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ORIGINAL RESEARCH

A glimpse into smartphone screen reader use among blind teenagers in rural Nepal

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ABSTRACT

Purpose: Access to appropriate assistive technology is a challenge worldwide and especially in low GDP-per-capita countries. Nepal is one example of a country with several coinciding challenges: some claim having a high rate of blindness in the general population, a low-GDP-per capita and some studies claim it has a low literacy rate, especially in rural areas. Without appropriate assistive technology, some disabled youth may not get full access to education.

Methods: To gain insight into assistive technology use in rural Nepal, five blind teenagers in a mixed secondary school with disabled and non-disabled students in rural Nepal were interviewed about their daily smartphone use.

Results: The results show that all the participants used screen readers on donated smartphones. None of the participants had received formal training in using smartphone screen readers and therefore lacked knowledge about basic and essential operational aspects of the devices as well as misguided expectations about the technology.

Conclusions: One implication of the findings is that smartphone accessibility features training material needs to be made easily available to schools and all disabled youth worldwide, as smartphones are increasingly becoming available in low-income remote regions with low literacy rates. The built-in accessibility features of smartphones promise disabled youth a non-stigmatizing platform for social participation and access to the information society.

➤ IMPLICATIONS FOR REHABILITATION

- The built-in accessibility features of smartphones provide disabled youth a non-stigmatizing practical platform for social participation and access to education.
- Training material on how to use smartphone accessibility features needs to be made easily available to schools and all disabled youth worldwide.

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Blind; visually impaired; smartphone; screen reader; Nepal; low-GDP per-capita countries; inclusion

Introduction

In 2012, it was estimated that around 285 million individuals worldwide are visually impaired, and that about 39 million of these could be defined as blind [1]. These estimates are based on surveys in 39 countries with an error margin of about 10–20%. In 2014, it was estimated that 19 million children were visually paired worldwide and 1.4 million could be classified as blind [2]. Children with reduced vision are more at risk not being able to complete basic education. Without education it is much harder to obtain employment and live an independent and dignified life.

The national literacy rate in Nepal was found to be low (around 66% in 2018) [3]. The literacy rate was much lower in rural areas (around 62%) compared to urban areas (around 84%), and yet with large differences between males (around 71%) and females (around 45%) [3]. Moreover, a study from 1998 estimated that the prevalence of blindness in Nepal was high (close to 1% of the population) [4]. A more recent study from 2012 of students in integrated schools for the blind in Nepal [5] revealed that some of the enrolled students were incorrectly diagnosed and 41% of the cases were avoidable. The authors concluded that many students categorized as blind could greatly benefit from optical intervention such as assistive technologies. Clearly, providing access to appropriate assistive technology is challenging in low GDP-per-capita countries (Nepal world rank 155 in 2020 according to the International Monetary Fund (IMF)). However, the lack of assistive technology use is not unique to low GDP per capita countries. A study from 2009 of visually impaired students in the US [6], which can be classified as a high GDP-per-capita region (world rank 10 in 2020 according to IMF), showed that a majority (more than half) did not use any software-based assistive technology. Moreover, these visually impaired students were not being trained to use assistive technologies in schools, contrary to what the professionals assumed.

Evidence of cost being a barrier to access of assistive technology can be interpreted from the results of McCarthy et al. [7], among others. They studied screen reader use in India in 2012 and found that most users relied on JAWS. Of these JAWS users, 56% relied on pirated software copies. They contrasted JAWS to the open source NVDA. NVDA eliminates the barriers related to the cost of screen reader software. The Indian screen reader users

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mostly used it for operating office applications, reading email and surfing the Internet.

This study therefore set out to get a glimpse into smartphone use among blind teenagers in rural Nepal. We decided to focus on smartphones as the cost of smartphones is constantly falling. Moreover, all smartphones come equipped with integrated accessibility features such as integrated screen readers. We focussed on blind users due to the alleged high prevalence of blindness in Nepal. To the best of our knowledge, there are no such documented studies available, although there are surveys of assistive technology use in other low GDP-per-capita countries, such as India (IMF world rank 116 in 2020). Although Nepal is geographically in a similar area as India, there are also many differences related to geography, culture, the size of the population and other socioeconomic attributes.

Related work

Although the history of smart device technologies goes back several decades such as the personal digital assistants (PDAs), the modern smartphone has been around for just over one decade. The iPhone was the first modern smartphone to emerge in 2007 with the HTC Dream as the first Android device in 2008. Yet, it took several years before the smartphone technology was as widely adopted in society as it is today. The documented studies into smartphones and accessibility therefore need to be viewed in relation to the technology adoption timeline as the timing of such studies may affect the results [8].

In 2015, Rodrigues et al. [9] followed five blind users who had never used smartphones before over an eight-week period while they were introduced to smartphones. They observed that blind users tended to use older types of phones as these were perceived as easier. They also identified that smartphones were challenging due to a lack of support and inconsistent accessibility feature behaviours. Especially, navigation inconsistencies made it difficult to build a mental model of the respective applications. They also found that the participants had problems inputting certain gestures (L-gestures), even after many trials. Participants also struggled with the bounds of the screen and capacitive buttons that do not have physical cues. Similar challenges with gestures and screen bounds were reported by Buzzi et al. [10].

Several studies have investigated smartphone use among blind in specific geographical regions. Vashistha et al. [11] describe how regular mobile phones (pre-smartphone devices) were used in rural low-income regions of India in 2015 by the means of services with voice interfaces operated by pressing the numeric keypad on the handset. This is also known as interactive voice response (IVR). Their structured phone-based survey revealed that all their participants had access to simple mobile phones, but 40% of these were shared. Of a total of 18 participants, six had access to smartphones with screen reader and internet connectivity. Of these, five used social media, four read email, three read news and one used the handset for music. In a study conducted in Bangalore, India in 2017 [8], 81 users with various levels of visual impairment were interviewed about their use of smartphones and traditional (feature phones). Their results revealed that several participants switched to smartphones despite being aware of usability challenges. Cost was a major issue and the authors addressed the barriers resulting from low-income individuals usually not sharing households with high wage earners. Males were found to have better access to second-hand devices as they had larger networks. Traditional feature phone users reported a stronger perception of access to public spaces.

In 2015, Al-Mouh and Al-Khalifa [12] surveyed smartphone use among 104 users with different levels of visual impairment in Saudi Arabia. Their results showed that nearly 80% of the respondents used smartphones, and of these about 80% used iPhones. The authors did not comment on these results considering the economic situation in Saudi Arabia, ranking 17th in the world in terms of GDP-per-capita. Moreover, it is not clear from the study how these statistics break down for the participants who were legally blind.

In 2012, Pal et al. [13] addressed the quality of text-to-speech for local languages. They acknowledge that the development of natural voices for the many languages of the world is expensive and consequently the speech quality is lacking for most languages. Moreover, the ranking list of general language use is different than the Internet language use. For instance, Hindi-Urdu are listed as the 5th most spoken language in the world, but it does not appear on the top 10 list of Internet language use. The authors point out that the wealthiest in India are English speakers, reducing the pressure to support more local languages. Given the shortcomings in the local language support, Pal et al. argue that the mechanical (non-natural) voices hold potential but require more training from users. Novice users are likely to prefer natural text-to-speech while more experienced users prefer fast speech. Moreover, they claim that most problems in speech comprehension can be solved through technical means. A study by Vashistha et al. [11] of blind users in India from 2015 shows that a majority does not have access to screen reader software in their local language.

Nearly a decade ago, Pal et al. [14] addressed the problem associated with the high cost of assistive technology. They argued that assistive technologies typically are designed and developed in high GDP-per-capita countries for its people and cultures. Such technologies are not necessarily suitable for people in low GDP-per-capita countries. They concluded that mobile phones provide a very promising assistive technology platform due to its low cost. The cost of mobile technology has decreased substantially over the last decade since Pal et al.'s study.

Given access to assistive technology, users also need to receive training on how to use the technology. Ari and Inan [15] point out that this is especially important in schools and that teachers are trained in how to teach the use of assistive technologies to students. A 2011 study of teachers in Texas, US who teach children with disabilities [16] revealed that 75% of these teachers had insufficient knowledge about assistive technologies and that 57% of the teacher lacked confidence to teach assistive technologies. The emergence of smartphones in society over the last decade may have improved teachers' confidence in, and knowledge of, technology. A lack of accessible teaching materials, such as Braille and audio books, was in 2014 also found to be a challenge in low GDP per capita countries [17].

Access to assistive technology and training in how to use assistive technology is not enough. Users often abandon assistive technologies because they perceive a social stigma associated with a device that usually relate to disability [18–20]. Therefore, to use mainstream devices such as smartphones as assistive technologies, it is believed to reduce or eliminate such perceived stigma [21] as users want to blend in and be like everybody else.

Generally, disabled individuals are more likely to be excluded from employment than individuals without a disability. The chance of being excluded from employment is even higher in low GDP per capita countries with high unemployment rates. Pal and Lakshmanan [22] confirmed that underemployment of visually impaired individuals is an issue in India. They therefore studied

Table 1. Participant details.

Participant ID	Gender	Age	Grade
1	Male	15	9th
2	Female	16	10th
3	Male	15	10th
4	Female	17	9th
5	Female	15	8th

visually impaired screen reader users who have succeeded in the Indian workforce. They found that these individuals usually are the only person in their respective organization who use screen readers.

The literature on assistive technologies for low vision and blind users is large. It spans from the early work on web accessibility [23], to more recent work on readability for screen readers [24], electronic white canes [25] and emerging systems that help in identifying people through face recognition [26]. To enable individuals through education, a substantial effort has been invested in assistive technologies for blind in the context of learning, especially targeting children [27]. Examples of very fundamental issues include smartphone games for learning Braille [28] as young blind individuals are reported to be resistant to learning reading given the convenience and availability of text-to-speech technology. Sánchez et al. [29] developed a multimodal videogame that relied on haptics to teach children navigation skills. Similarly, Yuan and Folmer [30] explored haptics for teaching music. The shift from visually oriented teaching to audio is also a key topic that has been explored [31] as well as tangible interaction for learning logic [32].

Social media usage among blind users has received attention in the research community [33], also in the context of low GDP-per-capita countries [13]. An early study by Wentz and Lazar [34] concluded that Facebook for mobile devices was more accessible than web-based Facebook, but with some features missing. Wu and Adamic [35] found that visually impaired users were as active in social media as non-visually impaired users. However, visually impaired users originally had smaller networks, but that this difference was disappearing.

Brady et al. [36] studied blind users' perceptions towards using social media to ask visual questions using the term "friend-sourcing". They also found that blind users are active on social media, but are generally not asking visual questions due to what the authors describe as high perceived social cost, that is, they did not want to become a burden and responses were slow, use was inaccessible and asking visual questions was perceived as compromising privacy. They suggest that systems should support blind users in trading their social networks for more private and high-quality results.

Photography has become an important part of social media. Jayant et al. [37] found that blind social media users also take photos. The most common use of photography was to document text. But photos were also used as mnemonic aids and for fun. Blind users also took pictures of friends and family for purposes of sharing as with non-visually impaired users. Lower down the list was photography for automatic object recognition, colour identification, signage recognition and remote assistance. Other studies of blind photography are included in [38,39].

There are also critical voices to the practice of introducing assistive technologies into countries with specific cultures. Sultana and Ahmed [40] used the negatively charged term "postcolonial computing" to describe the situation. They recommend the integration of occult practices and witchcraft with HCI through design. We oppose this view as occult practices and witchcraft have brutal consequences for vulnerable groups [41].

The touchscreen is the key smartphone input device. For a general overview of the history of touchscreen as input devices and their accessibility for blind users, see Grussenmeyer and Folmer [42].

Methods

Experimental design

Semi-structured interviews were used to obtain insight into the participants' experience with assistive technologies.

Participants

Five participants diagnosed as blind from birth were recruited from the state-run Shree Nepal Adarsha Secondary School in Shivraj Municipality, Shivpur, Kapilvastu which is a remote part of the mid-southern part of Nepal, about 10 h bus-ride from the Tribhuvan International Airport in Kathmandu. Although this school is in a remote and rural low-income area of Nepal, the school has a reputation of providing good academic results. Classes contain a mix of disabled and non-disabled students and there were several classes with visually impaired children. Initially, 21 visually impaired students were contacted. The inclusion criteria used in this study were for participants to be at secondary level of education, have visual impairment and be active users of assistive technologies. Some of the students were excluded as they were older than 17 years. Some declined to participate due to the voice recording. Several visually impaired students consulted at the school were not regular users of assistive technologies and hence did not meet the inclusion criteria. The participants included a mix of male and females in the age range from 15 to 17 (school grade 8–10). None of the participants were fluent in English. Although five participants is low, it is not uncommon in accessibility studies, see for instance (Table 1) [8].

Procedure

An interview guide was drafted in English in which some questions were open ended, and others were closed and more specific. The questionnaire was pilot tested in Norway on two international master students specializing in universal design of ICT systems, before the interview guide was translated into Nepalese by the first author who is a native Nepalese speaker. The school was contacted in advance and permission to conduct the study was given. The first author travelled to Nepal to conduct the recruiting, screening and interviews on site face-to-face. Each participant was briefed about the purpose and content of the study before giving their consent. They were informed that they could withdraw from the study at any time without having to provide a reason. The interviews were recorded, and each interview took between 20 and 30 min. Data collection was conducted from the middle of March to the end of April 2019. This included time to clear formalities of getting local permission to conduct the study, recruiting participants, and coinciding public holidays.

Analysis

The audio recordings of the interviews were transcribed verbatim and then translated into English by the first author. Next, the translated transcripts were analysed using the NVivo software

package for qualitative analysis by coding, organization into categories and themes, and relation analysis.

Ethics

The cohort can be classified as a vulnerable group and special care was taken to protect the privacy and anonymity of the participants. Prior to the fieldtrip, a formal application was submitted to the National Norwegian body that oversees the ethics in research (NSD) and a permit to take audio recordings was given (reference number 816990). A formal permission was also acquired from Shree Nepal Adarsha Secondary School. An audio recording of an interview can be used to identify a participant. Therefore, according to the strict data handling procedures the audio recordings were deleted after completing the transcriptions, and all personal identifying information were removed from the transcripts. Steps were also taken to formulate questions as to minimize the chance of evoking any negative emotional responses connected to the participants' self-image and disability.

Results

Smartphone practices

When asked about what types of assistive technologies they use in school, all the participants responded that they use smartphones. All the participants were using (android) smartphones donated by an international non-governmental organization (INGO). No other technologies were mentioned such as specialized camera systems or other reading devices. One participant also reflected over the lack of specialized assistive devices: "In developing countries such as ours (Nepal), assistive devices are not easily available in many places." All the participants reported that they use the built-in screen reader function (talkback) on the smartphone. The use of social media was mixed as two participants responded that they were not active in using social media, while one indicated using Facebook. Several indicated using internet voice calling and message chat using the IMO app.

The participants gave diverging replies on how they have learned to use screen readers. The school did not provide any formal training and the topic was not listed in the teaching plans. Yes, two of the participants reported that they learned to use screen readers while studying at the school, one participant learned to use the screen reader from his/her friend outside school, and one had learned it by him/herself.

The participants also reported that they used audio textbooks for their studies. These books were mostly provided on memory cards by the school. As pointed out by one participant "Audio format coursebooks are available in school for learning purposes. The government of Nepal mostly provides such types of textbooks. Sometimes we have to buy it on our own."

Smartphone shortcomings

Several participants said that they were unable to set up the accessibility features on their smartphone and fix problems by themselves, thereby relying on help from friends. One participant indicated that he did not know about the accessibility functions and several participants indicated unfamiliarity with accessing the accessibility function. One person said that "I didn't know about double click on the screen to access the AT" and another participant complained about the lack of shortcut buttons for activating the screen reader application. The re-activation of the screen reader application was also mentioned as an issue when the phone was switched off and restarted. Two of the participants reported that the found it hard to learn and to use the screen reader interface.

Several issues were mentioned regarding the use of the screen reader accessibility features. All the participants commented on the incorrect text-to-speech pronunciation of Nepalese. Comments included "talk-back does not pronounce many words correctly", "The female voice of the talk-back application does mispronunciation", "unclear pronunciation makes it hard to understand the proper meaning" and "the inappropriate pronunciations of the Nepali text makes it not understandable, and this is one of the reasons I am inactive in social media". One participant also pointed out that the mispronunciation did not only apply to Nepali, but also Hindi and Bengali which are also some of the many languages actively used in Nepal. One student also pointed out that that the speaking speed was too fast thereby occasionally missing vital points.

Discussion

Smartphone practices

The results gave an indication that there is high awareness about the benefits of smartphones in low-income rural areas of Nepal. Although the participants used donated handsets, they reported communicating with others that did not use donated handsets. The development of smartphone technology has resulted in the cost of entry-level handsets have fallen over the last decade, thereby lowering the bar for having access to computer technology and the Internet. Access to smartphone technology is therefore probably a decreasingly pressing issue. As observed in several studies, mobile technology is a pragmatic and cost-effective alternative in areas with limited wired network infrastructure [11].

It is also reassuring to observe that the blind teenage students interviewed are aware of, and active users of, screen reader functionality. Although the students were not formally given any training at the school in how to use the screen reader functionality, the students figured it out by themselves. Clearly, the students learned to use screen readers by themselves or from friends, and it is as expected that some started to use this technology before entering school. Smartphone handsets are becoming increasingly available, some students are likely to be technically interested, while others may be driven by a social/peer pressure to be a participant in social media activities [33,35,36]. In this context, we would consider the social pressure as a positive element that encourages the teenagers to explore the possibilities that are available. This will contribute to the build-up of experience and skills that can be used for other tasks related to their education and participation in society. Still, organized training programs are likely to be a mechanism that can unlock the opportunities that smartphones provide for these students. Formal training is also likely to help reduce the gaps caused by socioeconomic status and other opportunity and resource-related factors. The lack of formal training is also an issue in urban areas in high GDP per capita countries [6,15]. Perhaps the international community may contribute positively to this situation by designing updated training materials that are made available to all people in similar situations around the world?

Smartphone shortcomings

Despite the participants' ability to use screen readers, the respondents also indicated challenges with setting up accessibility

features and activating the screen reader as well as maintaining the accessibility functionality after reboots and restarts. Not only is it enough to learn how to use screen readers one also needs the skill to configure and set up the device. Given the fact that the average lifetime of a smartphone is about two years, it is likely that most people will own a range of handsets during their life and therefore need to set it up each time they replace their handset. There could also be situations where the user will have to borrow a handset or use a communal handset. Formal training is thus important [6,15]. However, designing such training programs is also challenging as there is a range of different handset manufacturers and models which are different. It is therefore important to focus on the general principles and not specific how-to recipes, giving the users the knowledge and skills to diagnose and solve problem independently. It is also challenging to update training courses to follow technological developments in areas with limited economic resources and trained specialists. To learn by oneself means that vital functions remain undiscovered, exemplified by the comment by one participant that the speech was too fast. One would expect a training programs to teach participants to control the speaking speed, slow in the beginning and then perhaps faster as the user gets accustomed to working with text-to-speech [12]. Rodrigues et al. [43] argue for simplifying the process of creating teaching material/tutorial content such that non-technical individuals are in a better position to contribute.

Another interpretation is that the smartphones have room for improvement in terms of how to activate and configure accessibility features. Standardization certainly would clearly help such that the features are activated in the same way irrespective of manufacturer, platform and model. A simple inspection of instructions provided by different android smartphone manufacturers confirms that the steps to activate the accessibility features vary. Several participants expressed that they wanted "shortcut" buttons for the activation of the accessibility features which could indicate that these features are perceived as being hidden inside deep menu hierarchies. One may ponder if it would be pragmatic to implement "invisible short cut buttons", i.e., simple standardized procedures, such as advanced touchscreen gestures, that could be employed on all handsets to quickly activate basic accessibility features, which would not interfere with the majority of users that do not use these features.

Another challenge mentioned by all the participants was the incorrectness of the quality of the text-to-speech pronunciation in Nepali and other languages spoken in Nepal. Indeed, the challenges of providing accurate pronunciations for smaller languages are well-known [11,12], and the support for speech recognition for smaller languages is even more limited. Clearly, most of the product development is driven by companies that must justify their development investments in terms of possible income. This is probably the reason why full language support is only available for the most widely spoken languages in the world such as English, Chinese, Spanish, German, etc. According to Ethnologue [44], Nepali is ranking the 65th most spoken language in the world, while Hindi is ranked 4th and Bengali 5th most frequent language – much higher than say French and German. Based on usage, one would have expected at least the Hindi and Bengali support to be perceived as stronger. It would have been interesting to have studied the participants coping strategies for compensating for the pronunciation limitations.

It is perhaps unrealistic to expect the support for the languages of the world to change rapidly. One may argue that the lack of local language support may serve as a motivation for learning other languages such as English which certainly is not a drawback. More importantly, as argued by Pal et al. [13] experienced screen readers are more likely to prefer speed with mechanical voices over naturalness and the aim for natural voices may therefore be somewhat misguided.

Conclusions

This study explored blind teenagers use of smartphones in schools in a rural and remote part of Nepal. The results show that the participants all use smartphones with screen reader accessibility functions, but they did not receive any formal training in how to use screen readers. The access to devices was seemingly not a major issue, but lack of training was. The participants indicated that they were unable to activate and configure the accessibility features by themselves. One implication of this study is that screen reader users also need to be trained in how to activate and configure the accessibility functionality, such as setting the speaking speed. Standardization of operating procedures for screen reader access would potentially also be constructive. Participants also expressed issues related to incorrect pronunciation of the local language. It therefore could be constructive to identify the coping strategies used by expert screen reader users to overcome local language pronunciation limitations in order to share best-practices among screen-reader users.

Disclosure statement

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

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