Educational Administration: Theory and Practice
2024,30(5), 797-809
ISSN:2148-2403
https://kuey.net/

Research Article

Breaking Barriers: A Multi-Sensory Journey for Visually Impaired Children

Yang Han[1], Norfarizah Mohd Bakhir[2*]

[1,2*]School of the Arts, Universiti Sains Malaysia, Penang, Malaysia
[1]School of the Arts and Design, Sanming University, Sanming, China

***Corresponding Author:** Norfarizah Mohd Bakhir
School of the Arts, Universiti Sains Malaysia, Penang, Malaysia

***Citation**: Yang Han, Norfarizah Mohd Bakhir (2024), Breaking Barriers: A Multi-Sensory Journey for Visually Impaired Children, *Educational Administration: Theory and Practice*, *30*(5), 797-809
Doi: 10.53555/kuey.v30i5.2952

ARTICLE INFO

ABSTRACT

This study investigates the impact of assistive technological tools on learning outcomes and user experience among visually impaired children in Hangzhou, Zhejiang, China, focusing on the mediating role of perceived satisfaction. The research explores the dynamics between different sensory organs' functions with assistive technological tools and their subsequent effects on visually impaired children's learning and experience. A quantitative research approach was employed, using a survey distributed to 98 visually impaired children from a special daycare and learning center, and data analysis was conducted through partial least squares structural equation modeling (PLS-SEM). The findings reveal that assistive technological tools significantly influence learning outcomes and user experience, highlighting the critical role of active participation and engagement in the assistive learning environment. In addition, perceived satisfaction mediated the relationship between assistive technological tools and user experience but not between assistive technological tools and learning outcomes. This study contributes to understanding how technological advancement can be optimized to enhance disability experiences and outcomes, providing valuable insights for educators, policymakers, and stakeholders around disabilities. The research highlights the importance of fostering engaging learning environments that support learning, personal growth, and exploring new knowledge and information for individuals with disabilities.

Keywords: Visually Impaired Children, Assistive Technological Tools, Learning Outcomes, User Experience, and Perceived Satisfaction.

INTRODUCTION

Visual impairment can occur due to several factors, such as age, genetics, childhood blindness, and virus infections (World Health Organization, 2023). Visually impaired individuals commonly face many challenges in daily activities, such as learning, reading, visiting, and interacting with others (World Health Organization, 2023). The World Health Organization (WHO) reported that at least 2.2 billion people are visually impaired or blind globally (World Health Organization, 2022). The visually impaired or the blind community is constantly side-lined by ordinary individuals or societies in many ways (Atan et al., 2023). The visually impaired or blind individuals usually require social and community support to ensure academic and social success (Chu & Chan, 2022). According to a study conducted at a high school for blind students, 22 out of 40 blind students were found suffering from depression and experiencing difficulties in their daily activities (Ishtiaq et al., 2016), including discussion with other students, learning, walking to class and restroom, interacting with teachers, and extracurricular activities (Ishtiaq et al., 2016). The participants of the study ranged between 10 and 22 years old.

Therefore, prioritizing providing learning opportunities, social support, and friendly environments for visually impaired individuals is crucial (Chu & Chan, 2024). Visually impaired individuals are curious and eager to learn about new incidents and knowledge (Betlej et al., 2023). Due to the inability to use visuals, visually impaired individuals face many difficulties and challenges in learning and reading (Tamma et al., 2021). Visually impaired individuals can travel and visit like ordinary individuals (Šintáková & Lasisi, 2021). However, they cannot feel or visualize the real world or environment (Šintáková & Lasisi, 2021). Even though there are tools for learning for blind or visually impaired individuals, the number of tools is still limited in e-learning activities (Chit et al., 2024). It is even less for travel or visiting tourist locations; visually impaired individuals need help to feel or see the actual environments (Obigbesan et al., 2023). Physiological characteristics in disability studies can be categorized into 1) Defect and 2) Compensatory (Dhakal & Bobrin, 2023). In terms of defects, individuals with specific disabilities cannot behave like normal individuals due to their incapability to function; thus, their physiological development cannot grow like normal individuals (Dhakal & Bobrin, 2023). In terms of compensatory, the incapability organ is compensated accordingly with other functional organs (Dhakal & Bobrin, 2023).

Visually impaired individuals have sight defects, but their other functional organs can perform better than normal individuals (World Health Organization, 2023). According to a previous study, 80% of information individuals receive is through their vision function, proving that vision is the primary sense of learning (Elewah et al., 2021). However, because the individual is visually impaired, he or she must depend on other available senses for learning, such as hearing and touching (Chit et al., 2024). Hearing can receive information, hear it, and process it to store it in the brain (Chit et al., 2024). The touching function can also provide helpful information that helps the visually impaired individual to feel the environment and learn by sensing textures and various shapes of objects (Mai et al., 2023). Touch increases the confidence and safe feeling of the visually impaired individual. The hearing and touching senses can facilitate and improve visually impaired individuals' learning by providing a more engaging and friendly learning environment and increasing the feeling of safety (Cho, 2021). In the modern technological world, technological and non-technological related tools and equipment exist to help the visually impaired individual learn and carry out daily activities (Kuriakose et al., 2022).

Previous studies show that visually impaired individuals use other senses, such as smell, to differentiate the types of fruits and textures. In addition, the sense of smell in the human sensory system can enhance human memory and facilitate learning in visually impaired individuals (Olofsson et al., 2021). Due to its significant impact on their learning performance, the usage of technological devices in an e-learning environment has been further enhanced (El- Sabagh, 2021). For example, visually impaired individuals use hearing to learn about daily news and improve their knowledge by wearing Air Pods or headphones. Besides, there is a blind-touching keyboard for tablets and smartphones for visually impaired individuals. This study aimed to investigate the multi-sensory journey of visually impaired children in China using technological advancement devices that affect visually impaired children's perceptions and experiences in learning. The primary sensory organs examined in this study are the sighting, hearing, and touching functions of the visually impaired children in learning and experiencing different knowledge and exploring environments.

LITERATURE REVIEW

The increase in visually impaired children has been related to the rise in the number of eye clinics, a decrease in the number of birth and pre-term births, and an increase in the number of children with multiple disabilities (Senjam & Chandra, 2020). Different definitions of vision impairment have been based on the eye's vision, and they are considered both corrected visual acuity and any restriction of the visual field (Kv & Vijayalakshimi, 2020). The most common vision impairment is based on the United Kingdom recommendations for certification: severely vision impaired or sight impaired. The recommendation for certification is summarised in Table 1:

Table 1: Criteria for United Kingdom recommendations for certification (adopted from Lingard (2021))

Severely vision impaired (Blind)	Sight impaired (Partially Sighted)
- Visual acuity < 3/60 with full visual field. - Visual acuity between 3/60 – 6/60, with severe visual field restriction. - Visual acuity of 6/60 or above with a very contracted visual field, especially in the lower region of the field.	- Visual acuity of 3/60 – 6/60 with full visual field. - Visual acuity 6/24 with moderate restriction of field or cloudy central vision. - Visual acuity 6/18 or better but with gross visual field abnormalities.

Vision Measurement and Scale

Vision impairment is defined by integrating visual acuity and field measures (World Health Organization, 2023). Visual acuity refers to the eye's ability to distinguish detailed vision (Marsden et al., 2014). Visual acuity is commonly used in clinical measures, which examine the individual's ability to recognize black colour and high-contrast letters, numbers, or symbols (a common standardized eye's ability test) on a white background (Daiber & Gnugnoli, 2024). Visual field measures are the method of examining all areas of the eye that can be seen when the eye is focused on a central point on the board (Josserand et al., 2022). The visual field is usually used to examine blind spots by detecting them in vision measurements. Table 1 summarizes the criteria for United Kingdom recommendations for certification in visual impairment measures.

The measurement is based on the Snellen chart, and the most minor line read is expressed as a fraction (for example, 6/18, 3/60, etc.) (Marsden et al., 2014). The vision clinical specialist will ask the patient to read from the Snellen chart. The measurement is as follows: the upper number is the distance from the individual to the chart, while the lower number is the distance the ordinary eye can see and read the little line on the chart (Azzam & Ronquillo, 2024). All measurements are in meters (measurement units). The vision clinical specialist will ask the individual to move closer to the chart when the individual cannot read the first line on the chart, which contains the most significant letter starting at 6 meters. The individual will be asked to move a meter closer to the chart when the individual is unable to see and read the letter at the point distance (Azzam & Ronquillo, 2024). For example, the visual acuity of 3/60 means that the individual is able to see and read at 3 meters, which represents the ordinary eye vision that is able to see and read at a distance of 60 meters.

The system used for the 6/6 notation of normal vision is based on the metric system (international standard). However, it is different from the measurement units used in the United States of America (USA). The USA used the measurement units of feet; thus, the test is based on the equivalent imperial distance of 20 feet, which is why the standard vision notation in the USA is written as 20/20 (Azzam & Ronquillo, 2024). A group of researchers developed a new type of measurement of vision impairment in 1976 (Azzam & Ronquillo, 2024; Caltrider et al., 2024). The National Vision Research Institute of Australia developed this new measurement. The latest measurement of vision impairment is the logMAR scale (logarithm of Minimum Angle of Resolution) (Sailoganatha et al., 2018). The logMAR scale is a new and more accurate scale to measure visual acuity than the Snellen Chart (Caltrider et al., 2024).

The logMAR scale uses a different optotype chart than the Snellen chart (Azzam & Ronquillo, 2024). The logMAR scale does not require a standard distance of 6 meters or 20 feet to operate (Azzam & Ronquillo, 2024). The logMAR scale is the most practical vision measurement scale in clinical examination rooms as it does not require ample space or long distances (Azzam & Ronquillo, 2024). The logMAR scale uses measurement units different from those in the Snellen chart (Caltrider et al., 2024). When using the logMAR scale to examine an individual, poorer vision is recorded as higher numbers (Noushad et al., 2012). For example, the scale in Snellen is 6/60, while it will be 1.00 on the logMAR scale, and the scale in Snellen is 6/6, while it will be 0.00 on the logMAR scale.

Visually Impaired Children

Childhood vision impairment can significantly impact children's psychological development and learning experiences (Loh et al., 2024). Visually impaired children can be affected from various dimensions, such as their social, emotional, and physical development (Elsman et al., 2021). These impacts directly affect their quality of life and the relationship between those visually impaired children and their family members (Bonsaksen et al., 2023). Previous studies divided visually impaired children into two categories, which are isolated visually impaired children and visually impaired children with additional impairments (Sharififard et al., 2022).

Previous studies reported that pre- and peri-natal insults were the largest group of causes (61.1%), with genetic causes the highest percentage of these (33%) (Lingard, 2021). Non-hereditary prenatal insults included hypoxia (2%), infection (2%) (such as cytomegalovirus, rubella, varicella), maternal drug use/substance abuse (1%), intrauterine growth retardation (0.5%) and hydrocephalus (0.25%) (Lingard, 2021). Peri-natal causes included tumors (4%), infection (3%) (such as Group B streptococcus, E. coli, tuberculosis), hydrocephalus (3%), hypoxia (3%) and injury (nonaccidental (2%), accidental (1%)) (Rahi & Cable, 2003; Lingard, 2021).

The primary sense for visually impaired children is hearing (Lingard, 2021). The hearing function works through tactile, motor, and auditory interaction (Lohse, 2022). Hearing allows visually impaired children to learn to understand the meaning of sound (Mlynski et al., 2021). Visually impaired children can receive information regarding sources or locations through sound transmitted into their ears (Mlynski et al., 2021). Even though visually impaired children can learn an object by reaching for it, the hearing function will not motivate them to learn more, like the visual function (Ghasemi Fard et al., 2023). Hence, a previous study concluded that visually impaired children's learning may be delayed to 14 months, while partial learning may be postponed to 3 months (Fast, 2018). It is much later for visually impaired children with additional disabilities (Fast, 2018). Visually impaired children with additional disabilities accounted for a significant proportion of the visually impaired children (Tham & Thao, 2021).

Previous studies reported that the ability to use hearing as the medium to learn is a real breakthrough in the development of visually impaired children and is the primary condition and main catalyst for their subsequent development (Getnet et al., 2021). The study also reported that visually impaired children can only learn how to walk independently after they have learned the balancing of walking guided by the hearing of sound (Getnet et al., 2021). The psychosocial impacts on parents can decrease the adverse effects on visually impaired children's development (Lupon et al., 2018). Previous studies found that parents are the primary motivation for developing visually impaired children's interest and mobility until the children can acquire sound/object concepts (Malik, 2023).

In the era of modern technology, visually impaired children are given similar opportunities as ordinary children to experience and enjoy the real world. Many technology giants, such as Microsoft, Google, Neurolink, and Apple, are making great efforts to develop tools and devices to help improve the quality of life of visually impaired children. Most technological devices and tools are designed based on hearing and touching functions, as visually impaired individuals widely use these two sensory organs to feel and sense the world and receive information. Of the two sensory organs, the hearing sense is the primary one.

Assistive Technological Tools for Visually Impaired Children

Previous studies show that visually impaired children have minimal opportunities to touch or use large letter-printed books, magnification devices, or tools in activities for ordinary children (Ghasemi Fard et al., 2023). Hence, many technological giants, such as Microsoft, Apple, Neurolink, and Amazon, have invested heavily in research and inventing new vision devices and tools for visually impaired individuals, especially children. Assistive technology integrates technological devices and services designed to help visually impaired individuals and people with other disabilities within desired environments, such as museums, universities, and learning centers (Manirajee et al., 2024; Messaoudi et al., 2022).

Assistive technology refers to any technological devices or tools used to maintain and improve the functional capabilities of individuals with disabilities (The Individuals with Disabilities Education Act, IDEA, 2024). This definition includes all kinds of disabilities and technological devices and tools. The functions of assistive technology are essential to visually impaired children and visually impaired children with other disabilities for accessing play, visiting, and learning to increase independence and to improve quality of life (Senjam et al., 2023). With assistive technology, visually impaired children can experience more success exploring the world. Assistive technology can increase the chance of visually impaired children communicating and interacting with others (Dyzel et al., 2020).

Visually impaired children are affected to access the curriculum and often require unique assistive technology to assist (Maurya & Maurya, 2018). The suitable adaptation of assistive technological tools and devices is essential to ensure that visually impaired children have full and equal access to every opportunity, such as learning, communicating, and exploring the world (Fernández-Batanero et al., 2022). Assistive technologies help visually impaired children access reading, writing, and daily activities and explore new things (Senjem et al., 2023). For visually impaired children with low functional vision, using low technological assistive technology, such as large-letter printed books, can be helpful and enable the visually impaired children to read to enhance knowledge and information (Senjam, 2019).

Computer screen enlargement software and a large monitor are high-level assistive technological tools for visually impaired individuals with low functional vision (Tang et al., 2023). Other vision-related assistive technological tools are also available. Over the years, many researchers and technological giants have developed other sensory organ assistive technological tools, such as tools that adopt hearing and touch functions (World Health Organization, 2024). The hearing function is not as powerful as the visionary sense, but it is the second most powerful organ (Hutmacher, 2019).

The hearing function enables visually impaired children to receive knowledge and information. Stereo or surround headphones or speakers can transfer information and knowledge to visually impaired children. Besides, in the modern, high-tech era, headphones or earphones can translate one language to another for the user. Many visually impaired learning institutions use this technology to help and facilitate the visually impaired individual's learning. In addition, the third most potent sensory organ is the touch sense of the individual. Previously, blind or visually impaired individuals needed to use a blind touch keyboard where the keyboard was fixed physically. However, with technological advancement, there is a touch keyboard that can form physical touch words instantly.

Hypotheses Development and Framework

Assistive technological tools are essential in enhancing learning and exploring new knowledge in visually impaired individuals, especially children. Studies have confirmed a direct correlation between the depth of assistive technological tools and improved learning outcomes, highlighting the significance of active participation. Further research points to the decline in learning motivation and its impact on outcomes, stressing the importance of interactive and engaging environments for individuals with disabilities, significantly the visually impaired, to sustain visually impaired individuals' interests and outcomes. Based on the above information, the following hypothesis is formed:

Hypothesis 1: Assistive Technological Tools have a significant influence on Learning Outcomes.

User experience plays a vital role in engaging with users, especially focusing on profoundly understanding them. User experience allows the researcher to understand what users need, what they feel is valuable and worthwhile, and their abilities and limitations. It influences feelings, thought processes, and actions toward task completion and is essential for learning outcomes. In visually impaired individuals' contexts, for instance, user experience has been linked to improved and enhanced visually impaired individuals' learning and exploring new knowledge and daily activities. Research indicates that assistive technological tools and devices can enhance the user experience by helping and improving individuals within the assistive environment (World Health Organization, 2024). This highlights the importance of using assistive technological tools to foster a better user experience. Based on the above information, the following hypothesis is formed:

Hypothesis 2: Assistive Technological Tools have a significant influence on User Experience.

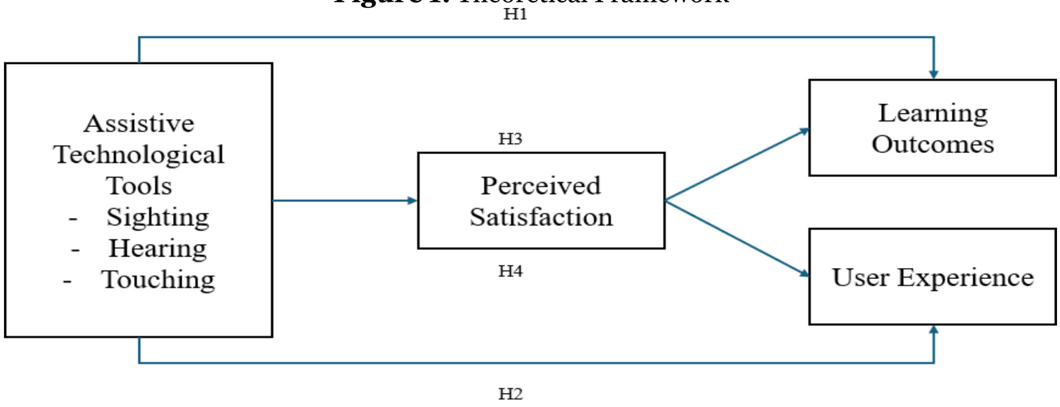
In social sciences and psychology, mediators play a crucial role in linking independent and dependent variables, helping to examine how external events gain psychological significance. Perceived satisfaction mediates the relationship between assistive technological tools and two critical outcomes: learning outcomes and user experience. This concept suggests that visually impaired individuals' satisfaction with learning experiences influences their engagement and motivation.

Satisfaction with assistive technological tools, including how they help them learn and explore new knowledge, affects learning outcomes (Svensson et al., 2021). Similarly, when visually impaired individuals find assistive technological tools satisfying, they reinforce their user experience, enhancing their confidence and motivation, which are crucial to their learning outcome and experience. Therefore, perceived satisfaction explains the impact of assistive technological tools on outcomes and experience and illustrates the complex dynamics of cognitive, emotional, and social factors in that environment. Based on the above information, the following hypotheses are formed:

Hypothesis 3: Perceived satisfaction significantly mediates assistive technological tools and learning outcomes.

Hypothesis 4: Perceived satisfaction significantly mediates assistive technological tools and user experience.

Figure 1: Theoretical Framework



METHODOLOGY

The study presents a framework (Figure 1) to explore learning outcomes and user experiences based on assistive technological tools. Assessing learning outcomes and user experiences using assistive technological tools is crucial to empirically testing this framework. A survey research approach aligns with previous methodologies to investigate learning outcomes and user experiences.

Study Design

The study is based on the user's perceived satisfaction with assistive technological tools for visually impaired children based on three sensory organs: sight, hearing, and touch. The study also tested the learning outcomes and user experiences using these three assistive technological tools based on three sensory organs. Items from previous studies are being adapted to measure different constructs in this study. Specifically, the measurement of assistive technological tools was adapted from Senjem et al. (2023), perceived satisfaction was adapted from Pozón-López et al. (2021), learning outcomes were adapted from Cicek et al. (2021), and user experience was adapted from Van Ommen et al. (2022).

For analysing the data, it is suggested that partial least squares structural equation modelling (PLS-SEM) be employed, as recommended by Hair and colleagues in 2021. This methodology is particularly effective for investigating complex models with causal relationships, making it highly appropriate for analysing the proposed

relationships among constructs in the theoretical framework. Following the guidance of Hair et al. (2021), the analysis should unfold in two phases. The first phase involves evaluating the measurement model's validity and reliability. The next phase focuses on analysing the structural model, where the research hypotheses are tested using bootstrapping techniques. This two-step analysis provides a solid basis for examining the conceptual model and validating the proposed research hypotheses.

Study Location

The best way to interact with visually impaired children is through supporting parties such as special daycares and learning centers for vision-impaired individuals. For this study, a unique daycare and learning center located in Hangzhou, Zhejiang, China, was contacted to get permission to conduct the research experiment with the members or children. Accordingly, with consent from the local authorities, the study was conducted at the special daycares and learning center. However, due to privacy concerns, the researchers are allowed to observe the experiment process undertaken by the center. The center provided data from the visually impaired children, the participants, who answered the survey at the end of the learning year.

Sample Size

According to Lazar et al. (2017), if the study includes visually impaired individuals and those visually impaired individuals are required to take part in the study, the optimum number of participants needed and within the acceptance range are between 5 and 10. Due to the inability to directly experiment with the participants in this study, the visually impaired children, the person in charge provided the survey data and questions for this study. The total number of participants available in the data provided was 98 visually impaired children.

Participants and Sampling Method

There are two main stakeholders in this study: visually impaired children and instructors involved in teaching and taking care of visually impaired children. The participants were identified and briefed on the background of the study to obtain their consent. Even though in the experiment, the researcher is not directly controlling the process but only observing the experiment process, the researcher still needs to explain to both stakeholders to obtain consent. The experiment is conducted in Hangzhou, Zhejiang, China, where the special daycare and learning center is located. The participant information sheets and consent forms were also prepared and submitted to the local authority and management of the special daycare and learning center for approval. The visually impaired children
also fill out the forms with the assistive technological tools from the data collector. As recommended by previous studies and researchers, it is severe and essential not to collect names or other sensitive data that can be used to identify the visually impaired individual to protect the participants' privacy and human rights. Thus, the names of participants were not collected during the experiment. The management of the special daycare and learning center provided the list of data without names and some sensitive information regarding the participants.

DATA ANALYSIS

Measurement Model

Internal consistency reliability was assessed using Cronbach's alpha and composite reliability scores. The results demonstrated that the model possesses adequate internal consistency, as both Cronbach's alpha and composite reliability values were above 0.7, indicating a reliable model (Henseler et al., 2015). In addition, the reliability of individual indicators was verified, with outer loadings surpassing 0.6 (Chin, 1998), and convergent validity was established with average variance extracted (AVE) values exceeding 0.5 (Fornell & Larcker, 1981), as detailed in Tables 1.

The Heterotrait Monotrait (HTMT) ratio of correlations was employed to assess discriminant validity. The analysis (Table 3) showed that all constructs stayed below the HTMT 0.85 threshold, confirming that discriminant validity was maintained (Henseler et al., 2015). These results, which meet the established criteria, are presented in Table 2.

Table 1: Results Summary for Multi-dimensional Constructs

Multi-dimensional Constructs									
Constructs	**Items**	**Indicator Reliability**	**Internal Consistency Reliability**		**Convergent Validity**	**Constructs**	**Internal Consistency Reliability**		**Convergent Validity**
First-Order		Outer Loadings	CA	CR	AVE	Second-Order	CA	CR	AVE
		>0.60	>0.7	>0.7	>0.5		>0.7	>0.7	>0.5

Sighting Sense (SS)	SS1 SS2 SS3 SS4	0.856 0.712 0.811 0.825	0.789	0.782	0.762				
Hearing Sense (HS)	HS1	0.853	0.771	0.882	0.813	Assistive Technological Tools (ATT)	0.872	0.898	0.602
	HS2	0.776							
	HS3	0.812							
	HS4	0.862							
	HS5	0.852							
	HS6	0.823							
Touching Sense (TS)	TS1	0.766	0.866	0.899	0.773				
	TS2	0.763							
	TS3	0.745							
	TS4	0.801							
	TS5	0.812							
	TS6	0.833							

Table 2: Results Summary for Uni-dimensional Constructs

Uni-dimensional Constructs					
Constructs	**Items**	**Indicator Reliability**	**Internal Consistency Reliability**		**Convergent Validity**
		Outer Loadings	**CA**	**CR**	**AVE**
		>0.60	>0.7	>0.7	>0.5
Perceived Satisfaction (PS)	PS1	0.782	0.896	0.945	0.715
	PS2	0.856			
	PS3	0.883			
	PS4	0.881			
	PS5	0.831			
	PS6	0.723			
	PS7	0.732			
Learning Outcomes (LO)	LO1	0.752	0.905	0.821	0.719
	LO2	0.862			
	LO3	0.843			
	LO4	0.872			
	LO5	0.851			
	LO6	0.901			
User Experience (UE)	SE1	0.773	0.903	0.857	0.692
	SE2	0.812			
	SE3	0.892			
	SE5	0.824			
	SE6	0.882			
	SE7	0.872			
	SE9	0.798			

Table 3: Discriminant Validity: Heterotrait Monotrait (HTMT) Criterion

	SS	**HS**	**TS**	**LO**	**PS**	**UE**
SS						
HS	0.524					
TS	0.802	0.561				
LO	0.756	0.298	0.678			
PS	0.421	0.253	0.545	0.523		
UE	0.332	0.256	0.247	0.462	0.282	

Structural Model

In line with the methodology proposed by Hair et al. (2021), the investigation of path relationships utilized 1,000 bootstrap samples, applying a one-tailed test with a significance threshold of 0.01. The results from the PLS-bootstrapping analysis are recorded in Tables 4 and Table 5.

Tables 4 and 5 present statistical findings from a study examining the direct effects and mediation effects within the context of assistive technological tools. Table 4 reports on direct effect hypotheses, showing path

relationships with their respective path coefficients (Beta), standard deviations, T statistics, P values, and confidence intervals. The path from Assistive Technological Tools (ATT) to Learning Outcomes (LO) and from Assistive Technological
Tools (ATT) to User Experience (UE) is both significant, with path coefficients of 0.652 and 0.472, respectively, and p-values at 0.000, indicating strong statistical significance.

Table 5 summarizes the mediation test effects, presenting the path coefficients for the relationships where Perceived Satisfaction (PS) acts as a mediator between ATT and LO (H3) and between ATT and UE (H4). The path coefficient for ATT -> PS -> LO is 0.026 with a p- value of 0.138, which leads to the rejection of the hypothesis, suggesting that PS does not significantly mediate the relationship between ATT and LO. Conversely, the path coefficient for ATT -> PS -> UE is 0.032 with a p-value of 0.007, leading to the acceptance of the hypothesis, indicating a significant mediating effect of PS on the relationship between ATT and UE.

Table 4: Direct Effect Hypotheses

Hypothesis					**Bootstrapped CI BC**		
Variable Relationship	**Path Coefficient Beta (β)**	**Standard Deviation (SD)**	**T Statistics (|O/STDEV|)**	***P* Values**	**5% LL**	**95% UL**	**Decision**
ATT->LO (H1)	0.652	0.026	16.472	0.000	0.647	0.694	Accept
ATT->UE (H2)	0.472	0.029	8.552	0.000	0.162	0.452	Accept

Notes: Significant at p<0.05**, ATT->Assistive Technological Tools, LO->Learning Outcomes, UE->User Experience

Table 5: Summary of Mediation Test Effects

Hypothesis					**Bootstrapped CI BC**		
Variable Relationship	**Path Coefficient Beta (*β*)**	**Standard Deviation (SD)**	**T Statistics (|O/STDEV|)**	***P* Values**	**5% LL**	**95% UL**	**Decision**
ATT->PS->LO (H3)	0.026	0.021	3.123	0.138	0.023	0.044	Reject
ATT->PS->UE (H4)	0.032	0.011	4.233	0.007	0.032	0.005	Accept

Notes: Significant at p<0.05**, ATT->Assistive Technological Tools, LO->Learning Outcomes, UE->User Experience

DISCUSSION AND CONCLUSION

This study investigates the dynamic relationship between assistive technological tools and their influence on the learning outcomes and user experience of visually impaired children in Hangzhou, Zhejiang, China, by observing how visually impaired children's perceived satisfaction levels mediate these effects. This study profoundly examines the relationship between various assistive technological tools — sighting, hearing, and touching — and their subsequent impact on learning outcomes and user experience. The results demonstrate that these assistive technological tools can improve the visually impaired children's perceived satisfaction, which can further enhance both the learning abilities and learning experience.

Furthermore, the study reveals the crucial role that visually impaired children's satisfaction with their learning outcomes plays in influencing user experiences. However, it does not similarly mediate the relationship with learning outcomes. Visually impaired children's perceived satisfaction does not mediate learning outcomes as the P value is more than the significant level, which is 0.05. The visually impaired children in this study may need to be motivated to use assistive technological tools in learning. They are not satisfied with the current learning technology. Even though they are visually impaired, they still know the latest technological developments, such as smartphones and virtual reality (VR) devices, which they cannot use as learning tools.

Even though there are assistive technological tools for visually impaired children, the more expensive they are, the more expensive it is to own or use them. There are still many limiting factors in the assistive technological tools for those with disabilities, significantly visually impaired individuals. Due to the cost of advanced assistive technological tools, many disability centers or institutions are adopting and using low-level assistive technological tools for visually impaired individuals to learn new knowledge. This is another reason the perceived satisfaction cannot mediate the learning outcome of the visually impaired children in this study.

Through this theoretical observation, this study contributes to a broader understanding of the user experience and learning outcomes by reinforcing and expanding upon the existing models concerning assistive technological tools. On the practical side, the insights from this study can offer a roadmap for technological giants, educational institutions, educational policymakers, and central government policymakers to draft and generate a more dynamic and supportive learning environment and experience that accommodates the various needs of disabilities and significantly visually impaired individuals. This needs to have become more pressing given global challenges such as the increased number of visually impaired individuals and the increasing number of individuals with vision damage due to technological impacts such as blue light from the device's screen.

Theoretical Implications

This study developed a framework for examining how assistive technological tools impact visually impaired children's learning outcomes and user experiences in Hangzhou, Zhejiang, China. It contributes to the broader theoretical discourse of the multisensory functions of disabilities, specifically visually impaired individuals, in learning and exploring knowledge and information.

This study investigation enhances existing scholars on the dynamics of assistive technological tools among disabilities and significantly visually impaired children and offers theoretical insights for implementing information related to assisting technology and human technology interaction for the disabilities. Such insights aim to enhance visually impaired children's engagement and the effective use of assistive technological tools, which have multiplied as part of the educational technology trend for disabilities and tools for exploring the world with better experiences.

Assistive technological tools that foster assistance and help learn and explore new information and knowledge can elevate user satisfaction, improve learning achievement, and enhance user experiences. This highlights the importance of addressing research gaps to enhance disabilities in learning, quality of life, and receiving knowledge and information. Furthermore, this study broadens the application of assistive technological tools and perceived satisfaction and user experience models within the context of visually impaired individuals, particularly children. It highlights the necessity of considering hearing and touching sensory functions in learning and exploring new knowledge from the perspective of visually impaired individuals, aspects often overlooked by researchers. Most previous studies considered vision- related technologies, but in this study, hearing and touching were used as the influencing factors to facilitate visually impaired individuals' learning and experiences. By validating and extending these theoretical perspectives, the research offers a more comprehensive understanding of assistive technological tools' role in learning and experiencing the success of disabilities.

Practical Implications

This study advances the understanding of assistive technological tools as a strategic tool to enhance the accessibility and adaptability of visually impaired children. It highlights the benefits of human technology interaction with disabilities to enhance and explore knowledge and information. It highlights the significance of creating assistive technological tools that cater to individuals with disabilities and significantly visually impaired, facilitating the optimal use of technological-related resources and balanced cognitive and affective growth. The technological giants should invent technological tools or devices for other sensory organs for individuals with specific disabilities. For example, individuals with vision impairment should use other sensory organs, such as hearing and touching, to learn instead of vision-related devices, which might limit the individual's learning.

Even though Neurolink by Elon Musk has developed a microchip that can be installed into the human brain or neuro control, it is still in the human experiment stage, which might take some years to commercialize. Hence, external assistive technological tools are still the best options for people with disabilities. The findings provide clear guidance for instructors on creating content for adaptive and assistive technological tools that enhance the learning experience and improve learning outcomes. For visually impaired individuals, particularly children, learning equipped with assistive technological tools offers invaluable continuity in their education, learning, and exploration of new knowledge and daily life activities.

At an institutional level, an assistive learning environment enables additional knowledge learning, thereby broadening visually impaired individuals' access to required resources and information. Consequently, this study enhances the overall quality of learning institutions. It supports the comprehensive evolution of educational and learning systems within special learning institutions for disabilities, such as centers or institutes for the significantly visually impaired. The insights gained here can be applied across various groups of different disabilities and inform the development of more effective learning and exploring strategies.

Limitations and Future Research

This study encounters several limitations due to various restrictions. Firstly, the sample size and scope are confined, as the data is collected within one particular learning center; the data does not encompass a broad segment of the visually impaired group in China, potentially restructuring the generalization of the study's findings, discussion, and conclusion. Secondly, this study focuses on special daycare and learning centers in Hangzhou, Zhejiang, China, which excludes other visually impaired individuals from other big cities like Beijing, Shanghai, and Tianjin, which may be influenced by factors like the assistive technological tools used in that particular area for learning and exploring knowledge and information.

Thirdly, the selection of three sensory organs might limit the usage of assistive technological tools for visually impaired individuals as several other sensory organs might be able to facilitate the visually impaired individual in learning and exploring knowledge. Furthermore, selecting model variables might not encompass all factors influencing assistive technological tools, learning outcomes, and user experience, as these can significantly vary across different contexts. This study centers on variables directly related to visually impaired children's learning outcomes and user experience, potentially omitting other influential factors. Therefore, the research may not fully account for all potential elements affecting visually impaired individuals.

Future research should include more locations to increase the accuracy and generalize the findings to all disabilities in China or other parts of the world. Besides, future studies can extend the study to individuals with disabilities other than vision impairment to better understand their needs and genuinely understand how to help them improve their quality of life.

CONCLUSION

The study investigates the impact of assistive technological tools on the learning outcomes and user experience of visually impaired children in Hangzhou, Zhejiang, China, highlighting the mediating role of perceived satisfaction. Findings indicate that these tools can enhance perceived satisfaction, improving learning abilities and experiences. However, economic barriers and reliance on lower-tier technologies need to be addressed. Theoretical contributions include a framework for analyzing assistive tool dynamics, while practical implications emphasize tailored tools and supportive learning environments. Future research should address sample size limitations and broaden data collection to encompass diverse disabilities and locations, offering comprehensive insights for enhancing the quality of life for individuals with disabilities worldwide.

Funding: No specific financial support was provided by any funding agency in the public, commercial, or non-profit sectors for this study.

Acknowledgments: Appreciation is extended to all the relevant departments, authorities, learning centers, and individuals for their assistance in finalizing this study.

Conflicts of Interest: The authors affirm no conflicts of interest.

REFERENCES

1. Atan, Y.S., Subaşı, M., Güzel Özdemir, P., & Batur, M. (2023). The Effect of Blindness on Biological Rhythms and the Consequences of Circadian Rhythm Disorder. Turk J Ophthalmol. 53(2), pp. 111-119. doi: 10.4274/tjo.galenos.2022.59296.
2. Azzam, D. & Ronquillo, Y. (2024). Snellen Chart. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK558961/. [Accessed in Jan 2024].
3. Betlej, A., Gondek, J., & Gondek, N. (2023). Ageing and Keeping Pace with Technology: A Grounded Theory Study on Blind Adults' Experiences of Adapting to New Technologies. Int J Environ Res Public Health, 20(3):1876. doi: 10.3390/ijerph20031876.
4. Bonsaksen, T., Brunes, A. & Heir, T. (2023). Quality of life in people with visual impairment compared with the general population. J Public Health (Berl.) https://doi.org/10.1007/s10389-023-01995-1.
5. Caltrider, D., Gupta, A., & Tripathy, K. (2024). Evaluation of Visual Acuity. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK564307/. [Accessed in Jan 2024].
6. Chin, W. W. (1998). Issues and opinion on structural equation modeling. MIS Quarterly: Management Information Systems, 22(1).
7. Chit, S.M., Yap, K.M. & Ahmad, A. (2024). Multi-sensory learning framework for visually impaired learners: Use of 3D, haptic, audio, olfactory media. Multimed Tools Appl (2024). https://doi.org/10.1007/s11042-024-18249-1.
8. Cho, J.D. (2021). A Study of Multi-Sensory Experience and Color Recognition in Visual Arts Appreciation of People with Visual Impairment. Electronics 2021, 10(4), 470; https://doi.org/10.3390/electronics10040470.
9. Chu, H.Y. & Chan, H.S. (2022). Loneliness and Social Support among the Middle-Aged and Elderly People with Visual Impairment. Int J Environ Res Public Health, 19(21),14600. doi: 10.3390/ijerph192114600.
10. Chu, H.Y. & Chan, H.S. (2024).The Effect of Vocational Training on Visually Impaired People's Quality of Life. Healthcare (Basel), 12(6):692. doi: 10.3390/healthcare12060692.

11. Cicek, I., Bernik, A., & Tomicic, I. (2021). Student thoughts on virtual reality in higher education—a survey questionnaire. Information (Switzerland), 12(4). https://doi.org/10.3390/info12040151.
12. Daiber, H.F. & Gnugnoli, D.M. (2024). Visual Acuity. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK563298/. [Accessed in Jan 2024].
13. Dhakal, A. & Bobrin, B.D. (2023). Cognitive Deficits. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK559052/. [Accessed in Jan 2024].
14. Dyzel, V., Oosterom-Calo, R., Worm, M., & Sterkenburg, P.S. (2020). Assistive Technology to Promote Communication and Social Interaction for People With Deafblindness: A Systematic Review. Front. Educ., Sec. Educational Psychology, 5 – 2020. https://doi.org/10.3389/feduc.2020.578389.
15. Elewah, A., Khalil, H., Badawi, A.A., & Rahnamayan, S. (2021). 3D-RadViz: Three Dimensional Radial Visualization for Large-Scale Data Visualization. 2021 IEEE Congress on Evolutionary Computation (CEC). DOI:10.1109/CEC45853.2021.9504983
16. El-Sabagh, H.A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. Int J Educ Technol High Educ 18(53) (2021). https://doi.org/10.1186/s41239-021-00289-4.
17. Elsman, E.B.M., Koel, M., van Nispen,R.M.A., & van Rens, G.H.M.B. (2021). Quality of Life and Participation of Children With Visual Impairment: Comparison With Population Reference Scores. Invest Ophthalmol Vis Sci., 62(7):14. doi: 10.1167/iovs.62.7.14.
18. Fast, D.K. (2018). Including Children with Visual Impairments in the Early Childhood Classroom. Early Childhood Education Edited by Donna Farland-Smith. Published by IntechOpen Limited.
19. Fernández-Batanero, J.M., Montenegro-Rueda, M., Fernández-Cerero, J., & Garcia-Martinez, I. (2022). Assistive technology for the inclusion of students with disabilities: a systematic review. Education Tech Research Dev 70, 1911–1930 (2022). https://doi.org/10.1007/s11423-022-10127-7.
20. Fornell, C. G., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50.
21. Getnet, M., Akalu, Y., Dagnew, B., Gela, Y.Y., Belsti, Y., Diress, M., Fekadu, S.A., & Seid, M.A. (2021). Visual impairment and its associated factors among medical and health sciences students at the University of Gondar, Northwest Ethiopia. PLoS One.,16(8):e0255369. doi: 10.1371/journal.pone.0255369.
22. Ghasemi Fard, F., Mirzaie, H., Hosseini, S.A., Riazi, A., & Ebadi, A. (2023). Vision-related tasks in children with visual impairment: a multi-method study. Front Psychol., 14:1180669. doi: 10.3389/fpsyg.2023.1180669. Erratum in: Front Psychol.
23. Hair, J. F., Hult, G. T. M., Ringle, C., Sarstedt, M., Danks, N., & Ray, S. (2021). Partial least squares structural equation modeling (PLS-SEM) using R: A workbook. In Springer.
24. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8.
25. Hutmacher F. (2019). Why Is There So Much More Research on Vision Than on Any Other Sensory Modality? Front Psychol., 10:2246. doi: 10.3389/fpsyg.2019.02246.
26. Ishtiaq, R., Chaudhary, M.H., Rana, M.A., & Jamil, A.R. (2016). Psychosocial implications of blindness and low vision in students of a school for children with blindness. Pak J Med Sci. 2016, 32(2):431-434. doi: http://dx.doi.org/10.12669/pjms.322.8737.
27. Josserand, M., Rosa-Salva, O., Versace, E., & Lemaire, B.S. (2022). Visual Field Analysis: A reliable method to score left and right eye use using automated tracking. Behav Res 54, pp. 1715–1724. https://doi.org/10.3758/s13428-021-01702-6.
28. Kuriakose, B., Shrestha, R., & Sandnes, F.E. (2022). Tools and Technologies for Blind and Visually Impaired Navigation Support: A Review, IETE Technical Review, 39(1), 3-18, DOI: 10.1080/02564602.2020.1819893.
29. Kv, V. & Vijayalakshmi, P. (2020). Understanding definitions of visual impairment and functional vision. Community Eye Health, 33(110), Pp. S16-S17.
30. Lazar, J., Feng, J. and Hochheiser, H. (2017) Research Methods in Human-Computer Interaction. 2nd Edition, Morgan Kaufmann, Cambridge.
31. Lingard, C.D. (2021). Hearing in visually impaired children. PhD Thesis. Retrieved from https://pure.manchester.ac.uk/ws/portalfiles/portal/248799664/FULL_TEXT.PDF. [Accessed in Jan 2024].
32. Loh, L., Prem-Senthil, M., & Constable, P.A. (2024). A systematic review of the impact of childhood vision impairment on reading and literacy in education. J Optom., 17(2):100495. doi: 10.1016/j.optom.2023.100495.
33. Lohse, M., Zimmer-Harwood, P., Dahmen, J.C., & King, A.J. (2022). Integration of somatosensory and motor-related information in the auditory system. Front Neurosci., 16:1010211. doi:

10.3389/fnins.2022.1010211.
34. Lupon, M., Armayones, M., & Cardona, G. (2018). Quality of life among parents of children with visual impairment: A literature review. Research in Developmental Disabilities, 83,
pp. 120-131. https://doi.org/10.1016/j.ridd.2018.08.013.
35. Mai, C., Xie, D., Zeng, L., Li, Z., Li, Z., Qiao, Z., Qu, Y., Liu, G., & Li, L. (2023). Laser
Sensing and Vision Sensing Smart Blind Cane: A Review. Sensors 2023, 23(2), 869; https://doi.org/10.3390/s23020869
36. Malik, S. (2023). Parental Involvement in Orientation and Mobility Within the Expanded Core Curriculum for Visually Impaired Learners in Pakistan: A Review of the Literature. Journal of Education, 203(1), pp. 92-102. https://doi.org/10.1177/0022057421991829.
37. Manirajee, L., Rashid, S.M.M., & Shariff, S.Q.H. (2024). Assistive Technology for Visually Impaired Individuals: A Systematic Literature Review (SLR). International Journal of Academic Research in Business and Social Sciences, 14(2). DOI:10.6007/IJARBSS/v14- i2/20827.

38. Marsden, J., Stevens, S., & Ebri, A. (2014). How to measure distance visual acuity. Community Eye Health, 27(85), pp.16.
39. Maurya, H.K. & Maurya, H.K. (2018). Assistive Technology for Students with Visual Impairment in Inclusive Education. In book: INCLUSION: Cross-Cultural Reflections on Policies, Practices and Approaches (pp.105-110). Publisher: Bharti Publication, New Delhi-110002.
40. Messaoudi, M.D., Menelas, B.J., & Mcheick, H. (2022). Review of Navigation Assistive Tools and Technologies for the Visually Impaired. Sensors (Basel)., 22(20):7888. doi: 10.3390/s22207888.
41. Mlynski, R., Kozlowski, E., & Adamczyk, J. (2021). Sounds That People with Visual Impairment Want to Experience. Int J Environ Res Public Health.,18(5):2630. doi: 10.3390/ijerph18052630.
42. Noushad, B., Thomas, J., & Amin, S.V. (2012). Reliability of a modified logMAR distant visual acuity chart for routine clinical use. Oman J Ophthalmol, 5(2):87-90. doi: 10.4103/0974- 620X.99370.
43. Obigbesan, E., Chapman, A., & Light, D. (2023). Positive experiences of visually impaired tourists, Current Issues in Tourism, DOI: 10.1080/13683500.2023.2214722
44. Olofsson, J.K., Ekström, I., Lindström, J., Syrjänen, E., Stigsdotter-Neely, A., Nyberg, L., Jonsson, S., & Larsson, M. (2021). Smell-Based Memory Training: Evidence of Olfactory Learning and Transfer to the Visual Domain. Chem Senses, 45(7), pp. 593-600. doi: 10.1093/chemse/bjaa049. Erratum in: Chem Senses.
45. Pozón-López, I., Higueras-Castillo, E., Muñoz-Leiva, F., & Liébana-Cabanillas, F. J. (2021). Perceived user satisfaction and intention to use massive open online courses (MOOCs). Journal of Computing in Higher Education, 33(1), 85–120. https://doi.org/10.1007/s12528-020-09257-9.
46. Rahi, J.S. and Cable, N. (2003) Severe visual impairment and blindness in children in the UK.
Lancet, 362, pp. 1359-1365. http://dx.doi.org/10.1016/S0140-6736(03)14631-4.
47. Sailoganathan, A., Osuobeni, E.P., & Siderov, J. (2018). A standardized logarithm of the minimum angle of resolution visual acuity chart in Hindi. Indian J Ophthalmol, 66(5),
pp. 634-640. doi: 10.4103/ijo.IJO_1074_17.
48. Senjam, S.S. & Chandra, P. (2020). Retinopathy of prematurity: Addressing the emerging burden in developing countries. J Family Med Prim Care, 9(6):2600-2605. doi: 10.4103/jfmpc.jfmpc_110_20.
49. Senjam, S.S. (2019). Assistive technology for students with visual disability: Classification matters. Kerala Journal of Ophthalmology, 31(2), pp. 86-91. DOI: 10.4103/kjo.kjo_36_19.
50. Senjam, S.S., Manna, S., Vashist, P., Gupta, V., Grover, S., Kumar, V.A., & Titiyal, J.S. (2023). Improving assistive technology access to students with low vision and blindness in Delhi: A school-based model. Indian J Ophthalmol.,71(1):257-262. doi: 10.4103/ijo.IJO_1281_22.
51. Sharififard, N., Sargeran, K., & Katayoun, K. (2022). Oral Health Status and Related Factors in Children with Visual Impairment Aged 7-11 Years: A Cross-Sectional Study. Front Dent.,19(13). doi: 10.18502/fid.v19i13.9216.
52. Šintáková, O., & Lasisi, T. T. (2021). Travel Motivation and Barriers to Travel for People with Visual Impairments. Czech Journal of Tourism, 9(1), 54-67. DOI: 10.2478/cjot-2020- 0004.
53. Svensson, I., Nordström, T., Lindeblad, E., Gustafson, S., Björn, M., Sand, C., Bäck, G.A., & Nilsson, S. (2021). Effects of assistive technology for students with reading and writing disabilities, Disability and Rehabilitation: Assistive Technology, 16(2), pp. 196-208, DOI: 10.1080/17483107.2019.1646821.
54. Tamma, S., Mohammed, N., & Kaouli, N. (2021). Challenges Faced by Visually Impaired Students in Writing with Lack of Assistive Technology. The Journal of AsiaTEFL 18(1),
pp. 345-354. DOI:10.18823/asiatefl.2021.18.1.26.345.
55. Tang, M., Manduchi, R., Chung, S., & Prado, R. (2023). Screen Magnification for Readers with Low Vision: A Study on Usability and Performance. ASSETS. Epub 2023.
56. Tham, N. T. , & Thao, D. T. (2021). The Current Situation of Children with Visual Impairment and Multiple Disabilities in Some Special Education Centers in Vietnam. American Journal of Educational Research, 9(4), 229-234.
57. The Individuals with Disabilities Education Act, IDEA. (2024). Section 1401. Retrieved from: https://sites.ed.gov/idea/statute-chapter-33/subchapter-

i/1401#:~:text=The%20term%20%E2%80%9Cassistive%20technology%20device,a%20child%20with%20a%20disability.. [Accessed in Jan 2024].
58. Van Ommen, C., Walton, C., & Chaparro, B. S. (2022). Applying User Experience (UX) Methods to Understand Assistive Technology (AT) for Video Gaming. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 66(1), 1201-1205. https://doi.org/10.1177/1071181322661467.
59. World Health Organization. (2022). Noncommunicable Diseases, Rehabilitation and Disability. Retrieved from https://www.who.int/teams/noncommunicable-diseases/sensory- functions-disability-and-rehabilitation/eye-care-vision-impairment-and-blindness#:~:text=Globally%2C%20at%20least%202.2%20billion,World%20Health%20Assembly%20resolution%20WHA73. [Accessed in Jan 2024]
60. World Health Organization. (2023). Blindness and vision impairment. Retrieved from https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. [Accessed in Jan 2024]
61. World Health Organization. (2024). Assistive technology. Retrieved from https://www.who.int/news-room/fact-sheets/detail/assistive-technology. [Accessed in Jan 2024].