Access to Knowledge: Online Education for People with Visual Impairments in a Global Context

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ABSTRACT
Online education has become an essential tool in ensuring equal access to learning opportunities for individuals with visual impairments. With over 2.2 billion people affected by some form of vision impairment globally, accessible digital education plays a crucial role in overcoming educational barriers. This article explores the advantages, challenges, and successful examples of online education for people with visual impairments, highlighting key technologies such as screen readers, Braille displays, and text-to-speech software. It also emphasizes the importance of personalized learning experiences, the integration of innovative technologies like AI, and the need for universal accessibility standards. Despite the progress, challenges remain, such as the lack of trained educators, inaccessible websites, and insufficient availability of specialized educational resources. This paper advocates for global collaboration, investment in assistive technologies, and raising awareness to foster inclusive education systems worldwide. By ensuring that online education is accessible to all, society can empower visually impaired individuals to thrive academically and professionally, fostering social inclusion and personal independence.

General Terms
Adaptive technologies, Visual impairments, Educational platforms, Web Content Accessibility Guidelines (WCAG), Screen readers, Braille displays, Text-to-speech (TTS), Global support programs, Flexible learning, Equal access, , Courses for visually impaired individuals, Social inclusion, Investment in technology, Cultural and social barriers, Quality of online lessons, Digital literacy for the visually impaired, Governmental and international support, Educational standards, International initiatives, Mobile accessibility apps, Artificial intelligence (AI) technologies, Global challenges and opportunities, COVID-19 and digital education

Keywords
Online education, Visual impairments, Accessibility, Adaptive technologies.

1. INTRODUCTION
In today's digitalized world, access to education through online platforms plays a critical role in ensuring equal opportunities for all. One of the main challenges faced by people with visual impairments is the lack of adapted educational resources that are easily accessible and effective. When tailored to their needs, online education can provide new opportunities for development, independence, and integration.

Over the last decades, education has undergone a significant transformation thanks to technology. Online education, once a niche opportunity, has now become a mainstream method of delivering knowledge. However, equal access to such education remains a challenge for many, especially those with visual impairments.

Visual impairments range from partial sight loss to complete blindness, affecting millions worldwide. According to the World Health Organization (WHO), over 2.2 billion people experience some form of vision impairment, underscoring the scale of this issue [1].

This article examines the advantages, challenges, and successful examples of online education for people with visual impairments globally. It is based on an analysis of existing examples from various countries, emphasizing the importance of modern approaches to digital education. Additionally, it highlights best practices and contemporary technologies used to ensure accessibility.

The goal is to demonstrate how technology can foster social inclusion while emphasizing the need for investments and innovative approaches.

2. IMPORTANCE OF ONLINE EDUCATION FOR PEOPLE WITH VISUAL IMPAIRMENTS
Online education is a crucial tool for people with visual impairments as it provides access to educational materials that might otherwise be unavailable in traditional formats.

Key advantages include:

- *Flexibility*: Learning can take place in a convenient environment and on a flexible schedule.
- *Access to Diverse Resources*: The availability of audiobooks, text files with screen readers, and interactive platforms.
- *Reduction of Physical Barriers*: Online platforms eliminate the need for physical travel to educational institutions, which is often challenging for people with visual impairments.

Online platforms offer adaptive technologies to improve digital accessibility and inclusion of people with visual impairments. **Screen readers** that convert text into synthesized speech allow users to "read" through hearing. **Braille displays** convert text information into Braille for tactile access. **Programmable keyboard shortcuts** simplify navigation and interaction with materials.

Online education achieves a personalized approach, allowing students to choose fonts, contrast, and color schemes for improved visual comfort and access resources in various formats – text, audio, or video – tailored to the specific needs of people with visual impairments. Online education removes the need for people with visual impairments to travel to physical educational institutions, saving time, effort, and financial resources while offering the comfort of studying from home. Students can choose courses from prestigious universities and educational institutions that might have been

previously inaccessible due to geographical or architectural barriers.

Despite its immense potential, some online platforms still fail to meet the needs of people with visual impairments. There are challenges in online education of people with visual impairments that must be addressed. Websites and educational materials are inaccessible and poorly organized without appropriate metadata and labels (alt text) for graphical content. Many courses include video lessons without verbal descriptions of visual components. Some instructors lack sufficient preparation to work with visually impaired students, leading to limited communication and ineffective teaching.

To overcome these barriers, society, institutions, and technology developers should make efforts to:

- Develop *international unified accessibility standards*, such as those outlined in the Web Content Accessibility Guidelines (WCAG), to ensure that every online educational platform meets the needs of visually impaired users.
- Invest in *innovative technologies* such as artificial intelligence and augmented reality to enrich learning by offering dynamic interaction with educational materials.
- Raise awareness and *train teachers* to use accessible resources, create inclusive content, and engage visually impaired students in discussions and activities.

3. INTERNATIONAL ACCESSIBILITY STANDARDS

International unified accessibility standards provide guidelines for creating accessible environments, digital content, and technologies for individuals with disabilities. These standards aim to ensure consistency across countries and sectors, fostering inclusivity and usability worldwide. Several standards are presented in table 1.

Table 1. International unified accessibility standards

Standard	Issued by	Purpose
Web Content Accessibility Guidelines (WCAG) [2]	World Wide Web Consortium (W3C)	Provides a comprehensive framework for making web content, software, and digital tools accessible to all users, including those with disabilities.
ISO 9241-171 (Ergonomics of Human-System Interaction) [3]	ISO Standards	Focuses on software accessibility and usability for people with disabilities.
ISO 14289-1 (PDF/UA) [4]	ISO Standards	Establishes guidelines for creating universally accessible PDFs.
ISO 21542 (Building Accessibility) [5]	ISO Standards	Provides design standards for buildings to ensure physical accessibility for individuals with disabilities.
Americans with Disabilities Act (ADA) Standards for Accessible Design [6]	U.S. Department of Justice	Mandates that all electronic and information technology (EIT) used by public and private entities must be accessible.
European Accessibility Act (EAA) [7]	European Union	Digital platforms, e-commerce, banking services, and more. Aligns with WCAG and EN 301 549 standards
EN 301 549 (Accessibility Requirements for ICT Products and Services) [8]	European Telecommunications Standards Institute	Defines accessibility requirements for ICT, including hardware, software, and web content.
UN Convention on the Rights of Persons with Disabilities [9]	United Nations	Promotes the rights of persons with disabilities, including accessibility to information, communication, technology, and the physical environment.
DAISY Standards (Digital Accessible Information System) [10]	DAISY Consortium	Sets standards for accessible multimedia publications, such as eBooks and audiobooks, for individuals with visual or print disabilities. Works with screen readers and braille displays.
Inclusive Design for Emerging Technologies (ISO/IEC 29138) [11]	International Organization for Standardization (ISO) and International Electrotechnical Commission	Focuses on accessibility in new and emerging technologies, such as AI and IoT devices.
Global Accessibility Reporting Initiative [12]	Mobile & Wireless Forum	Provides a database of accessible mobile devices and apps for users with disabilities.

These standards aim to ensure that digital and physical environments are accessible to all individuals, regardless of ability. WCAG and EN 301 549 focus specifically on digital accessibility.

Collaboration and adherence to these frameworks promote consistency and inclusivity across nations and industries.

4. ASSISTIVE TECHNOLOGIES

Assistive technology device means "*any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities*" of people with a disability [13]. It consists of tools, devices, and software designed to enable individuals with partial or total vision loss to access information, communicate, and navigate the physical world more effectively. These technologies often rely on alternative sensory inputs like hearing or touch, including

screen readers, Braille displays, text-to-speech tools, image and text recognition software etc.

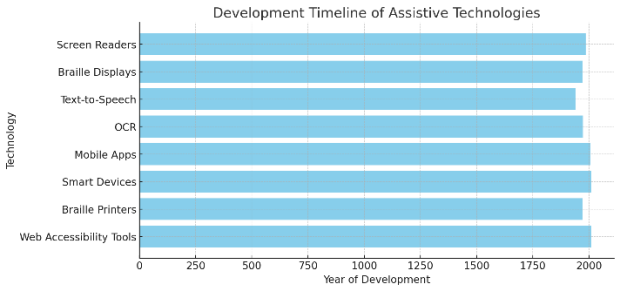

Figure 1: Development Timeline of Assistive Technologies

Screen Readers [14] The first screen reader was created by **IBM**, which developed a system known as the **IBM Screen Reader** in **1986**. It was one of the early advancements in assistive technology for individuals with visual impairments. Over the years, companies like **Freedom Scientific**, with their **JAWS** (Job Access With Speech) software, became major contributors to the development of screen readers. The first IBM screen reader was launched in **1986**. Later advancements, such as **JAWS**, were released by Freedom Scientific in **1997** and gained widespread use. Screen Readers are software that "reads" text content on a screen through synthesized voice or converts it into Braille. They enable navigation and interaction with complex interfaces such as websites, applications, and documents. Widely used screen readers are JAWS (Job Access with Speech), offering extensive functionality for Windows and VoiceOver, built-in screen reader for Apple devices (iOS and macOS). TalkBack is the standard screen reader for Android devices. NVDA (Non-Visual Desktop Access) is a free and open-source tool, compatible with Windows.

A *Braille display [15]* the technology for Braille displays was initially developed in the 1970s by companies like **Telesensory** and **Papenmeier** (a German company). One of the earliest devices was the **Optacon**, created by Telesensory. The first commercially available refreshable Braille displays appeared in the 1980s. Braille display is a hardware device that converts text information from the screen into Braille using movable pins, providing tactile access to information in real time. It enables effective reading of long texts and is useful for programming and language learning. Popular tools Braille displays are Focus Braille Display and Orbit Reader 20, convenient for mobile learning.

Text-to-Speech software (TTS) [16] Company Bell Labs is credited with the development of the first text-to-speech system. The earliest functional TTS system, named "Voder," was demonstrated by Bell Labs' Homer Dudley at the 1939 World's Fair. Modern TTS software development was significantly advanced by **DECtalk**, created by Digital Equipment Corporation in 1983. The initial demonstration by Bell Labs occurred in **1939**. DECtalk's software became a pivotal modern system, launched in **1983**. Text-to-Speech software (TTS*)* converts text information into realistic speech, making it accessible for people with visual impairments. Besides screen readers, it is used in e-readers and applications. There are many TTS solutions available such as NaturalReader, Google Text-to-Speech and Microsoft Narrator (integrated into Windows).

Optical Character Recognition (OCR) [17] the first functional OCR system was developed by **Ray Kurzweil**, whose company, Kurzweil Computer Products, introduced it. Earlier experiments with OCR technology were conducted by IBM in the 1950s. Kurzweil Computer Products introduced the first OCR system capable of recognizing text in multiple fonts in **1974**. Optical Character Recognition (OCR) technologies convert scanned documents, images, and handwritten text into digital text readable by screen readers. KNFB Reader converts text images into audio or Braille. Seeing AI (Microsoft) recognizes text, faces, and objects.

Mobile applications [18] the concept of mobile applications initially began with personal digital assistants (PDAs) like **Palm, Inc.** and **Microsoft** in the 90s. The true revolution in mobile apps began with the launch of the **Apple App Store** in **2008**, when **Apple** completely transformed the way mobile applications were accessed, offering them through a centralized store. The **Apple App Store** opened its doors in **2008**, marking the beginning of the massive growth of mobile applications. Mobile applications also offer a convenient way for visually impaired individuals to perform tasks on the go. Be My Eyes connects users with volunteers who provide visual assistance via video call. Aira helps professional agents in real time. Voice Dream Reader is an audio application for reading e-books and documents.

Smart devices and voice assistants [19] The initial concept of smart devices and voice assistants started with **Amazon**, which launched the **Amazon Echo** and its voice assistant **Alexa** in **2014**. This marked an important moment in the evolution of smart devices with voice control. However, **Apple** had already introduced the voice assistant **Siri** in **2011**, which initiated the trend for voice assistants on mobile devices. Smart devices and voice assistants operate via voice commands. Voice assistants are Siri, Google Assistant, and Alexa that can perform commands like internet searches, setting reminders, and reading messages. Smart glasses are OrCam MyEye which provide additional visual support by identifying objects, texts, and faces.

Braille Printers [20] The first known printer specifically designed for Braille printing was developed by **Braille Technologies**, founded by **Dr. Robert H. MacGregor**. Their **Braille embossers** were used widely starting in the 1950s. Another key player in the development of Braille printers was **IBM**, which developed and released the **IBM Braille Printer** in the 1970s. Braille printers first became available for widespread use in the **1970s**, with IBM releasing its Braille printer model in **1971**. Braille printers (Embossers) convert digital text into raised Braille, enabling printing for tactile reading. Braille printers are essential for access to educational materials and documents for people with visual impairments.

Browser extensions and web accessibility tools [21] in **1995**, **W3C (World Wide Web Consortium)** began developing web accessibility standards. Later, **Google** played a major role in promoting browser extensions and web accessibility tools through its browser, **Chrome**, which in **2010** introduced accessibility improvements, including extensions to help users with visual impairments. Browser extensions that included accessibility features started to be actively developed in **2010** and the following years, with significant new additions by **Google** and other tech companies. One key tool is **ChromeVox**, which was introduced alongside support for extensions in **2010**. Browser extensions and web accessibility tools adapt website content for better accessibility like Read Aloud, a browser extension that reads text content aloud, and Ad blockers focused on accessibility to reduce visual clutter on websites.

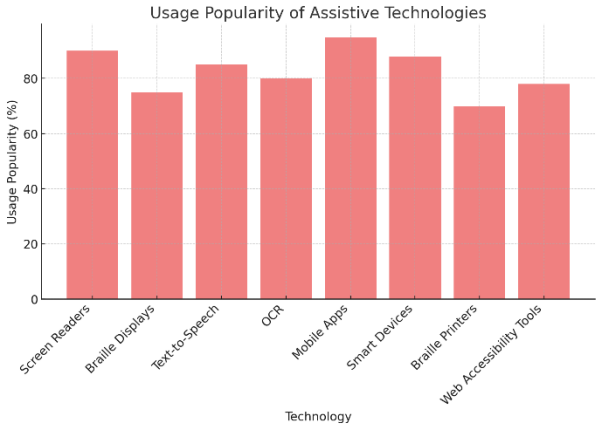

Figure 2: Usage Popularity of Assistive Technologies

Leading online education platforms are also introducing features for visually impaired users. For example, Coursera and edX support screen readers and provide transcripts for video materials. Khan Academy includes text summaries and audio content.

Assisting technologies not only facilitate learning but also promote independence for people with visual impairments. Continuous innovation ensures that more individuals can realize their potential and lead active lives.

5. BEST PRACTICES IN ONLINE EDUCATION

Many educational institutions worldwide prioritize inclusive learning platforms to accommodate students with disabilities, including those with visual impairments. These institutions integrate accessibility into their learning management systems (LMS), course design, and support services. Some of the best practices in providing accessibility are Harvard University, University of California, Berkeley, Open University (UK), University of Sydney (Australia).

- Harvard University (USA) offers accessible online courses through its Harvard Extension School and edX platform, which adheres to accessibility standards like WCAG. edX Platform is fully compatible with screen readers; includes text descriptions for visual resources (alt text) and video lessons with audio descriptions and detailed transcripts.
- University of California, Berkeley (USA) prioritizes accessibility in its digital platforms, offering course materials in accessible formats. The institution's Disabled Students' Program (DSP) provides assistive technology, real-time captioning, and transcription services.
- Open University (UK) is a pioneer in accessible online education, offering Braille copies of educational materials. Its platforms are tested for compatibility with screen readers and other assistive technologies. It supports specialized teams assisting students with visual impairments in adapting to the educational environment and mentorship programs with instructors trained to work with people with disabilities.
- University of Sydney (Australia) implements adaptive technology in its LMS, ensuring compatibility with screen readers and magnifiers and provides transcription and audio description services for lectures and videos.

Public national and international institutions are focused on providing accessibility through assistive technologies to the people with visual impairments:

- National Library for the Blind (USA - NLS) provides free access to thousands of educational resources, including e-books, audiobooks, and music lessons for visually impaired individuals.
- DAISY Consortium is an international initiative developing standards for accessible digital publications, including navigable audiobooks and study materials with text-to-speech integration and Braille compatibility.
- UNESCO Educational Programs encourage governments to implement accessibility policies, including providing adapted textbooks for blind and disabled individuals and online learning platforms that work with open technologies and universal design.

Technology companies focused on accessibility for people with visual impairments through development and application of innovative technologies and collaboration with educational institutions are Microsoft, Google and Apple.

- Microsoft develops software called Narrator (a built-in screen reader in Windows) and collaborates with institutions to ensure educational accessibility. The "Seeing AI" project helps visually impaired individuals by describing texts and objects in real time.
- Google develops Android mobile platform for visually impaired individuals, thanks to tools like TalkBack. Google Classroom offers features that simplify use for students with visual impairments.
- Apple introduces VoiceOver and other solutions that enable inclusive use of its devices for education. Universities working with Apple train instructors to create accessible lectures and presentations.

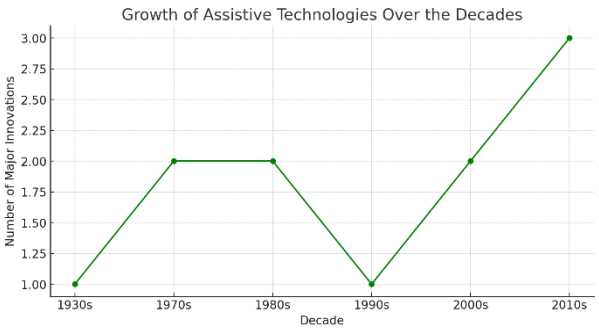

Figure 3: Growth of Assistive Technologies Over the Decades

These best practices demonstrate that inclusivity is achievable through the integration of technology, adherence to accessibility standards, and the provision of support services tailored to the needs of students with visual impairments.

6. SUCCESSFUL INCLUSIVE INITIATIVES

Inclusive education policies and practices are implemented in

various countries to support people with visual impairments. These initiatives often involve national legislation, technological innovations, and educational programs aimed at ensuring equitable access to education.

USA enforces strict accessibility standards in education, supported by Individuals with Disabilities Education Act (IDEA), which mandates free and appropriate public education for students with disabilities and ensures access to individualized education programs tailored to students' needs. In addition, the Assistive Technology Act provides funding for assistive technologies to support students with disabilities. Schools are required to provide accessible learning materials, braille resources, and assistive technologies like screen readers and magnifiers. Programs like Bookshare and the National Instructional Materials Access Center provide accessible educational resources to students with visual impairments.

Finland adopts Comprehensive Inclusive Education Policy that ensures all students, regardless of ability, attend the same schools and receive individualized support. Schools employ assistants to support students with disabilities in mainstream classrooms. Finnish schools integrate assistive technologies, such as braille devices and tactile maps, into daily learning. Teachers receive specialized training in inclusive pedagogy and the use of accessibility tools. Universities provide adapted educational materials and platforms, with specialized technology labs offering access to advanced equipment for blind students.

India guarantees free and compulsory education for all children, including those with disabilities by Right to Education Act and Persons with Disabilities Act. Samagra Shiksha Abhiyan is a government initiative promoting inclusive education with funding for assistive technologies, resource rooms, and training. The government collaborates with organizations like the National Institute for the Empowerment of Persons with Visual Disabilities to develop accessible curricula. Efforts include converting textbooks into braille and distributing tactile learning aids. The organization "Enable India" develops digital platforms combining audio lessons with programming training. The "Sugamya Pustakalaya" platform provides free access to thousands of audiobooks for visually impaired users.

Accessible Canada Act aims to create barrier-free environments in education, employment, and services. Schools are required to provide adaptive technology, braille resources, and accessible learning platforms. Universities like the University of Toronto offer services such as screen reader-compatible materials and tactile learning tools.

Australian Disability Standards for Education 2005 requires educational institutions to make reasonable adjustments to ensure equal participation for students with disabilities. The country adopts National Disability Strategy, a framework to promote accessibility and inclusion across sectors, including education. Schools implement accessible technologies like screen readers, large print materials, and tactile resources. Universities collaborate with the government to provide inclusive online learning platforms. The Australian government supports accessible online education programs through initiatives like Vision Australia, which offers specialized training tools for teachers working with visually impaired individuals and platforms with universal design accessible to people of all ages.

South Africa advocates for inclusive education by integrating students with disabilities into mainstream schools and promotes the use of digital tools and assistive technologies for accessible learning (White Paper 6 on Special Needs Education). Resource centers provide training and assistive devices to schools. Government initiatives, such as braille textbook production and tactile learning aids, support students with visual impairments.

Japan promotes equal opportunities in education for individuals with disabilities (Fundamental Law for Persons with Disabilities). The Special Needs Education System integrates students with disabilities into mainstream schools with personalized support. Schools use assistive technologies like braille devices and audio learning tools. Teachers receive specialized training in inclusive education practices.

The European Accessibility Act mandates accessibility standards for digital products and services, including educational materials. Countries like Sweden, Germany, and the Netherlands integrate inclusive education principles into national education systems. In addition, EU-funded projects, such as Erasmus+, promote accessible learning materials and inclusive training for educators. Schools use technologies like tactile graphics and braille displays to support visually impaired students.

Successful national practices involve strong legal frameworks, investment in assistive technologies, and inclusive teaching strategies. Collaboration with organizations, educators, and students ensures that policies translate into practical and effective inclusion.

7. GLOBAL CHALLENGES

Despite advancements in accessibility and the use of online technologies for people with visual impairments, there are still numerous global challenges hindering their full inclusion in education.

1. ***Limited access to technology*** *(cost barriers, Insufficient internet connectivity, digital Illiteracy)*
   - Specialized technologies like Braille displays, printers, or software (e.g., JAWS) are expensive and inaccessible for many, especially in developing countries.
   - Lack of high-speed internet in remote areas limits access to online platforms and resources.
   - Some visually impaired individuals, especially in less developed regions, lack the necessary technical skills to use adaptive technologies.
2. ***Lack of universal accessibility on online platforms*** *(non-optimized websites and resources, lack of standardization, video materials without audio descriptions)*
   - Many educational platforms are not fully compatible with screen readers and other assistive technologies.
   - Although standards like Web Content Accessibility Guidelines (WCAG) exist, not all websites comply, creating unequal access to content.
   - Visual lessons often lack descriptive narration, making content incomplete for visually impaired users.
3. ***Limited adapted educational resources*** *(need for improvement of technologies)*
   - Many textbooks, presentations, and resources are not provided in alternative formats like audio or Braille.

- Automated tools for converting text to audio or Braille often fail to deliver quality results, especially for complex materials like formulas, graphs, and diagrams.

4. ***Cultural and social barriers*** (*stigmatization and low expectations, lack of awareness*)
   - In some societies, visually impaired people are perceived as incapable of effective learning, leading to social isolation and low motivation.
   - Society and educational institutions often fail to understand the needs of visually impaired individuals, limiting innovation in accessibility.
5. ***Limited teacher preparation*** *(lack of training and low digital literacy)*
   - Teachers often lack specialized training or knowledge to work with visually impaired students.
   - Low digital literacy among some educators hinders the integration of accessibility technologies in the learning process.
6. ***Financial and institutional insufficiency*** *(insufficient funding, limited access to inclusive institutions*)
   - Educational systems in many countries do not provide enough resources to create and adapt educational materials.
   - In developing countries, suitable schools or support centers for visually impaired students are often unavailable.
7. ***Language challenges***
   - Specialized accessibility software and platforms often support a limited number of languages, complicating widespread access in countries with diverse official languages.
   - Accessible educational resources are limited to less commonly spoken languages.
8. ***Limited focus on STEM development***
   - Education in STEM disciplines remains challenging for visually impaired individuals because:
   - Equations, formulas, and graphs are often not accessible through screen readers.
   - There is a lack of specialized equipment for practical learning in technology and engineering fields.
9. ***Integration challenges for AI and Innovations***
   - Artificial intelligence (AI) and automated learning systems are not always designed with visually impaired users in mind, limiting their applicability.
   - The lack of personalized solutions makes some innovations less effective.
10. ***The COVID-19 pandemic***
    - The transition to online education without considering accessibility excluded many visually impaired students.
    - Some countries failed to create inclusive policies for addressing these issues during the urgent shift to digital education.

To address these challenges, the following measures are essential:

- To develop more accessible technologies through collaboration between tech companies and educational institutions.
- To raise awareness among teachers and society about the needs of visually impaired people.
- To standardize international accessibility guidelines and supporting initiatives like DAISY.
- To invest in education and subsidize adaptive technologies for broader access.
- To support developing countries through global programs by organizations such as UNESCO and the World Bank.

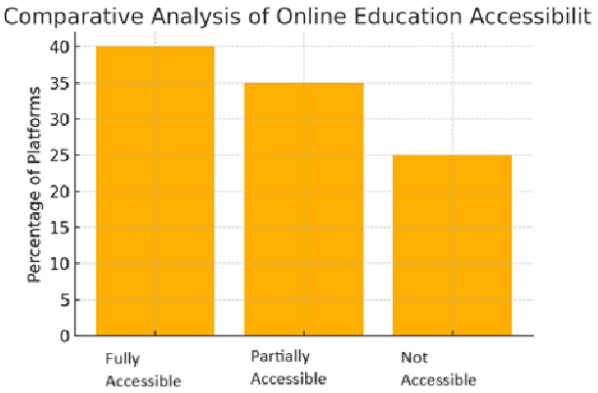

Figure 4: Comparative Analysis of Online Education Accessibility

8. METHODOLOGY

This study employs a qualitative approach to explore the landscape of online education for people with visual impairments. The research is based on a comprehensive analysis of international case studies, policy documents, and academic publications. Primary data sources include reports from global organizations such as the World Health Organization (WHO), UNESCO, and leading educational institutions. Secondary sources involve peer-reviewed articles that investigate best practices, challenges, and technological advancements in digital accessibility.

Selection Criteria:

1) Geographic Diversity: Examples from different regions to ensure a global perspective.

2) Technological Integration: Studies focusing on the implementation of adaptive technologies such as screen readers, Braille displays, and AI-based tools.

3) Policy Analysis: Examination of national and international accessibility standards and educational policies.

Data Analysis:

A comparative analysis was conducted to evaluate the effectiveness of various online educational platforms. Special attention was given to platforms adhering to the Web Content Accessibility Guidelines (WCAG) and those providing personalized learning experiences. This approach allows for a detailed understanding of both the challenges and opportunities present in the digital education landscape for visually impaired individuals globally.

9. CONCLUSION

Online education for people with visual impairments has enormous potential to transform the lives of millions worldwide, offering new opportunities for education and personal development. Despite existing challenges, technological innovations and the efforts of various organizations are making education increasingly accessible and inclusive.

Online learning serves as a powerful tool for overcoming social and economic barriers faced daily by visually impaired individuals. However, to fully harness its potential, international cooperation, development of standards, and engagement from institutions and technology companies are necessary. Only through an integrated approach can we ensure that no one is left behind in the education system in the digital era.

Online education is a significant means of providing equitable access to knowledge for people with visual impairments. It not only simplifies their lives but also contributes to building a more inclusive society where everyone has a chance for development. With the right technological support, societal engagement, and political will, this future is entirely achievable.

Successful global practices demonstrate that with proper policies, technologies, and collaboration among institutions and organizations, real inclusion is possible. These efforts create conditions where people with visual impairments not only access quality education but also thrive as active and successful members of society.

Nonetheless, additional investments and collaboration on a global scale are necessary to ensure that these technologies reach everyone in need. Furthermore, the future development of online educational systems must align with the evolving needs of users to provide truly equitable access to knowledge.

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