ICT-Based Assistive Technology for Empowering Persons with Visual Impairment

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ABSTRACT

The study employed comprehensive assistive technology (CAT) model to investigate use of ICT-based assistive technology (ICT-Based AT) for empowering persons with visual impairment. The objectives of the study wasto explore the strategies employed by people with visual impairments to learn ICT skills and the impact of using ICT-based AT for VIPs. Twenty-five (25) people with visual impairment graduate from the ICT skills training sessions at the Open University of Tanzania were interviewed using semi-structured interview guide. Findings indicated that ICT-Based AT training strategies for people with visual impairment require developing competences on keyboard and the use of screen reader. Furthermore, the use of ICT-Based AT has a significant positive impact on individuals with visual impairment in terms of enhancing their chances in accessing online learning, sense of empowerment and social inclusion. The present study makes a theoretical contribution to the field by enhancing the existing literature on the activity attributes of the CAT model. The study also calls for the government and stakeholders to enhance the use of ICT-Based AT for empowering persons with disabilities.

Keywords *Assistive technology, visual impairment, Open University of Tanzania, NVDA, ICT-Based AT.*

INTRODUCTION

According to the World Health Organization's (WHO) global report on vision, at least 2.2 billion individuals worldwide have some form of visual impairment;at least 1 billion have a condition that might have been avoided or is still unaddressed (WHO, 2017). According to Ackland et al. (2017), 89% of visually impaired people reside in low and middle-income nations. According to WHO (2017) and Fernandeset al. (2019),people with blindness and moderate to visual impairment is on increase, calling for intervention strategies to improve the livingstandards of people with blindness, including the use of ICT-based assistive technology. With the ageing population projected to grow significantly over the next few decades, the number of people with visual impairment is expected to rise (Fernandeset al., 2019). According to Bhowmick and Hazarika (2017),ICT can be used to improve the daily functioning of people with visual impairment by improving their performance in many activities. In the context of increased use of smartphones, there is an increase in access to information through the application of information and communication technologies (ICTs), which poses challenges to people with visual impairment. Assistive technology (ATs) can help people with visual impairments overcome limitations, improve their work skills, and achieve social inclusion (Ackland et al., 2017; Li &Xiong, 2017; Hersh& Johnson, 2010).

According to Park et al. (2019),ICT can be used by social workers, healthcare experts, and community members to promote the growth of social and health needs in the community. This study aims at exploring the views of persons with visual impairment on the use of ICT-based assistive technology for empowering persons with visual impairment. ICT is crucial for many aspects of life, and it is especially important for amusement and fun (Islam et al., 2020). Many individuals now use ICT as a source of enjoyment and as a regular part of their lives in the form of mobile and computer games. Mobile games not only give entertainment but also aid in reducing tension and frustration (Tollefsen&Lunde, 2004). This is especially true for disabled people. According to Garcia et al. (2009), gaming has a therapeutic effect on the body and mind. Thus, participation in ICT-based entertainment is crucial for those who are blind or visually impaired. However, because the majority of ICT-based entertainment tools are designed for normal people, blind individuals are denied this option. Making ICT accessible to everyone, including those with disabilities, is necessary to improve the quality of life.

This study addressed the following questions:

(1) What are the strategies employed by people with visual impairments to learn ICT skills?
(2) What are the impactsof using ICT-based AT for VIPs?

People with Visual Impairment in Tanzania

According to WHO (2011), disability refers to the adverse effects of the interaction between an individual (with a health condition) and that individual contextual factor (environmental and personal factors). Dissability includes impairments, activity limitations, and participation restrictions. It is estimated that 7.8% of people in Tanzania are disabled (Mnyanyi, 2014; United Republic of Tanzania, 2008).According to the 2008 Disability Survey conducted in Tanzania, the prevalence of vision impairment was 3.1% (Mnyanyi, 2014). About half of the people with disabilities (PWDs) (47.6%) were illiterate, compared to 25.3% of people without disabilities. Alsmost35% of PWDs aged 15 and older reported having trouble finding information in an accessible format; and 2% of children with disabilities used assistive devices. Such data suggests that it can be difficult for people with disabilities to receive social services, including schooling.

Access to services in the areas of health care (including rehabilitation), education, transportation, and employment is significantly hampered for people with disabilities (WHO, 2011). Due to pervasive barriers, people with disabilities are seen as belonging to a lower social class. This is because they have fewer employment opportunities, a very low income, and are unable to participate in daily activities, which increases their dependence (Sunsern et al., 2012; Wanaratwichit et al., 2008). It is argued here that, since disability in Tanzania like other countries will continue, there is a need to start developing means to support persons with special needs and disabilities so that they can adapt to the environment. Integrating ICT in teaching has become the practice in both developed and developing countries (Mnyanyi et al., 2012; Bingimlas, 2009; Dawes, 2001; Schiffmanet al., 2007; Hosieet al., 2005; Kim & Bonk, 2006). Mnyanyi et al. (2012) found that ICT has thepotential to create the learning opportunitiesfor all, including persons with visual impairment. Though ICT has thepotential to open up the opportunity for persons with special needs and disabilities,there are some challenges that limit its achievement. According to Mnyanyi et al. (2010),such ICT challenges are related to infrastructure, affordability, accessibility, adaptability, ICT trainers (human resources), economic scales and possible ICT

training opportunities for persons with special needs and disabilities. By 2016, only the Open University of Tanzania had provisions for ICT training for visually impaired and hearing-impaired persons in Tanzania. As such there are few people trained toteach ICT topersons with special needs and disabilities (Mnyanyi et al., 2012).

ICT-Based Assistive Technology

People who are visually impaired (VIP) encounter a variety of mobility challenges in cities. The rapid development of innovation and technical research advancements has offered the blind hope for developing ways to navigate smart cities and improve their quality of life(Ramadhan, 2018). Stevie Wonder, the visually-impaired pop singer, once said that "there's nothing on the iPhone or iPad that you can do that I can't do." (Huang et al, 2022). Consumer technologies like cell phones have given the blind and visually impaired additional opportunities to experience activities that are accessible to the general public. Assistive technology tools are made to help people with disabilities navigate around their challenges (Rose et al., 2005). Accessibility, as defined by the World Wide Web Consortium [W3C] (2016), is the capability of a website to be utilized without difficulty by people with disabilities. Assistive technology for those with visual impairments includes screen magnifiers, screen readers, and mouse scanners. The term "universal design" refers to a similar but broader idea that is used to create goods and services that are useable and accessible to everyone, regardless of their skills, colour, gender, culture, or other differences (Ostroff, 2011). In order to achieve inclusive education, the universal design concept is implemented in education through the use of the Universal Design for Learning (UDL) (Wilson, 2017).

Khan and Khusro (2021) looked into the problems, potential, and uses of smartphone-based assistive technologies for the blind and visually impaired. The study concentrated on the difficulties that people with visual impairment face when performing daily tasks. The findings indicated that people with visual impairment face several challenges including reading product labels, recognizing currency notes and navigating unfamiliar environments. People with visual impairment face challenges related to determining the appearance of a subject of interest, interacting with digital artefacts, using a smartphone's user interface, and selecting non-visual items on a screen. Findings showed that the development of smartphone-based assistive technology encouraged freedom, the convenience of use, and usability leading to an enhanced quality of life yet presents various

challenges. Findings also showed that in order to fully realize the promising potential of ICT-based treatment options for blind individuals, technology improvements, an accessibility-inclusive interface paradigm, and collaboration between medical professionals, computer professionals, usability experts, and domain users are required. Douglas et al. (2007) used an interview schedule with 1007 interviewees to examine the role of the WHO ICF as a framework to interpret barriers and to inclusion for people with visual impairment. Findings showed that the ICF provided a vocabulary to help visually impaired participants describe their lives in terms of participation and potential barriers to social inclusion. They also showed a clear relationship between age and computer use, with older visually impaired people being much less likely to use computers. The results also showed that despite the fact that technology offers many advantages, such as access to information and a path to employment, many blind and visually impaired people do not see the relevance of ICT. The study indicated ICT challenges related to individual barriers to using ICT (such as their visual impairment), and perceive social barriers to using ICT (such as the cost, availability, and accessibility of technology, as well as issues related to training).

To make mobile entertainment available to everyone in Bangladesh, Islam et al. (2020) looked at the design, implementation, and evaluation of a mobile game (BrickBlaster) for blind individuals. The study had 24 blind participants. The game was created with voice-over instructions, haptic feedback, vibro-tactile signals, and five stages in mind. The results showed that blind persons could use and play the game. The evaluation study's results indicate that each level's completion had a reasonable amount of difficulty in terms of time and attempts. The difficulty rose as the players advanced to the following level, as was to be expected. Analysis of the effect of the players' demographics (such as gender and whether they were in high school or college) on the game's playability in terms of success rate, attempts, level completion time, and player attitude metrics revealed no significant differences. Additionally, the game was highly rated for its usability, simplicity of learning, enjoyment, degree of involvement, and excitement. Finally, research revealed that participants were quite likely to play the game again and to tell others about it.

ICT Skills Training at the Open University of Tanzania

The Open University of Tanzania (OUT) is a public University that delivers learning through Open and Distance Learning mode. The University was established through the Act No. 17 of 1992 and became fully operational in 1994(Mnyanyiet al., 2010; Bisanda, 2009). The university started enrolling persons

with special needs and disabilities, especially, the visually impaired (the blind) in 1997 with support from David Anderson African Trust (DAAT). The programme had a component of using audiobooks recorded in audio cassettes. The visually impaired students were given a radio cassette and the audiobooks. During examinations, these students used a typewriter. Since 2004, the University started planning to use ICT in delivering teaching and learning. The question then was how to support the visually impaired students in the transition. By 2010, the university had established over 13 ICT laboratories for ICT training to the community. But none was catering for the needs of visually impaired students. In 2009, the University started looking for partners to support the establishment of ICT skills training for students with special needs and disabilities. It is until 2011 that OUT and partners including the Tanzania League of the Blind (TLB), Sightsavers, Tanzania Education Authority, and the Ministry of Education managed to launch ICT training for the visually impaired at The Open University of Tanzania. In the training, a total of 15 persons attended the training of whom two were hired by OUT as trainer of trainers(Makoye, 2017).

Theoretical Framework

This studyemployed a comprehensive assistive technology model (CAT) (Wang & Wu, 2021; Hersh& Johnson, 2008a, 2008b). The CAT model was created as a result of Cook and Hussey's (2002) Human Activity Assistive Technology (HAAT) Model, which is used to match assistive technology to a specific end-user (Hersh& Johnson, 2010). In a hierarchical tree structure with a number of categories at each level, the CAT Model covers a wide range of attribute components, including context attribute, person attribute, activities attribute, and AT attribute. This model offers a tabular checklist for the analysis and synthesis of AT as well as a systematic vocabulary and description for all aspects of AT applications. Through actual case in-depth interviews, this study supports three activities attributes in the CAT Model (Figure 1) combining sociological, psychological, communication, and cross-cutting disciplines in academic theory.

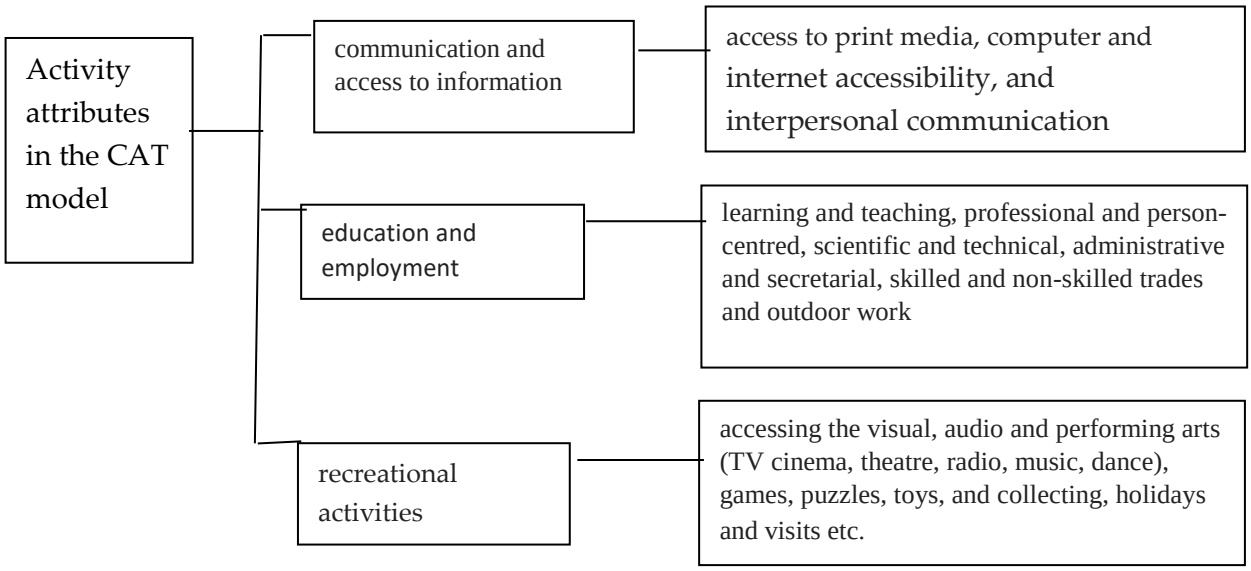

Figure 1: Activity attributes in the Comprehensive Assistive Technology (CAT) model modified from HershandJohnson (2010) and Wang andWu (2021).

Method

By employing the CAT model, this qualitative study conducted in-depth interview sessions to persons with visual impairment graduates of ICT skills training. Twenty-five (25) people with visual impairments who attended ICT skills training classes at the Open University of Tanzania were interviewed using semi-structured interview guide(Table 1).

Table 1: The Study Respondents

Age	Male	Female	Total
15- 25	5	6	11
26-45	7	3	10
Above 46	3	1	4
Total	**15**	**10**	**25**

The interviews took place between March 22, 2022, and April 22, 2022. The same interview guide was used to all the participants. Along with participant observations and focus group discussions, the interviews were directed to the research. The in-person interviews about people with visual impairment use of screen readers were broken down into two sections. Section one was on the strategies used for facilitating ICT skill training for people with visual impairment and the second session was on the impact ofICT-based AT. In the case of impact of

ICT-based AT included issues related to physical limitations, empowerment, social participation and how use of ICT-based AT affects their social inclusion.

Results

Strategies Employed by People with Visual Impairment to learn ICT Skills

Amponsah and Bekele (2022) state that despite the potential benefits associated with increasedaccess to and the calibre of education, including visually impaired students in online learning has remained a challenge. The UN's SDG 4 goal, which aims to ensure inclusive, equal, and equitable lifelong education for all by the year 2030, has given online learning increased significance in higher education institutions around the world. The majority of research showsthe existence of regulatory frameworks and some types of digital technology, but accessibility and usability continue to be an issue for people with visual impairment. There are specialized sections for people with visual impairment in institutions, but online learning help is still difficult to come by. Universities must create flexible and adaptable policies using inclusive and participatory methods. In this study, graduates of the ICT skills training for people with visual impairment explained strategies they used to learn ICT. The strategiesincludelearning the computer parts, learning the keyboard skills, windows navigation skills, and the use of screen readers before start learning the application software like MS Word and the internet. As one of the people with visual impairment (VIP) stated:

> *Learning ICT was interesting. The ICT facilitator was a blind person. That gave me confidence. Learning ICT skills started by touching different parts of the computer. Later I learnt keyboard skills. I also learnt listening skills to the screen reader like NVDA, and Windows navigation skills using the keyboard functions before learning the common computer skills like application software and the internet (VIP 5, Female, 26 years old).*

People with visual impairment need to learn the keyboard functions as they cannot use the mouse. Thus, they have to master Windows navigation using the keyboard functions (Mnyanyi et al., 2022). Persons with visual impairment used several strategies to master ICT skills including having some skills in keyboard, and some knowledge ofEnglish language as the synthesiser used was in English. However, later on, it was understood that one has to learn listening skills, so that they could follow the English language of the screen reader (synthesiser). For a visually impaired person to use a computer one must learn the keyboard because all commands are in the keyboard.

> *When I started learning ICT, I thought it was so difficult and that I cannot learn. I decided to attend all the sessions. On the first day, the teacher taught parts of the computer and mentioned a keyboard. Then because I regularly go to church, I thought there are things I know, like a keyboard. But when the teacher started teaching us, I became aware that the keyboard in the church is different from the one used in computers. Since I had some skills in the typewriter, it was easy for me to learn the keyboard skills (VIP 13, Male, 36 years old)*

Despite its positive effects on expanding educational access,ICT has its drawbacks. UNESCO (2011) lists several obstacles to using ICT.Such obstacles include the inadequate ICT resources and the ineffective use of available resources. Others areteachers' awareness of the advantages of using ICTs; teachers' attitudes toward using ICTs in the classroom; students' and parents' awareness and attitudes toward using ICTs.Other obstacles are the lack of flexibility in the current curriculum, teaching methods, and assessment methods; and the difficulties in meeting the needs of all students. When it comes to the ICT teaching and learning process, various persons with special needs and disabilities employ different tactics. The blind utilizes a synthesizer that is set to their preferred language, in this example Kiswahili in Tanzania.

The Impacts of using ICT-based AT forpeope with Visual Impairment

The positive impacts of ICT-based AT usage toward VIP include: creating access to education, access to employment, creating networking, improving performance in work and general life, improving access to skills development, creating independence, and breaking barriers to communication. A 53 years oldmale indicated the importance of ICT as supporting a person with visual impairment to online life dependence like the non-disabled. The old man was an engineer and lost sight at the age of 50. This person was one of the first graduates of ICT skills training at OUT. He Commented:

> *I was a Chemical Engineer and became visually impaired at the age of 50; I thought this was the end of life. But later I decided in myself that I have to do something. I joined braille skills training course and later decided to look for a job. I secured one at OUT and got ICT skills training course. After ICT training, I am now working as ICT facilitator for visually impaired persons. Above all, I have joined courses in social work and now I am doing my Master in Social Work degree. I do participate in online course and do perform well. I am determined. My self-determination led to receiving the Commonwealth Award in 2016 in Kuala Lumpur, Malaysia (VIP 2, Male 53 years).*

The other visually impaired person said, ICT led to secure a new job that enabled people with visual impairment to earn a living and improve the quality of life.

> *I had no job. After ICT training, I decided to search online some mobile applications and then started learning how to become a mobile phone repair. Now I am happy as ICT Skills training has created a self-employment job for me. I can repair mobile phone using software where I need to join some parts I ask support from the sighted peers but myself can put music in mobile phones and troubleshoot a mobile phone with easy. I also established training sessions through appointment (VIP 22, Male, 30 years old).*

With the assistance of ICT-based AT, most VIP can use daily life apps, such as social media like WhatsApp, telegram, mobile payment apps, and online shopping apps. Use of application software make life easier for people with visual impairment. With the use of online services, people with visual impairment find it easy to participate in online learning.

> *I was trained as a lawyer but never had a job. After attending ICT training at OUT I was employed as ICT facilitator for the visually impaired persons. Above all, initially, I was limited to friends who can come across to me.With ICT, have created more friends through networking. Through ICT, I was able to find new employment opportunity and further studies. I can decide to go online and study different books, online news and make online applications. ICT have changed completely my profession, from a lawyer to IT expert (VIP 23, Male, 35 years old).*

The modern economy requires everyone to have some minimum level of technology in order to participate fully in the modern economic, social, political and technological requirements (Haddad &Draxler, 2002). Further, ICT can enhance inclusion,as one of the ICT skills graduate narrated:

> *After my graduation on ICT skills training at OUT, I started teaching ICT at the college where all students are sighted. I feel proud as we all know sighted persons to believe that a visually impaired person can teach ICT is not easy,but I am doing it. I can prepare my slides independently and only support I need is when choosing image to include in my slides and on adjustment of my projector in class. I can also use track change and actually can do all things in Microsoft Office without problems. I can also use html and php programmes to create websites in my own (VIP 17, Male, 42 years old).*

The negative impact of ICT-based AT was noted by VIP 7, a 42 years old female participant who lost vision due illness at the age of 40. During her sighted life, she was a photographer in events and she was so happy with the skill. When she

became blind, she could use all the apps in a mobile phone, the only limitation she has is taking a photo as he narrates:

> *During my sighted life, I liked taking photo and changing the way I want sung apps. Now I can use many of the apps in my phone. The only challenge I face is how to take a photo. It is difficult,I have to ask someone to take a photo for me. With increasing discovery, may be one day I will be able to use my skills of taking a photo (VIP 7, Female 42 years old).*

People with visual impairment are empowered by ICT-based AT because it increases their access to knowledge and education. People with vision impairments can join in social events when participants convene in an online space or group for VIP through the use of ICT-based AT, which improves their social experience. They can create communities where they share knowledge, gain knowledge, discuss issues, and unwind. Their informational and social requirements are centred on issues related to finding employment, educational possibilities, monetary support, emotional support, and other forms of social support (Wang & Yu, 2017). Without AT, they are unable to manage everything, pursue online employment, online education opportunities, and VIP pleasure. A 32-year-old female with visual impairment had the following to say:

> *I have to say that the amount of information received is relatively more. If you don't read the screen, you won't be able to receive a lot of information, including news events job placement, online learning opportunities, leisure and business. If you don't have a screen reader, you can't participate at all. (VIP1, Female 32 years old).*

The challenges faced by persons with visual impairment is related to financial capacity that limits from buying software and thus depend on free software that has many disadvantages including pop-up messages and creating risks to information security. ICT has generally shown to support people with special needs and disabilities in supporting personal access to information and knowledge as a tool for improving a learner's access to information and knowledge in formal and non-formal learning situations.It supports learning and teaching situations for pedagogical, didactic uses, assisting in personal, learning development, and shaping new skills.ICT is also a tool for teachers to support learning, development of new skills,and in supporting the personal learning development of individuals with special needs and disabilities.

Conclusion

This study suggests that the utilization of ICT-Based Assistive Technology, specifically screen readers, has resulted in improved communication and information accessibility, as well as enhanced opportunities for education, employment, and leisure activities among individuals with visual impairment. Individuals who experience visual impairment have the ability to utilize Information and Communication Technology (ICT)-based Assistive Technology (AT) via screen readers on mobile phones and computers to access commonly used smartphone applications and internet services. This enables them to seek online employment opportunities, access educational resources, engage in online shopping or ordering services, and ultimately enhance their overall efficiency and engage in lifelong learning opportunities. The present study makes a theoretical contribution to the field by enhancing the existing literature on the Activities Attribute of the CAT model, from the aforementioned perspectives.

Technological empowerment expands individuals' self-awareness and decreases their reliance on others. It is argued that the existence of a "digital divide attribute" may result in inequity or destruction of relationships, such as limited access to ICT skills training that could reduce dependence and vulnerability to exploitation in pursuit of productivity enhancement. It should be noted that there exist certain limitations inherent to the assistive technologies themselves, including interface designs that may not be user-friendly for visually impaired persons, as well as restricted capabilities for recognizing visual media such as pictures and videos. Enhancing volunteer participation and advancing human civilization can potentially contribute towards addressing the issue and providing more sustainable resolutions. This study suggests that the use of ICT-Based Assistive Technology empowerspersons with visual impairment.The adoption of Information and Communication Technology (ICT)-based Assistive Technology (AT) such as smartphones and screen-reading software among individuals with visual impairment represents a seamless progression towards an enhanced standard of living. One limitation of this research pertains to the decontextualization of interviews.

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