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Review Article

Assistive Technology for People with Visual Loss

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Abstract

Assistive technology for people with visual disability is growing rapidly over the past few years around the world. Such technology enhances the functioning and performance of daily living skills, thereby improves the independent living. These technologies range from low cost to high end and expensive which include mobility, reading, writing, daily living, and communication technologies. Children primarily need technology for education whereas adults for routine living tasks. Over time the need as well as demand of such technologies will continue to grow due to expected increase in proportion of population with visual disability particularly in low middle-income countries like India. Therefore, the first and forefront strategy to improve assistive technology service for visual disability in India is to create awareness, sensitize among eye care professionals, potential beneficiaries, caregivers, and their families. The present paper highlights various type assistive technologies in which few of them incorporate with illustrations so the readers understand easily.

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Introduction

Assistive technology for people with disability is gaining a lot attention across the globe in the past few years.[1] Such assistive technology is one of the essential components while rehabilitation interventions is being planned for disabled people. Not only does the assistive technology help in enhancing the body functioning, but it improves daily performance, and independent living, thereby enhance the quality of life among these people.[2,3,4] The WHO Rehabilitation 2030: A Call for Action, therein ensuring equitable access to assistive technology to people with disability is one of the top priorities.[5] Further, The Global Research, Innovation, and Education in Assistive Technology (GREAT) Summit 2017, WHO identifies many research priorities on Assistive technology, practice areas and service delivery models for the assistive technologies.[6]

Similarly, Assistive Technology is an indispensable tool while managing for people with visual disability. Such people need assistive technology for various activities exclusively for mobility, daily living, reading and writing or employment etc. There are a wide range of assistive technology available starting from a simple, low cost like large print books to high end, very expensive like Refreshable Braille Display.[4] Under the Universal Eye Health coverage, quality rehabilitation and provision of appropriate assistive technology to people with visual loss is one of the key components.[7]

Assistive Technology

Based on International Standard Organization (ISO), the World Health Organization earlier in 2011 defines Assistive Technology as "any piece of equipment, product, or tool, whether it is acquired commercially, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities". [8] Later, the International Classification of Functioning, Disability and Health (ICF)-WHO reconceptualizes the term 'Health Technology' into Assistive Technology (AT) and Assistive Products (AP) in 2016.[1,9]

AT signifies as the application of organized knowledge and skills, and system to provide service of assistive products, including its scientific application. AP is any form of external product especially designed and produced or generally available, whose primary purpose is to improve an individual's functioning and independence living, and to enhance overall well-being.

Recently, the World Health Organization introduced the Global Cooperation on Assistive Technology (GATE) in 2014 to address the need of the substantial gap between the needs and supply of AT for persons with disabilities in all countries.[9] Under this initiative, the WHO published the first list of top 50 Priority APs on the basis of widespread need amongst the people with disability.[10] There are sixteen devices in the GATE list for people with visual impairment.

ATs for visually impaired (low vision) and blind people are based on a sense of touch or vibration, sound, and smell etc.[11,12] Out of these senses, historically the sense of touch has been used extensively to generate information. The present paper describes some common ATs based on the activities of the individuals with a special focus on students with visual disability. Evidence shows that the awareness about At for visual problems is significantly low among the eye care professionals, disabled people, even students in schools for the blind especially from low middle-income countries.[13,14] Therefore, this paper will help to improve the awareness about the AT of the visual disability.

A. Assistive Technology for Education

a. Assistive technologies for pre-academic learning

Supporting with ATs while learning of young children with visual impairment and blindness can enhance their academic and functional performance at a later stage of their education. The development of visual behaviors, haptic or tactile awareness, fine motor skills and use of the residual vision in playing and social interaction enable the learning of more sophisticated and complex functional behaviors and skills in subsequent years.[15,16] Few example are simple tactile

or embossed print toys, toys that give off light or produce sound, or Close Circuit Televisions-CCTV.[17]

b. Assistive technologies for reading

The act of reading is an esential to many activities in our daily life. Literacy is a requisite skill and knowledge for a wide range of work-related, leisure, and other life maintenance activities in today's societies. These technologies help in performance among individuals with visual loss.[17,18] Few examples are as follows

1. **Large print books:** Individuals with low vision have difficulty in reading small and usual print size text (N 6-8 or 1 M). Large size print text (N 20 or 2.5M) with font size of 16 to 18 helps in reading.
2. **Typoscope:** It can be used for either reading guide (one window) or writing guide (multiple windows) according to the design being made. Single window typoscope is useful for albinism (Figure 1).
3. **Reading stands:** It helps in avoiding from bending over the surfaces while viewing texts. It also helps to Braille readers.
4. **Low vision lamps:** Enhance lighting may help people with low vision to read easier, thereby, improving the reading performance. For example, compact fluorescent (CFL), incandescent lamps, light emitting diode, and halogen lamps etc. with different luminosity will be of help in reading. Objective measurement of the reading ability as well as subjective ratings of visual comfort with lighting preference should be considered in assessing the suitability.
5. **Optical magnifiers:** Optical magnifiers (near and distance), for example, hand-held magnifiers, dome, stand and pocket magnifiers, telescopes are task-specific optical aids that enlarge the image formed on the retina (Figure 2).
6. **Electronic Magnification Aids (EMA):** Electronic magnifiers are usually termed as electronic vision enhancement system (EVES). The devices range in size from large desktop units (Close Circuit Televisions -CCTV, Figure 3) to hand-held video magnifiers with different size.
7. **Braille Reading Materials (BRM):** Braille is a tactile system of raised dots that enables students with visual impairment to access the information by touching. Learning Braille reading with fingers is one of the oldest technique to route for literacy among the visually impaired and blind people. Braille codes use worldwide has a standard rectangular cell, which contains up to six dots in a 2 by 3 grid. Reading materials are typically available in 3 encoding levels. Grade 1, in which words are fully spelled; Grade 2, which uses abbreviations and contractions, and Grade 3, which involves authors' personal and nonstandard shorthand.
8. **Refreshable Braille Display (RBD):** Refreshable Braille Display works with a screen reader and enables the user to read what's on the computer screen by touch on Braille display. A Braille display has a different size from 12 to 80 Braille cells, each cell has 6 or 8 pins which are connected electronically to the computer to be able to move up and down when type on Perkins style key pad, and to display a Braille version of characters on the computer screen. The price of Braille displays is very expensive depending on the number of characters displayed.

Figure 1: *Typoscope*

Figure 2: *Magnifiers*

Figure 3: *CCTV*

9. **Braille Translator Software (BTS):** Braille Translation Software translates electronic documents into Braille codes and sends it to a Braille embosser (special Braille printer- Braille embosser) which produces a hard copy of the original text. BTS recognizes a variety of digital text files formats e.g. MS Word, PDF, HTML etc. The common translation software includes Duxbury Braille Translator, Braille 2000 etc.
10. **Audio Format Materials (AFM):** AFM is beneficial for many students with low vision and blind. It enables students to read or access information through hearing e.g. Digital Accessible Information System –DAISY, Book Port Plus etc. (Figure 4). There may be dedicated audio players e.g. Booksense; device that displays text and play, e.g. Victor Reader Stream; multipurpose audio devices e.g. I Pod, or computer software e.g. Easy Reader.
11. **Screen Readers Software:** This software allows people or students with low vision and blind to convert text on a computer screen and in documents to synthetic speech i.e. audio output as well as keystrokes entered on the keyboard, and navigational information. Screen readers require the use of keyboard shortcuts, most of which the user must memorize the keys. Many screen readers work with multiple programs, but some screen readers are specific to certain programs e.g. JAWS, NVDA, COBRA, SuperNova etc. NVDA is freely available online.

Figure 4: *DAISY*

c. Assistive technologies for writing

People with visual impairment and blindness face a lot of challenges in writing tasks involving typical writing or visual writing. There are varieties of assistive technologies available that support for writing tasks.[2,17] Few common are as follows:

1. **Braille slate and stylus:** This is a low cost, portable low-technique writing tool. It is like a pencil and paper concept. The slate is usually made from two panels that stabilizes the paper and while the stylus is used to punch through the holes in one of the panels to create the Braille dots.
2. **Jot a Dot:** It is also a low-tech writing tool made of light weight plastic material that is small and easily portable. It is useful for taking quick and short notes by students.
3. **Braille typewriter (Perkins Brailler):** It is a portable low tech writing tool with six keys corresponding to each of the six Braille dots. There are many models of the Perkins Brailler that suits according to the needs.
4. **Braille computer keyboards:** This is a specially designed computer key board which corresponds to Braille code on its keys.
5. **Large computer keyboards:** This is key board with 2.5 M notation print size (Figure 3).
6. **Digital audio recorder:** The non-displayed digital recorder is a specially designed for persons with visual impairment which can record teachers' lectures to replace writing notes e.g. PlexTalk.
7. **Braille electronic note taker:** It is a small and portable device for storing information with the used of the Braille or typewriter keyboards. The stored information can be accessed through an inbuilt speech synthesizer or a Braille or both.

d. Assistive technologies for mathematics

Learning mathematical concept is a great challenging task for students with visual loss. For instance, concepts such as direction, quantification, and shape require substantially more cognitive processing when visualization is not possible. Textual and audio supports, such as Braille textbooks and talking calculators, are useful in facilitating student's access to mathematics materials, however, tactile support and haptic technology at times offer advantages in the promotion of concrete mathematical understandings.[19,20] There are some assistive devices that use in mathematical learning. Few examples are as follows:

1. Braille compass, Braille ruler, Braille protractor
2. Raised line graph, Braille cube
3. Talking calculator
4. Tactile geometric kit (Figure 5)

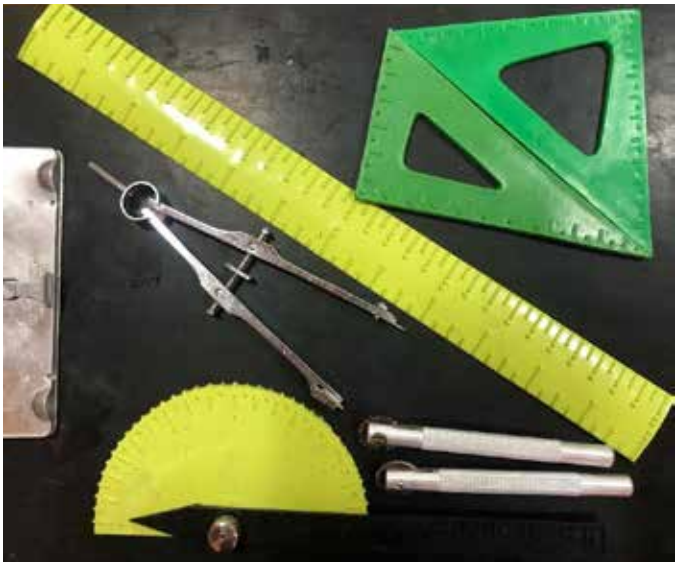

Figure 5: *Tactile geometric kit*

e. Assistive technologies for science learning

Learning science like maths is also traditionally depended on visually oriented concepts and information. Though this visual information is not made widely available in a format to learn sciences, there are some assistive technologies for

science. For example, tactile maps, tactile diagram set for sciences (Figure 6), tactile anatomy atlas, animal models, plants or 3-dimensional models objects e.g. DNA twist model. Students can touch and explore it.[20,21]

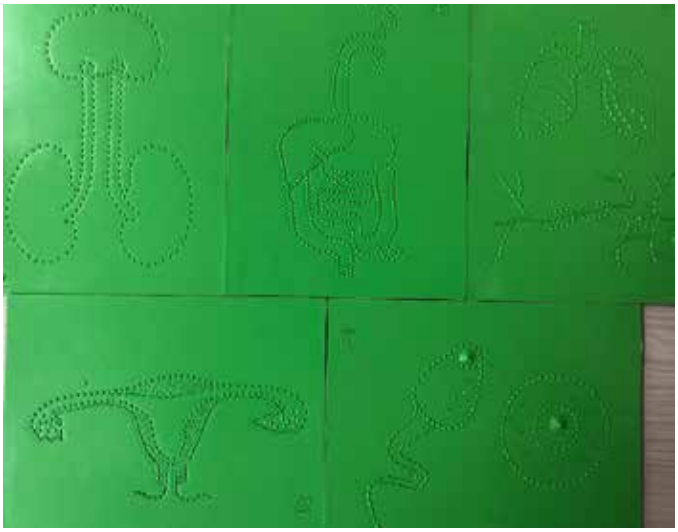

Figure 6: *Sciences*

B. Assistive technology for orientation and mobility

Orientation and mobility (O&M) are an essential component for daily and independent living in people with visual loss. Few example are as follows:

1. **Walking or long cane:** It is designed primarily for mobility tool to identify objects in the path of the users. The length of the cane depends upon the height of the user, and usually, it extends from the floor up to between sternum and under the chin when user is standing upright.
2. **Children's walking cane:** This cane works same as long walking cane but designated for use by children. It is shorter than long cane.
3. **Symbol or identification cane:** Symbol cane is primarily used to notify the general public that the person has a visual impairment or low vision. It is often shorter and lighter than others. It intends not to be used as a body support or to detect obstacles on the floor or as a mobility tool. Red and white color banded symbol cane highlight both visual and hearing impairment. Sometimes, a long symbol can be used for mobility to detect any kerbs, doorways or obstruction in low contrast. Such canes are intended to be used for persons with some residual visual function.
4. **Guide cane:** This is a short and thin cane but longer than symbol cane usually extending from the floor to the user's waist when standing upright with more limited mobility function. The guide cane is used to scan for kerbs and steps by individual with some residual visual function. It is usually used diagonally across the body for protection and warning the user of obstacles in low contrast or in dark or night time.
5. **Support cane:** The white support cane is designed to offer physically support to the user. This tool heavier and stronger and very limited role as a mobility device.
6. **Green cane:** It is used in some countries to designate the user as low vision while the white cane user is blind.

C. Assistive technology for games and leisure

It is important to keep in mind that people with visual loss will need to learn to play games with a sense other than sight. Many games and toys help to develop cognitive skills such as recognizing shapes, numbers, textures etc. It also promotes the development of social skills such as interacting with peers, participating in group activities. The following are some of the games that can be played by most people or children with visual loss with no special adaptation.[21]

1. Simon memory game
2. Cootie game to develop fine motor
3. Hot potato game for social interaction

There are numerous adaptation games that will allow blind and visually impaired people or children can play. Few examples of adaptive games are:

1. Peg boards, Tactile dice (Figure 7).
2. Audible balls
3. Large print with Braille cards, Braille chess, Large print paly cards (Figure 8)

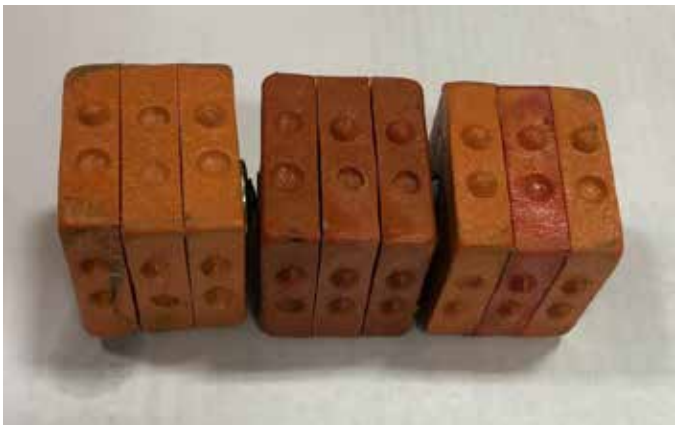

Figure 7: *Tactile dice*

Figure 8: *Large print play card*

D. Assistive technology for Activities of Daily Living (ADL)

Individuals with blindness and visual impairment require assistive technology for a wide range of their daily living activities, for instance, to facilitate daily living performance, to increase productivity, and independence living, participation in social life events etc. Assistive technologies for ADL are available.[17,22,23] Few examples are

1. **Liquid level sensor-** It is specially designed device which alerts visually impaired students by monitoring the level of liquid in a cup or glass either a sound or vibration or both as liquid touches at the tip of device.
2. **Talking color detector-** This device can differentiate a variety of colors with a voice once it touches on the surface.
3. **Talking watch or alarm clock**- This talking device clearly announces the time and can be used for alarm (Figure 9).

Figure 9: *Talking watch*

4. **Pill organizer-** This device is particularly useful for low vision or blind individuals who need to consume multiple medications every day. It has a separate compartment for pills taken in the different time of the day. Color code lids or Braille markings box are available (Figure 10).

Figure 10: *Pill organizer*

5. **Simplified mobile phone-** This is a simple basic phone which makes easier to feel and navigate. Features like the adjustable or large font or screen magnifiers, adjustable screen contrast and brightness or Braille entry may have in the phone. The smart phone accessibility has increased significantly in recent years. Many screen reading software or apps are available online without no extra cost to. It is also useful for the reading website, emails, other online information e.g. SEEING AI, AIRA App, VoiceOver, TalkBack, Narrator etc.
6. **Talking money Identifier-** It helps visually impaired individuals to identify money with a voice function. Other tactile note identifier is a money organizer wallet, notex, NoteChecker etc (Figure 11).

Figure 11: *Notex*

Conclusion

Globally, the need of assistive technology continues to increase along with rise in the population with visual disability. India, a home of highest number of blind population in the world certainly need to improve the awareness as well as accessing of assistive technology. The eye care professionals and other allied disciplines in the country are needed to be sensitized about various types of assistive technology and its application for the welfare of people with visual impairment. At the same time, it is also important to have a low cost and affordable assistive technologies for a resource limited country, India.

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