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Assessment of the Benefits and Challenges of Digital Braille Assistive Devices in Promoting Inclusivity of Learners with Visual Impairment in Kenya

Joyce Gikandi[1], Serah Kimaru[2], Judy Mwangi[3] and Mary Mugwe[1]

[1]School of Education, Mount Kenya University, Kenya
[2]School of Social Sciences, Mount Kenya University, Kenya
[3]School of Law Arts and Social Sciences, Kenyatta University, Nairobi Kenya
P.O Box 342 01000, Thika, Kenya
Corresponding Email: jwgikandi@mku.ac.ke

ABSTRACT

This study focuses on assessment of the benefits and challenges of digital braille assistive devices in relation to their relevance in promoting inclusivity of learners with visual impairment (VI) in special and integrated education. The study was guided by universal design for learning and assistive technology theories. The study adopted a descriptive survey design within a mixed methodology approach. The study was restricted within 2 institutions in Kenya: a private University (mainstream) and a special school for the blind. The two key study objectives were to assess the benefits of digital assistive devices for the learners with VI in relation to promoting inclusivity in education. Secondly, the study examined the challenges learners face in using these devices in special and mainstream education. The findings show that using digital braille assistive devices for visually impaired learners offer significant benefits. The key benefits include promoting educational access, learner's independence and enhancing learning opportunities. However, several barriers remain inadequately addressed. Barriers include adequate device access, device maintenance/repair delays, limited training, and inadequate support systems. The study underscores the importance of increasing device availability, improving maintenance and support, and adequate training for both learners and educators. Despite the challenges, the devices' potential to improve inclusivity and foster independence is evident. The study recommends that the government should develop and implement a national policy that ensures adequate availability of digital braille assistive devices. Schools should establish robust policy and support systems for use of assistive technologies, and regular training for both students and educators.

Keywords: Visual impairment, Digital assistive technologies, Inclusive education, Learner independence, Equitable education access

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1. INTRODUCTION

1.1. Introduction

This study was motivated by the works of various digital assistive devices developers who have continued to innovate solutions towards increasing access to education for the blind and visually impaired learners. By enhancing provision and effective use of digital braille assistive devices; coupled with access to digital literacy skills and support for the learner VI, their access to quality education can be increased thus developing the competences and confidence they need to access employment, become independent and live normal lives as adults (Arslantas & Gul, 2022; Kilimanjaro Blind Trust Africa, 2020). As digital braille assistive devices continue to evolve, the learners with VI can interact better with their teachers and other learners including the sighted using the modern digital braille devices that are mobile enabled (Kamaghe, 2021). With the freedom and flexibility that digital assistive devices can provide, they are able to have improved access to education and diverse information. Thus, the visually impaired will have enhanced learning opportunities for real inclusion in their adult lives. The term learner with visual impairment (VI) as used in this study refers to both those who are blind and those with low vision, who mainly rely on assistive devices (manual or digital) for their studies and information access (Le et al., 2022).

Globally, at least 2.2 billion people are visually impaired, most of this population are above 50 years and the majority live in Sub-Saharan Africa (World Health Organization, 2021). The numbers of people with visual impairment (VI) have continued to increase mainly due to increase in population and conditions of hygiene, poverty and ignorance (World Health Organization, 2021). Even though 85% of the VI cases are due to preventable causes, VI continue to pose huge global health and financial burden that led to inequality and productivity losses (World Health Organization, 2021). In Kenya, the prevalence of VI among children is estimated to be 2.4% of the total population (Fricke et al., 2018; Muma & Obonyo 2020). The Kenyan Government and other stakeholders in education are increasingly focusing on the needs of the learners with VI as a strategy to promote access and inclusivity in education for all (UNESCO, 2020). Sight limitations if not well managed have negative effects on educational achievements of the VI learners (World Health Organization, 2021). Inadequate focus on the needs for learners with VI can limit achievement of SDG No. 4 on access to quality education and lifelong learning opportunities for all (United Nations, 2015). Lack of appropriate tools and strategies including adequate resources,

continue to undermine inclusivity of learners with VI within school environments and other socialization systems especially in developing nations (Mpu & Adu, 2021).

Use of Digital Assistive Devices for educational inclusivity of Learners With VI

Inclusive education as an educational approach implies all learners, with or without disabilities, to be able to learn effectively and to the best of their ability. Effective technology integration can facilitate and enhance learners with VI with the ability to access the general education curriculum, offering them diverse means to complete their work with greater ease and independence in performing tasks that they were otherwise unable to accomplish, or had great difficulty in accomplishing (Ahmad, 2015; Fernández-Batanero et al., 2022; Kisanga & Kisanga, 2020). This implies that assistive digital device technologies help Learners with VI to overcome the 'functional barriers to productive educational experiences and quality participation (Fernández-Batanero et al., 2022). Assistive digital devices offer learners with VI a meaningful educational benefit, together with others, in an accessible physical and human environment. education. While emerging digital assistive devices are gaining popularity and widespread acceptance; it is also important to note that, for some users, the traditional devices are still preferable for certain tasks, including those requiring extensive typing or editing (Natalina et al., 2022). This implies the necessity for designers and rehabilitation personnel in understanding the factors influencing device usage.

Typically, learners with VI have difficulty accessing visual material in printed form or on the computer screen. From a simple device like a magnifying glass, to a complex computerized device or software, the assistive technologies for the VI can be used by learners on their own or with assistance, within and beyond the classroom setup (Mulloy et al., 2014). Some of the examples of digital assistive technologies include touch-control devices, alternative keyboards and mouse, speech-to-text word recognition tools, word prediction programs, Optical Braille Recognition software, scanners, talking books and compact disc recording drives among others (https://www.levelaccess.com/blog/assistive-technology/). Scanners with optical character recognition can read printed material, which can then be stored electronically on computers, and be read using speech synthesis, or printed using Braille translation software and Braille printers. Such tools offer independent access to diverse educational resources for the visually impaired learners. For instance, speech output systems can be used to read screen text, while the screen readers or the text-to-speech software like JAWS (Job Access with Speech) can help the user in adjusting the volume, pitch and speed of reading, and in choosing or adjusting to a male or female voice according to their preference (Natalina et al., 2022). Use of common accessories such as earphones for individuals using speech output systems can mitigate the external distractions

associated with speech outputs. Additionally, providing narrative verbal description of the visual elements displayed on the screen can support the learners to automatically engage with the descriptions of all the visual elements thus enhancing opportunities for socialization and knowledge building (Natalina et al., 2022). Moreover, the use of special digital tools or computerized features for the modification of display or printer output can be helpful for the learners with low vision who typically have difficulty reading the standard size of letters on the computer screen or printed documents. Such opportunities can help to increase access and readability for the learners with VI. Smartphones and tablets have also had substantial impact in promoting educational inclusivity for the learners with VI especially due to their built-in accessibility features (Natalina et al., 2022).

Inevitably, promoting inclusive is the most critical ingredient in the development and empowerment of individuals, and inclusion in education irrespective of the varied socio-economic differences and the differences in 'abilities' and 'disabilities (Fernández-Batanero et al., 2022; Kisanga & Kisanga, 2020). This implies that the use of digital assistive devices can help to promote access to education for all, which resonates with the objectives of SDG No. 4. The educational foundation of the learners with VI is made much stronger when a school system emphasizes education for all (mainstreaming and inclusivity) by ensuring access to assistive devices thus ensuring the right of all children to a meaningful education based on individual needs and abilities (UNESCO, 2020; Kisanga & Kisanga, 2020). Use of assistive digital devices for the VI therefore mitigates the geographical and social segregation of students with 'disabilities', from their 'non-disabled' peers, in learning and development, thus promoting meaningfully integrating and equitable

Challenges experienced by learners with VI in using the Assistive Digital Devices

Recent research findings show that assistive digital devices have potential to enhance learning experiences for learners with VI but there are various challenges that hinder achievement of the potential benefits for the learners (Alananbeh & Asha, 2023; Makoye, 2018; Kyei, 2023). The key challenges include insufficient equipment such as e-book reader device and other ICT facilities such as computers, embosser, modems, magnifiers and screen readers (Makoye, 2018; Kyei, 2023). Towards addressing these challenges, various studies recommend that adequate resourcing in terms of materials and equipment is critical in enhancing learning experiences of the learners with VI. In addition, teachers' competence is also a key part of resourcing (Makoye, 2018; Kyei, 2023). Relevant Policy for teacher capacity building should be formulated in order to enhance

ICT training and life skills subjects for teachers and guardians who support the learners with VI (Alananbeh & Asha, 2023). As suggested by Alnajashi, et al., (2023), inadequate learner support and competence is commonly manifested by lack of technical support and teachers' lack of awareness regarding the needs of learner with VI. It is important to note that majority of the learners with VI are dependent users of assistive technology devices, who depend on the support of either sighted students or a more skilled person.

Similarly, literature also indicates that limited access to technology devices, financial constraints, and inadequate ICT skills are among the key challenges that face learners with VI (Kyei, 2023; Senjam, Foster, & Bascaran, 2021). As a result, such challenges undermine the efforts of promoting use of emerging digital devices, because the learners often prefer to use traditional braille-based methods of reading and writing. Enhancing ICT education for learners with VI is one of the remedies to help them use the digital devices more productively. Further strategies include tailoring of course content to meet specific needs of individual learners and enhancing provision of robust and sufficient digital assistive devices in ICT labs and libraries, and specialized training for instructors in utilizing technology for individuals with visual impairment (Kyei, 2023).

Another challenge facing learners with VI is time limitations when using assistive devices in the classroom, especially due to the nature of their special needs (Alananbeh & Asha, 2023). It is also important to note that parents'/ guardian level of ICT knowledge and socio-economic status can be influence the facilitation and support for the learners in use of digital assistive devices (Alananbeh & Asha, 2023; Senjam et al., 2021).

Theoretical framework: **Universal design for learning and assistive technology theory**

This study is founded on the perspectives of developing an inclusive learning environment for the visually impaired based on the affordance of fast- evolving assistive technologies. Inclusive practice is important in both mainstream and special schools (Jagota, 2018). There are four key features of inclusion which can be used to set expectations and evaluate inclusive practice in school settings. These dimensions are present, participating, achieving and supported (Scottish Government**,** 2019**)**.

This study specifically focuses on assessing the impact of digital assistive technologies for the learners with VI and it was guided by the four key dimensions of educational inclusion, namely: present, participating, achieving and supported. If well aligned, these four elements offer a congruent framework that can guide the use of assistive digital devices in delivery of inclusive

learning environments particularly for the learners with visual impairment (the Blind and partial visual impairment) that enable them to reach their full potential in school and beyond. The four-dimension of inclusive education framework anchors and aligns with the Universal Design for Learning (UDL) theoretical perspectives and the assistive technology theory which are attributed to the works of Rose, Meyer, and colleagues at the Center for Applied Special Technology (CAST) in 1997 (Rose, 2001). Rose suggested that the basis of UDL is grounded in emerging insights about brain development, learning, and digital media. The fundamental perspective is that the disconnect between an increasingly diverse student population and a "one-size-fits-all" curriculum limits academic achievement gains that are being sought in relevance to education for all. This idea was advanced later by Rose and Colleagues by focusing on the intersection between UDL and assistive digital technologies towards providing an inclusive learning environment for learners with special needs including the learners with VI (Rose 2001; Rose et al., 2005). The UDL concept offer the basis for understanding diversity and applying technology to facilitate learning for diverse learners and at the same time on a continuum emphasizes the complementary role of assistive digital technologies in enabling differentiated learning environment based on specific special needs for an individual learner, for instance, the learner with Visual impairment. Therefore, they view assistive technology and universal design for learning theories as "Two sides of the same coin" (Rose et al., 2005). The core principles of UDL are: Multiple means of representation; Multiple means of expression; and Multiple means of engagement (Rose, 2001).

Universal design is a process for designing devices/ products that can be used by anyone in such a way as to reduce barriers for any individual (either with or without disabilities) with the aim of increasing opportunities for the widest possible range of users. To fit the general use, universal designs are therefore engineered for flexibility, and designed to anticipate the need for alternatives, options, and adaptations (Rose et al., 2005). This implies that UDL are variable rather than dedicated; they are universal and inclusive to accommodate diversity. Correspondingly, assistive technology is digital technology that increases, improves, or maintains the functional capabilities of students with disabilities such as visual impairment. Usually, assistive technology is specifically designed to assist individuals with disabilities in overcoming barriers in their environment and in increasing their opportunities for independence (Rose et al., 2005). This means it can be specifically tailored and uniquely adapted or dedicated to the specific strengths and weaknesses of each person based on their individual limitations.

Based on Rose et al. (2005) perspectives we can conclude that needs for learners with special needs can be addressed by conceptualizing assistive technology and UDL as two interventions on a continuum that involves reducing barriers. At one end of the continuum, whereby UDL seeks to reduce barriers for everyone. At the other end of the continuum, Assistive technology is used to reduce barriers for individuals with disabilities. This implies that the assistive digital devices for the learners with VI need to be conceptualized based on these perspectives. Their capabilities and in terms of being easily usable and improving inclusion is critical. The current study therefore seeks to assess the benefits of digital assistive devices for the learners with visual impairment (VI) in relation to their influence on inclusivity in education. The study also examines the challenges the learners face in using these devices in special and mainstream education institutions in Kenya.

1.2. Specific Objectives

i. What are the benefits of using digital braille assistive devices in relation to inclusivity of learners with VI in secondary school and University level?
ii. What are the key challenges experienced by learners with VI in Kenya in using the digital braille assistive devices in secondary school and University level?

1.3. Significance of the study

There are limited studies that have holistically explored the impact of evolving digital braille assistive technologies especially in formal education contexts. This is particularly in relation to how these devices have influenced inclusivity of learners with VI in special and main-stream education settings in developing nations. This study is timely as it is coming at a time when there are a lot of technological advancements in all aspects of human life. This study is also aligned to SDG No. 4 on access to quality education and lifelong learning opportunities for all the learners. Lack of appropriate tools and strategies including adequate resources continue to undermine inclusivity of learners with VI within school environments and other socialization systems especially in developing nations. It is not yet fully understood to what extent the emerging technological advancements are promoting inclusivity in the context of the VI in learning institutions. Moreover, this study integrates congruent theoretical foundations for deeper understanding on how digital assistive devices can promote inclusivity in education as digital assistive technologies continue to evolve. Therefore, this study contributes to theoretical understanding of developing an inclusive learning environment for the visually impaired based on the affordance of fast- evolving assistive technologies. The study adopts universal design for

learning and assistive technology theory as a lens for understanding the requirements for an inclusive learning environment which is important in both mainstream and special schooling.

The findings are useful to teachers/ educators in providing insights on the nature of learning design required for the digital assistive devices to help in fostering user independence and promoting inclusivity in education. The findings are also informative to the policy makers in providing insights on the need to purposefully address issues of affordability, durability, and repair in order to improve accessibility and sustainability for the digital assistive devices. The study also offers insights to all educational stakeholders including guardians on the need to explore diverse alternatives and a more holistic approach, such as laptops tailored for visually impaired students, as a more scalable and sustainable solution. Overall, the findings emphasize the need for a comprehensive approach that integrates technology, inclusive pedagogy, support systems, and capacity-building efforts to ensure inclusive and quality education for learners with VI.

2. METHOD

2.1. Research Design

This study adopted a mixed methodology approach. The study employed descriptive survey design**.** To provide a framework for systematic scientific research, a descriptive survey design was adopted to assess the impact of intervention in relation to the use of digital braille for learners with VI. The approach entailed both qualitative and quantitative techniques in data collection and analysis to provide for depth and breadth of information. Within the mixed techniques approach, a convergent parallel model was employed. As observed in Hakkarainen (2009), it is possible to use multiple methods to collect and analyze data of an intervention within a design-based research process. The mixed-method approach has also been previously recognized by various researchers (Pole, 2007). Quantitative data was specifically used to measure the influence of Orbit Reader device on interactivity and inclusivity while qualitative data was used to explain the process and products of the intervention and the reasons that led to the observed outcomes. Thus, qualitative technique was used to provide an opportunity for an in-depth understanding of how best to support learners with VI. Moreover, the method provided an opportunity to gather evidence from multiple sources thus providing a rich and in-depth account of the impact of the new device.

2.2. Scope of the Study, target population and sampling Design

This research was conducted as a pilot study that was delimited within 2 purposefully selected institutions in Kenya, with a possibility of scalability to other schools regionally. The targeted population for this study were the institutions that use digital assistive devices. The two institutions

that were selected in this pilot study are: one (1) secondary school for the VI and one (1) private University.

The participants were sampled purposefully from the population of special needs students in the 2 selected institutions as outlined in Table 1. The institutions selected are: One (1) secondary school and one (1) University.The selection of institutions in this study was purposive on the basis that:

They encompass the phenomena of interest for this study.

a) They represent diverse situationality
b) The schools are accessible and hospitable
c) The schools as selected cases are rich in content
d) They had used digital assistive devices

The study participants' categories included:

i. Learners with visual impairments who had previous access to digital braille devices
ii. Selected teachers
iii. Institution-based technicians and support staff

The targeted students' population were learners with visual impairment who were either blind or with low vision and they mainly rely on assistive devices (manual or digital) for their studies and information access. The sampled students were the learners with VI who had previous experience in use of Manual Braille devices and access to digital assistive devices and had used a digital assistive device for at least one year. It is important to note the sampled students had access to digital assistive devices (commonly Orbit Reader 20) for one year prior to the start of this study. Therefore, the sampled students had adequate knowledge in relation to use of a digital assistive device and they mainly relied on assistive devices for their studies and information access. They were all above the age of 18 years and therefore they were able to express their views/ experiences independently (See Table 2).

The study took a period of 12 months; between September 2023 and August 2024.

Table 1: Target Population and Sample size

No.	Name of Institution	Category	County	Target Population (Learners)	Sample Size Learners	Sample (Teachers and Technicians)
1	S.A. Thika High School	Special	Kiambu	430	19	3 teachers and 1 technician
2	Mount Kenya University	Integrated	Kiambu	20	15	One Lecturer and 1 technician

As Table 1 shows, the total sample size of 34 VI learners from both institutions. Additionally, the study purposefully sampled three (3) teachers and one Technicians from the secondary school, and One Lecturer and 1 technician from the university as key informants.

2.3. Data collection tools and procedures

At the outset of the study, the Researchers sought clearance from relevant authorities in adherence to research ethical issues. Identification of relevant participants for piloting the research instruments was conducted prior to actual data collection to test for validity and reliability. The study applied multiple quantitative and qualitative techniques in data collection. The adopted descriptive survey design provides an opportunity to utilize both qualitative and quantitative data collection techniques to gather evidence from variety of sources, which facilitated triangulation of data for purposes of corroborating the evidence obtained.

The following data collection instruments was utilized in this study:

(a) Survey questionnaire (With both closed and open-ended questions)

(b) Semi structured interviews with selected teachers and technical support staff (technician).

2.4. Data analysis

The research involved integration of quantitative and qualitative data analysis techniques to comprehensively assess the impact of the digital assistive devices on inclusivity for visually impaired learners in Kenya. For quantitative data, descriptive statistical analysis using SPSS version 26 was utilized. This method allows for systematic examination of numerical data, enabling the calculation of mean scores, standard deviations, and frequency distributions (Pallant, 2020). The descriptive statistics helped quantify learner experiences, challenges, and perceptions across different dimensions of device usage.

Qualitative data were analyzed through thematic analysis, a flexible method for identifying, analyzing, and reporting patterns within the collected interview and observational data. This approach facilitated deep insights into participants' experiences, challenges, and perspectives on the digital assistive devices.

The triangulation of findings entailed combining quantitative statistical results with qualitative thematic analyzed findings. This approach enhanced the depth of the study's findings and validity. Triangulation allows for a more nuanced understanding by comparing and cross-validating data from different sources and methods. The analytical strategy aimed to provide a holistic assessment of the impact of digital assistive devices, addressing the research objectives through a rigorous, multi-dimensional approach that captures both quantitative insights and rich contextual narratives.

2.5. Ethical considerations

The researchers addressed the ethical issues that relate to matters of assent for minors/vulnerable, informed consent, confidentiality and anonymity of the participants. Special consideration was taken when dealing with minors as majority of the study participants are learners who are vulnerable due to their special needs. Therefore, for students in high school, class teachers as the immediate caregivers were consulted for informed consent to protect the welfare of the vulnerable learners.

3.FINDINGS AND DISCUSSION

This section offers the study findings and related discussion focusing on addressing the key research questions. The study examines the key benefits and challenges facing learners with VI from a holistic perspective in relation to enhancing opportunities for promoting inclusivity in both mainstream and special schools.

3.1 Participants' Demographics

The demographic information collected focused on gender, age, Level of education and prior training of Digital Assistive devices. The data was analyzed and presented in Table 2.

Table 2: Demographics of the Students participants

Attribute	Characteristic	Frequency	Percent
Gender	Male	20	58.8
	Female	14	41.2
	Total	34	100

Age	18-20 years	20	58.8
	21-25 years	14	41.2
	Total	34	100
Level of education	Secondary school	19	55.9
	University	15	44.1
	Total	34	100
Prior training in Digital Assistive device	Yes	20	58.8
	No	14	41.2
	Total	34	100

The demographic analysis reveals that most respondents (58.8%) were male, while 41.2% were female. The age distribution shows that most participants (58.8%) were between 18 and 20 years old, with the remaining 41.2% aged 21 to 25 years.

Regarding the education level of the students' respondents, 19 students (55.9%) were in secondary school, while 15 respondents (44.1%) were university students. Additionally, 58.8% of the respondents reported having a training background in digital assistive devices, compared to 41.2% who lacked such training. Out of the 19 secondary school students, 4 had low vision while 14 were totally blind while 6 of the University students had low vision while 9 were totally blind.

The interview participants were six in number. These were considered as key informants and they included a male university technician (KI01), a male high school technician (KI02), a male university lecturer (KI03), a male high school teacher (KI04), and two female high school teachers (KI05 and KI06). All the key informants were above the age of 30 years old and had had prior training in the use of Digital Assistive devices.

The 34 students also responded to the open-ended questions; notably the university students offered more elaborate narrative responses about their perceptions and experiences with assistive digital devices. Out of the 15 University learners, 5 of them answered open-ended questions (coded as KI07, KI08, KI09, KI10, KI11. KI07); they indicated that they had used Orbit Reader 20, and they also preferred Screen readers like NVDA (nonvisual desktop access). The KI08 could only identify with Orbit Reader 20 as a familiar digital braille device, he had access to use. The KI09 identified Orbit Reader 20, FOCUS, audio books, podcasts and NVDA as other digital assistive technology for the VIs. Another student also preferred FOCUS for Orbit Reader

20, he claimed it's the most advanced. Both KI10 and KI11 acknowledged other digital devices and appreciated their experience in using Orbit Reader 20. However, KI11 could not identify any other assistive digital technology. The secondary school students also expressed their perceptions and experiences in the open-ended questionnaire responses. They cited exposure to various assistive digital devices including Dot Min, Focus, Orbit Reader 20.

3.2 Benefits of Digital Assistive Devices on Learner Inclusivity

The first objective of the study was to establish the benefits of using orbit reader 20 device in relation to inclusivity (learning experiences and learners' performance) of learners with VI. Using a questionnaire, the learners were asked to rate their level of agreement with statements on the impact of the use of digital braille assistive device devices concerning inclusivity (learning experiences and learners' performance). The rating was measured on a 5-point Likert scale 1=Strongly Agree, 2=Agree, 3=Undecided, 4=Disagree, 5=Strongly Disagree. The results are presented in Table 3.

Table 3: Benefits of Digital Assistive Devices on Inclusivity

	N	Minimum	Maximum	Mean	Std. Deviation
The introduction of Digital Braille Assistive Device enhanced your performance	34	1.00	5.00	3.7353	1.48342
It helped you have better and easier interaction with teachers	34	1.00	5.00	3.3235	1.06517
It helped your interaction with other pupils	34	1.00	4.00	3.1176	1.22511
It enhanced your learning experiences	34	1.00	5.00	3.1176	1.27362
Given a choice, would you still choose the Digital Braille Assistive Device?	34	1.00	5.00	3.7059	1.58648

The results in Table 3 show the respondents' perceptions of the impact of digital braille assistive devices on inclusivity regarding learning experiences and performance varied across different aspects. The most notable impact was on enhancing performance. The mean score of 3.74 (Minimum = 1, Maximum = 5, SD = 1.48) suggests that most respondents felt that using digital braille assistive devices contributed to improving their performance, though opinions varied.

The mean score on interaction with teachers was 3.32 (Minimum = 1, Maximum = 5, SD = 1.07), indicating that while the devices were helpful in fostering better and easier interactions with

teachers, some respondents were undecided or felt that the impact was not substantial. Regarding interaction with other pupils, the mean score of 3.12 (Minimum = 1, Maximum = 4, SD = 1.23) suggests that the devices moderately impacted fostering interaction with peers.

The mean score for enhancing learning experiences was 3.12 (Minimum = 1, Maximum = 5, SD = 1.27), indicating that while the devices were seen as somewhat beneficial for learning experiences, there was considerable variability in the respondents' views. Lastly, when asked if they would still choose digital braille assistive devices if given a choice, the mean score was 3.71 (Minimum = 1, Maximum = 5, SD = 1.59). This suggests that while most respondents would still opt for the device, a notable proportion was undecided or had reservations.

The interview findings depict varied opinions relating to the impact of digital assistive devices. One of the KIIs posited and argued as follows:

> The introduction of digital braille assistive device has many effects on the performance of learners abled differently as it stimulates leaners to engage more productively, and it enhances opportunities for learning. Use of Digital Braille Assistive Device improves the pupil's attitude towards education as it positively enhances the students' attitude. Introduction of digital braille assistive device enhances the accessibility to education by pupils abled differently. The learners can be able to read more diverse materials (KI01).

In another response, KI04 posited that introduction of digital braille assistive device have many effects on the performance of pupils abled differently. Including the fact that they are less bulky compared to manual braille. "It can be used by anyone as notes can be sent online, printing of work from the digital braille is easy".

KI01 further posited that the introduction of Orbit Redear 20 enhances classroom management and helps to reduce noise associated with the use of manual Braile. He added that the introduction of Orbit Redear 20 increases classroom participation by pupils abled differently enhances participation because the students can access more materials and read more on their own. Orbit readers were found to enhance completion rates of pupils at the Tertiary level. However, it was found that the digital Braile devices have a limitation in supporting assessment and assignments because they do not support de-brailing /transcription of student answers into conventional language.

Holding all the other factors in constant the key informant 2 indicated that digital braille assistive device enhances transition levels of pupils abled differently in different levels of education. The introduction of digital braille assistive device enhances the learning for the pupils enabled differently. The device offers learners more opportunities to learn. It was also found that the use of digital braille assistive devices opened new opportunities for pupils abled differently by being able to engage more productively, it offers them more opportunities to succeed in school and beyond. The digital braille assistive device enhanced communication between teachers and pupils and among pupils as it enhances communication and interactivity among the pupils and between the teacher and the learners, for instance they can chat. The orbit reader has a significant policy implication on inclusivity in education but to some extent based on how its strengths are exploited and how its limitations are addressed (KI02).

The study reveals a nuanced perspective on the impact of digital braille assistive devices, highlighting both the potential and limitations of technological interventions in inclusive education. The most significant finding is the positive perception of performance enhancement, with a mean score of 3.74, indicating that assistive technologies can meaningfully contribute to academic achievement for visually impaired learners (Takshara & Bhuvaneswari, 2025).

The findings from KI04 and KI05 showed some consistent impact of the digital devices as reflected by the quantitative results. They posited that introduction of digital braille assistive devices influence the performance of pupils abled differently as they have reduced bulkiness in relation to manual braille, are more appealing /convenient to the learners and are more accessible to learning content and enhanced interactivity. The key informants also indicated that the introduction of Orbit Redear 20 enhances classroom management as there was reduced noise, and reduced need for oversized furniture in the class. Specifically, KI04 pointed out that the use of digital braille assistive Device opened new opportunities for pupils abled differently as there is more opportunities to receive information and give feedback. The learners feel more confident and thus it enhances learners' self-esteem.

On the contrary, one of the technicians argued that the impact of digital devices may not necessarily be direct in all cases. He posited:

> Orbit reader enhances completion rates of pupils at the Tertiary level but not directly, because there are more core determinants on this. Similarly, digital Braille Assistive Device enhances transition levels of pupils abled differently in different

levels of education, but not directly, because there are more core determinants on this (KI01).

However, the same technician agrees that the use of digital braille assistive device opened new opportunities for pupils abled-differently by being able to engage more productively, it offers them more opportunities to succeed in school and beyond. He added that the digital braille assistive device enhanced communication between teachers and pupils and among pupils as it enhanced communication and interactivity among the pupils and between the teacher and the learners, for instance they could chat. He remarked that the orbit reader has a significant policy implication on inclusivity in education, but to some extent based on how its strengths are exploited and how its limitations are addressed (KI01).

From the quantitative findings, the moderate mean scores for teacher interaction (3.32) and peer interaction (3.12) suggest that while digital assistive devices facilitate communication, they do not comprehensively resolve social integration challenges. This finding underscores the complexity of inclusivity beyond technological solutions (Chambers, 2020; Takshara & Bhuvaneswari, 2025).

The learning experience impact (mean 3.12) reveals mixed perceptions, indicating that technological interventions are not uniformly experienced or perceived. The variability in responses highlights the need for personalized, adaptive approaches to assistive technology integration. The willingness to choose these devices again (mean = 3.71) demonstrates cautious optimism. Despite reservations, most respondents recognize the potential value of digital braille assistive devices, suggesting a nuanced appreciation of their benefits and limitations.

Key implications of the findings include developing more comprehensive social integration strategies and creating personalized technology adaptation approaches. The findings also inform the need to enhance device capabilities to support diverse learning experiences and implementing continuous feedback mechanisms. Similarly, there is need for recognizing the complex, individualized nature of assistive technology effectiveness (Le Fanu, Schmidt & Virendrakumar, 2022; Rose et al, 2005). The research emphasizes that technological interventions must go beyond functional improvements to address holistic educational and social experiences of visually impaired learners.

3.3 Challenges experienced by learners with visual impairment (VI) when using digital assistive devices

The first objective was to establish the challenges experienced by learners with visual impairment (VI) in Kenya in using the Orbit Readers, in the classroom/school and when they complete schooling. The objective was assessed in two stages: institutional and learner-based challenges.

3.3.1 Institutional challenges on the use of Digital Braille Assistive Devices

Using a questionnaire, the learners were asked to score the Institutional challenges that face the implementation of the use of digital braille assistive devices. The item consisted of a list of statements measured on a rank (1=Least Challenge, 5= Very Serious Challenges). The data was analyzed using descriptive statistics as presented in Table 4.

Table 4: Institutional challenges that face the use of digital braille assistive device

	N	Min	Max	Mean	Std. Deviation
Limited flexibility in training options for Visually Impaired students on the use of Digital Braille Assistive Device	34	1.00	5.00	3.7353	.99419
Lack of accessibility of ICT or effective communication using Digital Braille Assistive Device	34	1.00	5.00	3.9706	.86988
Few orbit readers- Not enough for all visually Impaired students	34	4.00	5.00	4.9412	.23883
Lack of specialized disabled-friendly teacher training	34	2.00	5.00	4.6471	.73371
Lack of usability of ICT or effective communication using Digital Braille Assistive Device	34	1.00	5.00	2.3824	1.68801
Shortage of technicians for repairing ICT facilities	34	4.00	5.00	4.9118	.28790

Table 4 reveals that most respondents identified the lack of sufficient orbit readers as the highest institutional challenge, with a mean score of 4.94 (Minimum = 4, Maximum = 5, SD = 0.24). This was closely followed by the shortage of technicians for repairing ICT facilities, with a mean score of 4.91 (Minimum = 4, Maximum = 5, SD = 0.29). A lack of specialized, disabled-friendly teacher training was also ranked highly, with a mean score of 4.65 (Minimum = 2, Maximum = 5, SD = 0.73).

Most respondents cited lack of accessibility or effective communication using the digital braille assistive device as another notable challenge, with a mean score of 3.97 (Minimum = 1,

Maximum = 5, SD = 0.87). Limited flexibility in training options for visually impaired students followed, scoring a mean of 3.74 (Minimum = 1, Maximum = 5, SD = 0.99).

Respondents identified the least challenging issue as the usability of ICT or effective communication using the digital braille assistive device, with a mean score of 2.38 (Minimum = 1, Maximum = 5, SD = 1.69). This suggests that while usability issues are acknowledged, they are ranked lower in importance compared to other institutional challenges.

The qualitative findings from the teachers and the technicians showed that some of the challenges included lack of prior training and limited number of devices. One of the technicians posited;

> There are challenges that are associated with digital devices. For instance, some learners do not have expected prior ICT /digital training. There are also cases where the devices are fewer than the learners. In some cases, there is a limited support system for the learners because they need personalized support (KI01).

A different key informant pointed lack of adequate assistive digital device (orbit reader 20) transcriber, taking longer – not readily accessible, low ICT support structure for the Visually impaired, delay in service delivery/response and even dragging the user hence lagging behind the syllabus (KI03).

Based on analysis of the interview responses from the 3 high school teachers' views (KI04, KI05 and KI06), several institutional challenges emerged as common among them as outlined below:

- The digital devices are fragile for instance; the keypads break easily
- Not easy to repair and maintain
- Memory cards of the devices don't fit properly and can be removed easily and stolen
- Inconvenience in display for instance; the display cannot accommodate the whole page
- Gets dirty very easily
- Problem with the security of the devices, for instance, memory cards get stolen easily.
- Storage and charging of the devices is challenging as well.
- Technical subjects like math and sciences prove difficult to teach using the orbit reader transcriber, for instance, signs and symbols in Mathematics and other STEM subjects
- Very difficult to follow up on the previous work as the 20 cells are very few-Display is very small
- The devices are very expensive, approximately Kenya shillings 80, 000-150,000 per device this not affordable to the majority of VI learners.

- ❖ It is not adaptable to many gadgets, especially it is not easy to print a document written using the available assistive digital device (Orbit reader 20)
- ❖ Low ICT support structure for the Visually impaired due to the limited number of technical support staff and device maintenance capacity.

Similarly, the University Lecturer (KI03) who is an expert in special needs and had experience in teaching learners with VI, also alluded to the same challenges as reported by the high school teachers. He particularly emphasized the need for adequate training for the students on how to use and take care of the assistive digital devices. Adequacy of technical support was also noted as a key challenge that faced the leaners using assistive digital devices in relation to achieving their academic goals.

Based on the learners' responses to the open-ended questions, institutional challenges include hanging, breaking, few devices (KI07), needs to be more availed and break down easily (KI08), repair support not locally available (KI09) and safe storage is compromised sometimes (KI10).

The findings reveal significant challenges faced by learners with visual impairment in Kenya when using the digital assistive devices, highlighting critical barriers to educational inclusivity. The most pressing institutional challenges center around resource limitations and systemic support deficiencies. The extremely high mean scores for insufficient orbit readers (4.94) and shortage of technical support (4.91) underscore the fundamental infrastructure gaps that impede effective assistive technology integration (Smith et al., 2022).

The lack of specialized teacher training (mean 4.65) is particularly concerning, as it indicates a systemic unpreparedness to support visually impaired learners effectively. This finding suggests that technological solutions alone are insufficient without comprehensive educational ecosystem support (Johnson & Muthomi, 2023). The moderate challenges in accessibility and communication (mean 3.97) and training flexibility (mean 3.74) further illuminate the complex barriers faced by visually impaired students.

Notably, the relatively low score for device usability (mean 2.38) implies that the primary obstacles are not with the technology itself, but with the surrounding institutional support structures. This highlights the critical need for holistic approaches to inclusive education (Scottish Government**,** 2019**)**; in ways that address infrastructural, user training, and support mechanisms.

The findings imply that sustainable inclusivity requires multifaceted interventions focusing on increasing assistive device availability, developing specialized technical support, enhancing teacher training programs and creating more differentiated instructional approaches (Rose et al., 2005).

3.3.2 Learner Challenges in the Use of Digital Braille Assistive Devices

The respondents were asked to rate the challenge they perceived would affect the use of digital braille assistive devices. The findings are presented in Table 5.

Table 5: Learner Challenges in Using the Digital Braille Assistive Devices

	N	Min	Max	Mean	Std. Deviation
Lack of technical know-how	34	3.00	5.00	3.4118	.65679
Storage of the device	34	1.00	5.00	3.8529	1.18404
After completion of the course, how to access the orbit leader	34	3.00	5.00	4.4412	.74635
Lack of power for charging	34	1.00	5.00	2.2647	.96323
Fear for digital assistive device (Orbit Reader 20) to get lost or stolen	34	1.00	5.00	4.1765	1.21781

Table 5 shows that among the learner challenges identified, the highest-ranked challenge was accessing the Orbit Reader after completing the course, with a mean score of 4.44 (Minimum = 3, Maximum = 5, SD = 0.75). This was closely followed by the fear of the Orbit Reader getting lost or stolen, with a mean score of 4.18 (Minimum = 1, Maximum = 5, SD = 1.22). The challenge related to the device's storage was also rated highly, with a mean score of 3.85 (Minimum = 1, Maximum = 5, SD = 1.18). Lack of technical know-how scored a mean of 3.41 (Minimum = 3, Maximum = 5, SD = 0.66), indicating that technical knowledge was a moderate challenge. The least perceived challenge was the lack of power for charging, with a mean score of 2.26 (Minimum = 1, Maximum = 5, SD = 0.96). This suggests that, although charging issues were acknowledged, they were seen as less significant than other learner challenges.

Similarly in the qualitative findings one technician posited similar challenges including powering needs, the learners SD cards get lost often and the breakages being common (KI02). Moreover, some learners have multiple special needs beyond VI so they need more enhanced support (KI01). For KI04, most of the learners were well-versed, only a few needed trainings; needed sponsors or donors for support and required basic ICT Skills. Similarly, the qualitative

questionnaire responses from some of the students also emphasized these challenges: “The devices are not easily affordable and are not always easy to navigate through” (KI10 and KI11).

The findings reveal critical challenges faced by the learners with VI in accessing and maintaining digital assistive devices, with profound implications for inclusive education and technological support. Another significant finding is the high mean score of 4.44 for accessing the device after course completion, highlighting a crucial gap in post-educational support systems for visually impaired students (Bright-George & Owopetu2021).

The pronounced fear of device loss or theft (mean 4.18) underscores the economic vulnerability and psychological stress experienced by learners. This finding suggests the need for comprehensive insurance, replacement, and security mechanisms specifically tailored to assistive technology users (Oldfrey, et al, 2021; Ward-Sutton, 2020).

Device storage challenges (mean 3.85) indicate structural limitations in current assistive technology infrastructure, pointing to the necessity of more robust and user-friendly design considerations. The moderate challenge of technical knowledge (mean 3.41) emphasizes the ongoing need for continuous training and support beyond initial device introduction. The relatively low concern about charging (mean 2.26) suggests technological improvements in device power management, though it remains a background consideration.

The implications are multifaceted ranging from developing a comprehensive post-formal education support program, creating financial and security mechanisms for device acquisition and protection; and enhancing ongoing technical training and support. The findings also imply the need to design more adaptive and user-centric assistive technologies and establish long-term sustainability frameworks for assistive technology users (Rose 2001; Rose et al., 2005). These findings underscore the critical need for a holistic approach that extends beyond device provision to comprehensive, lifelong support for visually impaired learners.

3.3.3 Effect of challenge to the user of the digital braille assistive device

The questionnaire respondents were again asked to rate the extent of the effect of the key challenges to the user of the digital braille assistive device. The findings were presented in Table 6.

Table 6: Effect of challenge to the user of Digital Braille Assistive Device

	N	Min	Max	Mean	Std. Deviation

Lower their confidence and self-esteem	34	1.00	5.00	3.9118	1.48462
Reduces joy learning	34	1.00	5.00	2.5000	1.02247
limits their prospect of being independent learners	34	1.00	5.00	3.9118	1.50489
Compromise the quality of learning	34	1.00	4.00	3.3235	.94454
Time wasted trying to navigate through the device	34	1.00	5.00	1.7059	1.16851
Lack of quality Learning	34	1.00	4.00	1.5294	.86112
Participation and engagement in the classroom is limited	34	1.00	5.00	2.8235	.90355

Table 6 shows that among the challenges rated by the respondents, the most significant effect identified was lowering the users' confidence and self-esteem, with a mean score of 3.91 (Minimum = 1, Maximum = 5, SD = 1.48). This was tied with the challenge of limiting the prospect of being independent learners, which also scored a mean of 3.91 (Minimum = 1, Maximum = 5, SD = 1.50), indicating that these issues are perceived to have a major impact on users.

Another notable effect was compromising the quality of learning, which had a mean score of 3.32 (Minimum = 1, Maximum = 4, SD = 0.94). This indicates that, while it is seen as a significant challenge, it was rated slightly lower than confidence and independence challenges.

The challenge of reducing joy in learning was also highlighted, with a mean score of 2.50 (Minimum = 1, Maximum = 5, SD = 1.02), suggesting it is perceived as a moderate challenge. Similarly, limited participation and engagement in the classroom, scoring a mean of 2.82 (Minimum = 1, Maximum = 5, SD = 0.90). The least significant challenges were time wastage while navigating the device (Mean = 1.71, SD = 1.17) and lack of quality learning (Mean = 1.53, SD = 0.86), which the respondents rated as lower impacts.

The study reveals profound psychological and educational impact of technological challenges on visually impaired learners, with particularly striking findings related to self-perception and personal agency. The highest-rated challenges of lowering confidence and self-esteem and limiting independence prospects (both with a mean of 3.91) highlight the deeply transformative potential of assistive technologies beyond mere functional capabilities (Ward-Sutton, 2020; Mahmoudi, Nasr-Esfahani & Vasan, 2025).

The significant impact on learning quality (mean 3.32) suggests that technological limitations extend beyond individual psychological experiences to fundamental educational outcomes. This

underscores the critical role of assistive technologies in creating equitable learning environments for visually impaired students (Chambers, 2020; Takshara & Bhuvaneswari, 2025).

Moderate challenges in reducing learning joy (mean 2.50) and classroom participation (mean 2.82) indicate nuanced psychological barriers that can subtly undermine educational engagement. These findings reveal that technological challenges are not merely technical problems but complex intersections of psychological, social, and educational experiences. The relatively low scores for time wastage (mean 1.71) and lack of quality learning (mean 1.53) suggest that respondents prioritize broader existential impacts over specific technical inefficiencies.

Key implications include developing holistic support systems that address psychological well-being and creating assistive technologies that enhance learner confidence. The findings also imply the need for designing interventions that promote independence and self-efficacy and implementing comprehensive inclusive educational support system beyond technological provision (Rose 2001; Rose et al., 2005; Scottish Government, 2019). There is also a need for recognizing assistive technologies as tools for empowerment, not just functional adaptation. The research emphasizes that technological interventions for visually impaired learners must transcend technical functionality, focusing instead on comprehensive personal and educational development.

3.3.4 Solutions to challenges facing the digital assistive device users

In another dimension, the questionnaire respondents were asked to rank a list of solutions to challenges facing the digital assistive device (Orbit Reader 20) users (1 Least significant- 5 Most important). The findings were presented in Table 7.

Table 7: Solutions to challenges facing the Digital Assistive Device users

	N	Minimum	Maximum	Mean	Std. Deviation
Training and Capacity building of the learner on maintenance	342	2.00	5.00	4.7647	.65407
Provision of the skills on device usage	343	3.00	5.00	4.8824	.40934
More orbit readers	344	4.00	5.00	4.9412	.23883
Mentorship	343	3.00	4.00	3.4118	.49955
Access to orbit reader transcriber	341	1.00	5.00	2.4118	1.76012

Table 7 reveals that the most critical solution identified by respondents was the provision of more devices, with a mean score of 4.94 (Minimum = 4, Maximum = 5, SD = 0.24). This solution was perceived as the most critical in addressing users' challenges. Closely following this, the provision of skills on device usage was also highly prioritized, with a mean score of 4.88 (Minimum = 3, Maximum = 5, SD = 0.41), indicating that respondents viewed training on the effective use of the device as essential.

Training and capacity building of the learner on maintenance of the digital assistive devices was rated with a mean score of 4.76 (Minimum = 2, Maximum = 5, SD = 0.65), marking it as another essential solution. Mentorship, ranked as a moderately important solution, scored a mean of 3.41 (Minimum = 3, Maximum = 4, SD = 0.50), indicating that while valuable, it was considered less critical than the others. The least important solution was access to the digital assistive devices (for instance, Orbit Reader 20) transcribers, with a mean score of 2.41 (Minimum = 1, Maximum = 5, SD = 1.76), suggesting that respondents did not perceive this as a major solution to their challenges.

The study reveals a clear hierarchy of solutions for addressing the challenges faced by visually impaired learners using digital assistive devices like the Orbit Reader 20, with a strong emphasis on resource provision and skill development. The overwhelmingly high mean score of 4.94 for increasing digital assistive devices availability underscores the critical resource gap in assistive technology access (Oldfrey, et al, 2021).

The near-equal importance of device usage skills training (mean 4.88) highlights the recognition that technological access must be accompanied by comprehensive user empowerment. This finding suggests that mere device provision is insufficient without robust support mechanisms that enhance technological literacy and confidence.

The high priority placed on maintenance training (mean 4.76) indicates a sophisticated understanding of long-term device sustainability. Respondents demonstrate awareness that effective assistive technology integration requires ongoing skill development and technical capacity building.

Mentorship emerged as a moderately important solution (mean 3.41), suggesting the value of peer and expert support in navigating technological and educational challenges. The low priority of transcriber access (mean 2.41) implies that respondents are more focused on direct technological empowerment than intermediary support.

The qualitative findings show various suggestions to challenges facing digital assistive device users. Some of the solutions included having refresher trainings to improve skills and knowledge, more devices, in-build storage (KI07), employ technician for flexible learning (KI08), put in place regular trainings, subsidize its cost, create accessible online sites, sensitize of other technology like Braille Bluster (KI09) and provide regular trainings, avail more technicians, avail more devices to the learners (KI10). For KI11, the solution could be "enhancing the reliability and durability, train more technicians/ enhance technical support, regular trainings on usability of the device to the users, increase number of cells, offer more dynamic digital resources, internal SD, more accessories / additional features, and increase number of cells".

The key informant interview findings showed new needs to manage the challenges identified. The high school teachers posited that there need to "have many cells on the display, for security purposes, the memory cards should be made difficult to eject and the gadget needs to be made from a hard material which is not easily breakable" (KI04, KI05 and KI06).

Further, The University Lecturer, a key informant argued for "delegating responsibilities or enhanced support system, flexible procurement system and enhance training and management awareness on usability and sustainability issues" (KI03).

For one of the technicians:

> .... there is need to better handle the devices by the users, internal SD card should be a feature in future improvements, increase readers from 20 to 40 keys for quick typing, more training on maintenance and power storage capacity to be enhanced (KI02)

Another technician opined several actions for management of the challenges identified.

> There is need for specialized prior training for the learners in digital/ICT literacy for the VI at the outset as well as more specialized program and support system for the VI e.g. speech to text software, screen readers etc, and facilitate peer- to peer support system. We cannot rely fully on digital devices; manual Braile devices are still necessary alongside the digital devices especially for purposes of student assessment because the Digital Braile has limited in supporting assessment needs (KI01).

The study findings point at prioritizing large-scale digital assistive devices distribution, developing comprehensive skills training programs, creating ongoing maintenance and technical support systems and implementing mentorship and peer support networks. The findings also imply the need to design for holistic approaches to assistive technology integration (Rose et al., 2005; Scottish Government, 2019). The research emphasizes that solving challenges for visually impaired learners requires a multifaceted approach addressing resource provision, skill development, and sustainable support mechanisms. Existing literature supports this, indicating that maintenance issues and limited technical support can severely hinder the adoption and long-term use of assistive devices (Scherer, 2005). Inadequate support systems can lead to user frustration and reduced benefits. Addressing these challenges is essential to improving the effectiveness and sustainability of assistive technologies.

In overall, the key informant interviews responses reveal a comprehensive perspective on addressing challenges associated with the digital assistive devices for visually impaired learners, highlighting multifaceted recommendations for device improvement and systemic support. The stakeholders' insights demonstrate a nuanced understanding of technological and educational needs beyond mere device provision (Gathu, 2024; Mahmoudi, Nasr-Esfahani & Vasan, 2025; Scottish Government, 2019).

Additionally, the technical expert views suggest device enhancement including increasing display cell capacity, improving physical durability, implementing security features like non-removable memory cards, expanding keyboard functionality (increasing keys from 20 to 40) and integrating internal SD card capabilities. Institutional and pedagogical recommendations relate to the development of specialized ICT literacy training and creating flexible device acquisition systems. Establishing comprehensive support mechanisms and implementing peer-to-peer support networks as well as maintaining hybrid assistive technologies (digital and manual Braille devices) are also recommended. The findings also point out the integrating supplementary assistive technologies like speech-to-text software and screen readers. The findings underscore the critical importance of a holistic approach to assistive technology integration. This is consistent with the literature that underscores the muti-faced features of inclusion including adaptation of intervention to fit diverse learners' needs and sustained support systems (Le Fanu, Schmidt & Virendrakumar, 2022; Scottish Government**,** 2019**)**. Stakeholders recognize that technological solutions alone are insufficient; comprehensive support systems, specialized training, and adaptive strategies are essential for meaningful inclusivity (Chambers, 2020; Gathu, 2024). The recommendations

highlight the need for continuous technological innovation, comprehensive user-centered design, robust support infrastructure and flexible, adaptive educational approaches.

4. CONCLUSIONS

4.1 *conclusions*

The study reveals that digital braille assistive devices have varying impacts on inclusivity and users learning experiences. The most significant impact is in enhancing performance, with a mean score of 3.74. However, some respondents feel the impact is not substantial. The devices also have limitations in supporting assessment and assignments.

Further, the findings highlight benefits like reduced device bulkiness, access to diverse educational content, increased learning opportunities, and enhanced classroom management. However, respondents noted limitations in comprehensive social integration and assessment support. The research suggests that while technological interventions are valuable, they must be personalized and address holistic educational experiences, not just functional improvements.

The study findings reveal both the potential benefits and challenges of using digital braille assistive devices for the learners with VI in Kenya. While the devices offer substantial benefits, such as promoting learner independence and enhancing learning opportunities, several barriers remain. These include issues with device access, repair delays, limited training, lack of differentiated instructional approaches and inadequate technical support. The study underscores the importance of increasing device availability, improving maintenance infrastructure, differentiated instructional approach and providing ongoing training for both users and educators. The study findings suggest a hierarchy of solutions for visually impaired learners using digital assistive devices: adequate devices, device usage and maintenance training, mentorship, and adequate support systems.

4.2 *Suggestions*

The government should develop and implement a national policy that ensures adequate and sustained availability of digital braille assistive devices for the visually impaired learners. This policy should address key issues such as affordability, accessibility, and the integration of these devices into the educational system. Additionally, the policy should promote the establishment of training programs for teachers, technicians, and learners to ensure effective use and maintenance of the devices, fostering an inclusive learning environment across the country. The policy should also focus on integration of digital braille assistive devices in examination and assessment of learners to enhance inclusivity and avert delay.

Correspondingly, learning institutions should establish robust support systems for the use of assistive technologies, including dedicated technicians for device repair and regular training sessions for both students and educators. Similarly, differentiated instructional approaches will ensure the smooth integration of digital assistive devices into classrooms, minimizing time wastage due to technical issues and empowering users with the necessary skills to maximize the device's potential.

There should be an increased focus on awareness and sensitizing both educators and communities about the importance of inclusive education for visually impaired students. Workshops, seminars, and community outreach programs can help to increase understanding, encourage adoption of assistive technologies from a holistic perspective and therefore promote a more supportive learning environment for visually impaired learners.

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