Technologies in Education for Visually Impaired People: A Literature Review

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Abstract The advancement of technology allows better assistive tools to be developed for people with visual impairment. In this chapter, a literary review is presented on the technologies that are used to support the education of people with visual impairments and describe about the seriousness and the impact of inclusive education which indicates equality among students regardless of the challenges they may have; the main technologies used are screen readers which allow the screen of the device to be heard through audio and the screen magnifiers which enlarge the text to make it easier to be read by the user with visual impairment; both technologies allow access to the mass media which help their education; finally, it is intended to obtain the main characteristics that these technologies must have for the future development of a new educational tool for visually impaired people.

Keywords Visual impairment · Inclusive education · Accessibility · Assistive technologies

1 Introduction

The International Classification of Functioning, Disability and Health (ICF) defines disability as all impairments, activity limitations, and participation restrictions. Disability is the interaction between individuals with a health condition and environmental factors [1].

Visual impairment is defined as a condition that directly involves the functioning of the eye, and it comes from moderate difficulty in perceiving lights to total blindness; therefore, the scope of information perceived by a person from the environment is limited, so this significantly compromises the physical integrity of those who suffer [2].

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According to the World Health Organization in 2010, there were almost 40 million people with visual disabilities in the world, which 80% of them are in working age; unfortunately, people with visual disabilities face challenges to reach the labor market, for example, some schools are not sufficiently adapted, so people with visual impairment cannot finish their studies; also, this population has problems with inaccessible public transport and urban mobility [3].

The inclusion of people with disabilities in the use of technologies can have a great impact for them since technologies can be developed or adapted according to the needs and characteristics of each user. In this case, users with visual impairments will benefit from technologies because they can provide information in another sense and would not necessarily depend on visual elements [4].

These adaptive technologies and tools can have a great impact and increase the orientation, mobility, and independence of visually impaired people and can help by providing information about the environment through other sensory means [5].

Inclusive education refers to vulnerable groups, that is, giving equality and providing the same educational services as non-vulnerable students; therefore, it implies that educational institutions require infrastructure, Internet, tools, and different types of support as well as that teachers have adequate equipment and training to teach quality teaching in order to achieve greater inclusion [6].

In this work, we will be searching for technologies and tools developed for people with visual impairment for their inclusion in education; later, we will describe the most important characteristics of these technologies for the future development of more accessible technologies for people with visual impairment.

2 Methodology

An international bibliographic review of the articles published in the databases was carried out through the National Consortium of Scientific and Technological Information Resources (CONRICYT), applying a time limit of 5 years (2015–2020). We also searched in Google Scholar applying the same time limit.

The keywords used were “discapacidad,” “visual,” “educación,” “tecnologías,” “inclusión,” and “accessibilidad” in Spanish and “disability,” “visual,” “accessibility,” “technologies,” “inclusive,” and “education” in English. The following compositions were made: “visual impairment,” “inclusive education,” “accessible education,” “teaching method,” and “visual impairment technology.”

The methodology of the bibliographic search was based on the collection of documents that talk about developed technologies to support teaching methods for people with visual impairments.

We selected the research papers whose focus were aimed to aid people with total blindness.

3 Results

The screen reader is an adaptive technology which is currently the main resource that allows people to access information and perform reading and writing tasks. This tool helps a student with visual impairment to have autonomy with reading a book, searching for information, downloading music, printing documents, writing letters, correcting errors with the spoken program, and having email, among other activities. Most common screen readers such as Non-Visual Desktop Access (NVDA) and Job Access With Speech (JAWS) are frequently used by interactive learning systems for visually impaired people [7].

Barros, Carrión, Cedillo, Idrovo, López, and Maldonado developed a Java application where the main objective is to teach students with visual impairments; the application is an audible multiple option questionary, and the user uses the numpad from the keyboard to answer the question; they used the numpad because the key "5" has a braille ubication to help the students [8].

Othmani, González, Rodrigo, and Perez made a study to value the distance education for 60 students with visual impairment, and they founded out positive results in their questionaries and interviews, but something to achieve this goal is that there should be full accessible interface to take class and accessible materials [9]. Juárez, Aquino, and Garcia in 2015 found that only five universities from Mexico offer distance educative programs to people with visual impairments, so this means that Mexican educative institutions should focus more to this type of programs to achieve a better inclusion [6].

Matoušek et al. developed a web-based system to facilitate access to educational materials by reading. Also, the system enables teachers to prepare and process arbitrary topics focusing on technical documents that contain mathematics and physics formulas. This was made for lower secondary school in the Czech Republic. The system converts the content automatically to speech, and it was evaluated by 41 students with visual impairments and 3 teachers. They had positive results, especially for the difficult topics [10].

Vera, Marcillo, and Pereira developed a system that helps blind people to learn their environment and be able to navigate in indoors or outdoors scenarios. The prototype is portable so they can use it when needed. It was evaluated by five people with visual impairment. The system can identify obstacles in real-life scenario, which is very helpful, and it is a low-cost solution for visually impaired people. Their study also found that it can be used in the rehabilitation of people who recently became blind. The prototype they developed showed positive results with aiding people with visual impairments to navigate [11].

Khan et al. proposed a mail system called TetraMail, an accessible blind-friendly email client; this mail system organizes the content of the screen in manageable partitions of five sections and rearranges the activities of an email in these five sections; it was evaluated by 38 blind people by performing 14 email activities; they compared this email client with other existent email clients, and the results demonstrate that TetraMail have a better user interaction experience [12].

Ferrand, Alouges, and Aussal developed an embedded device capable of guiding people using spatialized virtual sound source; with this device, they have been able to guide people to do sports like running or roller skating in a protected environment; using sound stimuli, their experiments showed positive results with blind users [13].

Cardillo, Li, and Caddemi developed a system that employs a radar that can be attached to a traditional white cane to aid navigation of visually impaired people. It detects obstacles in the scanned area, and it also discerns between human and nonhuman obstacles by detecting their breathing vital sign. This could have a great impact for visually impaired people specifically in the ways these people learn to navigate in new areas [14].

Iswahyudi, Anam, and Sujanarko developed a visual aid tool for visually impaired people based on a convolutional neural network; the system is focused on object detection and object positioning; it accepts video that is connected to a camera; voice commands are spoken by the user when he searches for an object; then the speech input is recognized by the device, and the system guides the user to find the object needed through the audio speaker output; this tool will help the visually impaired people to identify objects and the positions of them; this will help their independence [15].

Alkhalid, Kadhim Oleiwi, and Muhsin proposed a system based on face detection to aid visually impaired people to navigate independently; the system used Haar cascade algorithm and OpenCV using python; their results showed great effectiveness and efficiency; they will be working on detecting objects and vehicles too; this will cause a great impact for the independence of visually impaired people [16].

Aisy and Eliyawati proposed "Bluino," a walking support for visually impaired students; it is equipped with an ultrasonic HC-SR04 sensor to detect an object within 50 cm, which triggers a sound; this tool is attached to a box and placed on the user's leg; Bluino can help the visually impaired to detect objects and help their navigation [17].

Ersanty, Wibisono, Niratama, and Sasongko made a comparison of two common screen readers (JAWS and NVDA) and found that it does not influence on learning process outcome; these tools are only to support visual translation to audio forms; they made this comparison with Surabaya State University visually impaired students [18].

Lutfun Nahar, Riza Sulaiman, and Azizah Jaafar developed a low-cost system to learn math braille using Nemeth Braille and calculating numbers called "NC tutor" which provides voice and vibrational feedbacks to assist the users; it was developed mainly in JAVA, and it was evaluated by teachers, experts, and students and provided good results in these students in Bangladesh; it also had great results in usability tests [19].

Vetter proposed WELLE, a web-based music environment for blind people; this tool is developed in JavaScript and runs on standard browsers; this web application is text based and centered around an input field, which serves as the main interaction element; all the elements are accessible to a screen reader; it was tested in a 3 h workshop with a group of six pupils aged 10–14 years, whom five were blind and one was visually impaired; also, two blind teachers participated in the workshop and

showed positive results. WELLE is a work in progress and not yet a stable music environment but offers blind people quick and uncomplicated access to musical drafts and playful engagements with sounds through a textual interface [20].

Malaver and Molina developed a learning system that is made by virtual objects using Exelearning, this virtual objects are formed by an accessible video; in this tool, it was focused in teaching biology; in this particular case, the diversity of birds in Cundinamarca; in their results, it showed that students with visual impairments felt comfortable using the system, it also showed that most of the users think that this system helps to enhance their knowledge [21].

Cecily Morrison, Nicolas Villar, Anja Thieme, Zahra Ashktorab, Eloise Taysom, Oscar Salandin, Daniel Cletheroe, Greg Saul, Alan F Blackwell, Darren Edge, Martin Grayson, and Haiyan Zhang presented Torino, a tangible programming language for teaching programming concepts to children regardless of the level of vision; a tangible programming language uses physical objects to represent or interact with programming constructs; this makes a great way to teach programming concepts to visually impaired people; these tools were designed using an inclusive design; this means that it is not only for a specific type of users; it can be easily used by users with or without disabilities [22].

When reviewing the previous studies, we can now mention the main characteristics that a technology should have to help people with visual disabilities in their education; these characteristics are the following:

- The tool must be fully accessible with a screen reader.
- The tool should be accessible in any kind of device.
- You should be able to use the tool without having to be in a specific place.
- The tool should have a good usability.
- A multisensorial tool is highly recommended.

4 Conclusions

Present literature reviews show that multiple technologies to aid visually impaired people have been developed; most of these technologies are divided in two sections, that is, orientation and mobility and educational; it becomes a focus in the community to achieve inclusive education and an independence for visually impaired people.

In the Mexico 2020 population census, it was reported that there are more than 20 million people who have a disability; that is more than 16% of the entire population of the country. In this census, it was also reported that more than 12 million people have a visual problem, making this the most common disability in Mexico; therefore, it is necessary to develop new assistive technologies to aid people who are visually impaired.

The discovery of new technologies in teaching methods not only helps in the inclusive education, but they also help to increase their confidence. The development

of these teaching methods will help students with visual impairment to focus on the topics they prefer and not only the topics that are naturally accessible to them.

Multisensorial technologies not only help people with disabilities, but they also help to see and learn in different ways, so these technologies can enhance the knowledge of people without disabilities; in this literature review, the visually impaired people benefit more from the technologies that use audio instead of visual elements.

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