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The Challenges of Adopting M-Learning Assistive Technologies for Visually Impaired Learners in Higher Learning Institution in Tanzania

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Abstract—In the past decades, the world has experienced major changes in the advancement of learning technologies which has enabled learners to engage in their learning activities anywhere. The penetration of mobile phone internet users in Tanzania has been increasing from 2 million in 2011 to 23mil in 2017 The adoption of mobile-based learning (M-learning) for students who are visually impaired in Tanzania has become a major bottleneck since most of the e-learning contents assume that learners have sight and thus include a lot of visualizations. This causes visually impaired students in higher learning Institutions (HLIs) to face challenges such as technological knowledge gaps. Lack of skills and inaccessibility of online contents, which then lead to drop out of the university. The aim of this study is to determine the awareness and usage levels of existing mobile assistive technologies for visual impairment, and the remaining challenges that visually impaired students face, when using such tools on smartphones to access m-learning content from HLIs. in Tanzania. The research was conducted an observational and contextual inquiry study at three major HLIs. We found that 67% of respondents did not have knowledge of m-learning assistive technologies, and their technology barriers for visually impaired students. Also, knowledge, accessibility of Assistive technology and affordability can hinder the adoption of m-learning in Higher Learning Institutions.

Keywords—Assistive technologies; Higher Learning Institutions; M-learning; Mobile devices; Visual impairment

1 Introduction

The adoption of M-learning assistive technologies by visually impaired learners has been a major issue of discussion in the globe among the issues in m-learning. Different authors have described m-learning is an ability to provide/ receive educational learning contents in mobile devices such as tablets, smartphones, PDAs etc[1]–[3] at any time and anywhere hence create flexible learning Since m-learning is based on the use of mobile device at any time and any place, it makes it easier for learners to learn when they want to learn, and at their own pace [2], [4] and enhance teaching and learning in HLI. Overall, m-learning can play a vital role in education,

especially in HLIs in Tanzania by providing access to learning contents to students who are all over the country, affordable education provision and easy course transfer in all student surroundings.[5]. In the past decades, the world has witnessed gradual changes, as a result of the advancement in learning technology, which paves a way for economic development in the world[6]–[9]. Development and use of ICT in education sectors have led to increasing in a number of teaching and learning facilities including mobile learning (m learning), 3D based learning (games), and animation learning. ICT offers assistive learning to disables so as to improve the efficiency of acquiring knowledge. [10]. M-learning adoption has been increased due to the fact that most people nowadays have increased in usage of smartphone for their daily life. Most online-learning environments generally assume that all the learner has sight. For the case of visually impaired learners, it is difficult to engage themselves in using ICT adaptive tools for learning. It becomes very difficult for a visually impaired person to acquire knowledge when the concentration is made more on the graphical presentation of core learning contents. The objective of this research was to analyze the level of awareness and knowledge of technologies available for students with disabilities and identify gaps for improvement in Higher Learning Institutions. Methods used to get results was an interview with visually impaired students in higher learning institutions. The study found that most of the learners do not have knowledge and skills of using m-learning also are now aware of assistive technology used to access m-learning when using in smart devices i.e. smartphones, tablets, kindles, etc.

2 Literature Review

Visual impairment is a disability where a person has low vision or no sight at all [9]. According to the National Bureau of Statistics (NBS) of Tanzania, the number of visually impaired students decreases as they move up the education ladder to university level some of them tend to drop out of HLI due to academic challenges that they faced, with an estimated 250 students in HLI in 2018. Assistive technology is a device/umbrella which held people with disability to increase accessibility to their daily activities, for the case of visual impaired complaints of the barrier in accessing them through mobile phones,[3].Nowadays mobile devices provide a way to deliver assistive technologies i.e. screen readers to touch screen to be used by visually impaired learners and provide mobility help to them but [11]. The assistive technologies include screen reading software as shown in the table below:

Table 1. Types of Assistive Technologies Available for Mobile Devices

S/N	Assistive technology	Description	Pros	Limitations
1	Screen reading software	Reads items on the user's screens and the user's interactions		
	E.g. Voice Over on iOS and Talkback on Android	Reads icons, text, menus, features, emails and web pages. Also reads auto-corrected and auto-capitalized words before implementation while typing[12]	Free application Able to read a wide range of items	Available on iOS devices only i.e. iPhone, iPad (~23% worldwide market share in February 2019)
	Talkback for Android	Screen reader for Android devices. Use speech, vibrations, and other audible feedback to help users know what they are on the screen, what they are touching on the screen and what they can do with it. [13]	Free application Tactile feedback	Focuses on elements that are clickable Cannot read books, emails or web pages
2	Braille Input applications	Applications that allow users to enter text using the Braille alphabet		
	E.g. BrailleTouch	Smartphone app for eyes-free text entry using the standard 6-key Braille keyboard. It is 3by 2 binary matrix which is encoded by 63 characters[14]	Less expensive compared to other Braille keyboard apps It can be incorporated with existing mobile touch screen Allows faster and more efficient entry for visually impaired persons that standard keyboards	Costs almost $20 which is expensive for many people in developing countries No Image description.
3	Audio-book readers E.g. Audible	Reads audiobooks on iOS and Android		Limited to reading audiobooks only No image description
4	Audio Browsers E.g. Audio Browser	User-guided by speech as they browse the screen, Access to web pages, personal documents, and audio files.		It's in a hierarchical structure and users prefer horizontal structure[12]

Recently, there has been increased usage of mobiles devices in Tanzania due to the fact that it makes accessibility easier in every sector including education sector and there is increased number of telecommunication sectors which enable the usage of m-learning possible [7]. With the increased usage of mobile phones, the government has made it easier for institutions to engage in design and developing m-learning applications by facilitating the development of ICT tools for teaching and learning[15]. Higher education institutions have increasingly used web pages and Internet resources with essential learning materials and online learning (e-learning) still visually impaired students cannot benefit fully on accessibility [1]. According to[16], there are an estimated five HLI in Tanzania who uses m-leaning integrated into Moodle learning management system. Moodle is an open learning management system which is configured to run in operations system like Windows, Macintosh OS X also Linux. It was

designed to have features which accommodate learners including an ability to embedded resources, activity centered on different topics and discussion within the system. [17]. It is divided into three parts which accommodate both teachers and learners i.e. courses tools (course, assessments, study materials, and external links), students' part (notes, student drop box, student calendar and student manuals) and communication entity (discussion forum, chats, virtual classroom, students list and send mail). Moodle has been integrated into Moodle mobile where it is available in android devices and IOS devices called MOODLE Mobile that enables learners to use it anywhere and anytime and users can customize to fit the requirements needed. Most Higher learning institution in Tanzania has adapted MOODLE and customized it to their need for teaching and Learning.

The accessibility of learning content i.e. notes, assignments, quizzes and forums also made easier. OUTLMS(Open University of Tanzania Learning Management System), University Learning Management System(UDSM LMS customized from and SUZA Learning Management System which available in HLIs. However, these applications are inaccessible for visually impaired learners because they lack knowledge of assistive technology which enables students to read the content. This is due to the fact that most of the m-learning platform are of sighted persons and visually impaired persons are lagging behind in its usage. There are many barriers facing visually impaired students including access to information, and lack of proper education for instance in the Higher Learning Institution in Tanzania. Also, the use or adoption of M-learning Assistive technologies to visually impaired learners is not well known to learners, especially in Tanzania. People with visual impaired are among the least considered in the educational context of online learning[18]

Other authors stipulated on the accessibility of assistive devices for children with physical disabilities in Tanzania, where found that there is a government policy [19] which is silent about the usage of assistive technology and there is a limitation of how these students use assistive technology for learning in schools. Also,[10] narrated on using assistive technologies for visually impaired in primary schools by engaging teachers in preparing and narrated teaching aids for students and where students were using multimedia devices.[20]discussed incorporation clouding computing on m-mlearning for commerce, healthcare, and educations system to improve productivity in the nation. However [1] designed a framework for m-learning to be used in Higher institutions which motivate students to use it and learn in order to increase mobility and efficiency. [21]designed m-learning for professional development of the people especially those who are in offices who are not visual impaired [23]found that it is advantageous to use cloud computing for e-learning solutions and it influences the way the e-learning software projects are managed. [24] explained on the challenges that are facing learners on the usage of smartphones on taking photography by using VizWiz Social app which available in iPhone and limitation is that the app is only available in iPhone and identify image which has Barcode.

However, numerous research projects report that the majority of websites visited cannot be accessible to disabled students. Inaccessible online materials promote an educational divide where people with disabilities are denied equal access to public education [25], [26]. The objectives of this study were threefold. First, we aimed to

determine the level of awareness of smart devices, assistive technologies among visually impaired HLI students in Tanzania. Second, the study examined the knowledge and skills of assistive technologies and m-leanings available and third, identified challenges that facing visually impaired students and how they adapt them for learning in HLI.

3 Methodology

3.1 Participants

Thirty-three (33) participants (22 males, 11 female) took part in the study. 12 participants (36.4%) were between the ages of 24 to 29 and 10 participants (30%) were older than 36 years old and hence most of the participants were all already employed. Four (12%) of the participants were Ph.D. students, 6 (18%) were master's students and 23 (70%) were Bachelor degree students. Recruitment was done via schools in the HLIs, who provided names and contact details of students with disabilities. Only students with visual impairment were considered eligible. The participants were chosen based on the willingness to participate in the interview without disturbing their academic timetable. Before the interview, the researcher was granted consent from universities where the participants studied.

3.2 Data collection and analysis

Structured interviews and observation were used to collect data. Participants were interviewed on an individual basis for forty-five minutes each. At the beginning of the interview, participants were asked about their educational background, current education level, age, and other demographic characteristics. They were then asked questions about their knowledge on m-learning and assistive technologies including: "*Does your university have an m-learning platform?*", "*Do you know any m-learning platforms used in other HLIs in Tanzania?*", "*Do you know any assistive technologies for visual impairment on mobile devices*" and "*Which mobile assistive technologies do you use and what is your general experience with them?*" Questions on the challenges they face in accessing m-learning platforms at their universities including "*How do you participate in online learning using smart devices?*", "*What challenges do you face when accessing learning platforms?"* were then asked. All responses were filled out in a pre-typed form. Following the interview, participants were observed as they completed learning tasks such as accessing lecture notes on their universities' LMS using their own mobile devices. The task was meant to further shed light on the challenges the participants faced in accessing online content via smartphones and the strategies they used to mitigate these challenges. Both the challenges and mitigating strategies were recorded as keywords. After the exercise, participants were asked to respond "yes", "no" or "maybe" and to give reasons as to whether they felt they were able to read and understand the content provided. The interview responses and keywords were coded using an inductive approach. Frequency distributions, percentages, and

cross-tabulations were then used to determine the most frequently occurring challenges, mitigation techniques and recommendations from participants on how to address the existing shortcomings of m-learning for visually-impaired students.

4 Results and Discussion

This section presents the results obtained from the interview and observation study.

4.1 Mobile devices owned by participants

Only 11 participants (33%) owned smartphones. The remaining (n=22, 67%) owned dumb phones or feature phones. However, of the smartphone owners, 10 owned Android phones while 1 owned an iPhone 4. Five (5) of the smartphone owners were aware of the internet capabilities of their smartphones but did not use the internet, while the remaining 6 did not know how to access the internet on their smartphones. Participants who had feature phones also had access to smartphones when needed. Figure 1 shows the types of mobile devices owned by the participants.

4.2 Knowledge and use of assistive technologies available on mobile devices

Participants were only knowledgeable about assistive technologies that they had previously used. The most commonly known and used assistive technology was screen reading software e.g. Android's VoiceOver. Participants reported using screen reading for making calls and texting (n=27, 82%), downloading and reading documents (n=4, 12%) and browsing social media (n=2, 6%). Participants were unaware of other assistive technologies on mobile devices.

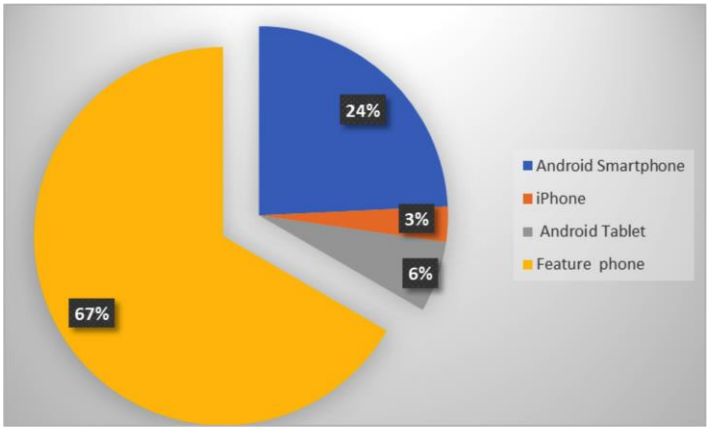

Fig. 1. Types of Mobile Devices Owned by Participants

4.3 M-learning knowledge and use

Most participants (n=27, 89%) initially reported not being knowledgeable about the concept of m-learning i.e. what it is and m-learning support in Tanzanian HLIs. After being explained, 23 participants (85%) reported that they had never used any m-learning platform and were unsure whether m-learning platforms were used by their universities and how these platforms could better support VLIs, while 4 (12%) reported that they had used their mobile devices to access the learning management platforms (e-learning platforms) at their universities. The other 6 (18%) participants who reported having an idea about m-learning mostly related it to the e-learning platforms used at their universities.

4.4 Usefulness of mobile assistive technologies for accessing learning content

Only five participants (17.2%) felt that assistive technologies were well designed for visually impaired learners as they helped with communicating (calling, texting) or web browsing activities. The majority, however (n=24, 82.8%) indicated that both smartphone applications and assistive technologies did not consider VILs in their interface and interactions design. For instance, screen reading was deemed useful for reading text only. However, lecture notes and other HLI resources typically contain many tables, graphs, and pictures, which could not be well read by the software. The participants remarked that this problem was not limited to the tools i.e. mobile devices only, but extended to the e-learning platforms used in their HLIs and the content hosted on them in general.

4.5 Learning management platforms content readability

Observation of participants performing learning tasks revealed that more than 89% of the learning management platforms available (e-learning, m-learning) in Tanzanian HLIs do not have integrated assistive features. Therefore, VILs have to use assistive technologies on their devices to access the content, and we confirmed participants' claims that screen readers were mostly appropriate for reading text. When attempting to read tables and figures, the alternative text provided (if at all provided) was the most useful information provided by screen reading. It was difficult for participants to pinpoint what data belonged to what column in the case of tables, and to remember the range of values read, while for figures no information on the content shown in the figure could be obtained. Overall, 27 participants (84.4%) felt they were not able to fully read and understand the contents uploaded on their universities' LMS, and only 2 (7%) felt they had managed to read and understand the content, although this applied only to content with alternative text provided.

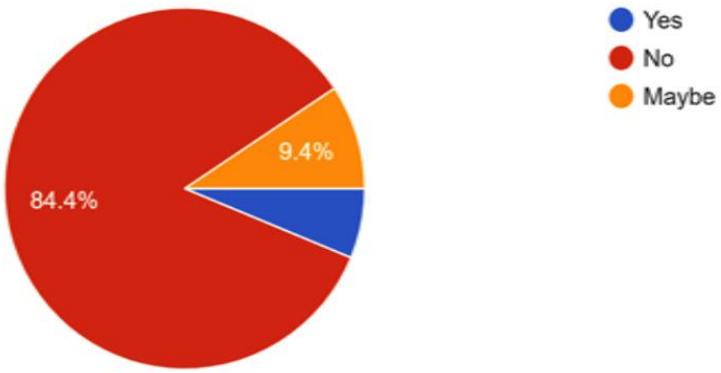

Fig. 2. Readability of graphical content when using mobile screen readers

4.6 Participants' opinions on easing M-learning adoption by VLIs

Twenty-eight participants (85.5 %) cited a lack of knowledge of different mobile assistive features and how to use them would be the main barrier to VILs adopting m-learning. However, twenty-six of these participants (79.4%) further noted that lack of integration of assistive technologies and accessible content in the HLI learning platforms themselves would also be a major barrier, as due to financial constraints, not every student would be able to own or have regular access to a feature phone or smartphone to use the assistive features if they are lacking on the platform. The need for special education teachers to be involved was determined as a crucial solution to easing m-learning adoption, as the teachers could help ensure content uploaded is more accessible given the capabilities and limitations of available accessibility tools. Seventeen participants (52.9%) also called for writing and enforcing of laws that require HLIs to provide accessible content and develop VLIs; skills on using assistive technology Participants emphasized the need for quick action as currently VILs who own feature phones mostly use them for communicating while those with smartphones mostly use search engines to find text-based notes. In addition, they mentioned their high interest as proof of an existing gap in meeting the needs of VIL at HLIs. Over 61% of participants voiced their intentions to engage in m-learning now that they had been shown how they could do so while 30% were interested but not sure if they would be able to be successfully do so without further training.

5 Discussion

The study aimed at analyzing the knowledge, awareness, challenges, and usability of m-learning assistive technologies available to be used by visually impaired learners. After examining the relationship between data variables, it was found that there is a correlation between knowledge and the use of m-learning to the usage of assistive

technology available in smart devices and knowing how to use it in daily life. Therefore, the finding advocates from learners' point of view that many higher learning Institutions in Tanzania are lacking m-learning technology only use e-learning for teaching and learning which sometimes make it difficult for visually impaired learners to engage in learning using their smart devices. Many challenges were identified regarding the adoption of m-learning including the financial constraints to purchase and usage of the devices, poor knowledge of m-learning existence in Tanzania is the key constraints compared to the skills and knowledge of usage. Also, there are Institutional challenges whereby utmost HLI are not yet in adopting and usage of m-learning platforms even though some of them have been using E-learning for teaching and learning. The research also found that attitude and behavior of leaners towards usage of smart devices for learning can hinder the usage of m-learning platforms hence HLI do not see the benefit of having it. Moreover, there are also challenges that involve technical know-how of smart devices including applications, physical attributes of mobile devices and network and memory capability. This is similar to the study which was done in Kuwait on acceptance of m-learning [27] and found that the use of mobile technology in learning is not as widespread as the devices themselves as most of the devices are used as means of communication and social media. Also, the study was done in Delhi universities whereby it was concluded that there was barrier inaccessibility of web contents faced by VIL in Libraries systems. Moreover, the study done in Australia believed that there was barrier faced visually impaired learner on the accessibility of graphical in web data and this is the challenge facing learners worldwide [28]hence there is a need to for developers to consider this group of learners when developing learning platforms. So, there is a need for availability of open education resources for mobile learning like Moodle Mobile, Blackboard Mobile to be customized to fit the need of learners and making access more affordable to the students. However available assistive technologies are lacking the capability to read and describe the graphical contents i.e. photos, charts, and graphical representation only text-based and some navigation are able to be translated hence for visual impaired becomes difficult for them to use alone without asking for help from others hence no privacy for them. The questions were asked: *Do you agree that m-learning needs to be supported so that it can enhance teaching and learning in Higher Learning Institutions*? Respondents agreed that it needs to be supported and enacted in HLI and should make sure that they have assistive technologies to be used by the visually impaired student alone without asking for help from others while using m-learning as one of the respondents said *Screen readers with high quality, especially those which can read pictorial representation or graphs.* By having smart devices with assistive technology capacities will enable visually impaired students M-learning is the new technology in Tanzania and some of higher learning institution is trying to implement it for teaching but with available assistive technology will make the learning easier.

6 Conclusion

The increasing investment in information technology and communication tools and devices in HLI for Visual Impaired learner will help increase and novelty their adaptation of the new m-learning assistive technology hence increases enrolment at HLI. There is a need to highlight the role of mobile computing technologies and application for the higher education sector and prepare the proper procedures and training to equip VI students with the best methods for the best usage. The study recommends that learners must be motivated by using a smartphone for learning, also provide m-learning assistive technologies knowledge and skills to them so that they can be able to apply it. Policies should give more attention on levitation awareness on m-learning technologies which are compatible to visually impaired learners More training should be provided either as short courses or embedded in their university training on the usage of m-learning which are recommended for visually impaired persons. In order for visually impaired learners to use m-learning platform, there is a need develop the assistive technology or the interface which have the ability to describe the graphical contents in their smart devices and the cost of the system should be low with simple and affordable. By doing so there will be no drop out in university and will increase the enrollment to visually impaired persons.

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