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Bridging to possible: Empowering visually impaired students through assistive technology rehabilitative training to become better students and future employees

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Abstract: Assistive technology (AT) has evolved rapidly and continues to develop among visually impaired students (VIS). The inclusion of VIS in mainstream education and employment is essential for building an inclusive society. However, it has been reported that VIS face numerous challenges in accessing and utilizing education and employment opportunities. This research paper aims to explore the effectiveness of assistive technology-based training in empowering VIS to become better future employees. The paper reviews various assistive technologies and their applications in facilitating learning and employment opportunities for visually impaired students. The study then uses a tri-level, mixed-method design to examine the impact of rehabilitative training that is based on assistive technology on the academic performance and employability of visually impaired students. The findings of the study reveal that assistive technology-based training has a significant positive impact on the academic performance and employability of VIS. The study recommends the integration of assistive technology-based training into the mainstream education system to provide equal learning and employment opportunities for visually impaired students.

Keywords: *Assistive technology (AT), Students with visual impairment (VIS) – special education, Technical challenges.*

1. Introduction

A consensus exists that it is time to unlock jobs for visually impaired college graduates and fill in the disability inclusion gap. Their inclusion and empowerment in the workforce of the future is vital. With digital transformation sweeping the world towards the Fourth Industrial Revolution, it is imperative to ensure that graduates are prepared for the job market. Students with visual impairment (VIS) need essential technological foundational skills that would allow them to be work-, career-, and life-ready. One of these skills is literacy in assistive technology (AT) which is fundamental in mainstream education as it helps to tap into students' potential and unique skill sets.

VIS face numerous challenges in acquiring quality education and job opportunities. According to the World Health Organization, approximately 285 million people are visually impaired worldwide, with 39 million of them being completely blind. The majority live in developing countries, where they face a lack of adequate support and infrastructure to address their needs.

The lack of access to appropriate assistive technology tools and inadequate training for utilizing them significantly limit the educational and employment prospects of visually impaired students. The use of AT in education and employment has the potential to level the playing field for visually impaired students and empower them to become better future employees, improving the accessibility, efficiency, and effectiveness of education and employment for visually impaired students.

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Despite the challenges, technology has made it increasingly possible for visually impaired individuals to access education and employment opportunities. Assistive technologies such as screen readers, braille displays, and magnification software have enabled visually impaired individuals to access digital content and perform once-impossible tasks.

According to the World Health Organization (WHO), more than one billion people worldwide need one or more assistive products and double this number is estimated to need at least one assistive product by 2030 [1]. AT can be any device, item, product, or software program that is used to enhance the functional capabilities of a disabled person. It provides access to digital content and performs tasks that were previously challenging or impossible. AT enables a healthy lifestyle, productivity, independence, and dignified lives, and helps participation in education, the labor market, and civic life. However, the effective use of assistive technologies requires specialized training, which is often lacking in developing countries. The purpose of this research paper is to explore the effectiveness of assistive technology-based training in empowering VIS to excel academically and become better future employees. Specifically, this research paper seeks to address the following objectives:

1. To provide VIS with specialized rehabilitation on AT that is intended to improve their digital literacy and employability.
2. To empower visually impaired students to become more independent and self-reliant.
3. To create a platform for visually impaired individuals to share their experiences and challenges with regard to accessing education and employment opportunities.
4. To highlight the role of AT in promoting inclusivity and equal opportunities for visually impaired individuals.

1.1. Research Questions

This study addresses the following research questions:

1. What technical services are available to VIS?
2. What challenges hinder VIS from using the available technical services?
3. To what extent do specific training programs that are designed for this purpose contribute to overcoming VIS challenges?
4. What are the social and professional impacts on training and improving the technical skills of VIS?

1.2. The Study Context & Population

This study took place in a public university located in the northern region of Saudi Arabia. This university established the Disability Resource Unit (DRU) to oversee the needs of disabled students and help facilitate their learning. In this context, the student population is estimated to be over 100, spread across the main campus and five remote sites.

2. Related Work

In recent years, researchers have become increasingly interested in investigating the use of technological devices to enhance the achievement of VIS in inclusive classrooms [2]. The United Nations Convention on the Rights of Persons with Disabilities emphasizes the rights of people with disabilities to access lifelong learning without discrimination as well as not being excluded from mainstream education due to their disability. The primary goal of education for students with disabilities is to provide the best resources and support within the most appropriate setting, enabling them to achieve the highest level of education achievable in a mainstream setting [3, 4]. However, the learning development of VIS in a higher education classroom depends on the effective implementation of teaching techniques and materials that enhance the learning experience [5]. Only a few studies, to the best of our knowledge, have been conducted on the AT services available for VIS in the Arab world (for example, Al Shehri, et al. [6]. However, these studies solely focused on the accessibility of AT for

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people with visual impairments, without identifying the primary challenges associated with its utilization and how to overcome these challenges.

In a different context, [7] study on VIS in the United States concluded that individuals with visual impairments do not fully benefit from the use of assistive technology within the home, at school, or in the community. Similarly, Kapperman and Sticken [8] reported that 60% of VIS were not benefitting from AT because of the challenges and lack of competency in their utilization. This study focuses on the technological services provided by the university to these students.

2.1. Definition of Visual Impairment

The International Statistical Classification of Diseases, Injuries, and Causes of Death, 10th revision (ICD-10), bases its definition of visual impairment on the best-corrected vision, i.e., visual acuity obtained with the best possible refractive correction. Visual impairment caused by uncorrected or inadequately corrected refractive errors is defined as visual acuity of less than 6/18 in the better eye that could be improved to equal to or better than 6/18 by refraction or pinhole, thus spanning the low vision and blindness categories as currently defined in the ICD-10 [9]. The current study uses the term *visual impairment* to include all degrees of impairment in addition to blindness.

Visually impaired students will need to learn Braille, orientation, mobility, and the use of assistive technologies with support from qualified individuals [10]. However, with inclusive education, VIS are often placed in environments heavily reliant on visual elements, with a limited presence of teachers qualified to support the visually impaired [11]. Although VIS are capable of studying various academic subjects similar to their sighted peers, they often encounter exclusion from certain major fields [12-14]. The situation becomes more concerning in higher education, where the curriculum becomes more specific. De Verdier and Ek [15] denoted that the level of accessibility of the course depends heavily on the subject teacher's knowledge and willingness, causing students with visual impairment to choose courses based not on their ability and interest, but on accessibility. This implies that VIS may miss out on the chance to study their preferred majors, hindering their ability to pursue a particular major in college and potentially pursue a career in that field.

The availability of educational support materials in universities, such as technological devices, plays an important role in promoting the adoption of inclusive education. The movement toward inclusive education would greatly benefit from obtaining and utilizing AT by VIS. All VIS are entitled to the independence and efficiency afforded by technology, including AT. Appropriate assistive technology enables VIS to access information and to complete tasks efficiently, thereby enabling them to achieve the highest level of independence. Kelly and Smith [16] suggest that technology promotes the acquisition of literacy, provides equal access to information required for employment, and for access to information, in general, and facilitates social and community networks. According to the Individuals with Disability Education Act (IDEA), any equipment that is used to improve the functional capabilities of individuals with disabilities is considered AT. By integrating AT within the university curriculum, teaching staff can assist VIS by providing remedies to specific learning problems and can promote independent learning.

2.1.1. Assistive Technology for Visually Impaired Students

AT can provide VIS with the necessary tools and resources to access and utilize education and employment opportunities. Various assistive technology tools are available that cater to the specific needs of visually impaired students. These tools include screen readers, braille displays, magnification software, text-to-speech software, and voice recognition software. They can facilitate the learning process and help visually impaired students to access and utilize educational resources.

2.1.2. Assistive Technology-Based Training

Assistive technology-based rehabilitation can equip VIS with the necessary skills and knowledge to utilize assistive technology tools effectively. The training can cover various aspects of assistive

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technology, including its applications, features, and functions. It can be conducted through various modes, including online training, webinars, and workshops, as well as hands-on sessions to help students practice using assistive technology tools.

The selection of AT depends on an evaluation of the student's needs and the adequate level of professionals qualified to assist students with visual impairment [17].

As specified in Individuals with Disabilities Education Act (IDEA) [18] school districts must ensure that all students have equitable access to AT devices and instruction as documented by the individualized education program. University programs should ensure the availability of assistive technologies tailored for individuals with blindness and low-vision, along with teachers proficient in their use. Professional development opportunities must be provided through partnerships among universities, organizations, and assistive technology vendors. This ensures that professionals remain up-to-date with emerging AT and have the chance to become skilled in instructing VI on their usage. Table 1 illustrates a list of resources that were suggested by Wiazowski [19] as possible considerations for AT for VIS.

Table 1.
Assistive Technology for VIS.

Assistive Device
Text-to-Braille translation software or other software to translate print to Braille.
An embosser (Braille printer).
Scanner with Optical Character Recognition (OCR) software.
Image simplifying software.
Image embossing devices.
Color copier with a magnification function.
Text-to-talk software.
Voice recording/dictation software.

3. Methodology

3.1. Study Design & Approach

An experimental approach is the most appropriate to the nature of the research, to achieve its objectives, and to verify the effect of the independent variable (the assistive technology interventions) on the independent variable (the challenges). This research is experimental in nature, despite how it uses the descriptive approach to assist the investigation. A qualitative approach was chosen to further assist in investigating the impact of assistive technology interventions in addressing these challenges. Qualitative research helps explore inquiries and helps researchers "understand the world as seen by the respondents" [20].

For the needs analysis and the challenges VIS encountered in terms of AT experiences, this research uses a mixed-method approach to achieve this objective. It encompasses the use of surveys and interviews to collect data from visually impaired students and their teachers. The surveys focus on collecting data on the students' experiences with AT, their levels of digital literacy, and their readiness for employment. The interviews will seek to explore the challenges and opportunities that visually impaired students face in accessing education and employment opportunities.

Additionally, this study will involve the development and implementation of a specialized AT training program that was experimented VIS. The training program will focus on improving the students' digital literacy and employability skills in related to AT. The training programs and conduction will be in collaboration with assistive technology experts and teachers who are experienced and have worked with VIS before.

As such, the study was carried out across three levels, as illustrated in Figure 1, outlining the schematic representation of the proposed methodology. As depicted in Figure 1, Level 1 indicates the

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technological services available to VIS, an assessment of the degree to which VIS can leverage these services for their benefit, and the identification of challenges that hinder their use of these services.

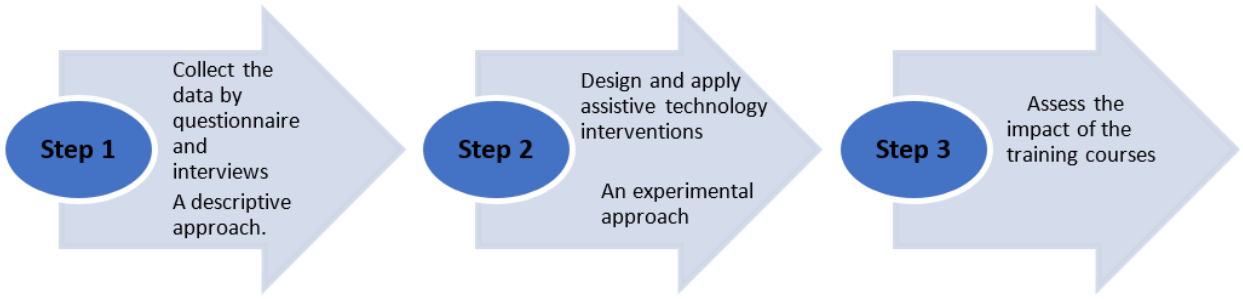

Figure 1.
Steps of the Research.

Stage 1

The initial stage was to construct the study's issue, which assisted in identifying the factors that might influence the adoption and use of AT by visually impaired university students in Saudi Arabia. This stage identified the available university AT services provided to VIS:

1. To assess the accessibility of the technical services.
2. To determine the challenges that hinder VIS from using these services.

The first study was quantitative based. This study collected many survey responses from VIS in Saudi universities to examine the relation between variables of the proposed models. The main goal of this stage was to determine the extent to which the factors influenced AT acceptability in Saudi Arabia. A qualitative study was included in Stage 3 to acquire a better understanding of the study outcomes. To check, analyze, explain, and provide a deeper understanding of stage 1 data, a semi-structured interview was conducted by the researcher with Saudi AT users and specialists.

Stage 2

Stage 4 entailed gathering, analyzing, and combining the findings from both the experiment in order to provide a clear image and a more interpretation of the phenomenon.

3.2. Study Instrumentations

In this study, primary data were collected using different methods and instruments. This included questionnaires, interviews, and participant case studies. The designed instruments were validated by specialized experts.

3.3. Questionnaires

As a quantitative method, online surveys were distributed amongst VIS. The purpose of conducting surveys was to explore:

- The extent to which available AT were utilized by VIS; and
- The challenges encountered when attempting to use the AT services.

A questionnaire consisting of 42 questions was developed, validated, and administered to visually impaired students. Drawing upon the researcher's experience and background knowledge of AT, with the assistance of another co-author, the questionnaire was designed to include suitable statements. The questionnaire was written in Arabic, the students native language, and consisted of three main sections. The first section collected demographic data, consisting of 6 items. Section Two comprised the key dimensions of the investigation, with the researchers identifying six main dimensions relating to the technological services available to VIS, as shown in Table 2.

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Table 2.
Items of Section Two of the Questionnaire.

Types of Technological services	No of Items	Questionnaire Items
Technological services available in infrastructure in buildings and classrooms	4	1 - 4
Technological services available in libraries and electronic educational resources	4	5 - 8
Technological services for comprehensive access to the university's website	3	9 - 11
Educational technology services for reading and writing in Braille	7	12 - 18
Technological services for students with low vision used in text enlargement	4	19 - 22
Technically trained and prepared human cadres	5	23 - 27

Section three of the questionnaire explores how participants use and benefit from these services. It includes open-ended questions that enquire about the challenges faced by VIS when using and benefiting from these services.

used to determine the effectiveness of an intervention or the effectiveness of a health service delivery.

3.4. General Characteristics of Study Participants

Through the purposeful sampling, a total number of twenty-eight VIS (11 males and 17 females) were included in the study. The participants were from different colleges, such as the College of Shari'a and College of Education and Arts. The mean age is 20.52 ± 0.97 of the participants. The participants had varying degrees of visual impairment. These participants were selected based on two specific criteria: 1) a currently enrolled student and 2) with a visual impairment. Table 3 provides a further description of the participants.

Table 3.
Subjects' demographics from the surveys.

#	Question	Option	N	%
Q1	Gender	Male	11	39%
		Female	17	71%
Q2	Student status	Freshman	5	18%
		Sophomore	5	18%
		Junior	9	32%
		Senior	9	32%
Q3	Degree of impairment	Blind	19	68%
		Low vision	9	32%
Q4	Major Field	Education	12	43%
		Business administration	3	10%
		Medical and applied sciences	1	3.5%
		Shari'a and Islamic regulations	6	21%
		Human Sciences	2	7%
		Others	4	14%

3.5. Focus Group Interviews

Students from both class sections were invited immediately after the last class session of the term to participate in a focus group. The purpose of conducting exploratory focused, in-depth group interviews was to further understand and triangulate. Although the context of the research does offer many of these devices for VIS, students still face many challenges in using and benefiting from them. This study involved interviewing these students to identify the challenges and to provide training programs by qualified specialists aimed at overcoming these hurdles.

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3.7. Interventional Training Programs

A small group of four blind students were selected, all at the first and or second academic level, for participation in the AT interventional training courses. According to Creswell [21] selecting a large sample for qualitative studies can result in superficial insights.

3.8. Ethical considerations

This study followed all research ethics. The aims and procedures of the study were explained to each potential participant, after which students signed informed consent forms to participate. Once the study began, participants had the freedom to withdraw at any time without penalty. To ensure anonymity, possible identifying information, such as names, students' ID numbers and IP addresses, was eliminated from the records and was not collected.

3.9. Procedures

Initially, the students' learning needs, experiences, and challenges from the two-part questionnaire and the open-ended questions along with the interview transcripts were analyzed.

In stage 2, the assistive technology interventions were designed. During this stage, two training courses were designed and implemented based on the needs identified in the initial stage. Several outcomes aimed at addressing the challenges of visually impaired students were identified. These outcomes were put into two training courses. The first course is entitled "Accessibility of educational content within the Blackboard system for students with visual impairment." The second training course was on "Skills of using the developed Braille Sense," and each spanned three days. Designed interventions were implemented with four VIS participants. After the official permissions were obtained, the courses were recorded on camera and conducted by professional trainers. The final step involved conducting an evaluated case study to ascertain the impact of these training courses on the VIS.

3.10. Data Processing and Analysis

The data gathered from the survey respondents were analyzed quantitatively and descriptively. IBM Statistical Program for Social Science (SPSS® version 26) was employed to analyze instructors' responses to the questionnaire items in terms of frequency, percentage, mean, and standard deviation (SD). The gathered qualitative data was transcribed and then analyzed thematically. The thematic analysis involved several key aspects: collecting data on technological services provided by the university to VIS, determining students' use and benefit from these services, and defining the challenges faced by VIS in using and benefiting from these services.

4. Results and Findings

4.1. Previous Results

In a previous study conducted within this research project, different findings emerged. Different outcomes were found at a significance level of 0.01 between students with visual impairments, students with hearing impairments, and students with physical impairments. This was revealed in the total score of their response regarding the challenges faced by individuals with disabilities in utilizing the University's services intended for VIS, as shown in Table 4. It was also found that technological challenges are the most thought-provoking for VIS. These findings prompted us to conduct the current study.

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Table 4.
One-way ANOVA test results based on the disability type variable.

Challenges of VIS		Mean square	DF	F	Sig
Academic Challenges	VIS	23.52	1.77	25.34	0.000
	SHI	22.12	2.29		
	SPI	18.30	3.98		
Technological Challenges	VIS	41.55	2.72	43.93	0.000
	SHI	35.35	4.30		
	SPI	32.96	3.59		
Environmental Challenges	VIS	16.71	3.70	11.36	0.000
	SHI	15.58	2.96		
	SPI	12.50	3.12		
Administrative challenges	VIS	6.35	1.40	2.16	0.122
	SHI	5.54	1.53		
	SPI	6.08	1.56		
Total	VIS	87.94	5.42	59.68	0.000
	SHI	78.58	7.37		
	SPI	69.88	5.40		

4.2. Types of Technological Services Providing to VIS

The analysis of questionnaire responses and interviews conducted before the technological intervention phase, involving students who were yet to receive training on the use of assistive technologies, revealed many challenges. Despite the availability of many technological services, whether hardware or technical support services, these students faced many problems in engaging with e-learning. They also struggled with using modern technology to navigate the campus and modern technological applications. In the current research findings, VIS expressed support for the idea of inclusion. They also praised the technological and other auxiliary services provided to them by the university, acknowledging their role in bridging the gap of discrimination that existed between persons with disabilities and those without.

The respondents were asked about the most accessible technical services provided to VIS. The findings show that 21 (75%) of respondents found educational technology services for reading and writing in Braille easily accessible. Additionally, 21 (71.4%) participants indicated that technological services for students with low vision used in text enlargement, were readily available. Moreover, 16 (57.1%) contributors identified the accessibility of technological services available in libraries and electronic educational resources. 13 (54.2%) cited technically trained and prepared human cadres. 8 (28.6%) mentioned the availability of technological services in building infrastructure and classrooms. Finally, 7 (25%) used technological services for comprehensive access to the university's website, as Table 5 illustrates:

Table 5.
The Accessibility of Technology Services by VIS.

Types of technological services	Frequency	Percentage
Technological services available in building infrastructure and classrooms	8	28.6
Technological services available in libraries and electronic educational resources	16	57.1
Technological services for comprehensive access to the university's website	7	25
Educational technology services for reading and writing in Braille	21	75
Technological services for students with low vision used in text enlargement	20	71.4
Technically trained and prepared human cadres	13	54.2

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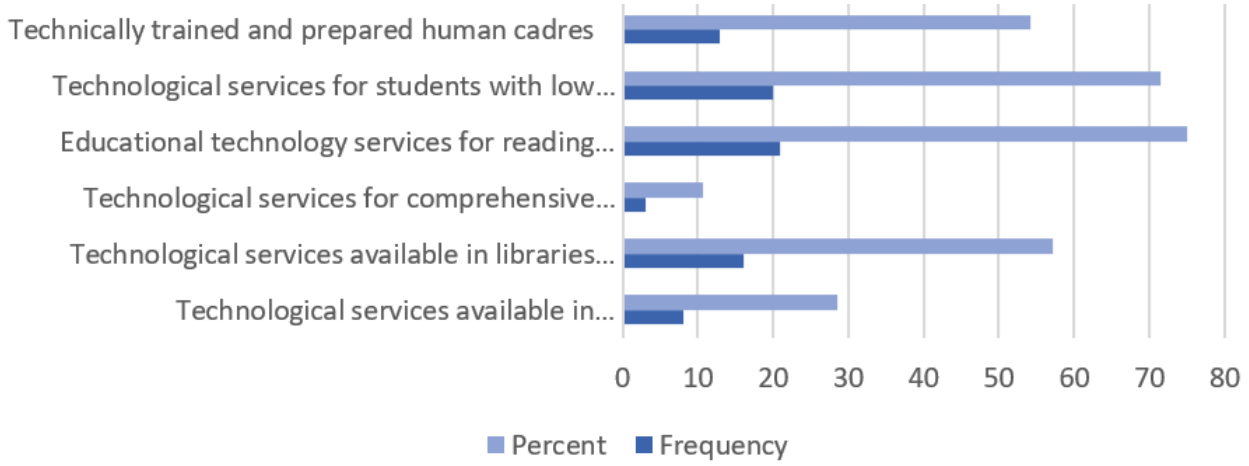

Figure 2.
Technology Services and their Accessibility by VIS.

4.3. The Extent of VIS' Use of Technological Services Provided

VIS were asked to indicate how often they made use of available technological services to enhance the quality of their learning experience. The results show that 4 (14.3%) of respondents said educational technology services for reading and writing in Braille were easily used and benefited from, whereas 18 (64.3%) indicated technological services for students with low vision used in text enlargement. On the other hand, 21 (75%) named technological services available in libraries and electronic educational resources, 12 (42.9%) cited technically trained and prepared human cadres, and 25 (89.3%) mentioned technological services available in infrastructure in buildings and classroom. Finally, 6 (21.4%) stated technological services for comprehensive access to the university's website, as Table 6 illustrates.

Table 6.
The Extent of VIS' Use of Technological Services Provided.

Types of Technological Services	Frequency	Percentage
Technological services available in building infrastructure and classrooms	25	89.3
Technological services available in libraries and electronic educational resources	21	75
Technological services for comprehensive access to the university's website	6	21.4
Educational technology services for reading and writing in Braille	4	14.3
Technological services for students with low vision used in text enlargement	18	64.3
Technically trained and prepared human cadres	12	42.9

Figure 3 represents the extent of VIS' use of technological services provided to students at the Disability Resource Unit (DRU).

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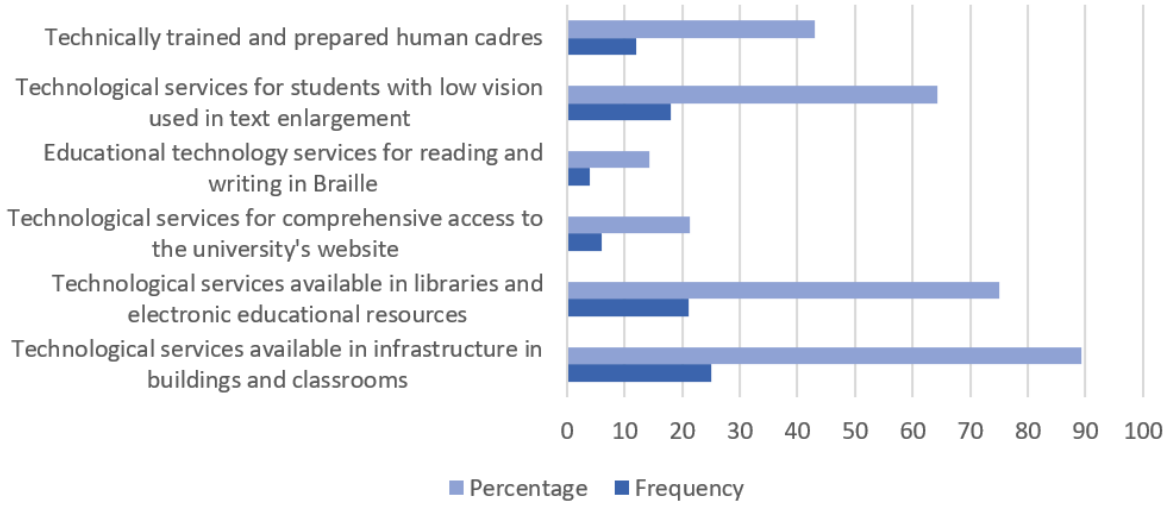

Figure 3.
The Extent of VIS' Use of Technological Services Provided.

The most critical challenges that interfere with the use of technical services of VIS have been stated as follows:

- Lack of trainers or instructors in the university
- Most of the services are aware, but we do not know how to use them.
- We cannot use electronics, including e-learning
- We cannot use the advanced Braille Sense device despite its importance in the educational process.
- Not receiving any training courses on the use of these devices

4.4. Challenges Constraining the Use of VIS Technological Services Provided

During the interviews, VIS were also asked to answer open-ended questions, which aimed to identify the most important challenges they face when using the technological services available at the university. The respondents were asked to indicate the challenges faced by VIS when accessing and using technological services. The data collected (Table 6) show that the most significant challenges faced by VIS include difficulties with educational technology services for reading and writing in Braille, comprehensive access to the university's website, and availability of technically trained and prepared human cadres. These services represent where VIS can particularly benefit from.

4.5. The Interventional Training Programs

The outcomes of the first course "Some commands that VIS should learn" help to thoroughly examine the analysis of the results (Table 7).

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Table 7.
The Outcomes (O) of the First Training Course.

N	The Commands	N	The Commands
O1	Check time	O21	Wireless toggle
O2	Check date	O22	Bluetooth toggle
O4	Setting and modifying password	O23	Controlling the volume, speed, and pitch of the TTS
O5	Switching media modes	O24	Setup internet
O6	Turn touch gestures on/off	O25	Change device name
O7	Check network status	O26	Working with files and folders
O8	Display compass heading	O27	Executing e-mail
O9	Turn one-handed mode on/off	O28	Navigating accounts and mailboxes
O10	Turn LCD display on/off	O29	Using the tools menu
O11	Switch between open apps	O30	Managing word processor commands
O12	Open task manager	O31	Using the Media Player to play audio files
O13	Open notifications (Android)	O32	Using the DAISY Player on the Polaris
O14	LCD on/off	O33	Managing an address
O15	The voice on/off	O34	Adding an appointment
O16	Braille display on/off	O35	Setting alarm options
O17	Voice volume up/down	O36	Launching the stopwatch
O18	Main volume up/down	O37	Using the calculator
O19	Voice rate	O38	Backup/restore personalized settings
O20	Voice pitch		

Table 8 presents data that includes an analysis of the results from the first course, including pre-practical test and post-practical test results. It displays the responses provided for each command and the percent achievement of each student through command-based and outcomes-based analysis.

As seen in Table 9, the responses provided by VIS during the interviews were categorized into 'correct answers', 'partially correct answers', and 'incorrect answers'. To determine the overall achievement, a scoring system was employed: 2 marks were given for command-based achievement, outcome-based achievement, and correct answers, 1 mark for partially correct answers (Part of the required steps), and 0 marks for incorrect answers or any unanswered item.

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Table 8.
The Result of the Pre-test and Post-test Analysis.

N	S1		S2		S3		S4	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
O1	✗	✓	✗	✓	✗	✓	✗	✓
O2	✗	✓	✓	✓	✗	✓	✗	✓
O3	✗	✓	✗	✓	✗	✓	✗	✓
O4	✓	✓	✗	✓	✗	✓	✗	✓
O5	✗	✓	✗	✓	✗	✓	✗	✓
O6	✗	✓	✗	✓	✗	✓	✓	✓
O7	✗	✓	✗	✓	✗	✓	✗	✓
O8	✗	✓	✗	✓	✗	✓	✗	✓
O9	✗	✓	✓	✓	✗	✓	✗	✓
O10	✗	✓	✗	✓	✗	✓	✗	✓
O11	✗	✓	✗	✓	✗	✓	✗	✓
O12	✗	✓	✗	✓	✗	✓	✗	✓
O13	✓	✓	✗	✓	✗	✓	✗	✓
O14	✗	✓	✗	✓	✗	✓	✗	✓
O15	✗	✓	✓	✓	✗	✓	✗	✓
O16	✗	✓	✗	✓	✗	✓	✗	✓
O17	✗	✓	✗	✓	✗	✓	✗	✓
O18	✗	✓	✗	✓	✗	✓	✗	✓
O19	✗	✓	✗	✓	✗	✓	✗	✓
O20	✗	✓	✗	✓	✗	✓	✗	✓
O21	✗	✓	✓	✓	✗	✓	✗	✓
O22	✗	✓	✗	✓	✗	✓	✗	✓
O23	✗	✓	✗	✓	✗	✓	✗	✓
O24	✗	✓	✗	✓	✗	✓	✗	✓
O25	✗	✓	✗	✓	✗	✓	✓	✓
O26	✓	✓	✗	✓	✗	✓	✗	✓
O27	✓	✓	✗	✓	✗	✓	✗	✓
O28	✗	✓	✗	✓	✗	✓	✗	✓
O29	✗	✓	✗	✓	✗	✓	✗	✓
O30	✗	✓	✗	✓	✗	✓	✗	✓
O31	✗	✓	✓	✓	✗	✓	✗	✓
O32	✗	✓	✗	✓	✓	✓	✗	✓
O33	✗	✓	✗	✓	✗	✓	✓	✓
O34	✗	✓	✓	✓	✗	✓	✗	✓
O35	✗	✓	✓	✓	✗	✓	✗	✓
O36	✗	✓	✗	✓	✗	✓	✗	✓
O37	✓	✓	✗	✓	✗	✓	✗	✓
O38	✗	✓	✗	✓	✗	✓	✗	✓

As for the outcomes of the second training course, these were classified as learning outcomes. By using Bloom's Taxonomy, we can better analyze the findings, as illustrated in Table 9.

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Table 9.
Analysis of Learning Outcomes of the Second Training Course.

Learning outcomes	Cognitive/Knowledge Dimensions	Targeted subject and concept
LO1: The student learns about the basic concepts of e-learning, its characteristics, benefits, and educational capabilities for VIS	Conceptual knowledge / Understanding dimension	E-learning, its characteristics, benefits, and educational capabilities for VIS
LO2: The student recognizes how to use the Blackboard icons	Conceptual knowledge / Remembering the dimension	The Blackboard icons
LO3: The student learns how to Accomplish tasks of the courses required of him/her	Procedural knowledge/Appling dimension	Accomplishing tasks through blackboard
LO4: VIS learn ways to communicate effectively with faculty members through the Blackboard	Conceptual knowledge / Understanding dimension and applying dimension	Methods of communication during the blackboard
LO5: The student gains knowledge about learning methods on the Blackboard platform.	Conceptual knowledge / Understanding dimension	The learning methods on the Blackboard platform
LO6: The student understands the appropriate methods for completing the activities required of them and submitting them through the Blackboard	Conceptual knowledge / Understanding dimension and applying dimension	The appropriate methods for completing the activities during the Blackboard
LO7: The student masters the skills of using the individual and self-learning systems found on Blackboard	Conceptual knowledge / Evaluating dimension	The individual and self-learning systems found on Blackboard
LO8: The student employs computer education systems in appropriate educational situations	Procedural knowledge/Applying dimension	computer education systems

The data shown in Table 10 includes the analysis of the learning outcomes from the second training course: Specifically, LO1 pertains to acquiring basic knowledge about E-learning, encompassing concepts related to E-learning, its features, benefits, and educational potential for VIS. Meanwhile; LO2 encourages students to become familiar with using Blackboard icons to aid in recalling these dimensions; LO3 helps students learn how to accomplish course-related tasks through the Blackboard; LO4 is designed to support VIS with developing communication skills with faculty members through the Blackboard; LO5 focuses on teaching students various learning methods within the Blackboard platform; LO6 encourages students to understand the appropriate methods for completing and submitting assignments through the Blackboard by applying required dimensions; LO7 helps students master the skills of using the individual and self-learning systems found on the Blackboard that target individual and self-learning systems; Finally, LO8 instructs students on the appropriate use of computer-based educations systems in various educational contexts.

Table 10.
The Result of the Pre-test and Post-test Analysis.

N	S1		S2		S3		S4	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
O1	✗	✓	✗	✓	✗	✓	✗	✓
O2	✗	✓	✗	✓	✗	✓	✗	✓
O3	✗	✓	✗	✓	✗	✓	✗	✓
O4	✗	✓	✗	✓	✗	✓	✗	✓
O5	✗	✓	✗	✓	✗	✓	✗	✓
O6	✗	✓	✗	✓	✗	✓	✗	✓
O7	✗	✓	✗	✓	✗	✓	✗	✓
O8	✗	✓	✗	✓	✗	✓	✗	✓

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5. Conclusion

The research paper was motivated by the need to provide equal opportunities to VIS who often face numerous challenges in acquiring quality education and job opportunities. Consequently, it investigated the challenges faced by VIS in accessing quality education and employment opportunities. It, hence, provided specialized AT rehabilitation to improve students' digital literacy and employability skills. This study sought to empower VIS to become more independent and self-reliant. By highlighting the role of AT in promoting inclusivity and equal opportunities, the study hoped to create a more inclusive and equitable society for visually impaired individuals. The integration of assistive technology-based training in mainstream education can provide visually impaired students with equal learning opportunities and empower them to become better future employees. The study highlights the importance of providing visually impaired students with appropriate assistive technology tools and training to access and utilize education and employment opportunities. The study recommends the incorporation of assistive technology-based training in the mainstream education system to build an inclusive society that provides equal opportunities for all.

The necessity of AT services continues to increase with the rising number of individuals with visual disabilities. Saudi Arabia, with a significant population of VIS, requires educational advancements, and the integration of assistive technology is crucial for enhancing their learning effectiveness. Professionals and other related disciplines in Saudi Arabia needed to be prepared for technological challenges related to assistive technology and its application for the welfare of VIS.

At the same time, ensuring the affordability of assistive technologies for VIS is essential to assist them in overcoming the challenges highlighted in the study's findings when engaging with E-learning. With that being said, significant efforts should be dedicated to facilitating VIS in utilizing contemporary technological tools for campus navigation and modern applications. This initiative can further promote inclusivity within the campus environment, effectively narrowing the existing gap in discrimination between individuals with and without disabilities.

5.1. Study Limitations & Future Research

It deems necessary to identify the most appropriate AT to meet the needs of students according to their disabilities, as well as to promote training plans for teachers in order to implement these tools properly in the classroom. In this way, future research should explore the use of AT in relation to the type and degree of disability of learners. In this sense, it is also necessary to investigate effective teaching and learning strategies for these learners. In order to do so, it is necessary for teachers to have an adequate level of training, so that they can apply these tools in the classroom.

5.2. Study Implications

All educational institutions in Saudi Arabia should seek to offer better assistance to students with disabilities, including ensuring a setting for learning that is adapted to their requirements and suitable infrastructure. Appropriate mechanisms should be established to provide improved AT support for impaired students. A relevant unit or center should be established to promote VIS ongoing education and increase accessibility of AT. Ideally, both VIS and their instructors should be well-trained on how to utilize AT in the classroom and in all other learning facilities.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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