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ASSISTIVE TECHNOLOGY FOR STUDENTS WITH VISUAL IMPAIRMENT AT THE SECONDARY LEVEL: AVAILABILITY AND DEMOGRAPHIC DIFFERENCES

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Abstract

Use of Assistive technology (AT) is essential to guaranteeing fair educational access, especially at the secondary level when academic demands increase among students with visual Impairment (VI). The two key objectives of this study were 1) to find out the availability of assistive technology devices; 2) and demographic variations in the perceived impact of assistive technology on the students with visual impairment in the special schools of Punjab. Research design used was quantitative descriptive. A self-developed instrument was employed to gather data from 175 students of Grades 9 and 10 who were enrolled in 24 special education institutions, using census approach. Availability of assistive devices was evaluated using descriptive statistics, and demographic differences were investigated using independent sample t-tests. The findings indicate greater usage of high-tech devices (M = 13.62) compared to mid-tech (M = 7.01) and low-tech devices (M = 6.43). Gender and grade level did not show any statistically significant differences (p >.05). However, there was a significant difference (p <.05), with low-vision pupils reporting greater perceived benefits than blind students on the basis of type of visual impairment. It has been recommended to emphasize the necessity of deliberate policy initiatives and allocation of funds for the enhancement of assistive technology support based on the findings of the study.

INTRODUCTION

A crucial element of inclusive education initiatives is providing students with disabilities an equal access to school and learning resources. Assistive technology (AT) is widely recognized as a critical enabler of participation, independence, and academic success for students with visual impairments (World Health Organization [WHO], 2019; Hartong et al., 2006; Lee, 2024). At the secondary level, academic challenges increase, requiring advanced engagement, digital literacy, and the capacity for autonomous study (Van der Zanden et al., 2020; Lesmini&Hidayat, 2019). Low-tech to high-tech assistive technology includes gadgets like screen readers and braille devices (Chambers, 2020; Amin et al., 2024; Mahmoudi-Dehaki et al., 2025).

Despite global advancements, disparities in the accessibility of assistive technology persist, particularly in developing countries (Matsieli&Mutula, 2024; Rice, 2022; Olumorin

et al., 2022). Low funding, inadequate infrastructure, and insufficient teacher education all hinder effective assistive device integration (Nazir et al., 2024; Vouglanis, 2024; Kapur, 2018). There are still differences in the accessibility of technology in Pakistan, even if special education facilities are spread across all provinces (Jahanzaib et al., 2023; Dineen et al., 2007). There is currently a dearth of empirical research on assistive device accessibility and demographic equity (Jahanzaib et al., 2023; Oira, 2014). This study attempts to bridge these gaps in the context of Punjab, Pakistan.

Students with visual impairments often find it difficult to stay focused during learning assignments when they must rely on aural or tactile modalities that call for higher levels of cognitive processing (Afzal & Rafiq, 2021). For instance, blind or visually impaired students may find it challenging to concentrate and comprehend material during academic projects if they must spend a lot of time interacting with tactile objects or audio recordings (Alghamdi, 2021). Students may find it more difficult to concentrate for extended periods of time due to the additional cognitive effort associated with processing non-visual information, which may have an effect on their academic engagement. In this way, assistive technologies play a crucial role in lowering the cognitive demands of conventional teaching approaches and facilitating access to educational materials.

Screen readers and speech-to-text software are examples of technological tools that greatly improve students' involvement, focus, and engagement in learning environments. These technologies work by either allowing users to generate written responses using verbal input or by translating written text into auditory output. As a result, they reduce the mental strain associated with reading and writing assignments, freeing up students to concentrate more on comprehension and critical thinking than on the technical aspects of obtaining textual content (Ul-Ain et al., 2025). By using these technologies, students may effectively "read" digital texts and react orally, eliminating obstacles that could otherwise cause them to lose focus or do poorly academically (Alnahdi, 2020; Van der Zanden et al., 2020). Assistive technology greatly helps create a more inclusive and accessible learning environment for visually impaired students by lowering such distracting barriers.

Assistive technologies have demonstrated considerable efficacy in improving students' solution-focused and problem-solving skills by providing several ways for students to interact with academic work. For example, in the context of teaching mathematics, assistive technology tools can enable students with visual impairments to access problem sets and computational procedures that may not be feasible using conventional teaching methods. These tools allow students to interact with mathematical content in ways that best meet their needs, for as through accessible computer interfaces, tactile representations, or auditory descriptions. Additionally, by allowing students to divide more complicated problems into smaller, more manageable components, assistive technologies can help them adopt methodical approaches to solving complex problems. In addition to making comprehension easier, this methodical approach fosters critical thinking and autonomous problem-solving skills (Rice, 2022).

The phrase "Assistive Technology (AT)" generally refers to a range of devices, applications, and systems designed to assist individuals with disabilities in carrying out tasks that would be extremely difficult or nearly impossible without the use of technology. The primary objective of these technologies is to improve people's freedom, functional abilities, and overall quality of life. People with impairments, especially those who are blind or visually impaired, can participate more effectively in social, professional, and educational activities due to assistive technologies. By filling accessibility gaps, these devices help people overcome challenges brought on by physical, cognitive, or sensory impairments (Amin et al., 2024).

Assistive technologies are frequently divided into many categories based on their complexity and level of technological sophistication. The most basic type is low-technology assistive devices, which are usually low-cost, straightforward

instruments that don't need energy or sophisticated technological knowledge to function. These gadgets are especially useful in educational settings where access to more sophisticated technology may be restricted. They can be used right away to fulfill specific needs. Braille slates for writing in Braille and tactile rulers for measuring tasks are two examples of low-tech assistive devices. These technologies enable visually impaired pupils to participate in educational tasks like writing, drawing, or measuring increased freedom by offering tactile input that promotes spatial awareness (Chambers, 2020).

Mid-technology assistive devices are in a different category from more sophisticated high-tech systems and simple low-tech instruments. Because they often incorporate electronic components and run by batteries, these devices are more versatile than low-tech solutions while still being somewhat accessible and simple to use. Mid-tech gadgets are designed to enhance educational experiences by providing additional support through digital or audio components. Electronic calculators, digital voice recorders, and audiobooks are a few examples of gadgets that enable students to record information, access educational materials in audio format, and complete calculations more rapidly. These tools can significantly increase learning opportunities by enabling students to access educational materials in ways that satisfy their sensory needs (IRIS Center, 2025).

The most advanced form of assistive technology is represented by high-tech equipment. These technologies are distinguished by their intricacy and dependence on specific software or electronic systems intended to provide accessibility for people with disabilities. Refreshable Braille displays that translate digital text into tactile Braille characters, screen readers that interpret text on computer screens audibly, and optical character recognition (OCR) systems that digitize printed materials and transform them into accessible digital formats or speech are a few examples of high-tech assistive technologies. By allowing visually impaired students to freely read both printed and digital texts, these technologies greatly increase the variety of academic materials available to them. As a result, these resources are essential for encouraging academic inclusion and bolstering students' independence in learning settings (Amin et al., 2024).

Numerous systemic issues have been brought to light by research on the accessibility and use of assistive technologies in educational settings. For example, Jahanzaib and Fatima (2021) examined the integration and accessibility of technologies created especially for visually impaired students in Punjab's public special education facilities. According to their research, many schools lacked basic supplies including computers, Braille textbooks, and other specialized teaching aids. Students' capacity to actively engage in academic activities and their prospects for autonomous learning were severely hampered by the lack of such tools.

It has been reported that even when specific materials are available, they are limited, outdated or inadequate, making it challenging for students to use them successfully. The teachers also lack training in case of availability. Shortage of funds have also been a barrier. These limitations ultimately made it more difficult for visually impaired students to succeed academically and highlighted the need for better facilities and technology support in educational institutions.

The significant beneficial effects of assistive technology on students' learning outcomes and academic performance have been further highlighted by recent academic study. For instance, Aftab et al. (2024) found that students who used Braille note-taking devices and screen-reading software significantly improved their reading and writing skills. With the use of these tools, pupils were able to generate written work more independently and access written content more effectively. Similar to this, Alnahdi (2020) emphasized in a thorough review of the literature how assistive technology promotes a variety of methods to problem-solving and improves students' performance in a variety of academic fields. The review was concluded reporting that assistive technology help students achieve better results in a variety of educational tasks by making

it easier for the learners with visual impairment to access information, interact with course materials, and more successfully demonstrate their knowledge.

Furthermore, (Olumorin et al.', 2022) reported that students who received specialized assistive technology performed noticeably better academically than those who did not. In order to maximize their efficacy in promoting comprehension, engagement, and skill development, customized assistance aids were discovered to more precisely match each student's unique learning needs. Together, these results demonstrate the revolutionary potential of assistive technologies in improving visually impaired students' educational experiences and emphasize the significance of guaranteeing fair access to these resources in educational systems.

Statement of the Problem

Students with visual impairments have considerable obstacles when trying to access printed and digital academic materials at the secondary level, where curriculum demands increase and autonomous learning becomes crucial (WHO, 2019; Lee, 2024). Although there is no actual data on the availability of assistive technology at the secondary-level special education schools/centers for visual impairment in Punjab, however, it has the potential to lessen their functional and academic difficulties. The study aims at giving a clear picture of assistive devices and their usage in the schools/centers for the visual impairment. Additionally, it is unclear if demographic factors like gender, grade level, or kind of visual impairment affect access to assistive technology and perceived benefits (Nazir et al., 2024; Amin et al., 2024).

Policymakers and administrators might not be able to create fair technological solutions without systematic evidence (Alnahdi et al., 2024; Mahmoudi-Dehaki et al., 2025). This study has tried to fill the gap by looking at the availability of assistive technology devices and demographic variations among secondary-level students with visual impairment.

Significance of the Study

This study makes multiple contributions to the literature. First, it offers factual information about the availability of assistive technology in secondary education in underdeveloped nations (Jahanzaib et al., 2023; Nazir et al., 2024). In order to inform equity-focused policy decisions, it has also focused on demographic differences (Olumorin et al., 2022; Vouglanis, 2024). Third, the results provide useful guidance on resource allocation and technology training for special education teachers, school administrators, and educational planners (Rice, 2022; Chambers, 2020).

The study promotes the creation of customized assistive technology methods by finding disparities according to the kind of visual impairment (Amin et al., 2024; Ghosh & Yadav, 2024). The findings could help government organizations and educational establishments improve inclusive practices and enhance learning outcomes for visually impaired pupils through integration of assistive technology (World Health Organization, 2019; Van der Zanden et al., 2020).

Research Questions

The following research questions served as a guide for the study:

1. What assistive technology tools are accessible for visually impaired pupils in Punjab, Pakistan's secondary special education institutions?
2. Is there a statistically significant difference in assistive technology availability and perceived academic impact based on:

a. Gender?
b. Grade level (9th and 10th)?
c. Nature of visual impairment (blind and low vision)?

Literature Review

Visual impairment includes both blindness and low vision and significantly affects access to educational materials (WHO, 2019; Hartong et al., 2006). Secondary education requires independent reading, digital engagement, and critical thinking skills (Van der Zanden et al.,

2020; Lesmini&Hidayat, 2019), making assistive technology essential.

Assistive technology refers to the devices and systems that enable people with disabilities to perform tasks that would be nearly impossible or extraordinarily challenging without assistance. Such technologies aim to enhance independence and the overall functionality, along with the quality of life for people suffering from various forms of disabilities, as well as those with visual impairments (Amin et al., 2024). Assistive technology has made it easier for students with visual impairments to socialize, learn, and engage academically, thus improving their quality of life.

Assistive technologies are categorized as low-tech, mid-tech, and high-tech devices (Chambers, 2020). Low-tech tools include Braille slates and raised-line materials. Mid-tech devices include Perkins Braillers and talking calculators. High-tech tools include screen readers, text-to-speech software, OCR systems, and Braille embossers (Amin et al., 2024; Mahmoudi-Dehaki et al., 2025; Vouglanis, 2024).

Research continuously highlights that assistive technology improves academic independence and engagement (Nazir et al., 2024; Vouglanis, 2024; Nihal, 2019). Nonetheless, there are still differences in accessibility between institutions and demographic groups (Olumorin et al., 2022; Kapur, 2018). Only a small amount of empirical research in Pakistan has particularly examined demographic variations in secondary assistive technology availability (Jahanzaib et al., 2023; Oira, 2014).

A key cognitive ability that allows students to assimilate knowledge, come up with answers, and participate in self-directed learning is problem-solving. However, compared to their sighted peers, children with visual impairments may find many problem-solving tasks more difficult due to the lack of visual information. In order to help visually-impaired students overcome these obstacles and successfully engage in academic activities across a variety of subject areas, Assistive Technology (AT) has become a crucial tool. Research shows that by allowing students to acquire information through various sensory channels and technological interfaces, AT promotes the development of autonomous thinking, critical reasoning, and problem-solving skills. As a result, the use of assistive technology in the classroom has grown in importance for helping visually impaired students enhance their autonomy and cognitive abilities.

Numerous studies demonstrate how assistive technology can help students become more adept at addressing problems. For example, Kapucu and Kizilaslan (2022) investigated how a visually challenged learner may learn the notion of constant speed using smartphone applications, Braille printers, and haptic devices. According to their findings, children were able to independently gather data, analyze information, and create scientific explanations thanks to technology. Similarly, Booths (2022) investigated the effects of sophisticated assistive technology, including screen readers and Braille displays, and showed that these tools allow visually impaired pupils to perform reading, writing, and analytical tasks on their own. But the study also made clear that sufficient institutional support and teacher training are necessary for the successful integration of assistive technology.

Research shows that assistive technology improves students' academic freedom and cognitive engagement. For instance, Abualrejal et al. (2021) examined the use of assistive technology in a special education setting and discovered that resources like audiobooks and tactile maps greatly enhanced students' engagement in class activities and bolstered their capacity for problem-solving. In the field of mathematics education, technology tools like talking calculators and Braille displays enable visually challenged students to access numerical data without the need for visual signals, which promotes mathematical reasoning and autonomous computation (Daroni, Gunarhadi, &Legowo, 2018). According to Sujathamalini et al. (2023), visually impaired students can connect with learning materials and build problem-solving techniques through independent exploration thanks to digital technology like screen readers and tactile interfaces.

Assistive technology is essential for helping visually impaired pupils become more

independent and self-sufficient. Booths (2022) asserts that technologies like voice-recognition software, Braille displays, and screen readers enable students to access educational resources and do projects on their own, decreasing dependency on classmates and teachers. This autonomy boosts students' self-esteem and motivates them to engage fully in class activities. Research by Joisten et al. (2015) shows that assistive technologies, such as text-to-speech software and internet-based platforms, enhance digital engagement and social participation among people with visual impairments, allowing them to access information, communicate successfully, and take part in social and educational settings.

Technological advancements have also improved mobility and everyday life abilities for those who are blind or visually challenged. For example, Filetti et al. (2024) created an auditory-feedback mobility aid that supports outdoor navigation using contemporary technologies. Users can safely and freely navigate unfamiliar places with the system's real-time audio clues. Additionally, computer vision technologies have been investigated to help visually impaired people with tasks like object recognition and obstacle detection. According to research by Sivan and Darsan (2016), camera-based systems with sophisticated algorithms may recognize things and give users feedback, allowing them to carry out daily tasks more independently.

It has also been acknowledged that non-visual sensory feedback systems are crucial instruments for improving the lives of those who are blind or visually impaired. Hu et al. (2019) claims that learners can interact with instructional materials without using their eyes. While auditory systems translate written content into spoken language, devices like tactile maps and Braille displays use touch to convey spatial information. These technologies improve accessibility, foster independence in daily and academic tasks, and stimulate active classroom engagement.

It has been extensively documented how assistive technology generally affects visually impaired students' life. A study carried out in Pakistan's Multan division looked at how assistive technology affected visually impaired pupils' everyday living abilities, social engagement, and academic achievement. The researchers discovered that assistive technologies greatly enhanced students' educational experiences, independence, and social involvement using a standardized questionnaire given to students from government special education schools (Shaheen et al., 2024). These results emphasize how crucial it is to incorporate assistive technology into formal education institutions in order to promote the wellbeing and academic achievement of visually impaired students.

Low-tech, mid-tech, and high-tech devices are standard classifications for assistive technologies used in education. Low-tech gadgets are straightforward, low-cost instruments that don't need energy or sophisticated training. Braille slates, tactile rulers, communication boards, and graphic organizers are a few examples of tools that enable visually impaired pupils to access educational resources and carry out simple tasks (Chambers, 2020). According to research, these gadgets are especially helpful in settings with low resources in early childhood education since they offer useful assistance without requiring complex technology infrastructure (Moffitt & Grayson, 2018).

Batteries or electrical components are usually needed for mid-tech gadgets, which represent an intermediate level of technological sophistication. Adaptive keyboards, talking calculators, audiobooks, and digital recorders are a few examples. These gadgets enable visually handicapped students to freely access material, record lectures, and carry out mathematical computations. According to studies, mid-tech assistive technologies improve learning outcomes and classroom engagement by offering easily accessible substitutes for conventional teaching resources (IRIS Center, 2025; Das & Pal, 2024).

High-tech assistive technology uses specialized digital technologies and sophisticated software systems. Screen readers, Braille note-takers, optical character recognition (OCR) devices, and refreshable Braille displays that translate digital text into tactile Braille output are a few examples (Amin et al., 2024). For visually challenged

students, these technologies greatly increase access to digital information and academic resources. According to research by Tuttle and Carter (2022), these technologies improve academic achievement and engagement by empowering students to read, write, and navigate digital environments on their own.

There are still a number of obstacles in its way, especially in poor nations even with assistive technology's potential advantages. According to studies conducted in Punjab, Pakistan, many schools lack the advanced assistive technology, qualified teachers, and the resources needed to properly support visually impaired students. For instance, Jahanzaib and Fatima's (2021) study discovered that a large number of public special education institutions lack basic tools like computers, Braille books, and accessible learning technology. Aftab et al. (2022) found that many teachers are not well trained in the use of assistive technologies, which restricts how well they may be incorporated into lessons.

Additionally, cognitive functions like memory and concentration are greatly enhanced by assistive technology. By presenting information through accessible aural channels rather than visual formats, technologies like screen readers, text-to-speech systems, and auditory feedback tools assist pupils in maintaining focus. Marrichal et al. (2022) reports that audio and haptic feedback systems improve visually impaired learners' task engagement and focus, especially while performing difficult activities like solving mathematical puzzles. Additionally, students may manage activities, create reminders, and interact with digital devices without using visual interfaces like speech-based technologies, voice assistants and dictation tools, which lessen cognitive load and enhance learning outcomes (Rivers & McGrath, 2017).

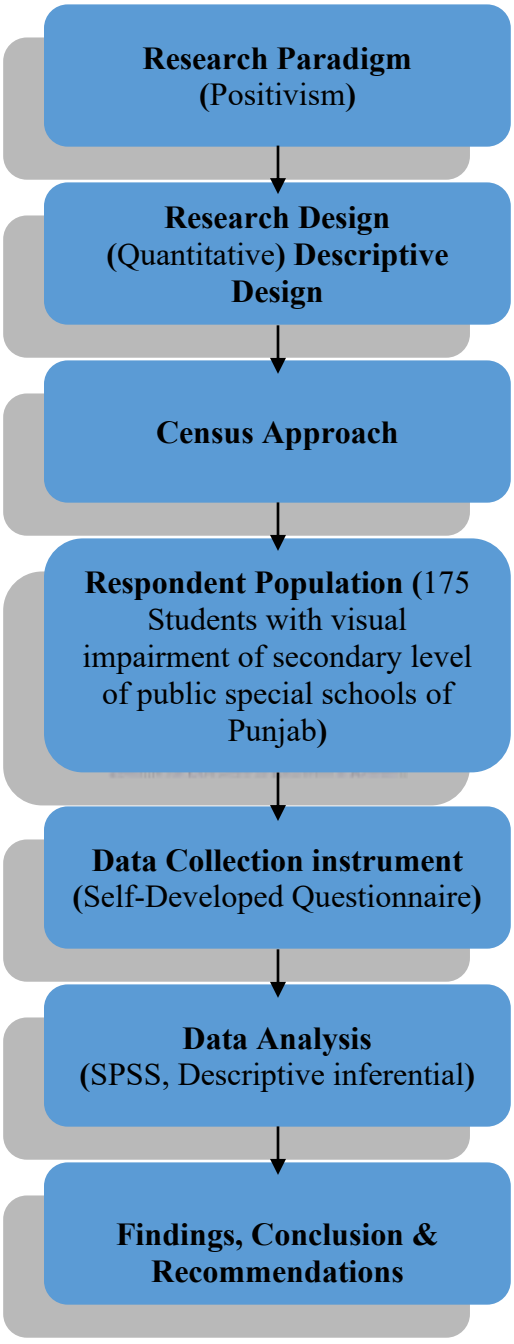
Furthermore, multimodal assistive devices that integrate haptic, tactile, and aural feedback have demonstrated encouraging outcomes in promoting attention and learning processes. Students can interact with tactile surfaces while getting aural instructions while using Talking Tactile Tablet (T3), which improves comprehension and engagement. Through a variety of sensory pathways, these technologies allow visually impaired students to complete challenging tasks while retaining focus and comprehension (Tuttle & Carter, 2023).

Overall, review of literature shows that assistive technology is essential for enhancing students with visual impairments' academic achievement, independence, and quality of life. Assistive technologies help lower the obstacles related to visual impairment by facilitating participation in social and academic activities, aiding cognitive processes, and providing access to educational materials. To ensure that visually impaired students may fully benefit from technology breakthroughs in education, however, sufficient infrastructure, teacher training, and policy support are necessary for the successful deployment of new technologies.

Methodology

Following is the methodology and procedure of the study:

Figure 1:



Research Paradigm

The positivist research paradigm, which underpins this study, holds that reality is an objective phenomenon that can be comprehended by measurement and observation.

Research Design
The survey design used was quantitative descriptive.

Census Approach
The whole population of 175 pupils enrolled in Grades 9 and 10 across 24 special education institutes in Punjab, (Blind = 100, Low Vision = 75) participated in the data collection using the census approach.

Instrumentation
Researcher created and got validated a self-developed instrument. Reliability analysis yielded Cronbach's $\alpha = .95$

Validity and Reliability Procedure
Pilot Study
To assess the research instrument's applicability, viability, and clarity, a pilot study was carried out before the primary data collection. To fill out the questionnaire, a small sample of individuals who were comparable to the target population was chosen. The pilot study's main goal was to find out any possible problems with the items' phrasing, structure, and comprehension. The questions' comprehensibility and relevance to the study's goals were assessed through participant feedback. Before the instrument was used in the main trial, a few small changes were made to increase its efficacy and clarity based on the observations and responses received during the pilot phase.

Validity Procedure
The degree to which a research tool assesses what it is supposed to measure accurately is known as validity. Experts in the fields of educational research and special education evaluated the questionnaire to guarantee content validity. These specialists assessed the items' suitability, relevance, and compatibility with the goals of the study. Their recommendations were taken into consideration to improve the instrument's phrasing and structure, guaranteeing that each item accurately reflected the concepts being studied. The instrument's adequate coverage of pertinent areas of assistive technology and its effects on visually impaired pupils was confirmed by the expert review procedure.

Reliability Procedure
The stability and consistency of a research tool in measuring a notion across time is referred to as reliability. Internal consistency metrics were used in this study to evaluate reliability in order to ascertain whether the questionnaire's items yielded consistent results. Reliability testing techniques, like Cronbach's alpha, were used to analyze the pilot study answers in order to assess the items' consistency. The equipment proved steady and reliable for collecting data for the primary investigation, according to a satisfactory reliability value of 0.95. This procedure guaranteed that when the questionnaire was given to a broader sample population, the results would be consistent and dependable.

Data Analysis
SPSS was used to conduct descriptive statistics (Mean tendency) and independent sample t-tests to find out demographic differences (statistical significance was set at $p < .05$).

Findings
Following are the findings of the study:

Demographic Information of Students with Visual Impairment N=175		
Demographic Variables	**Frequency f**	**Percentage %**
Gender		
Female	49	28
Male	126	72
Nature of visual impairment		
Blind		
Low vision	100	57.1
	75	42.9
Class/Grade Level		
9th	69	39.4
10th	106	60.6

Above Table shows the gender distribution. There were 72% boys and 28% girls. 57.1% were blind and 42.9% had low vision. The 10th grade students were 60.6%, and the 9th class was 39.4%.

Availability of Assistive Technology (RQ1)

Findings indicate high availability of Perkins Braillers (87.4%), Braille books (85.1%), screen readers (79.4%), and text-to-speech software (75.4%). Moderate availability was observed for smartphones/tablets (69.7%) and navigation applications (54.3%). Lower availability was noted for OCR software (39.4%), Braille embossers (37.1%), tactile keyboards (34.9%), and large-print keyboards (29.7%)

Overall mean scores indicate greater aggregate usage of high-tech devices (M = 13.62) compared to mid-tech (M = 7.01) and low-tech devices (M = 6.43).

Demographic Differences (RQ2)

No significant differences were found based on gender or grade level ($p > .05$), indicating equitable distribution across these categories.

However, statistically significant difference was found based on the nature of visual impairment ($p < .05$). Low-vision students reported higher perceived assistive technology benefit (M = 121.63) than blind students (M = 116.18).

Conclusion

According to the study's findings, among low-tech devices, Braille books and displays are the most available, followed by raised-line paper, hand-held magnifiers, and large-print materials, in descending order of availability. For mid-tech devices, availability ranked from highest to lowest as Perkins Braillers, audiobooks, talking calculators, and talking clocks. Regarding high-tech devices, their availability in special education schools decreased in the following order: screen readers, text-to-speech software, smartphones/tablets, navigation applications, CCTV, OCR software, Braille embossers, tactile keyboards, and large-print keyboards. Overall, high-tech devices are used more frequently than both mid-tech and low-tech devices. No significant differences in availability or usage were observed based on gender or grade level (9th and 10th) among students with visual impairment. However, a significant difference emerged based on the nature of visual impairment, with students having low vision demonstrating higher mean scores compared to those who were blind.

Recommendations

- The Department of Special Education and relevant government authorities should increase funding to expand the provision of both low-tech and high-tech assistive devices tailored to various types and levels of visual impairment.
- Enhancing access to cutting-edge high-tech tools, such as tactile keyboards, Braille embossers,

OCR software, and other digital learning technologies that demonstrated relatively low availability, should receive particular attention.

- Teacher education and professional development frameworks should incorporate systematic pre-service and in-service training programs on assistive technology.
- Braille-based, audio-supported, and tactile learning materials are examples of inclusive instructional practices that may be incorporated into the curriculum in order to meet the varied needs of blind and low-vision students.
- Policymakers should set up monitoring and evaluation systems at the provincial level to ensure that assistive technologies are distributed fairly, maintained properly, and implemented sustainably across secondary-level special education institutions.

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