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ASSISTIVE TECHNOLOGY FOR STUDENTS WITH VISUAL IMPAIRMENTS

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ABSTRACT

Visual impairment is a disability resulting in partial or complete loss of vision. It results in hindrance to performing daily chores, thereby decreasing the quality of life. This study aims to augment the user's experience with digital interfaces (e.g., the display system of personal computers and smartphones) through the design of an efficient system enabling easier and more effective user navigation.

Assistive technology for the visually impaired and blind people is a research field that is gaining increasing prominence owing to an explosion of new interest in it from disparate disciplines. The field has a very relevant social impact on our ever-increasing aging and blind populations. While many excellent state-of-the-art accounts have been written to date, all of them are subjective in nature. We performed an objective statistical survey across the various sub-disciplines in the field and applied information analysis and network-theory techniques to answer several key questions relevant to the field. To analyze the field, we compiled an extensive database of scientific research publications over the last two decades. We inferred interesting patterns and statistics concerning the main research areas and underlying themes, identified leading journals and conferences, captured growth patterns of the research field; identified active research communities, and present our interpretation of trends in the field for the near future.

The study of the educational process of students with visual impairments shows that they can generally receive a successful education on an equal basis with others. On the other hand, the educational process of students with visual impairments is accompanied by several difficulties associated with the fact that they cannot see.

One of the ways to effectively solve this problem is computer assistive technologies based on programs for the blind and visually impaired, information sources (through sound reproduction, an

auxiliary point, or listening to a large text). Computer assistive technologies are easy to understand and allow you to work independently with a regular personal computer, and general-purpose programs (MS Word, Internet Explorer, etc.) to obtain a normal user experience. For students with visual impairments, these functions have a significant compensatory effect, allowing assistance to the visually impaired (scanning, reading plain text, preparing printed documents, etc.).

Keywords: assistive technology, visual impairments, visually impaired, blind, typhlotechnology, screen readers, JAWS, NVDA, information analysis, electronic travel aids, inclusion, research.

INTRODUCTION

The World Health Organization (WHO) reported that at least 2.2 billion people worldwide have a visual impairment or blindness (World Health Organization, 2022). Unlike congenital blindness, acquired visual impairment has often been diagnosed due to aging, lifestyle factors, or heredity effects (Swenor, Lee, Varadaraj, Whitson, & Ramulu, 2019). Presbyopia caused by aging has had the greatest impact on visual impairment and has been the second most common cause of blindness worldwide (Holden, et al., 2008). 1.09 billion people, over the age of 35, suffer from visual impairment due to presbyopia, and as life expectancy increases, the rate of acquired blindness is expected to increase more and more significantly (Bourne, et.al., 2017).

The field of assistive technology, commonly considered to be technology designed for individuals with some form of impairment (or elderly people), is a vital field expanding at a swift pace since it derives from many disciplines and is mainly driven by technology. Assistive technology for the visually impaired and Blind people is concerned with "technologies, equipment, devices, apparatus, services, systems, processes and environmental modifications" that enable them to overcome various physical, social, infrastructural and accessibility barriers to independence and live active, productive and independent lives as equal members of the society. Vision is an extremely vital sensory modality in humans, the loss of it affects the performance of almost all activities of daily living and instrumental activities of daily living; thereby hampering an individual's quality of life, general lifestyle, personal relationships and career. Therefore, technology that facilitates accessibility, safety, and improved quality of life has a very relevant social impact (Kajimoto, Suzuki, Kanno, 2014). Moreover, with our ever-increasing aging and blind populations, it has the potential to broadly impact our quality of life in the future. This has driven novel research across many disparate disciplines, from cognitive psychology and neuroprosthetics to computer vision and sensor processing to rehabilitation engineering. More recently, advances in computer vision, wearable technology, multisensory research, and medical interventions have facilitated the development of numerous assistive technology solutions for students with visual impairments.

This research is important because social inclusion will contribute to a more correct understanding of the surrounding world and easier understanding and communication. Visual Impairments lead to a lot of secondary disorders. Visual impairments negatively affect the formation of other systems that are closely related to vision: fine motor skills, spatial orientation, object perception, etc.

LITERATURE REVIEW

Learning with assistive technology has some challenges. Visually impaired students must learn how to use technology effectively, having mastered the general information and principles of using technology. A student can not use a computer without proper knowledge. These technologies can be used together, which greatly speeds up the interaction with the computer.

The main part of the computer system for students with visual impairments is the screen access software. This is an intermediary program between the operating system and tools that produce ordinary text and graphic information in audio form. There are many such programs in the world, but the most popular among Windows users are Jaws (Job Access With Speech), and NVDA (NonVisual Desktop Access).

Assistive technologies and devices play a significant role in the professional and social rehabilitation of students with visual impairments. Contemporary assistive technologies for visually impaired students are developing in three main areas: educational, industrial and cultural.

Assistive technologies for students with visual impairments are associated with ophthalmology, tiflopsychology, physiology, radio electronics, telemechanics and automation, biomechanics, as well as with engineering psychology, ergonomics, some areas of cybernetics (technical, biological).

The task of educational assistive technologies is to optimize the educational process of studying the basics of science, as well as the polytechnic and industrial training of the blind and visually impaired. Production assistive technologies are associated with the ability to perform production operations previously inaccessible to students with visual impairments, including control and measurement work, using special assistive technologies, devices and aids.

Moreover, there exists a need for the collaboration of medical skills and modern technology for developing assistive devices for the visually impaired (Siddhartha, Arunkumar, Chavan, & Uma, 2018).

There are several existing products and features to help the visually impaired such as Braille display, screen readers, gesture recognition, image recognition, ultra-haptics technology, launchers on smartphones, and PC operating systems having speech recognition for navigation (Garcia-Macias, Ramos, Hashimoto-Beltran, & Hernandez, 2019)

There are many different optical aids, technical devices, machines and devices designed for low-vision and blind students.

Optical technologies include various types of magnifiers (mechanical, reference, stationary), glasses (microscopic, telescopic, hyperocular), monoculars and binoculars, upper optical devices for the visually impaired, designed for reading, writing, drawing, projection magnifying assistive devices. All these tools can be used for visual work at short and long distances.

Blind students use white canes for spatial orientation in the environment, as well as ultrasound locators that emit and receive signals reflected from objects that contain information about the direction and distance of objects, and various types of sound landmarks.

Several assistive technologies for blind learners demonstrate the phenomena of light reflection and refraction; students can perform photometric work in physics, and get the opportunity to observe the phenomenon of perspective, the apparent movement of the Sun, the Moon, cloud cover, etc. Household items include liquid and bulk food and medicine dispensers, clocks, thermometers and other household items with tactile symbols, needle threads, bread slicers, vegetable peelers and more. School supplies include visual aids designed for tactile perception (tactile maps and globes, relief drawings and diagrams), Braille Typewriters, Perkins Brailler, etc.

To ensure the safety of blind students in an unfamiliar environment or difficult road conditions, several sophisticated electronic devices have been developed based on the principles of light, sound and ultrasound positioning that warn of near obstacles. Assistive technologies are an effective way to compensate for severe visual impairments.

One of the current problems of raising and teaching children with visual impairments has always been and remains the teaching of Orientation and Mobility with assistive technologies. Orientation and Mobility of visually impaired persons are considered by Teachers of Students with Visual Impairments as an important condition for the formation of a full personality and inclusion in society (May & LaPierre, 2008).

For a long period of time there was an opinion in psychology that only the eye is capable of perceiving space. Later it was confirmed that not only the eye but also the hand can perceive space.

METHODOLOGY

To study the level of social inclusion skills of students with visual impairments using assistive technology, we conducted a study using the tools and tasks we proposed.

In the research participated 10 students of the high grade of Yerevan N. Tigranyan special school N14 for children with visual impairments. Before conducting the research, we studied of medical documents of the students. We first explained to the children the methods of performing the proposed task and then started the actual work. The research on the development of social inclusion skills of

children with visual impairments through assistive technologies was carried out in two phases. At first, we tried to find out the extent to which students master assistive technologies.

The first step is to determine the level of ability to use assistive technology. We offer children to perform simple actions: to use the computer correctly, to perform simple steps using a special system.

RESULTS

During the work, it became clear that only 6 out of 10 students can use the computer without external help, 2 of them performed the actions with the help of the teacher, and 2 students could not complete the assignments. 3 students were able to fully use the "Arev" system, 3 students were working with help, and 4 students were unable or refused to complete the tasks.2 students were able to communicate with the help of typhlotechnological means, 3 turned to the help of the teacher, and the others found it very difficult.

During the conversation with the students, we found out that they like working with computer technology, and communicating with friends and family members. However, if students with low vision or partially sighted students do not face problems when using computer technology, blind people have a lot of difficulties when performing these activities. This circumstance is also a reason for the difficulty of social inclusion of the blind.

Table 1.

Indicators of the level of inclusion of students with visual impairment using assistive technologies

Tasks	Research results n=10, 100%							
	Can't use		With difficulty		With help		Independently	
	n	%	n	%	n	%	n	%
Ability to use computer programs	2	20	2	20	6	60	-	-
Communication skills with assistive technology	5	50	3	30	2	20	-	-

Assistive technologies help learners promote communication, improve access to information, and increase independence. These tools, which include low-tech materials (flip boards, boards for pictures),

mid-tech devices (single button, single overlay displays and high-tech devices (electronics, computer software), help maximize a child's ability to transfer information, learn and communicate.

- The audio description describes visual information. You can turn on the audio description loudly so everyone can hear it, or turn on an assistive listening device (ALD) so that only the student wearing headphones can hear;
- Computers that can be used in the classroom as assistive technology to demonstrate assignments. Computers have many accessibility settings that make them easier to use; zoom, large print, high contrast display, etc.;
- E-books that include large print or text-to-speech functionality;
- Image descriptions or alternative text, read aloud and describe what is shown in the image using a screen reader;
- A large-print keyboard, with one model having bright yellow keys and large black letters, although modifications to conventional keyboards such as braille or large-print stickers are also applicable. High-contrast virtual keyboards are also available for most smartphones and tablets;
- A screen reader is a program that reads all text on a computer screen using a synthesized voice. Screen readers aren't just on computers, many smartphones and tablets also have their screen readers. But not every website or software application is accessible to screen reader users, tactile materials allow users to learn by touch. Tactile materials can be outlines or full 3D models and can include Braille;
- Virtual assistants, sometimes called voice assistants, perform tasks or services for users based on spoken instructions or questions. Virtual assistants can read information aloud or perform tasks without requiring the user to look at the screen;
- External displays can be used to further enlarge the information on the screen. Some learners may have multiple external displays or simply use it to project information from a smaller display (Svajyan, et. al., 2022).

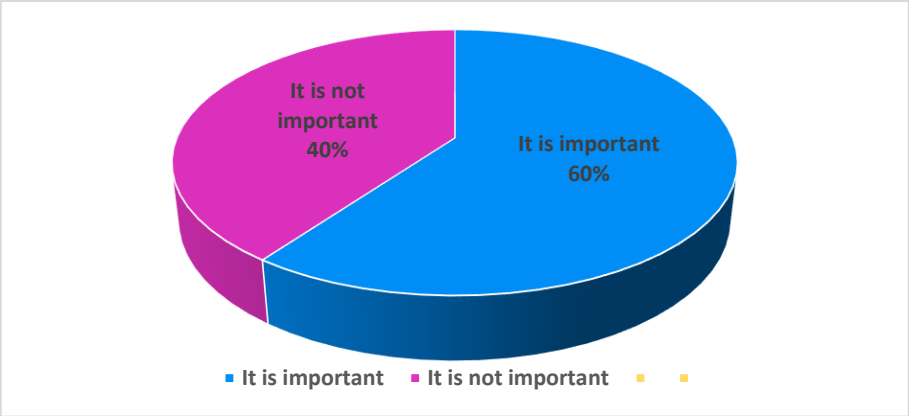
During the research, the following methods were used: a study of special literature, analysis and comparison of leading experience, conversation, and survey. In the research participated teachers and tutors of Yerevan N.Tigranyan special school N14 for children with visual impairments. The survey was conducted with a special questionnaire developed by us. Various answers were given to the questions. The majority of respondents emphasize the role of typhlotechnologies in the process of inclusion, but do not use specially developed methods, of typhlotechnologies.

In the course of the research, we tried to find out how the studied specialists treat this problem, what place they allocate to the development of the process of inclusion using typhlotechnologies, special devices in the educational process or the routine of the day, what methods and means do they use for this purpose?

The results of the research show that the majority of the teachers and educators interviewed (60%) value the role of technology in the process of inclusion, and 40% do not value the role of technology in the process of inclusion of children with visual impairments (Figure 1).

Figure 1.

Indicators of the importance of the role of typhlotechnology in the process of inclusion of students with visual impairments

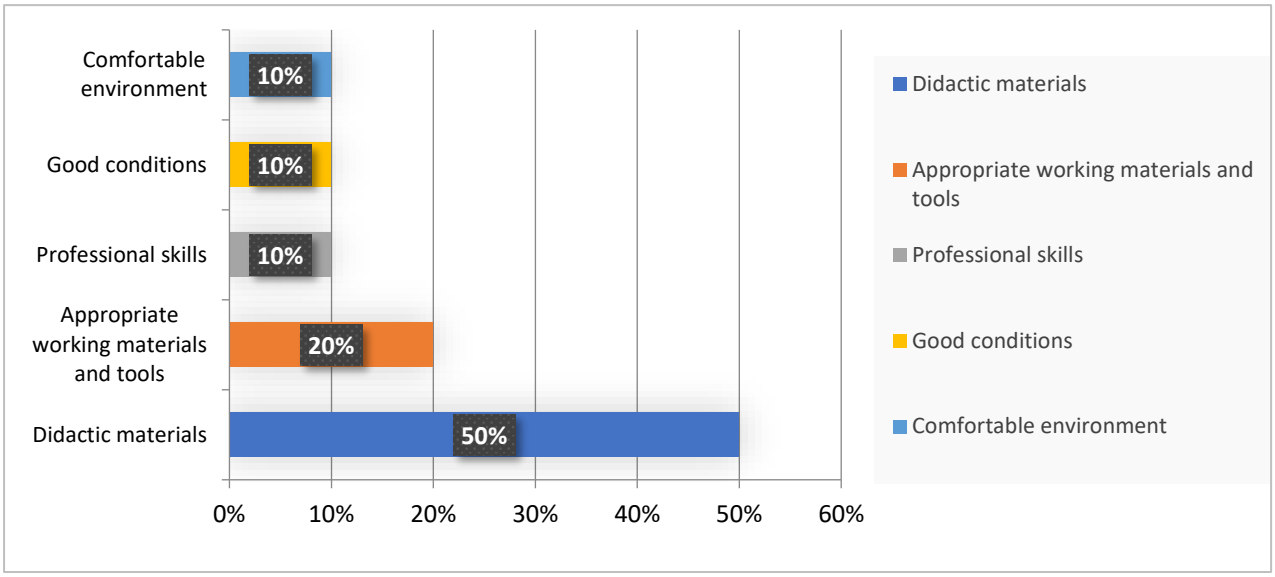


However, the respondents gave different answers to the question of what conditions are needed for inclusion. For example:

1. “Didactic materials” - 50%,
2. “Appropriate working materials and tools” - 20%,
3. “Professional skills” - 10%,
4. “Good conditions” - 10%,
5. “Comfortable environment” - 10% of responses (Figure 2).

Figure 2.

Indicators of the level of awareness of teachers and tutors about the necessary conditions for the inclusion of students with visual impairments.



Thus, it became clear from the surveys, observations, and conversations that on the one hand, all the respondents mentioned the significance and importance of the development of inclusion of students with visual impairments through typhlotechnologies, but on the other hand, they did not use appropriate means and methods. A part frankly states that they don't know and don't use special literature, and they don't have relevant knowledge and experience on the inclusion of children with visual impairments through computer technology.

As a result of surveys conducted among teachers and high school students, it became clear that only the “Arev” system is used in the school. They note that the system has many shortcomings: the quantity of languages is small, the possibilities are limited, and the pronunciation is inconvenient.

Some of the visually impaired students are only able to fully use this system, others can use the “Arev” system with difficulty or with the help of a teacher.

Now, all over the world, people with visual impairments use modern technologies, and special devices, which provide a wide opportunity for education and active development of social life.

Students with visual impairments use computer speech programs (JAWS, NVDA) to read almost anything on the computer out loud. For example, if a program says that a file is in mp3 format, a blind person will understand that it is an audio file. JAWS can say out loud when a file was created, what size it is, and what color a letter of text is.

“Talking" programs enable students with visual impairments to independently use the computer, and the Internet, “read”, edit texts in different languages, listen to music, communicate and other

opportunities. They play a huge role in a visually impaired student's education, work, as well as communication and information.

Most people around the world use JAWS, NVDA, and other “talking” programs. The “Arev” system was created in Armenia, which was developed by Armenian scientists at the Yerevan Research Institute of Mathematical Machines. The program was created in 2004. A center was opened in the building of the institute, where blind people attend and learn how to use “Arev”.

The "Arev” system has made a big revolution in the lives of blind people living in Armenia, but there are certain disadvantages that reduce its use. The number of languages in “Arev-4” is less, “Arev-4” is a modified version of the “Arev” system, which has 6 languages, and languages can be easily added if necessary. It has different pronunciation speeds, works with the Windows system, allows you to use the Internet, the program is in Armenian. And “Arev-2” is designed for blind musicians, who can listen to notes and compose using this system. “Arev” also has a video scanner (scanner) that recognizes the text, turns it into a computer voice, and reads Armenian, Russian and English.

However, many visually impaired users report several problems with the Armenian “talking” program.

Many blind students claim that the pronunciation of “Arev” is inconvenient. They mainly use the NVDA (Non-Visual Desktop Access) program because they consider it a great advantage that the program includes more than 40 languages.

NVDA also provides the ability to control the sound - slow it down, boost it, stop it. This program is used in more than 120 countries of the world, it is portable and can be downloaded.

This almost flawless JAWS program, which is the most popular in the world, does not have Armenian, it is available only in English and Russian, which are of better quality, promote social inclusion and give better opportunities to users, in particular, to use all the possibilities of the Internet.

Below are the advantages and disadvantages of computer typhlotechnologies revealed as a result of the survey, conversations, and observations.

Table 2.

Indicators of the results of a survey conducted among teachers and students about the positive and negative aspects of typhlotechnology

Computer typhlotechnology	**Advantages**	**Disadvantages**

JAWS	Can mention: • file creation date, • file volume, • text font color.	The program is not Armenian. They do not teach and practice at school.
NVDA	More than 40 languages.	The program is not Armenian. They do not teach and practice at school.
„Arev" system	The program is in Armenian. Allows. • learn the system independently (in Armenian and Russian), • learn the keyboard by yourself.	The pronunciation is awkward. There are few languages. Opportunities are limited. They do not teach and practice at school.

The goal of the "Arev" typhloinformation system is to implement communication of visually impaired students through computers and to support their integration into society.

As a result of the survey conducted among teachers and students about the positive and negative aspects of computer technology, as well as our observations, it was found that not all students fully use the "Arev" system.

DISCUSSION

The research problem is most relevant, it is of great importance in the process of the pedagogical-psychological adaptation, physical environment, and inclusion of students with visual impairments, but teachers are not enough aware of the means of developing this process.

Despite the importance of the formation and development of the process of adaptation to the pedagogical-psychological and physical environment, the inclusion of students with visual impairments in special literature and practice is still considered little studied. Studying this issue and selecting, developing, and coordinating appropriate measures will contribute to the inclusion of students with visual impairments.

As a result of our research, it was found that assistive technologies contribute to increasing the level of inclusion of students with visual impairments.

CONCLUSION

The needs of the visually impaired and blind students are greater than ever before. Assistive technology as a mature field will continue to gain prominence and impact the lives of visually impaired and blind individuals (and elderly people) in ways not previously possible. The increase in functionality of mainstream mobile technologies, advances in computer vision processing algorithms, miniaturization of electronic devices, and cutting-edge new medical interventions are expected to drive this field further toward the challenges and reality of creating successful assistive technology.

After studying the technical means mentioned above, we concluded that these means can serve as "artificial vision" for people with visual impairments. The application of all this contributes to the development of spatial orientation of the blind, orientation in macro and micro environments, visual perception, social inclusion, and the development of other important functions.

Thus, computer typhlotechnology can be an indispensable gift to blind and visually impaired students and will be indispensable until all hidden human possibilities are fully revealed.

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