

Effectiveness of ICT Based Interventions for Students with Sensory Impairment: A Review of Studies

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Abstract

In the 21st century Information and Communication Technology (ICT) has become an important component for inclusive education. It supports students with sensory impairment especially those with visual and hearing impairment to access education at par with non-disabled students. The practical application of ICT in inclusive classrooms involves a range of assistive technologies, such as screen reading software and refreshable Braille displays for students with visual impairment, alongside real-time captioning and induction loops for those with hearing impairments. This paper reviews a range of studies that examine the effectiveness of ICT-based interventions in enhancing learning outcomes, communication and participation for these students. Review of studies reveal that for students with visual impairment, screen reading software, magnifiers, AI-based mobile applications and refreshable Braille displays, improve access to information, reading efficiency, and independent learning. For students with hearing impairment, tools such as speech-to-text applications, real-time captioning services, sign language apps and listening devices have been found to enhance comprehension, language development and learning. Further review of studies also highlights that while ICT-based interventions are largely effective, their impact is influenced by various factors such as cost, accessibility, availability and teacher preparedness. The paper concludes that including ICT into inclusive classrooms supported by training, policy and accessible digital infrastructure can greatly contribute to the academic and social inclusion of students with sensory impairments.

Keywords: ICT; Intervention; Sensory Impairment; Inclusive Education

1. Introduction

The integration of ICT in classroom has created a major shift in education system. It is facilitating new modalities of learning that effectively bypass traditional barriers faced by students with disabilities. For students with sensory impairments, particularly those with visual or hearing impairment, ICT is playing an important role in removing barriers and facilitating inclusive education. Students with sensory impairment face unique challenges in regular classrooms. These include difficulties in accessing information, limited opportunities for classroom interaction, and underdeveloped literacy skills compared to their non-disabled peers (Baglama et al., 2018). Traditional lecture-based methods, which rely heavily on verbal instruction, often fail to meet their learning needs. Furthermore, students with hearing impairment use sign language as their primary mode of communication and therefore require visual or text-based instructional support. On the other hand, students with visual impairment use Braille and auditory mode to access information given in the printed books. As a result, without specific interventions, students with sensory impairment may struggle to understand abstract concepts, engage in collaborative learning, or

follow fast-paced lectures; all of which are keys to academic success. The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) and the Sustainable Development Goals (SDG 4) emphasize the right of all students to inclusive and quality education. Article-9 of the UNCRPD highlights that access to information and communication technology is essential for inclusive education. According to the Census, 2011 there are 2.21% of the population lives with some form of disability. In India, efforts to integrate ICT into inclusive education have been initiated through programs such as the Digital India initiative and the National Education Policy (NEP 2020). But challenges persist particularly in rural areas where students with sensory impairment often lack access to assistive devices, trained teachers and flexible curriculum (Chacko et al., 2012). Furthermore, the pedagogical potential of ICT is associated with constructivist educational theory. In constructivist classrooms, students engage with content, collaborate with peers, and reflect on their understanding processes that are enriched through ICT.

The incorporation of assistive technologies such as screen reading software, Braille displays, captioning tools, speech-to-text systems and sign language apps has made educational content more accessible than ever before. Moreover, the integration of artificial intelligence (AI), machine learning and mobile-based accessible applications have been provided. This paper reviews recent studies to examine the effectiveness of ICT based interventions in supporting learning outcomes, communication, and inclusion for sensory-impaired students.

2. Need & Importance of the study

ICT has become an important part of the education system. Digital learning platforms, online resources, and assistive technologies are widely used in schools and higher education institutions. However, students with sensory impairments often face difficulties in accessing learning materials and participating in inclusive classroom. ICT-based interventions are expected to reduce these difficulties, but their effectiveness needs to be clearly understood. Many ICT and AI-based assistive tools such as screen readers, speech-to-text applications, captioning services, and accessible learning apps are available today. Although these tools are increasingly used, there is limited awareness about how effective they are in improving learning, communication, and participation of students with sensory impairments. Therefore, it is necessary to review existing studies to understand how these ICT-based interventions support students with visual and hearing impairments and what challenges they face while using these technologies.

This study is important because it helps teachers and institutions to understand which ICT tools are useful and how they can be used effectively for inclusive education. The findings of this review can help in improving teaching-learning practices, planning training programs for teachers, and selecting appropriate assistive technologies for students with sensory impairments. The study is also significant from the perspective of inclusive education, as it highlights the role of ICT in providing equal learning opportunities, promoting independence, and increasing participation of students with sensory impairments.

3. Methodology of the Study

The present study used the review method of research. The purpose of the study was to understand the effectiveness of ICT based interventions for students with sensory impairments, especially

visual and hearing impairments. The data for the study were collected from secondary sources such as research articles, review papers, theses, conference papers, and reports related to ICT and special education. These studies were collected from online academic sources like Google Scholar, ERIC, and ResearchGate. Only those studies which focused on ICT-based interventions for students with visual impairment and hearing impairment were selected. Studies related to other disabilities were not included. The selected studies were mainly from the last 10 years.

After collecting the studies, the researcher carefully read and analyzed them. The findings were grouped under two themes i.e. ICT for students with visual impairment, and ICT for students with hearing impairment. Under these two themes benefits of ICT and challenges in the use of ICT were also included. Since this study was based on already published research, no participants were directly involved, and proper references were given to all sources used in the study.

4. ICT for Students with Visual Impairment: Review of Studies

ICT is playing an important role in improving accessibility and learning opportunities for students with visual impairment. ICT helps overcome barriers related to print materials, independent learning and mobility by providing assistive technologies. Over the years, several studies have examined the effectiveness of ICT tools such as screen reading software, screen magnifiers, optical character recognition (OCR) software, refreshable Braille displays, and AI-based mobile applications in supporting students with visual impairment.

Studies reveal that screen reading software such as JAWS, NVDA, and TalkBack are among the most widely used ICT tools by students with visual impairment. Research by Kelly and Smith (2011) found that screen readers completely improve access to digital text, online learning platforms, and academic resources. This leads to greater independence and confidence among students with visual impairment. Similarly, Al-Azawei, Serenelli, and Lundqvist (2016) reported that screen reading software compatibility is a key factor influencing the usability of learning management systems for students with visual impairment. Another important area of ICT use is OCR-based applications and text-to-speech tools. These tools enable students with visual impairment to convert printed text into accessible digital formats. Khowaja and Kazi (2020) observed that mobile OCR applications support students with visual impairment to read print textbooks and examination materials more efficiently. These tools reduce dependency on human readers, support self-paced learning and improve academic achievement.

Refreshable Braille displays and Braille notetakers have also been highlighted in several studies as effective ICT tools for students with visual impairment. According to Gerber (2017), refreshable braille displays enhance literacy skills, note-taking ability and access to math and science stream subjects for students with visual impairment. However, the high cost of these ICT tools remains a major limitation, particularly in developing countries like India. Recent research has focused on AI-based and mobile assistive technologies, such as Seeing AI, Envision AI, and Google Lookout. Wang (2023) reviewed studies on AI applications for visual impairment and found that AI-powered object recognition, scene description, and text reading applications significantly improve real-world information access. These technologies are useful in inclusive and higher education institutions, where students need quick and independent access to visual information.

While these benefits are significant, several studies point out challenges in the effective use of ICT for students with visual impairment. Common issues include lack of training, inaccessible digital content,

language limitations in AI tools and inadequate institutional support (Babu & Singh, 2021; Al-Azawei et al., 2016). These findings of various studies suggest that technology alone is not sufficient; proper training of students and teachers, accessible content design, and supportive policies are equally important. Overall, the reviewed studies indicate that ICT has a positive impact on academic performance, independence and participation of students with visual impairment. When ICT is used appropriately, it serves as a powerful tool for inclusive education.

5. ICT for Students with Hearing Impairment: Review of Studies

ICT is also playing an important role in improving access to education for students with hearing impairment. ICT supporting to reduce communication barriers by providing visual access to auditory information. Digital and AI-based technologies such as speech-to-text applications, captioning systems, sign language learning apps and hearing assistive technologies are supporting students with hearing impairment in inclusive education.

Studies have highlighted the effectiveness of speech-to-text and real-time captioning devices in enhancing classroom learning for students with hearing impairment. Research by Stinson and Stevenson (2013) found that real-time captioning services significantly improved lecture comprehension and note-taking skills among deaf and hard-of-hearing students. Similarly, Marschark et al. (2015) reported that students using captioned lectures demonstrated better understanding of course content compared to those without caption support. Smith and Okolo (2010) observed that captioned instructional videos help students with hearing impairment in improving vocabulary and content comprehension. Another important ICT intervention for students with hearing impairment is to sign language-based applications. Studies show that mobile apps and video-based platforms support sign language, help in language learning and communication skills of students with hearing impairment. According to Debevc, Stjepanovic and Holzinger (2014), the use of sign language videos and interactive visual content enhances engagement and supports bilingual education approaches for deaf learners.

Hearing assistive technologies such as FM systems and classroom amplification devices, have also been found effective in improving speech and reducing listening effort for students with hearing impairment. Thoutenhooft (2018) reported that these technologies enhance classroom participation and academic performance in inclusive classrooms. However, the study also noted that proper maintenance and teacher awareness are essential for effective use. Recent studies emphasize the growing role of AI-based tools such as automated speech recognition (ASR), live transcription apps, and AI-powered captioning systems. According to Zeng et al. (2021), AI-based captioning tools improve accessibility and independence for students with hearing impairment, though accuracy may vary due to accent, speed of speech, and background noise.

Despite these benefits, several challenges remain in the effective use of ICT for students with hearing impairment. Common issues include limited availability of sign language content, inaccuracies in automated captions, lack of teacher training, and inadequate institutional support (Marschark et al., 2015; Zeng et al., 2021). These challenges highlight the need for proper training, inclusive content design, and supportive educational policies. Overall, the reviewed studies indicate that ICT-based interventions enhance access, communication, and participation of students with hearing impairment. When used appropriately, ICT supports inclusive education for students with hearing impairment.

Table-1: Comparison of ICT for Students with Visual and Hearing Impairment*

Aspect	Students with Visual Impairment (VI)	Students with Hearing Impairment (HI)
Primary Learning Barrier	Difficulty in accessing printed and visual information	Difficulty in accessing spoken and auditory information
Main Purpose of ICT Use	Access to text, visual content, and independent learning	Access to spoken language, communication, and comprehension
Key ICT Tools Used	Screen reading software (JAWS, NVDA, Talkback), screen magnifiers, OCR apps, refreshable Braille displays, AI-based apps (Seeing AI, Envision AI)	Speech-to-text apps, real-time captioning, captioned videos, sign language apps, FM systems, AI-based transcription tools
Role of AI-Based Technologies	Object recognition, text reading, scene description, navigation assistance	Automated speech recognition, live transcription, AI-based captioning
Educational Benefits Reported	Improved access to digital content, enhanced independence, better reading efficiency, increased confidence	Improved lecture comprehension, better notetaking, enhanced classroom participation, improved communication
Learning Level Focused in Studies	Secondary and higher education, inclusive education settings	Inclusive classrooms and higher education institutions
Impact on Independence	High, reduces dependence on readers and scribes	Moderate to high, reduces dependence on interpreters and note-takers
Major Challenges Identified	High cost of devices, inaccessible digital content, lack of training, language limitations in AI apps	Inaccurate captions, limited sign language resources, lack of teacher training, technical issues
Teacher and Institutional Role	Need for accessible content design and training in assistive technologies	Need for captioned content, awareness of hearing assistive technologies, and inclusive teaching strategies
Overall Effectiveness	ICT is highly effective when accessible content and proper training are provided	ICT is effective when caption accuracy, sign language support, and teacher readiness are ensured
Key Research Support	Kelly & Smith (2011); Khowaja & Kazi (2020); Wang (2023)	Stinson & Stevenson (2013); Marschark et al. (2015); Zeng et al. (2021)

*This comparison is based on the findings of reviews of studies.

Conclusion

This review shows that ICT plays an important role in the education of students with sensory impairments, especially visual and hearing impairments. The reviewed studies clearly indicate that ICT tools help these students to access learning materials, understand classroom teaching and participate actively in curricular and co-curricular activities. For students with visual impairment, tools such as screen reading software, OCR applications, Braille devices and AI-based mobile apps help in reading, writing, and independent learning. For students with hearing impairment, speech-to-text tools, captioning devices, sign language apps, and hearing assistive devices help in better understanding of lectures and communication in the classroom.

However, the reviews also reveal several challenges that limit the effective use of ICT. These challenges are high cost of devices, lack of accessible digital content, limited training of teachers and technical difficulties. ICT has strong potential to promote inclusive education and equal learning opportunities for students with sensory impairments. To fully realize this potential, educational institutions must ensure accessible content design, provide adequate training for teachers and students, and adopt supportive policies that encourage the effective use of ICT.

References

Al-Azawei, A., Serenelli, F., & Lundqvist, K. (2016). Universal design for learning (UDL): A content analysis of peer-reviewed journal papers from 2012 to 2015. *Journal of the Scholarship of Teaching and Learning*, 16(3), 39–56. <https://doi.org/10.14434/josotl.v16i3.19295>

Baglama, B., Haksiz, M., & Uzunboylu, H. (2018). Technologies used in education of hearing-impaired individuals. *International Journal of Emerging Technologies in Learning (iJET)*, 13(9), 53–63. <https://doi.org/10.3991/ijet.v13i09.8303>

Babu, R., & Singh, R. (2021). Assistive technology and accessibility challenges for students with visual impairment in higher education. *International Journal of Inclusive Education*, 25(9), 1032–1046.

Chacko, C. J., Jose, A., Akkara, J., & Pillai, M. K. (2012). Enabling access for persons with disabilities to higher education and workplace: Role of ICT and assistive technologies. Fourth Wave Foundation & Indian Institute of Management, Bangalore.

Debevc, M., Stjepanovic, Z., & Holzinger, A. (2014). Development and evaluation of an e-learning course for deaf and hard of hearing based on the advanced adaptation approach. *International Journal of Human-Computer Interaction*, 30(8), 597–614. <https://doi.org/10.1080/10447318.2014.920530>

Gerber, E. (2017). The impact of Braille technology on literacy development of students with visual impairment. *Journal of Visual Impairment & Blindness*, 111(5), 455–467.

Kelly, S. M., & Smith, D. W. (2011). The impact of assistive technology on the educational performance of students with visual impairments: A synthesis of the research. *Journal of Visual Impairment & Blindness*, 105(2), 73–83.

Khowaja, S., & Kazi, A. (2020). Mobile OCR applications as assistive tools for students with visual impairment. *Assistive Technology*, 32(2), 96–104. <https://doi.org/10.1080/10400435.2018.1453517>

Marschark, M., Sapere, P., Convertino, C., & Pelz, J. (2015). Learning via direct and mediated instruction by deaf students. *Journal of Deaf Studies and Deaf Education*, 20(1), 1–14. <https://doi.org/10.1093/deafed/enu017>

Smith, D. W., & Okolo, C. M. (2010). Response to intervention and evidence-based practices for students with hearing impairment. *Exceptionality*, 18(4), 213–230.

Stinson, M., & Stevenson, S. (2013). Effects of C-Print and automated speech-to-text services on classroom participation of deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education*, 18(3), 336–345. <https://doi.org/10.1093/deafed/ent014>

Thoutenhoofd, E. (2018). Hearing technologies in inclusive education settings: A review. *International Journal of Audiology*, 57(5), 334–342. <https://doi.org/10.1080/14992027.2018.1427785>

Wang, J. (2023). Artificial intelligence applications for persons with visual impairment: A review of recent studies. *Artificial Intelligence Review*, 56(1), 123–145.

Zeng, Y., Zhao, L., & Liu, Q. (2021). Automatic speech recognition and accessibility for deaf and hard-of-hearing learners: A review. *Assistive Technology*, 33(4), 209–218. <https://doi.org/10.1080/10400435.2019.1681686>