INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 14, Issue 2, (2024) E-ISSN: 2222-6990

Assistive Technology for Visually Impaired Individuals: A Systematic Literature Review (SLR)

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v14-i2/20827 DOI:10.6007/IJARBSS/v14-i2/20827

Published Date: 13 February 2024

Abstract

Assistive technology is a tool that helps people with disabilities to facilitate their daily lifestyle. Based on the *International* Agency for the Prevention of Blindness (IAPB), children with vision impairments have lower levels of educational attainment compared to typical children. The aim of this study is to identify the assistive technologies that exist in assisting visually impaired individuals improve their lifestyle. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model is used to identify articles from the database of Scopus, Web of Science (WOS), Research Gate, Google Scholar and MYCITE. 108 articles related to the assistive technology of visually impaired individuals were screened while only 20 articles were selected for further evaluation. Articles are selected in the range of 10 years from 2013 to 2023. The findings of the study were divided into 3 main themes, namely, mobility, accessibility and challenges. The finding reveals that less research and articles found on the usage of assistive technology in Malaysia. Most articles are related to the technical side and the production of assistive technological innovations as well as users feedback. The empowerment of artificial technology for visually impaired individuals should be given more attention so that the government's aspiration in creating a 'Disabled People-Friendly Environment' and 'Education for All' policy can be achieved with excellence.

Keywords: Assistive Technology, Visually Impaired Individuals, Blindness

Introduction

Sustainable Development Goals (SDG) is a universal call to form a better world for all individuals in the world by 2030. The SDGs consist of 17 pre-set goals. One of the goals is SDG 4 which ensures quality and equal inclusive education and promotes lifelong learning opportunities for all. However, children with vision problems cannot reach their full potential due to the disability factor. Based on the International Agency for the Prevention of Blindness (IAPB), children with vision impairments have lower levels of educational attainment than other typical children. Therefore, visually impaired children should be given the opportunity

to reach a potential level by being exposed to various methods of artificial technology or assistive technologies available.

The World Health Organization (WHO) says at least 2.2 billion people encounter vision problems while 1 billion of them have vision impairments that can still be addressed. In addition, the WHO estimates that 36% of people with long-distance vision problems are the result of refractive errors or vision problems caused by the lack of proper concentration of light on the retina due to the shape of the eye. The WHO also stated that 17% of people with vision problems because of cataracts have received access to appropriate interventions. According to Persons with Disabilities Act (2008), people with disabilities are entitled to access to non-discriminatory education. Therefore, Special Education Needs pupils (SEN) are entitled to an education equivalent to other typical pupils. SEN pupils with vision problems require technological aids that can facilitate the process of teaching and learning in the classroom without limitations. Limited accessibility affects the chances of SEN with vision problems to reach their full potential.

Vision is a sense used by an individual to collect information about the environment around them (Madake et al., 2023). People with visual impairment experience vision problems from birth or because of an accident or injury. Assistive technology is a method that helps people with disabilities to facilitate their daily lifestyle. Assistive technologies are also used in the recovery process to improve the functionality of limbs disturbed with disabilities while improving the quality of life of these people (Texeira et al., 2023). Assistive technology of visually impaired individuals refers to the devices created to help them identify their position, direction and provide assistance while doing activities inside or outside the premises (Madake et al., 2023). SEN pupils with vision problems require practical technology to increase their potential during the teaching and learning process in and out of the classroom. The lives of individuals with vision problems are greatly simplified with the help of assistive technology from the aspects of learning, reading, digital document management, two-way communication and digital information acquisition processes (Asebriy et al., 2018). This facility can increase the accessibility of the visually impaired students to gain knowledge without limitation.

Assistive facilities for vision impairment people can prevent distractions or obstacles at bottom waist level while walking (Buchsa et al., 2017). However, the aids are not able to help visually impaired individuals avoid obstruction from the waist level and above while walking (Manduchi, 2011; Buchsa et al., 2017). The application of technological elements in the aids of visually impaired individuals cost a lot of money. This makes the aids unaffordable due to the overpriced (Mehta et al., 2016). Overpriced aids are not available to the visually impaired who are from low-income families such as SEN pupils with vision problems in government schools that are still under remuneration and family care who are unable to provide high-quality technology facilities and still rely on cheaper and less effective aids.

Assistive technology plays an important role in ensuring that the quality of life of visually impaired individuals can be improved. The use of aids such as white sticks is no longer effective and requires more effective aids to facilitate their daily living. There have been many studies that discuss effective assistive technologies for visually impaired people. The studies focused on assistive technologies from the aspects of mobility, accessibility and others that

can help improve the quality of life of the visually impaired in developing countries. However, there are still limitations in the use of assistive technology in Malaysian government schools. The technology used is less effective in helping visually impaired students in schools.

Methodology

Articles Search Strategy

This systematic literature research (SLR) aims to identify technologies designed and used by visually impaired individuals. This objective is the starting point of searching for articles related to assistive technology for visually impaired individuals. Scopus, WoS, MyCite and Research Gate databases were used in searching for technology-related articles for visually impaired individuals. The Google Scholars database was used as a support in articles search. In the articles search procedure, article search keywords were determined based on the study title (Mat et al., 2020). In this SLR, the keywords used were in English and Malay. The keywords used were 'technology for the blind', 'intelligence technology for people with visual impairment', 'technology for blind', 'technology and blind'. The Boolean search method was used in searching for articles to ease the process of searching the article related to technology for people with visual disabilities. Joklitschke et al (2018) stated that searching for articles using the right keywords is an important element in the production of a comprehensive systematic literature study.

Table 1
Distribution of articles by database

Database	Articles
Scopus	6
WoS	3
MyCite	3
Research Gate	5
Google Scholar	3

Criteria of Instrument

The setting of a strong set of criteria is the first step in comparing literature highlights in a study (Xiao & Watson, 2019). In this study, several criteria were set to facilitate the process of searching for articles as well as the process of acceptance and rejection of articles. In this SLR, the search for articles focused on articles published from the year of 2013 to 2023. This limit was set to avoid any doubt about the findings of the literature review. In addition, in this SLR, English and Malay were used in the process of article searching. This was to avoid misunderstandings and errors in the findings of the study. This SLR focuses on published articles, proceedings and thesis to obtain extensive literature review on the topic of study. Meanwhile, local and foreign studies were also analysed to compare the use of assistive technology of visually impaired individuals at home and outside environment.

Table 2
SLR search criteria

Criteria	Description
Year	2013- 2023 (10 years)
Language	English & Malay
Type	Articles, proceedings and thesis
Coverage	Local and international

The PRISMA model was used as a guide in the search for literature highlights in this study. PRISMA, The Preferred Reporting Items for Systematic Reviews and Meta- Analyses was introduced in 2009. The PRISMA model can help in writing literature and formulating a clear literature review (Randour et al., 2020). This model was used in the process of searching articles and filtering articles systematically and comprehensively. This model involves four stages, namely the first level of identification, the second stage of screening, the third level of eligibility and the fourth stage of inclusion.

Based on the PRISMA model, a total of 108 were recovered from the database as stated in figure 1. After screening stage 1, a total of 63 articles were selected to the next level. At the screening stage, repeating articles were removed. Analysis of the title, abstract and findings of the study helped in this screening where 45 articles were rejected. At the qualification level, articles that meet the criteria and use of relevant vision-impaired individual technologies were selected. At this stage only 20 articles were selected for the study of this SLR. Table 3 shows the list of articles selected at the inclusion level for analytical purpose in the SLR.

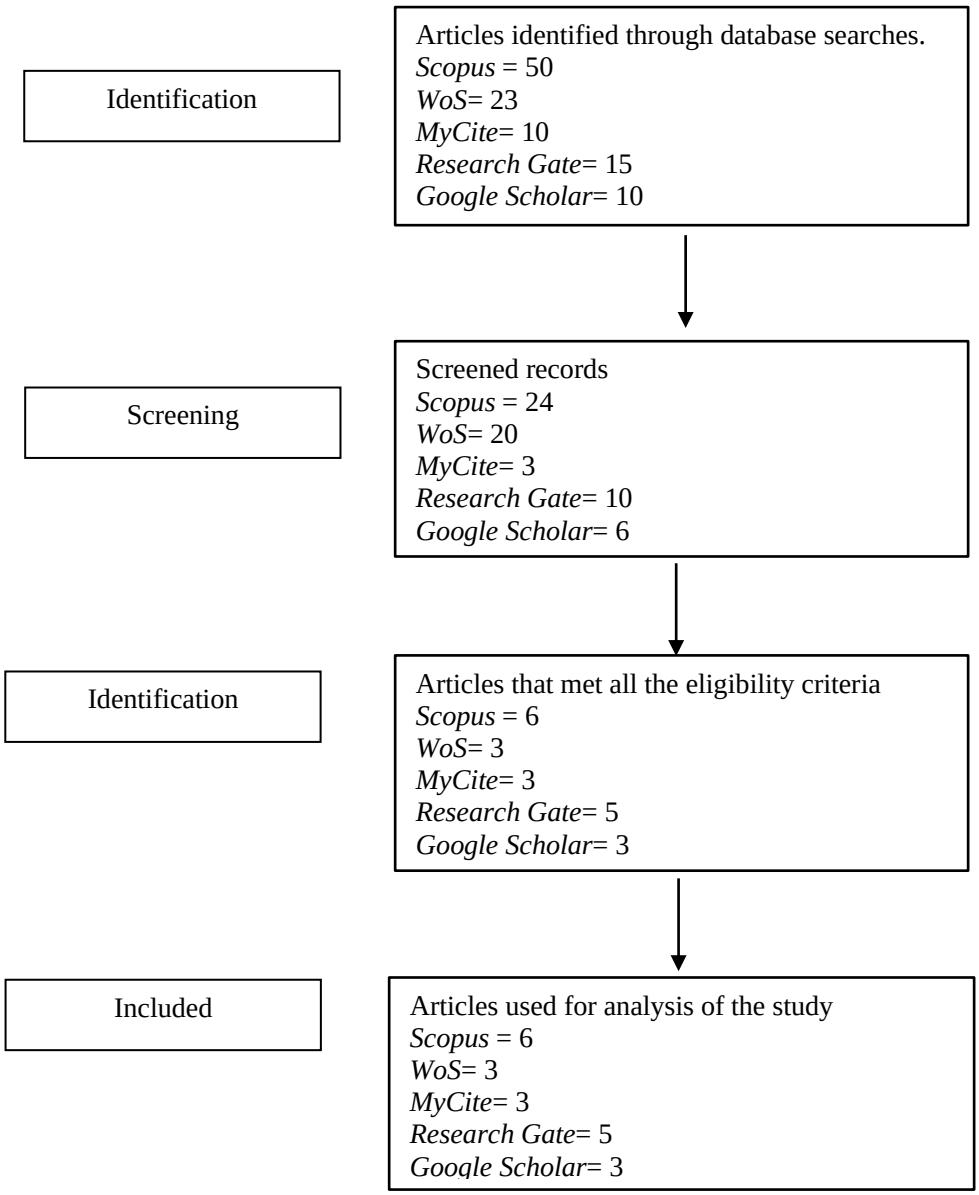

Figure 1: PRISMA Model Flowchart

Table 3
List of articles

Author (Year of Publish)	Title	Journal	Objective
Minhat et.al (2020)	Enhancing the usability of tactile map for the visually impaired	Journal of Engineering and Science Research	Design and identify the effectiveness of touch maps for the visually impaired people
Sahazati Md Rozali et. al (2021)	Development of smart glove system for blind people	International Journal of Electrical Engineering and Applied Sciences	Design and develop a 'smart glove' to help the mobility of the visually impaired people
Velazques et.al (2018)	An outdoor navigation system for blind pedestrians	Applied Science	Identify the effectiveness of GPS technology and touch

	using GPS and tactile-foot feedback		sensory devices in improving mobility of visually impaired people
Madake et.al (2023)	A qualitative and quantitative analysis of research in mobility technologies for visually impaired people	IEEE Access	Analyse the evolution of assistive technology in helping visually impaired people in terms of movement, characteristics of assistive technology and challenges in the application of assistive technology
Mehta et.al (2017)	Smart Path Guidance mobile aid for visually disabled persons	Procedia Computer Science	Design and develop Smart Path Guidance mobile software for people with visual disabilities
Texeira et.al (2023)	Wearable haptic device as mobility aid for blind people: Electronic cane	JOJ Ophthalmol	Design and test the effectiveness of haptic systems that can be installed on the batons of blind people in detecting obstacles and alerting users (visually impaired people)
Buchs et.al (2017)	Waist-up protection for blind individuals using the EyeCane as a primary and secondary mobility aid	Restorative Neurology and Neuroscience	Develop an aid that can help detect obstacles and dangers above the waist level of the visually impaired people and help the mobility of the visually impaired people
Khusro et. al (2022)	Haptic feedback to assist blind people in indoor environment using vibration patterns	Sensors	Identify the feedback of visually impaired people on instant feedback system specifically designed to receive information based on vibration patterns
Meliones & Sampson (2018)	Blind museum tourer: A system for self-guided tours in museums and blind indoor navigation	Technologies	Identify the location of the visually impaired people in the building, and the indication of the surface-mounted assist contact path combined with Bluetooth (BLE) and location pin function, to produce an accurate in-building positioning system
Mamafha et. al (2023)	Availability and use of assistive technologies at selected South African public libraries	African Journal of Disability	Study the use of assistive technology facilities in public libraries in the cities of Ekurhuleni and

			Johannesburg in South Africa
Liang et. al (2022)	Assessing people with visual impairments' access to information, awareness and satisfaction with high-tech assistive technology	British Journal of Visual Impairment	Study the effectiveness of assistive technology as well as the level of knowledge, awareness and level of user satisfaction among the visually impaired people
Sin et. al (2015)	Mobile text reader for people with low vision	Teknologi	Design and build mobile text reader software
Asebriy et. al (2018)	An assistive technology for braille users to support mathematical learning: a semantic retrieval system	Symmetry	Development of math skills for Braille users with new assistive technologies developed to obtain semantic mathematical information from the web
Elbehiery & Wahab (2014)	Smart touch phones blind assistant system	American Journal of Systems and Software	Making smartphones a tool used by vision disabled people that helps them move freely outside, move from one place to another and overcome barrier with RFID
Mohd Noor et.al (2019)	Touch-based system and development of braille writing system	Communications on Stochastic Analysis	Identifying the history of the existence of touch-based writing and the development of Braille
Hickson et.al (2023)	Accessing and delivering online education in the time of COVID-19: Challenges for visually impaired people in Malaysia	eJOMS - Journal of Media and Society	Investigate the challenges and obstacles faced by people with visual impairment during the COVID-19 pandemic in Malaysia
Santos et.al (2021)	Are electronic white canes better than traditional canes? A comparative study with blind and blindfolded participants	Universal Access in the Information Society	Study the effectiveness of the use of white canes (electronic sticks) compared to white sticks
Wei & Alias (2023)	Cabaran menggunakan alat bantu teknologi dalam pengajaran dan pembelajaran murid pendidikan khas penglihatan	Malaysian Journal of Social Sciences and Humanities (MJSSH)	Identifying the challenges faced by teachers and visually impaired students in using technological aids in teaching and learning
Abdul Majid et.al (2022)	Isu serta cabaran pengajaran dan pembelajaran murid berpenglihatan terhad dalam kalangan guru di sekolah rendah	Malaysian Journal of Social Sciences and Humanities (MJSSH)	Identifying the constraints and challenges faced by visually impaired students in mastering and learning Braille literacy in primary school settings

Al- Jarf (2021)	Blind Saudi female college students and assistive technologies: A case study	International Journal of Research in Engineering, IT and Social Sciences	Study the use of assistive technology and the challenges faced by a blind student at a Saudi university

Findings

Based on the analyses of 20 articles, the findings of the study can be divided into 3 main themes, mobility, accessibility and challenges. The findings based on themes are discussed to ease readers understanding.

Mobility

Electronic / Technology Walking Stick

From the selected 20 articles, 7 articles were studied the aspects of mobility among visually impaired individuals. Technology has been used to help visually impaired individuals for them to live their daily life with minimal assistant from others. Out of these 7 articles, a total of 4 articles have stated that the use of walking sticks modified according to technology to improve the navigation process among visually impaired individuals. The use of Eye cane and Electronic Cane improves barrier detection and navigation abilities among visually impaired individuals (Buchs et al., 2017; Texeira et al., 2023). Similar results were recorded in studies conducted by (Mehta et al., 2017; Velazques et al., 2018). In these four studies, the white stick has been combined with technological aspects so that barrier detection and navigation of visually impaired individuals can be improved. Eye Cane and Electronic Cane use haptic signalling technology so that obstacles in the environment can be identified, signals in the form of vibrations are received by the white stick so that the user can dodge obstacles and subsequently subdue or step around the identified obstacles (Buchs et al., 2017). Ultrasonic was used to build devices used in conjunction with white walking sticks whereby GPS technology was used in the construction of the GPS External Navigation System and *Tactile Foot* (Velazques et al., 2018). The use of new technologies to improve mobility among people with visual impairment requires practical training for visually impaired individuals. Visually impaired individuals have trouble using new technologies (Buchs et al., 2017). This statement is also supported by Velazques and colleagues in a study conducted in 2018.

Gloves

Smart Glove is a technology developed to help the mobility of people with visual impairment. Compared to the four articles discussed earlier, Smart Glove is a glove technology developed to help the people with visual impairment (Rozali et al., 2021). It is used in addition to white walking sticks to improve barrier detection and navigation of visually impaired individuals in new environments. It uses ultrasonic technology, buzzer, and audio technology. However, Smart Glove was not tested on visually impaired individuals in this study and the effectiveness of Smart Glove towards the mobility of visually impaired individuals was not discussed in the study conducted by Rozali and colleagues in 2021.

Tactile map

A touch map that uses the sense of touch and the Braille system to facilitate the mobility of visually impaired individuals is also discussed in one of the selected articles (Minhat et al., 2020). A touch map or tactile map can help visually impaired individuals in the navigation

process outside and inside a building. In the study conducted by Minhat et al (2020), researchers designed a talking touch map translated from Braille. The TacTalk touch map uses the Braille system (symbol) and audio files to facilitate the movement of visually impaired individuals in the navigation process (Minhat et al., 2020).

Accessibility

According to the *Kamus Dewan* (4th Edition), accessibility is defined as a process or means of accessing, obtaining and using a data or information. Assistive technology accessible to visually impaired individuals using a variety of appropriate mediums and approaches. Visually impaired individuals need assistive technology to access information and facilities to improve their lifestyle. Based on the 20 articles obtained, 8 articles are classified into accessibility themes that are broken down into smartphone usage accessibility, user satisfaction and education.

Smartphone usage

The rapid development of technology in developed countries involves the development of advanced and modern technologies. The use of electronic devices is considered necessary and important in the daily life of every individual. Based on the article analysis, there are 3 articles related to the use of smartphones as an assistive technology for visually impaired individuals in everyday life. The Elbehiery and Abdel-Wahab (2014) study stated individuals with vision impairment move freely from one place to another without hindrance by using smartphones that were improved with current technology. The use of GPS or accurate location indicators allows visually impaired individuals to move freely without major assistance thus becoming more independent. However, the visually impaired individuals are unable to access smartphones to the maximum due to vision constraints and the physical form of the latest smartphones that do not have a blind-friendly keyboard (Elbehiery & Abdel-Wahab, 2014). Elbehiery and Abdel-Wahab (2014) stated that technology is used to change traffic lights via radio-frequency identification (RFID) technology. RFID readers will read the RFID tags pasted on the smartphone to detect the presence of visually impaired individuals who try to cross the road.

The use of GPS on smartphones and other electronic devices focuses only on locations outside the building. The GPS system is built to point the direction outside the building and cannot be used inside the building. Therefore, visually impaired individuals are more likely to experience difficulties indoors compare to outdoors. Meliones and Sampson (2016) have introduced a pedestrian navigation app with a smartphone, BlindHelper and a self-guided tour navigation system at the museum, BlindMuseumTourer that provides an independent experience of accessing facilities and activities in the museum. The implementation of this system requires a stable internet network to enable BlindMuseumTourer to be widely used in buildings. In addition, the Meliones and Sampson (2016) study also combined tactile pathway elements with bluetooth that work to help visually impaired individuals move more safely indoors. An automotive technology using smartphones developed by Meliones and Sampson (2016) provides many benefits to the accessibility of visually impaired individuals. In addition, this study can also be adapted in other buildings such as hospitals, schools and others.

Accessibility using a smartphone with noise elements becomes one of the key elements in assisting visually impaired individuals while using smartphones. Limitations in vision make

other senses more sensitive and function properly. However, crowded and noisy environment prevent the users from listening and interpreting the messages or information. Here, listening devices such as headphones come to rescue. Thus, Khusro et al. (2022) have introduced vibration patterns on the phone to help visually impaired individuals in crowded noisy environment. Studies were conducted on several visually impaired individuals in public places. The vibration patterns are capable on providing navigation information, nearby barriers and patent-shaped morse codes to form words. Feedback from respondents stated that they were able to identify and memorize approximately 10 vibration patterns. Extra time and practise is needed to memorize all the resulting vibration patterns. Khusro et al. (2022) also stated that senior aged respondents who rarely use smartphones argued that vibration pattern application should be accompanied by voice recordings as they are still struggling to use the new technologies.

User satisfaction

2 articles focus the feedback of visually impaired individuals using the intelligence technology provided. Study by Liang et al (2022) were conducted to identify sources of knowledge, awareness of assistive technologies and satisfaction of using assistive technologies by visually impaired individuals. Studies were conducted on visually impaired individuals in the age range of 21 to 68 years. Users of this assistive technology provide diverse feedback on the use of certain auxiliary devices. Most users know about the latest artificial technology information from mass media and the internet. However, according to Liang et al (2022) visually impaired individuals stated they rarely obtain information regarding assistive technology through medical practitioners. The lack of information about certain assistive technologies makes their use unflattering. A new assistive technology needs to get more effective coverage and dissemination of information to be adopted by visually impaired users.

The study of Mamafha et al (2023) discusses the readiness of public libraries in the cities of Ekurhuleni and Johannesburg in South Africa in providing assistive technology services to visually impaired individuals. The study participants were visually impaired individuals and librarians from libraries in both cities involved. The findings from the Mamafha et al (2023) study stated that computer facilities are insufficient to meet the needs of internet services, audio recording, screen magnifying software and reading used by the visually impaired individuals and typical people. Individuals with visual impairment individuals face difficulty using existing artificial facilities due to lack of guidance on how to use these facilities. Libraries in both cities are also accessed and used by visually impaired individuals who are 40 years of age or older and not working. Individuals with visual impairment from the under-40s rarely use assistive facilities in libraries because they are more exposed to modern and up-to-date assistive technologies. Strategies to reduce the difficulties encountered while using assistive technologies were discussed (Mamafha et al., 2023). This study illustrates the importance of assistive technology as a medium of dissemination of important information and knowledge.

Education

There are 3 articles related to accessibility in education. Noor et al (2017) study was conducted to identify the history of the existence of touch-based writing and the development of Braille in Malaysia. Through writing and representation of symbols representing letters or numbers, visually impaired individuals can spread ideas and share

knowledge more widely. Mastering Braille reading skills can help the visually impaired to deepen their knowledge and receive learning opportunities as their typical friends. Mohd Noor et al (2017) study stated that the findings of learning to read touch-based writing were pioneered by the Muslim community due to the high desire to learn in the old days. Nevertheless, the discovery of touch-based writing learning is more commercial and spread by western academics (Noor et al., 2017). Reading touch-based writing is the earliest automotive technology that exists in history. The method of reading using Braille was successfully invented and helped many individuals with vision problems around the world.

The use of the Braille code in education is widely used in all subjects. Textbooks were printed with braille writing to help students gain access to formal education. Asebriy et al (2018) conducted a study focused on the development of mathematical skills for Braille users with new assistive technologies. The study converted mathematical formulas in the form of braille into MathML code systems using a computer. Mathematical formulas translated in the form of MathML code can be widely used to help students with visual impairment to answer math questions more systematically and quickly. The difference in mathematical braille by area also creates difficulties for visually impaired individuals to study mathematics more universally (Asebriy et al., 2018). The exchange of documents to the form of braille is also widely used. Thus, Asebriy et al (2018) highlighted a system that is universal for all mathematical braille users around the world using computer systems. Accessibility in mathematics is able to encourage the interest of the blind in science and mathematics as well as create new assistive technologies in line with current developments.

Teng et al (2015) conducted a study involving mobile software with smartphones that allows visually impaired individuals to access text information. By using a mobile phone, users with vision impairment can identify things by stitching image techniques or grafting pictures. The user only needs to take pictures, which will be analysed and translated in the form of words or sentences. This can help visually impaired individuals to read text from books, newspapers and other reading mediums with optical character recognition techniques or optical character recognition from text pictures to multilingual translations to users (Teng et al., 2015). The process of receiving knowledge will be easier with the use of this application. In addition, if the text used is not from a known language, the system can still translate the language in English but still retain the dialect sound of the original language (Teng et al., 2015).

Challenges

Various challenges and obstacles have been faced in the construction and use of assistive technology for the visually impaired. The challenges and obstacles encountered can be divided into sub-topics; financial, knowledge, training and attitude.

Financial

The design and construction process of new technologies for visually impaired individuals takes time and high funding costs. One of the challenges faced by visually impaired individuals is the purchase of assistive technology involving high costs (Wei and Alias, 2023; Hickson et al., 2023). This statement is supported by studies conducted by Al- Jarf (2021). Vision-impaired students studying at the University of Saudi faced the challenge of purchasing *Braille Sense Note-Taker* aid technology because of the high cost. In addition, technological aids also

involve high costs if they were to be repaired or maintained (Al- Jarf, 2021). In the study conducted by Santos and colleagues (2021), the cost of an electronic walking stick doubled when compared to a white stick. The high cost of owning assistive technology is an obstacle in the overall use of assistive technology. In schools, the allocation of the Ministry of Education (MOE) for the technology of assistance are insufficient for students with vision problems (Wei & Alias, 2023).

Knowledge

The knowledge of instructors and users of assistive technology is an important aspect of the effectiveness of a technological application. At the school level, teachers have trouble teaching visually impaired pupils using assistive technology due to lack of knowledge and skills (Wei & Alias, 2023). Individuals with visual impairment face problems in using assistive technology because they are not adequately guided. In the study conducted by Santos and colleagues (2021), study respondents needed time and attention as well as tutoring in using electronic walking sticks as the new technology affected their walking speed and also to learn how to interpret the signals received. During the COVID-19 pandemic, vision-impaired students had trouble taking online classes because they had no knowledge in using assistive technology software (Hickson et al., 2023). Visually impaired students face problem in using Braille due to lack of knowledge of how to use as they receive their training (Abdul et., 2022). At the university level, lecturer teaching students with visual impairment cannot help nor understand the needs of students because they do not have the knowledge and skills in assistive technology for the people of visual impairment (Al- Jarf, 2021).

Training

In most schools, teachers are unable to use assistive technology for visually impaired pupils because they do not receive courses and training on assistive technology and how it is used (Wei & Alias, 2023). The integration of technology in teaching is interrupted because teachers are not given courses. This statement is supported by a study conducted by (Hickson and colleagues, 2023). According to them, assistive technologies for visually impaired individuals are often not used in classes because teachers do not know how to use them. (Hickson et al., 2023). Vision impaired students are unable to take online classes because they are not given adequate training on the use of technology. In a case study conducted by Al- Jarf (2021), the respondent faced challenges while sitting for test because the lecturer did not have the knowledge in preparing the question paper in the form of *Braille*. This suggests that lecturers were not given training on how to use *Braille.*

Behaviours/ Attitude

The attitudes and behaviours of the visually impaired individuals are also one of the obstacles in the development of technology. Visually impaired students show no interest in learning new technology adoption techniques (Wei & Alias, 2023). This is because they think that the use of mobility aids causes them to rely heavily on assistive technology in their daily lives. In addition, negative views from those around them and classmates also led to a decline in the use of assistive technology among visually impaired individuals. (Wei & Alias, 2023). The commitment of vision-impaired students deteriorated because they were not given support in the use of aids. At the higher institutional level, the awareness of lecturers towards the needs of visually impaired individuals in the classroom is bad as instructors do not wait for visually impaired students to listen and interpret the content of lectures (Al- Jarf, 2021).

Discussion

The assistive technologies studied this SLR show that technologies for visually impaired individuals are heavily geared towards mobility and accessibility of the provided facilities. The development of assistive mobility technology is aimed on reducing the rate of accidents that occur among visually impaired individuals. It is reported that 88% of visually impaired individuals regularly experience accidents during their lifetime due to white walking sticks defaults and guide dogs failing to warn and signal to visually impaired individuals (Manduchi & Kurniawan, 2011). Thus, mobility technologies designed and developed for the mobility of visually impaired individuals help them in detecting and avoiding obstacles (Buchs et al., 2017; Texeira et al., 2023). The use of Smart Glove and TicTalk (touch map) can also help the movement of visually impaired individuals (Rozali et al., 2021; Minhat et al., 2020). Development of assistive technology for visually impaired individuals occurs to improve their mobility while avoiding accident rates.

Among the seven studies on mobility selected in this SLR, only 3 studies were tested to identify their effectiveness ((Buchs et al., 2017; Minhat et al., 2020; Velazques et al., 2018). The study conducted by Velazques and colleagues (2018) was tested among non-blind respondents. Such situations may cause readers to question the validity of the findings. However, designed and developed technologies can guarantee the mobility and accessibility of visually impaired individuals. Training and tutoring should be provided for visually impaired individuals to increase and enhance the usage of new technologies developed (Buchs et al., 2017). Without proper training, the developed assistive technologies will not reach the target.

Studies related to mobility did not consider the mobility of vision-impaired students at school. All studies related to mobility focused on respondents who were not school students. The respondents of the studies consisted of adults and university students. Therefore, the use, acceptance, and effectiveness of mobility assistive technology among pupils cannot be identified in this SLR. However, research on mobility among visually impaired students is one of the key elements in line with the Persons with Disabilities Act 2008.

Based on the findings of the study, accessibility of assistive technology includes smartphone use, user satisfaction of assistive technology and accessibility in education. The use of technological devices such as mobile phones and computers plays an important role in the accessibility of visually impaired individuals to obtain information and be independent in public places. Software or applications have been developed by local and foreign researchers to ensure that the accessibility of the visually impaired to improve their standard of living and facilitate their daily lives. Meliones and Sampson (2016) has launched the Blind Museum Tourer system at the museum can also be adapted in the use of other indoor navigation such as hospitals, shopping malls, airports and others. The development of this navigation system has a positive impact in ensuring that the accessibility of the visually impaired is widened without having to rely on specific assistance. Adaptation of the use of smartphone technology became a favourite due to the shape and size that is convenient to carry around.

New automotive technologies need to be refined and tested to get feedback from respondents from all age groups. The rapid pace of technology makes some visually impaired individuals still lag and unable to access assistive technology. The development of assistive technologies that help various parties is highly recommended. However, users feedback needs to be considered to ensure that the built-in assistive technology tools can be used. Visually impaired users in the libraries of both cities studied agreed that the assistive technology provided is very helpful in the process of information search, finding jobs and learning (Mamafha et al., 2023). However, there were also users who were not satisfied with

the assistance available due to lack of guidance and knowledge on using the aid. Based on the findings of the study, related parties such as librarians and media staff involved need to be more vigilant and take proactive measures to help all users with special needs get better and more user-friendly access to assistive technology.

Accessibility in education using assistive technology is one of the important aspects in providing equal opportunities for visually impaired students. Education in Malaysia needs to move forward aligned with the technological development. The use of advanced smartphones and gadgets in schools should be paid attention to. Smartphones can be used to translate written documents into voice forms that can be used by visually impaired students (Teng et al., 2015). The use of computers to translate mathematical formulas into Braille forms of writing is also important technology in helping visually impaired students expand knowledge in the field of science and mathematics (Asebriy et al., 2018). The Ministry of Education (MOE) should consider the use of gadgets in schools especially for SEN classes in schools that need to be exposed early to be ready to use practical technology better and more efficiently.

In the process of producing new technologies for visually impaired individuals various challenges have to be faced and overcome. High cost for purchases Wei & Alias (2023); Hickson et al (2023) maintenance Al- Jarf (2021) of assistive technologies has given impact on the use of assistive technology among visually impaired individuals. The allocation from MOE and private bodies is crucial in providing assistive technologies in schools and universities. Assistive technologies such as *Braille*, electronic sticks and text readers can help visually impaired students to access educational facilities just like the typical pupils.

At school and university, the usage of assistive technologies is affected badly due to the low level of knowledge among the teaching staff (Wei & Alias, 2023; Al- Jarf, 2021). Teachers and lecturers should be given training and courses on assistive technology so that visually impaired students can receive appropriate guidance. Knowledge on *Braille* can help teachers to teach visually impaired students in inclusive classes. Knowledge of this assistive technology can help teachers create an environment that is sensitive to the needs of visually impaired students in a class. Emotional and mental health of visually impaired individuals is also one of the challenges in the use of assistive technology. As stated in the findings section of the study, visually impaired individuals do not like to use assistive equipment for mobility and accessibility purposes (Wei & Alias, 2023). This situation led to low use of aids among visually impaired individuals. Their mental health needs to be given attention by health professionals so that they are passionate on using assistive technology in their daily lives.

Limitations of The Study

In this SLR, the selected articles are in the range of 10 years only 2013 to 2023. Only articles that revolve around assistive technology were used in this study. Realistic technologies used before this period have been ignored regardless of their effectiveness among visually impaired users. However, the researchers managed to find important points and information based on the reading of the articles within a predetermined time frame. In addition, the findings of this SLR are more focused on the field of science of technology compared to social science. The findings of the articles are more on technology and engineering science journals that use complex scientific and technological terms compare to more understandable social science terms that are frequently used in the world of education. The technology used in the design and construction of assistive technology devices for visually impaired individuals is a new element to the reader. However, it is hoped that the review of the resulting systematic literature can be well communicated based on accurate understanding and information by

the researchers. The studies found were less about on visually impaired students in Malaysia. The articles found touched more on the technical side and the production of assistive technological innovations as well as user feedback in general. The analysed articles showed a lack of research and studies related to assistive technology in schools. Related studies should be carried out to identify technology-based learning methods to be used in schools in Malaysia in particular.

Conclusion

This SLR which is based on 20 selected articles can provide a real picture of the construction, usage and challenges in assistive technology for the visually impaired individuals. Overall, the assistive technologies designed and developed for visually impaired individuals can be best used to assist them in various aspects such as mobility and accessibility in their daily lives. Convenience of assistive technology can help improve the standard of living of visually impaired individuals of all ages. Therefore, the use and empowerment of assistive technology among visually impaired individuals should be given attention so that the government's intention in creating a 'Disabled People Friendly Environment' and 'Education For All' policy can be achieved with excellence.

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