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ORIGINAL RESEARCH

The role of assistive technology devices in fostering the participation and learning of students with visual impairment in higher education institutions in Tanzania

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ABSTRACT

Purpose of the article: This study explored the role of assistive technology devices in facilitating the participation and learning of students with visual impairment in higher education institutions in Tanzania.

Materials and methods: Twenty-one respondents were purposively involved in an open-ended questionnaire survey and semi-structured interview, seventeen of whom were students with visual impairment and four were transcribers. Data were analysed using descriptive and thematic analysis.

Results and conclusions: The study found that students with visual impairment were well-acquainted with the meaning of assistive technology. However, their knowledge was limited to the assistive technology devices available at their institution. Most of the students with visual impairment emerged as *dependent* users of assistive technology devices, who depend on the support of either sighted students or a more skilled person. The study further established that the institution under review has only a few basic assistive technology devices, at the disposal of students. The study also established the benefits of assistive technology for students with visual impairment as giving them greater access to educational materials and widening their employment prospects. Based on these findings the study recommends that higher education institutions provide adequate and sustainable funding for assistive technology to ensure that students with visual impairment benefit from the education they get. Furthermore, students with visual impairment need encouragement to make use of the modern assistive technology devices available and learn how to use them to ease their sense of exclusion and dependence on sighted students.

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Visual impairment; assistive technology; higher education; learning

➤ IMPLICATIONS FOR REHABILITATION

- The accessibility of assistive technology for persons with disabilities is a human right just as access to medical or other health services, and education.
- People with disability including those with visual impairment need utmost support for them to acquire and access AT to enhance their participation in learning and contribution to societal development without unnecessary inhibitions.
- Students with visual impairments (VI) require a variety of learning support mechanisms to cater for their learning and mobility needs to be productive in society.
- Stakeholders should develop strategies that focus on supporting and meeting the learning needs of students with VI. These interventions may include assessing the nature of the learning disability and environmental modifications to enhance the learning performance of such students as well as ensuring both the availability and accessibility of AT devices and products for students with VI.
- Inclusion of assistive technology in the national disability policy can serve as a guide for supporting students with learning difficulties including those with VI on a sustainable basis and within the national framework.
- When included in the policy, education stakeholders and people with VI can have grounds to fight for and defend their rights enshrined in both the constitution, legal instruments, and policy documents.

Introduction

Numerous articles have been published over the past few years on the effective use of technology to help individuals with learning disabilities [1–3]. Though technology has been widely employed in the classroom for some time, relatively little attention has been paid, particularly in the developing world, to including students with visual impairment (VI). Yet, studies have shown that technological tools can improve the learning and performance of these individuals [4–6].

In fact, enhancing the learning and participation of students with VI in inclusive educational settings requires the provision of materials in an accessible format and/or use of assistive technology (AT) [7,8]. In this regard, extant literature defines AT as any acquired, modified or customised resource or facility to increase,

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maintain or enhance the functional capabilities of a person with a disability [9–11]. It incorporates the use of either software (audio method) or devices that enlarge standard print or provide access to ink print using software [7,12].

Students with VI either have low vision or are totally blind [13]. Those with low vision can read books in large print using their primary means of learning (vision) or with the aid of magnifying devices, whereas totally blind students rely on tactile (Braille print) and auditory senses to learn [8,13]. However, with the introduction of modern devices and advances in technology, AT has proven to be more useful in enhancing the learning and participation of students with VI in addition to boosting their ability to cope with the demands of the challenging inclusive setting in schools [4,7,8].

In this era of educational inclusion, integration and globalisation, students with VI at all educational levels need AT to facilitate their participation in learning activities, improve and achieve their educational outcomes, such as learning, communication and self-sufficiency, and, eventually, become useful citizens [6,11,14,15]. In the absence of books in Braille and large print formats in most libraries in Tanzania's higher education institutions [16–19], AT is an invaluable alternative for students with VI to optimise their education outcomes [11].

Classification of assistive technology

The World Health Organisation [20] listed fifty AT devices for people with diverse disabilities, sixteen for persons with VI. For example, people with low vision can use magnifying devices whereas totally blind people can have recourse to Braille print, Braille writing equipment and white canes to comprehend the information given.

Assistive technology falls under either low-tech or high-tech categories [4,21]. Low-tech devices include typewriters, manual Perkins Braille machines and white canes whereas high-tech devices include, screen readers (Non-Visual Desktop Access (NVDA), Microsoft Job Access with Speech (JAWS), magnifying devices (Closed-circuit television (CCTV)), Non-Visual Desktop Access, Braille note touch and embossers [4,6,22]. A screen reader gives computers a voice that translates written words and keyboard commands into human-sounding speech, which enables students with VI, especially those who are totally blind, to visualise on-screen displays, hence making it possible for them to read materials in electronic format, search for materials on the Internet, type their work and interact with others on social media [22,23,24]. Furthermore, magnifying devices that enlarge the font size enable students with low vision to read educational materials, either in hard copy or electronic format [6,7]. Similarly, embossers enhance communication between students with VI and sighted teachers/lecturers, by changing information from ink print into Braille and from Braille into ink print for sighted lecturers.

Senjam [6], who claims that there is no universal classification of AT for persons with VI, classifies them based on major educational activities undertaken: *reading* (close circuit television, low vision aids, optical magnifiers, computer with a screen reader, Braille print and embosser machine); *writing* (Perkins Braille, computer with a screen reader); *science* (tactile maps and diagrams); *mathematics* (talking calculators, Braille compass, ruler, protractor and abacus, tactile geometric kits and raised graphs); *orientation* and *mobility* (long walking canes); *games* and *leisure* (Braille cubes and chess); and *daily leaving activities* (talking watches).

Benefits of assistive technology in facilitating the learning of students with visual impairment in higher education

Improving reading and writing

AT is essential in improving the reading and writing of students with VI [15]. In this regard, extant literature indicates that, through AT, students with VI become more fluent and accurate when typing [25] by minimising typing errors occasioned by lack of vision when these students use a screen reader [26].

Improving comprehension and reading speed

Generally, AT tends to improve the comprehension and reading speed of students with low vision, as they can access educational materials either in large or standard format using AT [7]. To access materials in large format students with low vision require educational materials to be in optimal font size [24,26]. Students with low vision using AT can read literature with no difference evident between a student reading it in font size 10 with AT and one reading it in font size 18 [7,24]. In fact, print size determines reading speed [12]. In other words, students with low vision lack AT for accessing educational materials at their disposal, it would require more time to read them than their sighted peers.

Enhancing accessibility of electronic materials and audiobooks

Through screen readers, such as NVDA and JAWS, students with VI can easily access educational materials in electronic format, including e-journals, e-books, lecture notes and other materials [12,17]. Screen readers have enabled postgraduate students with VI in Tanzania to write their research proposals, PhD theses and master's dissertations, as few libraries have books in accessible formats [16].

Minimising over-dependence on sighted students

Students with VI have been found to depend significantly on their sighted peers due to the numerous academic barriers they experience in higher education [11,18,27]. The coping strategy of most postgraduate students with VI in Tanzania entail using readers in reading books and journal articles, which are not in accessible formats [28]. However, with AT, students with VI can access books and journal articles without depending on their sighted peers [24].

Enhancing accessibility of educational materials at any place and any time

The accessibility of Braille and large print books is limited in terms of time and space [7,24]. Implicitly, a student with VI seeking access to a Braille or large print book has to go to a library when it is open and read it there, or take notes, because, as reported by Kisanga [17], some postgraduate students with VI were not allowed to check books out. With the use of AT, students with VI can conveniently access education materials in their own time and space and at their own pace using an AT equipped computer and sufficient bandwidth to access the Internet [26].

Rationale for the study

Notwithstanding the benefits of AT for students with VI, many educational institutions use Braille and large print educational materials as opposed to AT [18,27,29], which is attributed to students with VI and support staff not knowing how to use AT, shortage of AT computers and other AT devices and the exorbitant cost of buying them [30–34]. The situation is even worse in developing countries such as Tanzania, due to the low level of

technology and irregular power supply [35]. Students with VI rely more on using readers to access books and journal articles than on using AT [17]. The over-dependence on readers has cast doubt on whether students with VI are well-versed with the role of AT in helping them to learn, and aware of the AT devices available in their educational institution.

Students with VI deserve attention because they suffer from limited access to information and social stigmatisation. Directly or indirectly, these factors reduce their chances of meeting their educational needs and accessing of social services within and outside their institution. This study, therefore, explores the awareness of students with VI and transcribers of the role of AT in enhancing the participation and learning of students with VI in higher education institutions. The following research questions guided the study.

1. What do students with VI understand about AT?
2. Which AT devices are needed to support the learning of students with VI?
3. Which AT devices are available at the institution under review?
4. How do students with VI access AT?
5. What are the benefits of AT for the learning and participation of students with VI?

Materials and methods

Participants

The study involved twenty-one respondents drawn from one higher education institution selected purposively due to its long experience in supporting students with VI in Tanzania [17]. These respondents comprised seventeen students with VI and four transcribers, who support them at the special education unit. Transcribers have undergone training to support students with VI in academic matters, particularly in converting materials from Braille to ink print and vice-versa. Their main role is to enhance the students with VI's access to education material in addition to linking lecturers and students. To avoid a low response rate, all the 37 students with VI were invited to participate in the study, but only 17 took part.

Procedure

Open-ended questionnaires and semi-structured interviews were used to collect data from the respondents on the types of AT that enhance the participation and learning of the students with VI, those available in their institution, and the benefits associated with AT. Open-ended questions helped to collect data and confirm students' readiness and ability to use AT. In this regard, the students responded to the questions in the questionnaire and dispatched it *via* email to the researcher. Specifically, students with VI were asked to choose a method they were more comfortable with between a semi-structured interview and open-ended questions in a questionnaire. Four (4) out of seventeen students opted for participation in semi-structured interviews whereas thirteen students chose the questionnaire. All four transcribers responded to the questionnaire with open-ended questions.

The study adhered to all ethical issues, such as informed consent, anonymity, and confidentiality before and after data collection, and during data analysis [36,37]. Verbal consent was obtained from all the respondents involved in the study prior to data collection. Regarding anonymity, the institution involved in this study remains unidentified and is presented simply as a public institution *under review,* whereas students with VI are referred to as S1 to S17 and transcribers as T1 to T4. Moreover, in the verbatim quotations, UG stands for *undergraduate* and PG stands for *postgraduate* students. Similarly, TB represents *totally blind* students and LV *low vision* students.

Data analysis

The resultant data were subjected to descriptive and thematic analysis aimed to identify, organise, interpret and establish the themes emerging from the data [38–40]. The analysis was guided by Clarke and Braun's six stages [39]. The deductive method mainly helped to derive themes and sub-themes from the data [40]. The literature on AT for students with VI that was reviewed in relation to the research objectives. The inductive method was also used to generate themes, especially in relation to the second and third research questions, which explored whether the AT available at their institution benefitted students with VI [40,41]. The study used descriptive analysis to present the data in frequencies and percentages.

Results

Characteristics of participants

The study collected data from 21 respondents, 17 of whom were students with VI and four were transcribers, all drawn from one public higher learning institution in Tanzania. All the respondents completed a self-administered questionnaire.

Students

Out of the 17 students involved in the study, five (29.5%) were females and 12 (70.6%) were males. In terms of degree programme, eight (47.1%) students were pursuing a bachelor's degree, six (35.3%) a master's degree and three (17.6%) a PhD, as illustrated in Table 1.

As Table 1 on the age profile illustrates, two (11.8%) were aged between 18 and 22, five (29.4%) between 23 and 30, and 10 (58.8%) were aged above 30. Data on the nature of impairment indicated that 13 (76.5%) students were totally blind whereas four

Table 1. Basic characteristics of students.

		Frequency and percentage in the study	
Characteristics	Category	*N*	%
Gender	Female	5	29.4
	Male	12	70.6
Degree programme	Bachelor's Degree	8	47.1
	Master's Degree	6	35.3
	PhD	3	17.6
Age group	18−22 years	2	11.8
	23−30 years	5	29.4
	Over 30 years	10	58.8
Nature of impairment	Totally Blind	13	76.5
	Low Vision	4	23.5
Onset of impairment	0−6 years	5	29.4
	7−14 years	5	29.4
	Over 14 years	2	11.8
	Born with It	5	29.4
Education placement (Primary education)	Inclusive	9	52.9
	Special	3	17.6
	Integrated	4	23.5
	Regular	1	5.9
Education placement (Secondary education)	Inclusive	14	82.4
	Special	1	5.9
	Integrated	1	5.9
	Regular	1	5.9
Total		17	100.0

(23.5%) had low vision. Regarding the onset of impairment, the analysis revealed that, 12 (70.6%) students suffered the impairment after they were born whereas five (29.4%) were born with it suggesting a further research to determine the cause of it. Among those who suffered the impairment after birth, for five (29.4.0%) students this development occurred when they were aged between 0 and 6, five (29.4%) at between 7 and 14, and two (11.8%) after the age of 14. Finally, the data on education placement shows that most of the students received inclusive education in both primary and secondary school.

The information presented in Table 1 shows that the most of students in this study were totally blind males aged above 30, pursuing a bachelor's degree. Moreover, they acquired blindness during their childhood and attended inclusive primary and secondary schools.

Transcribers

Of the four transcribers, one was female and three were male. Two had a master's degree and the other two had a bachelor's degree. Their work experience ranged from 1 to 13 years and all had specialised in visual impairment (Table 2).

Respondents' understanding of assistive technology

The first research question explored the respondents' understanding of AT. In particular, the participants responded to the question: "What do you understand by the term, 'assistive technology'?" Data was collected using questionnaires with open-ended questions and semi-structured interviews involving all the 21 respondents. The responses were analysed to identify the most recurring themes, as summarised in Table 3.

The data in Table 3 summarises AT as devices, services, software programmes and products, whether acquired commercially off-the-shelf or modified or customised to increase, maintain or improve the functional abilities of individuals with a disability to participate in the learning process. The definition provided by the respondents suggests that students with VI at the institution under review are conversant with what AT entails.

Assistive technology devices supporting the learning of students with VI

The second research question explored whether students with VI were aware of AT devices that could facilitate their participation and learning process. The participants responded to the question: "Which AT devices are needed to support the learning of students with VI?". The response s from all the participants were as summarised in Figure 1.

Figure 1 shows that a computer with a screen reader was the AT device mentioned by most of the respondents (18, 85.7%) followed by the Perkins Braille and embossers, which were both mentioned by 13 (61.9%) of the respondents. Free open-source screen readers, Non-Visual Desktop Access (NVDA), Thunder screen reader or Microsoft Job Access With Speech (JAWS), which allow blind and visually-impaired students to read the screen with text-to-speech output, were also mentioned by many of the respondents. Voice recorders, electronic white canes and note-takers were also reported as useful for fostering participation and learning whereas a video magnifier, though important, was mentioned by only seven (33.3%) respondents.

Assistive technology devices available at the institution under review

The third research question explored the AT devices available for students with VI at the institution under review. In particular, the study aimed to answer the question, "Which assistive technologies are available at your institution?" Figure 2 presents the responses of all the 21 participants:

Of the 21 respondents, 19 (90.5%) confirmed the existence of computers with a screen reader, that students with VI frequently used. Other items available at the institution under review were reported to be embossers (Braille printers) with Duxbury software, mentioned by 16 (76.2%) respondents, and Perkins Braille reported by 15 (71.4%) respondents. Furthermore, a voice recorder and white cane were reported by 14 (66.7%) and 13 (61.9%) respondents, respectively. However, the white canes mentioned were not digitised and the electronic note-takers were not in use because they were damaged. Other AT devices mentioned were close circuit television and typewriters.

Table 2. Basic characteristics of transcribers.

				Duration in the Special Unit		
Transcriber S/N	Gender	Position in the Special Unit	Specialization	Months	Years	Qualification
T1	M	Transcriber	VI	156	13	Master
T2	M	Transcriber	VI	90	7.5	Master
T3	F	Transcriber	VI	2	0.17	Bachelor
T4	M	Transcriber	VI	12	1	Bachelor

T: Transcriber.

Table 3. Definition of assistive technology by the respondents.

		Frequency and percentage in the study	
S/N	Definition of assistive technology: *Themes that emerged*	*N*	%
1	AT devices and services, whether acquired commercially off-the-shelf or modified or customised, are used to increase, maintain, or improve the abilities of individuals with a disability	2	10
2	They are any equipment, item, software program or product that are used to improve, maintain or increase the functional abilities of persons with VI, hearing and intellectual impairment to participate, achieve or be independent.	3	14
3	They are devices or instruments that facilitate the learning and interactions of persons with disabilities	11	52
4	They are special systems designed to enable a person with VI to utilise the existing tools designed mainly to be used by non-disabled persons	5	24
	Total	21	100

NB: $N = 21$ (include both students and transcribers).

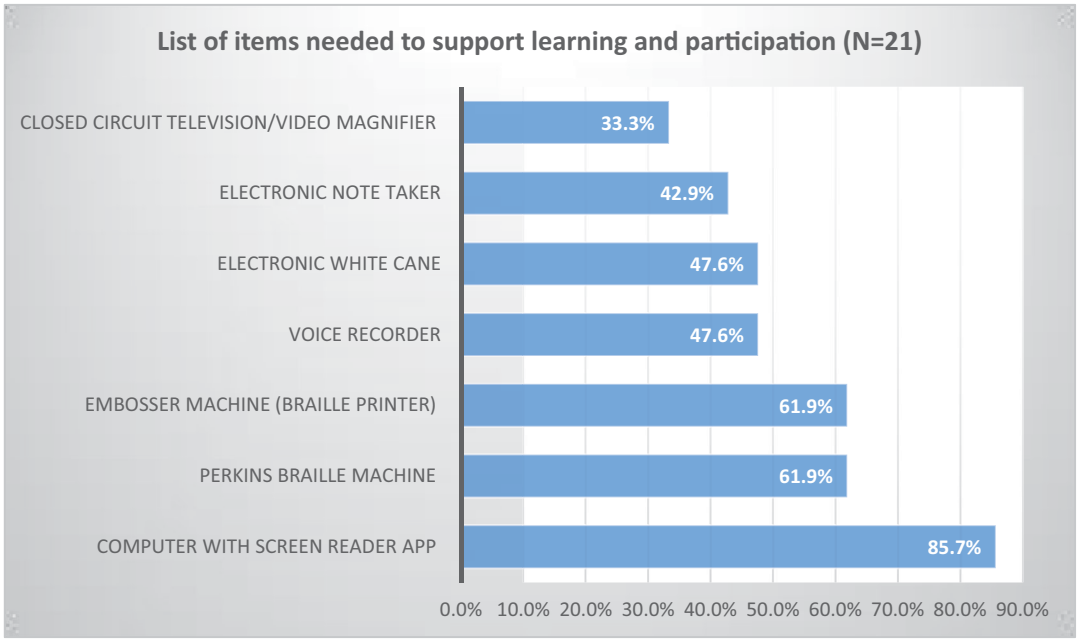

Figure 1. List of items needed to support learning and participation.

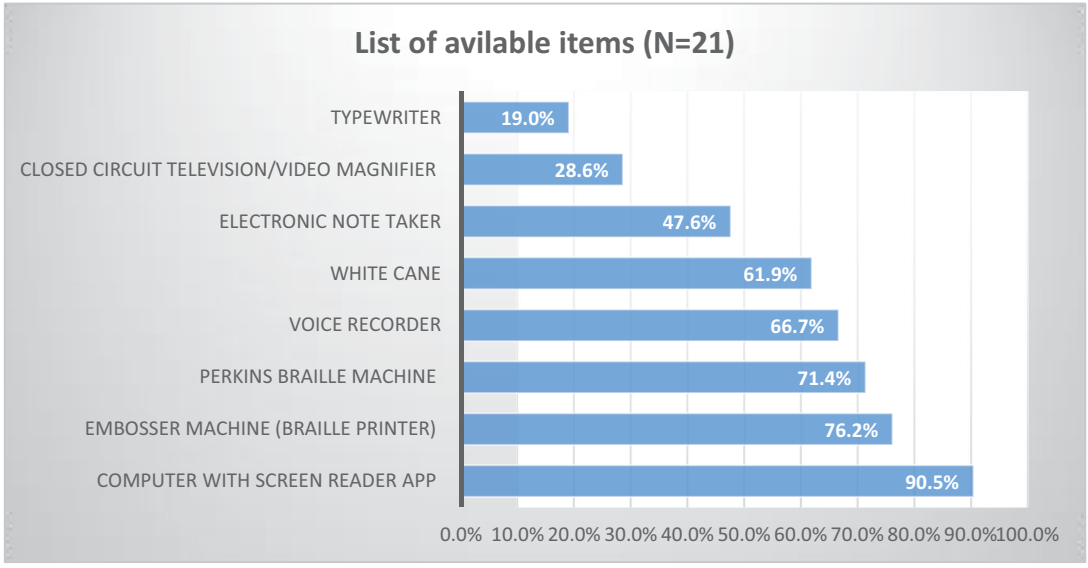

Figure 2. List of items available at the institution under review.

Students' access to the assistive technology devices available

The fourth research question investigated how students accessed the AT devices available. In this regard, the study was aimed to answer the question, "What is your opinion of the accessibility of assistive technology devices available at your institution?" The responses of students with VI revealed that they could access them as either *partially dependent* or *fully independent* as Table 4 illustrates.

Partial accessibility

The study results indicate that most of the students (70.6%) depended on the support of either staff from the special education unit or sighted colleagues when accessing AT devices. This group of students are categorised in Table 4 as *partially dependent* because they can sometimes access AT devices on their own, but require the help of others during other times because of their lack of knowledge on some advanced computer applications. In this regard, S14 said:

> I can access AT devices independently when performing some functions (e.g. writing, reading or editing a word document using a computer, or audio recording and replaying the content, etc.), but I need the assistance of a non-visually impaired person when performing some functions, such as drawing tables and figures using a computer (S14, Male, PG, TB)

Similarly, S8 said, "I can use some AT devices by myself, but not others, for example, I may need a sighted person to help with some functions on the computer. Otherwise, I can copy and read documents on my own" (S8, Female, UG, TB). The narrations of S14 and S8 show that some students with VI can use AT for simple operations; however, they need the sighted person's help for sophisticated tasks such as drawing tables and figures, which suggests that they lack sufficient knowledge on AT and attendant applications. These findings also indicate that students'

Table 4. Accessibility of assistive technology devices by students with VI.

Accessibility of AT devices: *themes that emerged*		Frequency and percentage in the study	
		N	%
Fully Independent	I can access AT devices independently. For instance, I normally use my personal computer installed with NVDA to write reports, assignments, emails and documents using MS Power point and Excel. I also use a smartphone with an inbuilt Android accessibility suite (Talkback screen reader) to write documents, email, chat using WhatsApp, make calls, compose and send messages, withdraw and send money (through sim-banking), and pay bills. I also access information on YouTube, Facebook, and other social media (S1, Male, PG, TB). I can access AT devices independently by writing with the use of a personal computer. I also write Braille using Perkins Braille or Marburg frames. I also listen to various readings using NVDA installed in the computer (S4, Male, PG, TB) Independently, because the operation has been reconciled with the user (S11, Male, UG, LV), (S11, Male, UG, TB)	4	23.5
Partially dependent (i.e. human assistance was required to access some devices)	I can access Perkins Braille, white cane and typewriter independently. I can access the rest with assistance (S2, Male, PG, TB); I can easily access some AT devices without assistance, for instance, Perkins Braille and white canes. However, it is difficult for me to operate some devices, such as digital voice recorders and electronic note takers, because either they don't have screen readers (e.g. digital Voice Recorders) or I have not been trained (e.g. electronic note takers). In addition, some devices cannot be accessed by students with VI because they are for office use only (e.g. embossers) (S3, Male, PG, TB). I can use the following AT devices independently, Braille machine, voice recorder, white cane and smart phone, but the rest I can't use independently. (S5, Female, PG, TB) Normally, I access the available AT devices independently or with assistance (S6, Male, PG, TB) Sometimes we need assistance but in most cases we can access them independently (S13, Female, UG, LV) Some of the AT devices I can use by myself, but not others, e.g., computers. For some functions I may need a sighted person. Otherwise, I can copy and read documents on my own (S8, Female, UG, TB) We were given training so I can access most applications myself. But on other occasions I need assistance (S10, Male, UG, TB)) I can access them independently when performing some functions (e.g. writing, reading or editing a word document using a computer, or audio recording and replaying the content, etc.), but I need a non-visually impaired person to assist me with performing some functions, such as drawing tables and figures using a computer (S14, Male, PG, TB) Independently as I know how to use some of them (S15, Female, UG, TB) In most cases I am independent but sometimes human assistance is necessary (S16, Male, UG, LV) I can access AT devices with the help of readers, who help me to access e-books, journals, soft and hard copy materials (S17, Female, PG, TB)	13	76.5

dependence when operating devices such as digital voice recorders and electronic note-takers stem from their lack of screen readers:

> I can easily access some AT devices without assistance, for instance, the Perkins Braille and white canes. However, I find it difficult to operate devices, such as digital voice recorders and electronic note takers, either because they don't have screen readers (for example, digital voice recorders) or I haven't been trained to use, for example, electronic note takers. In addition, some devices cannot be accessed by students with VI because they are for office use only (such as embossers) (S3, Male, PG, TB).

This statement suggests two major barriers to the accessibility of AT for students with VI in higher education institutions in Tanzania: The shortage of AT devices and limited knowledge on how to operate them. In other words, higher education institutions should consider the prior knowledge of learners when buying AT software and devices and should equip students with the knowledge and skills for using such AT devices before introducing them.

Additionally, the study found that *partially dependent* students easily accessed the Perkins Braille machines, voice recorders, white canes, smart phones and typewriters independently, without any human support, as remarked by S2: "I can use Braille, voice recorders, white canes and smart phones, but I can't use the rest independently" (S5, Female, PG, TB). In the same vein S2 said, "I can access Perkins Braille machines, white canes and typewriters independently, but I can access the rest with assistance" (S2, Male, PG, TB). These two statements imply that the most of the students with VI in the institution under review were more able to operate low than high tech devices due to their lack of exposure to the latter at the lower levels of their education. It was also established during analysis that most of the students with VI started learning how to use computers and associated software in higher education.

Overall, most students with VI were found to be more conversant with low tech AT devices, which they can access without human assistance, but may require support from their readers or sighted colleagues to access computers with screen readers. Because these devices contain advanced features, students with VI may need further training to eliminate dependency and utilise AT devices much more independently. Although they had a basic knowledge of the few devices available, they need to be exposed to the more advanced AT devices to enable them to become independent.

Fully independent accessibility

The second category of learners, however, indicated to be *fully independent*. These were four (23.5%) students who reported not requiring human support to operate AT devices. As S1 put it:

> I access AT devices independently. For instance, I normally use my personal computer installed with NVDA to write reports, assignments, emails. and documents using MS Power point and Excel. I also use a smartphone with an inbuilt Android accessibility suite (Talkback screen reader) to write documents, emails, chat using WhatsApp, make calls, compose and send messages, withdraw and send money (through sim-banking) and pay bills. I also access information on YouTube, Facebook, and other social media (S1 Male, PG, TB).

In a similar vein, S4 explained

> I can access the AT devices independently writing with the use of a personal computer. I can also write Braille using Perkins Braille or

> Marburg frames. I can also listen to various readings using NVDA installed in the computer (S4, Male, PG, TB).

Although most of the students with VI depended on sighted colleagues to access AT devices, some accessed and used AT devices independently. All the four students, who reported having the ability to access AT devices independently, were male. This calls for further analysis to examine the influence of gender on the accessibility of AT devices.

Assistive technology devices' benefits for students with VI

The fifth research question investigated the benefits of AT devices in facilitating the participation and learning of students with VI. Data was collected from both students with VI and transcribers. The findings from the study revealed six themes as summarised in Figure 3. The six themes are expounded below.

Increase self-confidence and independence

The study findings show that students' self-confidence and independence are major benefits accruing from AT devices, as reported by 52.4 percent of the participants using an AT device. In this regard, S3 said, "AT increases the independence of a person with VI when it comes to accessing soft copy materials. A screen reader can be put on a computer screen to read such materials with ease" (S3, Male, PG, TB). Another respondent similarly argued, "Assistive technology gets rid of dependence and evens the playing ground for people with and without disabilities" (S9, Male, UG, TB). These two statements suggest that AT devices reduce the dependence of students with VI on sighted students, including their readers. Consequently, the students could work independently at their own pace. In fact, those who depended on sighted students were forced to work at the pace in accordance with the timetable of their assistants. This reality has cost implications for higher learning institutions, as a good number of students with VI and those with special needs use AT devices; they may reduce the number of *personal assistants* who support these students in academic matters when the application of AT took hold among students.

The state of independence reported in this study does not only relates to academic issues but also to the orientation and mobility of students with VI, who reported that they use white canes to be less dependent on sighted human guides. In other words, the white cane simplified their daily routine as they could plan for a certain activity without worrying about getting support from sighted persons. Independence in using AT devices for most activities also gave them more privacy than usually possible.

Figure 3. Benefits of Assistive Technology.

Enhancing students' interactions

The respondents reported AT devices to enhance students' interactions among themselves regardless of their disabilities, with their lecturers and the learning content. This AT benefit was reported by 33.3% of the respondents. In this regard, S17 said, "It simplifies student-teacher, student-student and student-content interactions". As such, AT devices have facilitated socialisation and communication between students with VI and their counterparts, on the one hand, and with their lecturers, on the other hand. Specifically, the students with VI reported that AT enabled them, especially at the postgraduate level, to send their research work in electronic format as an attachment *via* email for the lecturer read and provide feedback. Moreover, findings show that students with VI could use AT devices to exchange on social media platforms, such as Facebook, Instagram, and WhatsApp.

The findings also indicate that students with VI use their smartphones with an inbuilt Android accessibility suite (talkback screen reader) to write documents, send emails and chat mainly on WhatsApp and Facebook. They also reported accessing information on YouTube and other social media. The *Talkback* application in their Android smartphones allowed them to hear what is on the screen or what they touch and get audible feedback. As a result, students with VI easily interacted with their devices and other users.

Generally, AT devices were found to motivate students with VI to participate in inclusive classrooms in addition to informing them about current trends not only on education, but also on worldly issues generally.

Enhanced access to electronic materials

Enhanced access to electronic materials emerged as the third benefit of AT reported by both responding students and transcribers. For example, T2 said: "AT devices enable students with VI to access and store information from the Internet and libraries around the world" (T2, Male, MA). Impliedly, AT devices reduce barriers that students with VI usually face when accessing of information and academic materials. Reinforcing this idea, a student said: "Assistive technology devices have now made it possible for students with VI to communicate with other persons, including those without VI, by sending and receiving emails and sharing academic resources online" (S11, Male, UG, TB). Moreover, students with VI can now independently access course outlines and the curriculum; previously they had to rely on the assistance of sighted students.

Widening of employment prospects and opportunities

The findings indicate other benefits associated with the use of AT devices revealed to include the enhanced job prospects and opportunities of people with VI in both the public and private sectors. One respondent reported, "With AT devices individuals with VI can compete with sighted individuals in the job market, regardless of their disability" (S16, Male, UG, TB). Another respondent said: "AT has increased the accessibility of information on jobs available and has helped me to advance my career" (S17, Female, PG, TB). These accounts suggest that the use of AT devices enhances the employability of persons with VI for two reasons. First, they provide direct access to information on job opportunities at the right time for persons with VI, instead of indirectly through third parties, their sighted peers, which occasionally resulted in getting job application information too late for them to apply for the vacancy. Second, AT makes then less dependent as they could now do things on their own without recourse to the sighted colleagues. In this regard, persons with VI

can perform their assigned duties at their workplace on their own using AT devices, thereby earning the trust of employers, who might have a negative perception of the abilities of people with VI.

Increased trustworthiness of students' work

Through using computers with screen readers, students with VI now can write, edit, proofread, format and correct their own, as opposed to typewriters devoid of such technology-enhanced features. Most significantly, AT devices allow lecturers to mark examination scripts of students with VI, without the services of a middle person – a transcriber: "Higher education students with VI are now able to take examinations using computers, which are marked directly by lecturers that was not possible before" (T4, Male, BD). This development allows lecturers directly mark examination scripts of students with VI. This has eliminated the doubt that existed before on whether the transcribed scripts really originated from the student without transcribers tampering with the responses [17].

Discussion

This study has explored the understanding of students with VI on AT, their awareness of such AT devices they need to participate and learn in higher education, the AT devices available and accessible in their respective institution, and the AT benefits that facilitate participation and learning. The study findings indicate that the most of the participants [76% ($n = 16$)] appear to be better acquainted with the meaning of AT, because they provided definitions that embraced all categories of disabilities, than the 24 percent ($n = 5$), whose definition focussed on individuals with VI alone. The definition provided by the respondents is consistent with the operational definition of assistive technology being "any resource or facility acquired, modified or customised to increase, maintain or enhance the functional capabilities of a child with a disability" [9–11]. Their understanding could be associated with the regular training students with VI receive at the institution under review in each academic year, coupled with their exposure to and interaction with the Internet as one of the sources of information for learning purposes. However, their awareness of requisite AT devices supportive of their learning process was limited to the devices available at their institution, since most of them mentioned only computers with a screen reader, Braille machines and embossers. The Braille note touch was mentioned by only one student who happened to own this AT device. It emerged that most of the students with VI relied more on the devices available in their institution, which are few in number, hence making them dependent on their sighted peers.

The results are also consistent with those of Oira's [42] study, which found that most of the research participants relied more on Braille machines and computers with screen readers for learning than on other AT devices. However, contrary to Oira's [42] study, most of the students with VI in this study favoured computers with screen readers to perform the tasks of reading/writing and searching for electronic resources on the Internet much more quickly and efficiently than when they deployed other AT devices. Yet, over-reliance on only the AT devices available in their institution meant that students with VI lacked interest in broadening their understanding of other potentially even more viable AT option that could further foster their participation and learning. Moreover, other AT devices appeared too expensive for either their institution with a limited budget or students with special education needs to afford them as individuals.

Furthermore, the findings on the AT devices available at the institution under review are consistent with those of Oira's [42] study that also established that, though scarce in number, computers with JAWS screen reader were far more popular than other AT devices among students with VI. This popularity could be attributable to most of the students owning laptops with free open-source screen readers. In fact, the institutional AT devices were only made available to the students with VI during examinations. Even then, evidence from secondary data suggests that the institution under review has concentrated on devices that are easily obtainable and cheaper than others that are essential – albeit more expensive – for this category of learners to enable them to learn with greater flexibility. This inclination appear tied to the stringent budget that hindered the growth of the education sector in Tanzania generally [43] and, inevitably, limited grants allocated to students with special education needs in the country [17,19]. Thus, higher education institutions need to have adequate and sustainable funding for students with special needs for the acquisition of AT and other supportive devices in addition to providing suitable learning environments for them.

The study also found that only four out of 17 students with VI who participated in this study were fully *independent users*. Implicitly, most of these students were *dependent users*. This scenario can be explained as follows. Three of the four students who were independent users were postgraduate students taking programmes that prompted them to search for materials from different sources, including the Internet, to enrich their academic research and writing. Thus they completed their assignments, wrote their proposals, conducted research and produced research reports independently. Undergraduate students, on the other hand, mostly depended on sighted peers and transcribers for their academic progress. These findings are consistent with Johnstone's [4], who also found that a good number of students completely depended on sighted individuals for assistance.

Furthermore, out of the four students found to be fully independent users, three were classified as totally blind since early childhood (0–6 years). In this regard, extant literature has revealed that the onset of impairment plays a crucial role in coping with such a state. Indeed, those who are born blind and those who go blind at a tender young (e.g., during pre-school) cope better with academic and social issues than their counterparts who go blind much later in life [28,44].

Overall, the study has underscored six themes – as outlined in the findings – on the facilitative benefits of AT devices for both undergraduate and postgraduate students with VI. In this regard, the findings concur with previous studies on the benefits of assistive technology [7,12,15–17,24–26], which show that AT devices reduce the barriers preventing persons with VI from functioning effectively in society. Indeed, they give these students the same opportunity to access and benefit from the education provided. This study indicates that AT devices *widen the employment prospects and opportunities* for people with VI by making them independent learners and employees. This finding is consistent with Lancioni [45], who similarly found that AT devices enable persons with VI to get engaged in simple occupations and work activities.

Several studies have explored factors associated with the unemployment of persons with VI [11,17,18], which include employers' negative perception that it would cost them more to hire people with VI because they would also have to pay for their personal assistants [17]. In other words, persons with VI are more likely to be unemployed than those who are sighted because of this double-pay requirement. In fact, global data from the *World*

Report on Disability shows that "persons with disabilities experienced significant labour market disadvantage" than persons without disabilities [11, p. 11]. If employers' negative perception of the ability of people with VI is not addressed, it might lead to their being discriminated in getting employment. Thus, employers need to make recruitment receptive to persons with VI and provide an adaptive working environment and AT devices that would engender their independent existence at the work place. As the World Health Organisation [11, p. 13] aptly contends, "increasing access to assistive technology increases independence, improves participation, and may reduce care and support costs". With AT, persons with disabilities generally and those with VI specifically could accomplish tasks on their own without depending on the goodwill of sighted people.

Conclusion

Students with VI require a variety of AT devices to cater for their learning and mobility needs in addition to enabling them to write and read proficiently and become self-reliant. This study has explored the role of AT devices in helping students with VI in higher education institutions. In particular, the study has established that students with VI had a good understanding of AT devices, although their knowledge was limited to those ATs available at their institution. As such, there was a need to expose them to other essential modern AT devices. After all, the study found that these students were more familiar with computers with free open-source screen readers and Braille machines than with other devices, such as Braille note touch. The AT devices reported in the institution under review suggest that the budg*et al*located to higher education institutions, including the one under review, does not consider the specific needs of students with VI and others with special education requirements.

Implications for rehabilitation

The accessibility of assistive technology for persons with disabilities is a human right just as access to medical or other health services, and education. Students with VI require a variety of learning support mechanisms to cater for their learning and mobility needs to be productive in society. Stakeholders should, thus, develop strategies that focus on supporting and meeting the learning needs of students with VI. These interventions may include:

i. Assessing the nature of the learning disability and whether it significantly limits the students' functional capacities. This can serve as a basis for developing effective learning strategy.
ii. Environmental modifications based on individual's needs in an educational institution, which are vital to smoothen the mobility and enhance the learning performance of such students.
iii. Ensuring both the availability and accessibility of AT devices and products for students with VI. After all, availability of AT devices without ready accessibility could be counterproductive. In this regard, education institutions can make AT accessible through regular training on ICT and AT for both students with VI and their transcribers.
iv. Inclusion of assistive technology in the national disability policy as such a blueprint can serve as a guide for supporting students with learning difficulties including those with VI on a sustainable basis and within the national framework. When included in the policy, education stakeholders and people with VI can have grounds to fight for and defend their rights enshrined in both the constitution, legal instruments, and policy documents.

What the study findings, conclusion and recommendations suggest is that people with disability including those with visual impairment need utmost support for them to acquire and access AT to enhance their participation in earning and contribution to societal development without unnecessary inhibitions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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