustainable inclusive education for students using hearing devices. *International Journal of Inclusive Education*, *28*(4), 344–359. https://doi.org/10.1080/13603116.2021.1938711

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036

Alford, A. D., Bencak, J. M., Tucker, E. A., Williams, D. C., Courson, F. F., Buchanan, B. J., Greene, A. N., & Clark, M. D. (2023). Is the Window of Learning Only Cracked Open? Parents' Perspectives on Virtual Learning for Deaf and Hard of Hearing Students. *American Annals of the Deaf*, *168*(3), 17–28. https://doi.org/10.1353/aad.2023.a917247

Alsudairy, N. A., & Eltantawy, M. M. (2024). Special Education Teachers' Perceptions of Using Artificial Intelligence in Educating Students with Disabilities. *Journal of Intellectual Disability - Diagnosis and Treatment*, *12*(2), 92–102. https://doi.org/10.6000/2292-2598.2024.12.02.5

Arnaud, S. (2023). Speaking Machines, the Trial of Articulation, and Deaf Education in Modern France. *Modern Intellectual History*, *20*(3), 715–737. https://doi.org/10.1017/S1479244322000294

Asogwa, U. D., Ofoegbu, T. O., Eseadi, C., Ogbonna, C. S., Eskay, M., Nji, G. C., Ngwoke, O. R., Nwosumba, V. C., Onah, B. I., & Das, U. N. (2020). The effect of a video-guided educational technology intervention on the academic self-concept of adolescent students with hearing impairment: Implications for physical education. *Medicine (United States)*, *99*(30), E21054. https://doi.org/10.1097/MD.0000000000021054

Aurelrius, E., Henrisen Sikoko, A., Rakun, E., & Azizah, K. (2025). Transfer Learning and Custom Loss Applied to Transformer-Based Text Translation for Sign Language Animated Subtitles. *IEEE Access*, *13*, 36858–36876. https://doi.org/10.1109/ACCESS.2025.3542785

Basham, J. D., Stahl, W. S., Ortiz, K. R., Rice, M. F., & Smith, S. J. (2015). *Equity Matters: Digital & Online Learning for Students with Disabilities*. 150 p. http://centerononlinelearning.org/publications/annual-publication-2015/

Basonbul, N. A. S. (2023). Shifting to D-learning during crises: Optimal experiences based on Saudi teachers of Deaf students' viewpoint. *Online Journal of Communication and Media Technologies*, *13*(1). https://doi.org/10.30935/ojcmt/12861

Bratu, M., Muntean, C. H., Buica-Belciu, C., Stan, S., & Muntean, G.-M. (2024). Impact of NEWTON Technology-Enhanced Learning Solutions on Knowledge Acquisition in Pilots Involving Students With Hearing Impairments. *IEEE Transactions on Education*, *67*(3), 472–482. https://doi.org/10.1109/TE.2024.3378103

Campbell, E. E., Bervinchak, D., DesJardin, J., Ceh, K., Lehnert, K., Grammer, D., & Francis, H. W. (2024). Home Literacy Practices for Young Children With Cochlear Implants. *COMMUNICATION DISORDERS QUARTERLY*, *46*(1), 12–25. https://doi.org/10.1177/15257401231185878

Chen, C., Kaenampornpan, P., & Sapaso, P. (2024). Development of Tailored Teaching Model for Beginning Piano Level among Visually Impaired Students. *Journal of Ecohumanism*, *3*(3), 161–173. https://doi.org/10.62754/joe.v3i3.3353

Chit, S. M., Yap, K. M., & Ahmad, A. (2024). Multisensory learning framework for visually impaired learners: Use of 3D, haptic, audio, olfactory media. *Multimedia Tools and Applications*, *83*(34), 81711–81723. https://doi.org/10.1007/s11042-024-18249-1

de Lima, L. A. A., Cavazzani, A. L. M., & da Silva, M. V. G. (2023). Assistive Technologies: Resources For Visually And Hearing Impaired People. *Revista Praxis Educacional*, *19*(50). https://doi.org/10.22481/praxisedu.v19i50.11455 WE - Emerging Sources Citation Index (ESCI)

de LIMA, P. V., Novato, T. da S., & de Carvalho, M. P. (2022). Challenges And Coping Measures In The Education Of The Deaf And Hearing Impaired In Times Of Pandemic. *Revista Brasileira de Educacao Especial*. https://doi.org/10.1590/1980-54702022v28e0055

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036
Ekasari, D., Wagino, W., Dwirisnanda, D. A., Nur, D. R. K., Minarsih, N. M. M., Wijiastuti, A., Abidin, Z., & Penehafo, A. E. (2025). The Use Of Assistive Technology Applications In Improving The Learning Outcomes Of Students With Hearing Disabilities. *Journal of Engineering Science and Technology*, *20*(2), 31–38. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105002287972&partnerID=40&md5=c4d935cfd6b3f3a2402ebbf901a0981f

Felippe, J. M. S., & Dias, R. D. R. (2024). The profile and educational needs of deaf students at the Instituto Federal Fluminense. *Revista Eletronica Pesquiseduca*, *16*(40), 163–183. https://doi.org/10.58422/repesq.2023.e1543 WE - Emerging Sources Citation Index (ESCI)

Francisco, M. P. B. U., Sulse, L. D., & Wang, Y. (2024). Visualizing a Framework in Teaching Literacy to Filipino Deaf Students in Multimodal Learning Spaces. *American Annals of the Deaf*, *168*(5), 311–326. https://doi.org/10.1353/aad.2024.a927616

Gabova, K., Furstova, J., & Tavel, P. (2024). Wireless microphones for students who are deaf and hard of hearing: Czech teachers' perspective. *Journal of Research in Special Educational Needs*, *24*(1), 68–79. https://doi.org/10.1111/1471-3802.12614

Gehret, A. U., & Elliot, L. B. (2025). Perceptions of e-learning by deaf and hard of hearing students using asynchronous multimedia tutorials. *Educational Technology Research and Development*. https://doi.org/10.1007/s11423-025-10476-z

Graham, P. J., Neild, R., & Kenyon, K. (2023). Deaf Education Teachers and Online Instruction: Ensuring Equity in Instructional Activities and Collaboration. *American Annals of the Deaf*, *168*(3), 55–70. https://doi.org/10.1353/aad.2023.a917250

Graham, P. J., Neild, R., Kenyon, K., Alford, A. D., Bencak, J. M., Tucker, E. A., Williams, D. C., Courson, F. F., Buchanan, B. J., Greene, A. N., Clark, M. D., Vasel, H., Ragonis, N., Francisco, M. P. B. U., Sulse, L. D., Wang, Y., Jones, C. T., Murphy, E. L., Imashev, A., … Luo, H. (2024). Learning sign language with mixed reality applications - the exploratory case study with deaf students. *American Annals of the Deaf*, *168*(3), 17–28. https://doi.org/10.1007/s11423-025-10476-z

Haris, F., Taufan, J., Aulia, F., Komaini, A., & Pranoto, N. W. (2023). Development of the Physical Activity Learning through QR Code Android-Based and Teaching Books for the Deaf. *International Journal of Human Movement and Sports Sciences*, *11*(3), 683–690. https://doi.org/10.13189/saj.2023.110323

Izaguirre, E. D., Abásolo, M. J., & Collazos, C. A. (2024). Mobile and collaborative application to teach lip reading to deaf children. *Campus Virtuales*, *13*(1), 25–33. https://doi.org/10.54988/cv.2024.1.1122 WE - Emerging Sources Citation Index (ESCI)

Jones, C. T., & Murphy, E. L. (2024). Cripping sex education: reflections on a public pedagogy project. *Sex Education*. https://doi.org/10.1080/14681811.2024.2362389

Khasawneh, M. A. S. (2024). Teacher Opinions on the Role of Educational Robots in Enhancing Programming Skills among Hearing-Impaired Students. *International Journal of Learning, Teaching and Educational Research*, *23*(5), 309–322. https://doi.org/10.26803/ijlter.23.5.16

Kitchenham, B. (2007). Guidelines for performing systematic literature reviews in software engineering. *Technical Report, Ver. 2.3 EBSE Technical Report. EBSE*.

Knoors, H., Tang, G., & Marschark, M. (2014). Bilingualism and Bilingual Deaf Education. In *Bilingualism and Bilingual Deaf Education*. https://doi.org/10.1093/acprof:oso/9780199371815.003.0001

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036

Kožuh, I., Čakš, P., & Debevc, M. (2022). Contemporary Assistive Technologies for Students with Hearing Loss in Higher Education. In M. K., K. G., M. K., M. R., C. R. M., & P. P. (Eds.), *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 13341 LNCS* (pp. 512–521). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-08648-9_60

Krasavina, J. V, Ponomarenko, E. P., Serebryakova, Y. V, & Zhuikova, O. V. (2021). The use of information and communication technologies when teaching students with hearing impairment at a technical university. *Perspektivy Nauki i Obrazovania*, *52*(4), 418–435. https://doi.org/10.32744/pse.2021.4.28

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Orlando, I., Chiariello, V., & Desideri, L. (2024). Enabling People With Intellectual and Sensory Disabilities to Trigger a Tablet's Delivery of Task Instructions by Walking to the Tablet: Proof-of-Concept Study. *Jmir Rehabilitation And Assistive Technologies*, *11*. https://doi.org/10.2196/59315 WE - Emerging Sources Citation Index (ESCI)

Lawal, A., Cavus, N., Lawan, A. A., & Sani, I. (2024). Hausar Kurma: Development and Evaluation of Interactive Mobile App for the English-Hausa Sign Language Alphabet. *IEEE Access*, *12*, 46012–46023. https://doi.org/10.1109/ACCESS.2024.3381538

Lersilp, T., & Lersilp, S. (2019). Use of information technology for communication and learning in secondary school students with a hearing disability. *Education Sciences*, *9*(1). https://doi.org/10.3390/educsci9010057

Lockwood, C., Munn, Z., & Porritt, K. (2015). Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. *International Journal of Evidence-Based Healthcare*. https://doi.org/10.1097/XEB.0000000000000062

Luft, P., & Brochu, C. (2023). Online Learning Challenges and Strategies: Visual Fatigue and Split Visual Attention. *American Annals of the Deaf*, *168*(3), 71–92. https://doi.org/10.1353/aad.2023.a917251

Mingsiritham, K., & Chanyawudhiwan, G. (2020). Experiment of the prototype of online learning resources on massive open online course (MOOC) to develop life skills in using technology media for hearing impaired students. *International Journal of Emerging Technologies in Learning*, *15*(3), 242–249. https://doi.org/10.3991/ijet.v15i03.12059

Moher D, Liberati A, Tetzlaff J, A. D. (2009). PRISMA 2009 Flow Diagram. In *The PRISMA statement*.

Moin, M., Saadat, S., Rafique, S., Maqsood, A., Lal, A., Vohra, F., Alam, M. K., & Ahmed, N. (2021). Impact of Oral Health Educational Interventions on Oral Hygiene Status of Children with Hearing Loss: A Randomized Controlled Trial. *BioMed Research International*. https://doi.org/10.1155/2021/5185613

Mtani, H., Kaijage, S., & Mduma, N. (2024). Technology Literacy Among Primary School Teachers For Enhancing Numeracy And Literacy Skills Of Early-Grade Pupils With Hearing Impairments In Tanzania. *Information Technologies And Learning Tools*, *103*(5), 151–173. https://doi.org/10.33407/itlt.v103i5.5793 WE - Emerging Sources Citation Index (ESCI)

Naami, A., & Mort, K. S. T. (2023). Inclusive education in Ghana: How prepared are the teachers? *Frontiers in Education*. https://doi.org/10.3389/feduc.2023.1056630

Nasir, N. A. M., Hashim, H., Rashid, S. M. M., & Yunus, M. M. (2021). Exploring the Potential Usage of Mobile Technologies Among the Hearing-Impaired Students in Learning

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036

English as a Second Language (ESL). *International Journal of Interactive Mobile Technologies*, *15*(19), 48–63. https://doi.org/10.3991/ijim.v15i19.22137

Nordin, N., Yunus, M. M., Zaharudin, R., Salehi, H., Mohd Yasin, M. H., & Embi, M. A. (2015). Identifying the challenges and barriers hearing-impaired learners face with using ICT education courses. *Journal of Theoretical and Applied Information Technology*, *78*(3), 327–335.https://www.scopus.com/inward/record.uri?eid=2-s2.0-84940667459&partnerID=40&md5=a63a11c2a2b3b939e9893b1a0037ce3c

Oreshkina, O. A., & Slitikov, P. V. (2022). The Experience of BMSTU's Teachers on Remote Teaching Chemistry of Hearing Impaired Students in the Pandemic. *European Journal of Contemporary Education*. https://doi.org/10.13187/ejced.2022.4.1176

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *The BMJ*. https://doi.org/10.1136/bmj.n71

Paim, P., Prietch, S. S., & Sánchez, J. A. (2023). Adapting Co-design Techniques for the Construction of a Learning Environment of a Written Second Language for the D/deaf. *Interacting with Computers*, *35*(2), 315–329. https://doi.org/10.1093/iwc/iwac023

Papadopoulos, K., Koustriava, E., Isaraj, L., Chronopoulou, E., Manganello, F., & Molina-Carmona, R. (2024). Assistive Technology for Higher Education Students with Disabilities: A Qualitative Research. *Digital*, *4*(2), 501–511. https://doi.org/10.3390/digital4020025

Perez-Enriquez, M., Luis Lopez-Cuadrado, J., & González-Carrasco, I. (2024). A Holistic Approach to Enhance Learning Experiences for People With Hearing Disabilities in Online and Traditional Classroom Settings. *IEEE Access*, *12*, 186493–186509. https://doi.org/10.1109/ACCESS.2024.3513715

Poornima, I. G. A., Priya, G. S., Yogaraja, C. A., Venkatesh, R., & Shalini, P. (2024). Hand and Sign Recognition of Alphabets Using YOLOv5. *SN Computer Science*, *5*(3). https://doi.org/10.1007/s42979-024-02628-4

Probert, B., Neild, R., & Graham, P. (2023). Reflections From the Pandemic: Lessons Learned. *American Annals of the Deaf*, *168*(3), 105–111. https://doi.org/10.1353/aad.2023.a917253

Qilong, L., & Xiaomei, L. (2011). Notice of Retraction: Modern education technology in the hearing-impaired students of university teaching. *2011 International Conference on E-Business and E-Government, ICEE2011 - Proceedings*, 8085–8087. https://doi.org/10.1109/ICEBEG.2011.5887124

Samonte, M. J. C. (2020). An Assistive Technology Using FSL, Speech Recognition, Gamification and Online Handwritten Character Recognition in Learning Statistics for Students with Hearing and Speech Impairment. *ACM International Conference Proceeding Series*, 92–97. https://doi.org/10.1145/3404709.3404746

Sbattella, L., & Tedesco, R. (2013). Innovative ICT solutions supporting students with learning disability and hearing impairments during classes. In E. P., C. U. of Portugal, A. L., T. U. of Lisbon, G. G.J., Z. University, N. A., U. of Dundee, M. N.E., & Statped (Eds.), *Assistive Technology Research Series* (Vol. 33, pp. 1171–1178). https://doi.org/10.3233/978-1-61499-304-9-1171

Segura, M., Osorio, R., & Zavala, A. (2023). Extended Reality Model for Accessibility in Learning for Deaf and Hearing Students (Programming Logic Case). *International*

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 10 Issue 58 (June 2025) PP. 541-561
DOI 10.35631/IJEPC.1058036

Journal of Modern Education and Computer Science, *15*(4), 1–17. https://doi.org/10.5815/ijmecs.2023.04.01

Snoddon, K., & Madaparthi, K. (2023). Conceptualizing the role of mediation in an online American Sign Language teaching model for parents of deaf children. *Deafness and Education International*, *25*(1), 4–20. https://doi.org/10.1080/14643154.2022.2076010

Terry, J., Parkinson, R., Meara, R., England, R., Nosek, M., Humpreys, I., & Howells, A. (2025). Nursing students' knowledge of working with D/deaf and hard of hearing patients: Evaluation of a deaf awareness elearning package. *Nurse Education Today*, *144*. https://doi.org/10.1016/j.nedt.2024.106446

Ulrich, L., Carmassi, G., Garelli, P., Lo Presti, G., Ramondetti, G., Marullo, G., Innocente, C., & Vezzetti, E. (2024). SIGNIFY: Leveraging Machine Learning and Gesture Recognition for Sign Language Teaching Through a Serious Game. *Future Internet*, *16*(12). https://doi.org/10.3390/fi16120447

Ur Rehman, N., Javed Aftab, M., & Hadayat Ali, H. (2024). *Role of Technology Integration in Educational Settings for Students with Hearing Impairment Role of Technology Integration in Educational Settings*. *46*(1), 87–105.

Vasel, H., & Ragonis, N. (2024). Empowering hearing-impaired students: A mobile learning intervention in Israeli Arab elementary education. *Journal of Research in Special Educational Needs* , *24*(4), 1093–1104. https://doi.org/10.1111/1471-3802.12697

Weber, J., Hayward, D., Skyer, M., & Snively, S. (2024). Applied deaf aesthetics toward transforming deaf higher education. *JOURNAL OF DEAF STUDIES AND DEAF EDUCATION*, *30*(1), 108–125. https://doi.org/10.1093/jdsade/enae050

Wu, X. F., & Xu, J. C. (2010). Notice of Retraction: Fully play the advantages of educational technology to support individualized education for hearing-impaired students. *Proceedings - 2010 3rd IEEE International Conference on Computer Science and Information Technology, ICCSIT 2010*, *7*, 96–99. https://doi.org/10.1109/ICCSIT.2010.5563812

Yusoff, N. F. A., Abas, U. H., Jaffar, M. N., Ali, A. A. M., Noor, M., Hanid, M. F. A., & Raus, N. M. (2024). Augmented Reality Technology For Arabic Vocabulary Learning As A Model Of Quran Reflection For Hearing-Impairment Adults. *IJAZ ARABI JOURNAL OF ARABIC LEARNING*, *7*(3), 1126–1129. https://doi.org/10.18860/ijazarabi.V7i3.26641 WE - Emerging Sources Citation Index (ESCI)

Zaharudin, R., Nordin, N., & Mohd Yasin, M. H. (2011). Online ICT-courses integrated for the hearing-impaired individuals' education: A preliminary study from the students' perception. *Communications in Computer and Information Science*, *251 CCIS*(PART 1), 56–63. https://doi.org/10.1007/978-3-642-25327-0_6

Zhang, H., Wang, Z., Zong, S., Wu, H., Jiang, R., Cui, Y., Li, S., & Luo, H. (2024). Impact of intelligent learning environments on perception and presence of hearing-impaired college students: Findings of design-based research. *Educational Technology and Society*, *27*(4), 352–374. https://doi.org/10.30191/ETS.202410_27(4).SP09