

A new Assistive Technology in Android Platform to aid Vocabulary Knowledge Acquirement in Indian Sign Language for better Reading Comprehension in L2 and Mathematical Ability

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Abstract—A new app on android platform has been proposed and designed to help speech and hearing impaired persons to develop vocabulary knowledge in breadth as well as depth in Indian Sign Language (ISL) through the learning of relevant synonyms and antonyms and mapped into semantic connotation via sign inputs to recognize the symbols in absence of sound through some visual clues (Sign Video). The vocabulary acquirement scheme in ISL is chosen in such a way that the understanding capability and logical sense in the second language (L2) will grow automatically. Finally, the android app in different regional languages (English with ten regional languages) used in India has been implemented, thus introducing a mobile App based Indian Sign Language Dictionary with synonyms, antonyms, presently in Bengali, along with different sentence making examples. This app is so aimed that the intellectual ability, writing skill and mathematical ability of the speech and hearing impaired can flourish in tandem with learning of normal students.

Index Terms—ISL, Vocabulary Knowledge, Reading Comprehension, Synonym-Antonym, Mathematical ability

I. INTRODUCTION

Early language or vocabulary development of a child depends upon environmental input like oral language. Oral language is the key to a child's development. Although language acquisition is a very robust process there is evidence that the rate at which children develop language is sensitive to the amount of input they receive from the adults around them. The quality of input that children receive is likely to be more important than the quantity. For most children, language develops

automatically. Just by being around other people, children start to speak (James et al. 2017) [1]. It is already established that certain cognitive skills, such as working memory, phonological processing skills and morphological awareness are directly connected with early vocabulary growth of children. These cognitive skills along with environmental factors are responsible for children's initial vocabulary and vocabulary growth (Song et al. 2015) [2]. However, this development comes from social or academic opportunities or interaction. The standard system cannot facilitate appropriately all communities, especially those who are suffering from different disabilities. Census 2001 has revealed that over 21 million people in India have been suffering from different kinds of disability. This is equivalent to 2.1% of the population. Coming to more recent records, as per census 2011, out of India's 121 Cr population, 2.68 Cr persons are disabled which is 2.21% of the total population. Furthermore, the Census 2011 revealed the type of disability percentage where 19% are with disability in hearing, 7% are with disability in speech. So the number of disabled persons in hearing and speech is not at all ignorable in India, and assistive technology is therefore necessary to provide practical aid in widely varying situations of life as well as quality education to those people. However, there still does not exist a substantial Indian Sign Language (ISL) corpus for use as the first language (L1) for Indian deaf community in contrast to the American Sign Language (L1) that is well established for the English (second language, i.e. L2) speaking deaf community worldwide. While one reason is definitely the

lack of attention and consequently research in this domain in India, a no less significant reason is also the wide diversity varying across geographic location with marked differences in habits and behavioral patterns of the people from communities like Gujarati to Assamese, Urdu to Tamil in terms of second language (L2) for the Indian deaf community, and teaching materials used for the deaf community in India are generally bilingual in English (i.e. sign to English or vice-versa). One goal of the present research is to take a few steps towards developing an L1 (ISL) to L2 (different Indian languages) and vice-versa platform as a whole for the ISL. However, that is not the only goal. Let us elaborate. Researchers have demonstrated that Vocabulary Knowledge Acquisition (VKA) in L1 (ISL) enhances reading comprehension in L2 for spoken languages (Proctor et al. 2006 [3]; Miller et al. 2006 [4]). VKA, in turn, consists of two aspects: a) breadth (i.e. size of vocabulary, and b) depth (i.e. different meanings and usages of words and their interrelations). The android platform based ISL-VKA app being developed in the present work promises to take care of these aspects of VKA in L1, presently in the specific context of improving reading comprehension in one of the richest of the L2 Indian languages, viz. Bengali.

II. LITERATURE REVIEW FOR SIMILAR APPS

Worldwide, there are a few mobile applications for hearing impaired including some on android platform. The reader may go through the works of some of the researchers listed here through references [5] [6] [7] [8] [9] [10] [11] [12] [13] [14]. Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Coimbatore in collaboration with C-DAC & Indian Sign Language Research & Training Centre (ISLRTC) under Department of Empowerment of Persons with Disabilities (DEPwD) have developed an ISL dictionary but the focus has still not been Vocabulary Knowledge Acquisition both in breadth and depth through the learning procedures of synonyms, antonyms, and sentence formation. No emphasis has also till now been given on further impact of reading comprehension skill development app building that may enhance mathematical acumen of the hearing impaired.

III. MATERIALS & METHODS

A. Survey Work, Relevant Literatures and Planning

At the outset, we conducted survey in various speech & hearing impaired schools to understand the fundamental requirement of the students and through discussion with students, teachers and parents, we tried to identify the deficiencies with respect to the normal students. Regarding this we have prepared questionnaires for educational and motivational test which is authorized by expert. Educational abilities were tested both in language and mathematics. Initial survey was conducted for speech & hearing impaired students from various Bengali Medium government schools within West Bengal to understand their exact needs and issues faced in their education. The participants of the study were 100 students from various schools, out of which 48 were from Bengali Medium special schools for the speech and hearing impaired,

and 50 were from normal Bengali Medium school belonging to West Bengal, India. Of the 48 speech and hearing impaired students, 23 were female, out of which 3 were 70-79% hearing impaired, 18 were 80-99% hearing impaired, while 2 were 100% hearing impaired. Among the 25 male students, 10 were 75-79% hearing impaired, 8 were 80-89% hearing impaired, 5 were 90-99% hearing impaired, while 2 were 100% hearing impaired. There were 50 normal students (control group) of same age group from the same school. In both the groups the socio-economic condition varies from lower middle to upper middle class background. Surveys were rolled out to understand the generic vocabulary utilized by the Speech & Hearing Impaired students, Socio-Economic background, their Academic Motivations, the Schools motivation and the actual requirement of sign language to any student. It was observed that the speech & hearing impaired students were not too far from the normal students with regards to the calligraphy and they could more or less successfully replicate what was written on board. However, they could not often create a self-thought response from their vocabulary and lacked in reading comprehension of their second language (L2), Bengali in our present case. It was seen that they were unable to understand the sense of the language majorly affecting proper sentence formations, usage of tenses and understanding of synonyms and antonyms. This last mentioned we shall elaborate further in the next paragraph. Overall, as a result of these deficiencies, they were found uninterested to read newspaper, story book etc. which further impairs their reading comprehension ability. Additionally, they were also found severely lacking in arithmetic, mensuration etc. where language understanding is an essential part of solving the sums. Our experiences with these students who belonged to traditional Bengali families were markedly similar to works done on American Sign Language (ASL) with respect to English as L2. Let us come to these issues one by one which helped us in planning and designing the app. First, we identified that the breadth and depth in Vocabulary Knowledge Acquisition (VKA) is deeply integrated with both synonyms and semantically equivalent uses of words as well as antonyms and opposite uses of the words. Ouellette (2006) [15] has demonstrated that the knowledge in opposite words and uses actually elaborates the meaning of each of the words and strengthens vocabulary depth. Some authors (e.g. Jones and Murphy 2005 [16]) also demonstrated that knowledge of antonyms provides evidence for cognitive development and the representation of such knowledge in the language. However, before the works of Novogrodsky et al. (2014) [17], little was known about the importance of antonyms in sign languages. In the same vein, there have been only some recent studies on arithmetic and in general mathematics proficiency of deaf children ([18] [19] [20] [21]). It has been found that the hearing impaired children are retarded in mathematics relative to their hearing peers mainly because of two reasons: a) comparatively poorer linguistic skills, and b) problems in social interaction like inferior teacher expectations, inappropriate teaching methods. Lastly, in the Indian context, Zeshan et al. (2005) [22] have

demonstrated that because the teaching materials are bilingual in ISL and English, it has led to a remarkable increase in English (L2 by default) proficiency for many deaf trainees, and it has been found that for trainees with practically no knowledge of English very quickly developed to a stage where they had a vocabulary of several hundred words, could make sense of English phrases and sentences which were part of their teaching materials, and even developed a basic understanding of English grammar without any formal instruction. This show that such students who are more likely to come in touch with their provincial speaking/mother language materials (books/newspapers etc. stand a even better chance of linguistic ability development if ISL can be corresponded to such Indian languages as L2) Based on all these observations mentioned above, we planned to design a new app for assisting in the area of social communication, education, rehabilitation and bring everyone (mute, hearing impaired, normal etc.) onto the common platform with special emphasis VKA leading to better reading comprehension in L2 which in turn will also enhance their overall mathematical abilities. The mobile application tries to achieve a seamless bi-directional communication between regular students and hearing and speech impaired students. The application addresses two prominent issues that are commonly encountered. First, India lacks a uniform, substantial corpus in ISL and we have developed various variants to support the provincial speech & hearing impaired students. Secondly, there is no effective means to communicate between the speech & hearing impaired and normal students which may lead to inclusive development. There were several hurdles faced during the initial phase of the experiment such as validating the most acceptable signs across various languages, improving the vocabulary and the sense of grammar for speech & hearing impaired students. These require further attention and study in future. Presently we have restricted ourselves to a creating a database of vocabulary in Bengali on the basis of Bengali books of the West Bengal Board of Secondary Education from class II to VIII. The vocabulary is chosen based on the feedback from the teachers/special educators who teach hearing impaired student. Some key feature of our proposed work (Mobile app) at the present stage of design and development is given below:

- Help hearing impaired to interact more with normal people.
- Offer a useful tool for parents to teach their hearing impaired or mute child.
- Help to develop understanding ability and logical sense of word through synonyms and antonyms and also sentence formation example.
- Help to develop mathematical reasoning and ability to solve arithmetic.

B. App Design

User Interface design is the most important part of this app. UI is suitably designed maintaining the following following points/charecteristics:

- Several regional languages are used in India. So we have used multiple language and also English to use this application irrespective of any region.
- We have given special care to build up the vocabulary for better understanding as well as linguistic development. We have provided sign video, symbol, antonyms, synonyms and also use of this word in different sentences which will improve their application skill.
- A powerful sophisticated search engine is provided to search the particular word from the considerably large (to be further expanded) database.
- Opposite word is carefully included in the dictionary to build up the logical sense and conceptualize the topic. The vocabulary is specially chosen from Bengali medium school book so that the understanding and problem solving capability can increase.
- The app can be utilized as a Indian Sign Language (ISL) Dictionary in 11 regional languages in the country. Initially we focused on Bengali vocabulary with synonyms-antonyms along with different sentence making examples. Since our preliminary work towards developing the Android ISL app has been initiated from the state of West Bengal, Bengali being the L2 against ISL as L1, we decided to take the help of a Bengali sign language corpus developed by Indias neighbouring SAARC nation, the Bangla Ishara Bhasaha Avidhan or Bengali Sign Language Dictionary edited by Bangladesh Sign Language Committee, 1997 edition [23]).
- Around 1000 words (separately offered in 11 languages) which have been signed by the Indian Sign Language Research and Training Center(ISLRTC), New Delhi have been made available as part of the app.

Fig. 1 represents a layout synopsis of the designed app.

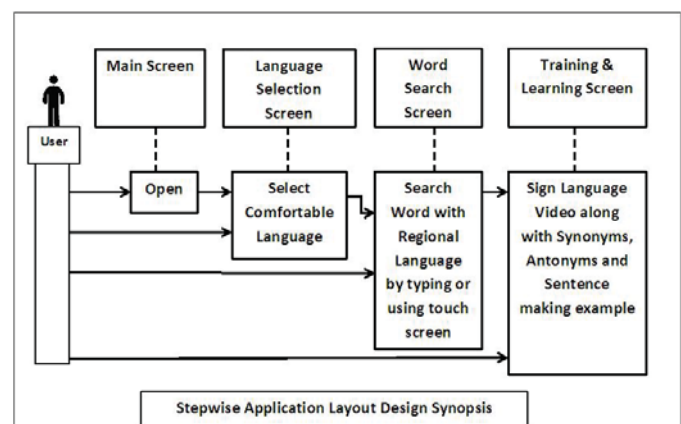


Fig. 1. Layout Design of the App.

C. Steps for Database Creation:

As suggested by special educators, psychologists, sign language experts, more than 1000 words (frequently used in text books include mathematics) have been selected (Bengali books of the West Bengal Board of Secondary Education

from class II to VIII) for Dictionary and translate into eleven different languages taking help of Google Translator (English, Malayalam, Tamil, Telugu, Marathi, Punjabi, Gujrati, Nepali, Hindi, Bengali and Urdu). Initially we are developing Bengali vocabulary app based database with synonyms and antonyms (of adjectives, adverbs, verbs) with sentence formation. This kind of database will be part of this app for different languages in future as different language experts from different regions is needed to complete the app. For other languages except Bengali, at present, only the word and sign video are available in the respective languages. In Fig. 2 we present a snapshot of the overall database.

D. Video Recording

ISL videos have been collected for sign language database. All the sign videos were prepared and verified by Indian Sign Language Research Training Center (ISLRTC), an autonomous organization under the administrative and financial control of Department of Empowerment of Persons with Disabilities (Divyangjan), Ministry of Social Justice & Empowerment, Government of India.

E. App Development:

The proposed application was implemented for android based digital device such as smart phones and tablet computers. The application is built using Android Studio version 3.1.2. The UI layout is performed through XML for different user interaction screen. Relative layout is designed so that the application can fit irrespective of the size and resolution of the mobile set. Vocabulary for different regional languages and their corresponding sign video file is maintained through SQL Lite database. As a programming language, Java is used to integrate all those files to build the executable. For the test run, android based simulator and physical device both are used.

IV. RESULTS & DISCUSSION

The mobile application is designed for smooth and easy interaction for normal people with the speech & hearing impaired (HI). A normal person will be able to select his comfortable language with the ISL-VKA app. He/she can then easily write the message, that needs to be communicated to the HI person on search option. The message is then converted to sign in L1 (ISL in the present case) and shown to the HI person. On the other hand, the speech & hearing impaired, when he/she is unable to understand some text in L2, say, while trying to read a storybook/newspaper, will also be able to take help of the ISL-VKA app. For this, he/she gives the text as input, search for the sign gestures related the text that he /she was unable to comprehend. Such use of the app will therefore increase his/her reading comprehension in L2. Further she could also learn new words using this application. Additionally, Synonyms, antonyms and sentence making example are given so that they can easily understand the syntactic meaning of the word. A teacher can teach their students to increase the vocabulary with syntactic meaning, synonyms and antonyms. A snapshot of the Language selection screen is

shown in Fig. 3. Fig. 4 displays the Search Engine in English to Bengali.

In Fig. 5 two sample words semantically opposite has been presented along with snapshot of the sign video. The screen shows display of the corresponding antonyms, synonyms and some typical examples of use of the words. Fig. 6 shows the same for two words commonly used in arithmetic.

The proposed technology was tested using four different ways. In the first phase, White box testing was performed inside SDK to check the coding standard and unit testing was done to check the functionality of each module. Alongside, Integration testing was performed to check the functionality of whole module. The second test was achieved by launching the application on different phone devices. The third test was performed on the different versions of android. Finally User acceptance testing was executed by asking some deaf persons, their parents, their teacher to test the benefit and ease of use of the application. In the first verification test, the application was simulated properly in android studio. Unit Testing and Integration testing was performed with the developer without any errors or bugs. The second test was performed to ensure that the application is working correctly on different screen sizes and resolutions, it was tested on various devices from different manufacturers such as Lenevo, Redmi, Samsung Galaxy etc. In this test, the application worked properly on the different devices. In the third stage we have installed the app in different version of android like Kitkat, Lollipop, Marshmallow and Nougat and it is working fine. For the last verification test, we performed user acceptance testing that gives direct input on how real users use the system. We evaluated our application by testing it on deaf users and normal volunteers. We have measured the benefit of the app on a four point Likert scale. The questionnaire contains a few simple questions with a scale of four answers (1 = Poor, 2= Average, 3= Good, 4 = Excellent). These are meant to probe whether the app is easy to install, easy to use, search engine is good, short response time is required, semantic meaning is helpful to understand, quality of video is good to understand etc. The final outcome is that about 95% of the deaf and dumb were satisfied about the easiness of using the system. Interestingly, teacher, parents and normal people who use the application found the application useful. The teachers of the hearing impaired students suggested us that after training they can ensure us the actual improvement of the students with proper statistics.

V. CONCLUSION

In this paper, we present an efficient application to understand and develop reading comprehension skill in L2 for the hearing impaired student through newer strategies of vocabulary knowledge development in ISL. This application aims to help the deaf community by providing them with an attractive communication and learning tool. The work introduces a Mobile application that enables communication between hearing impaired and normal people in our society. It is specially developed for 10 regional languages in India and also in English language, the present work deals with

The screenshot shows the ISL Dictionary app interface. At the top, there is a status bar with a signal strength icon, a Wi-Fi icon, a battery icon, and the time 2:24. Below the status bar is a blue header bar with the text "ISL Dictionary" and a small icon of a person. The main content area consists of a vertical list of ten colored rectangular buttons, each containing text in all caps. The buttons are: "ENGLISH" (light green), "ENGLISH TO HINDI" (purple), "ENGLISH TO BENGALI" (pink), "ENGLISH TO NEPALI" (blue), "ENGLISH TO PUNJABI" (light green), "ENGLISH TO GUJRATI" (orange), "ENGLISH TO TAMIL" (light blue), "ENGLISH TO TELEGU" (light orange), and "ENGLISH TO URDU" (light green). At the bottom of the screen, there is a black navigation bar with three white icons: a back arrow, a circle, and a square.

ISL Dictionary

ENGLISH

ENGLISH TO HINDI

ENGLISH TO BENGALI

ENGLISH TO NEPALI

ENGLISH TO PUNJABI

ENGLISH TO GUJRATI

ENGLISH TO TAMIL

ENGLISH TO TELEGU

ENGLISH TO URDU

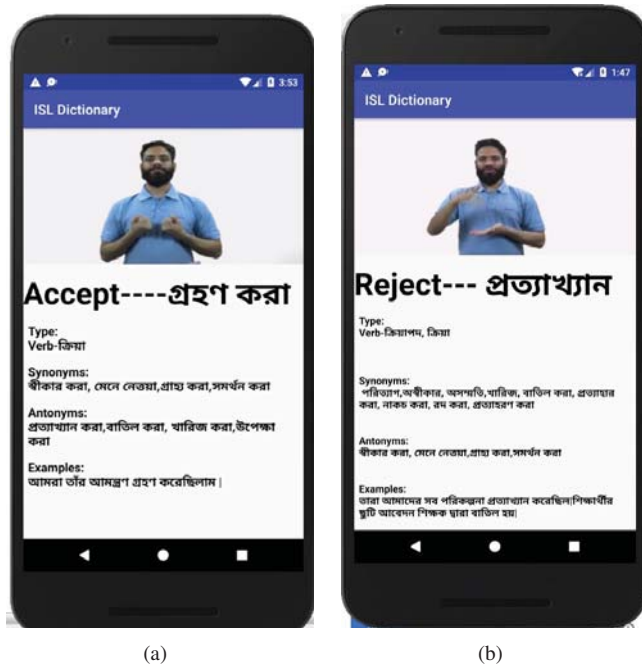


Fig. 5. (a) and (b) represent two sample opposite words with synonyms, antonyms, uses.

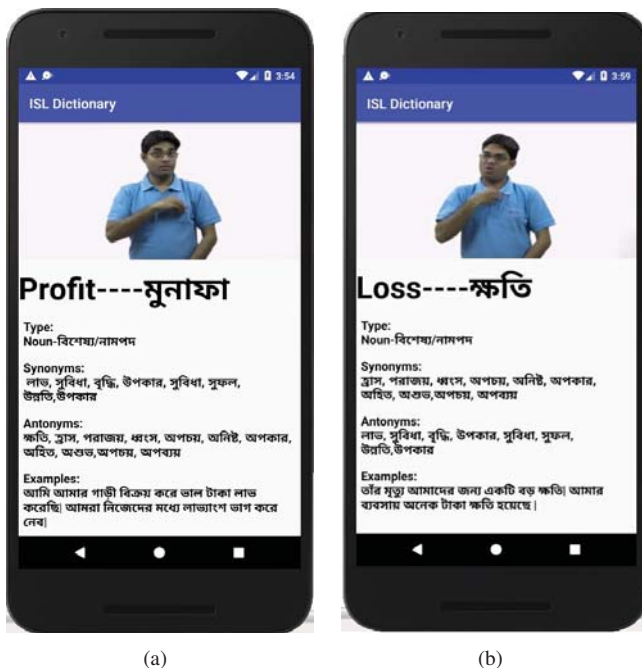


Fig. 6. (a) and (b) represent two sample opposite words with synonyms, antonyms, uses.

discussions.

REFERENCES

- [1] Law, James, et al. "Early Language Development: Needs, provision, and intervention for preschool children from socio-economically disadvantage backgrounds." Institute of Education-London (2017).
- [2] Song, Shuang, et al. "Tracing children's vocabulary development from preschool through the schoolage years: An 8year longitudinal study." *Developmental science* 18.1 (2015): 119-131.
- [3] Proctor, C. P., August, D., Carlo, M. S., & Snow, C. (2006). The intriguing role of Spanish language vocabulary knowledge in predicting English reading comprehension. *Journal of Educational Psychology*, 98, 159169.
- [4] Miller, J. F., Heilmann, J., Nockerts, A., Iglesias, A., Fabiano, L., & Francis, D. J. (2006). Oral language and reading in bilingual children. *Learning Disabilities Research & Practice*, 21, 3043.
- [5] Kaur, Sandeep, and Maninder Singh. "Indian Sign Language animation generation system." *Next Generation Computing Technologies (NGCT)*, 2015 1st International Conference on. IEEE, 2015.
- [6] Kumar, A. Sujith, and Shahabaz Begum. "Sign Mobiles: An Android App For Specially Able People." *International Journal of Advanced Research in Computer Science and Software Engineering* 4.9 (2014).
- [7] Swamy, Shanmukha, M. P. Chethan, and MahanteshGatwadi. "Indian sign language interpreter with android implementation." *International Journal of Computer Applications* 97.13 (2014).
- [8] Android App for Indian Sign language 2017-2018 <https://www.srkv.org/android-app-for-indian-sign-language/>
- [9] Kamat, Rachana, et al. "MonVoix-An Android Application for hearing impaired people." *Journal of Communications Technology, Electronics and Computer Science* 8 (2016): 24-28.
- [10] Rao, G. Ananth, and P. V. V. Kishore. "Selfie video based continuous Indian sign language recognition system." *Ain Shams Engineering Journal* (2017).
- [11] First 'Indian Sign Language' Dictionary Of 3000 Words Launched In Delhi, ThaawarchandGehlot, Union Minister for Social Justice and Empowerment, today launched the first 'Indian Sign Language Dictionary'.
- [12] Subhaashini, G. V. S., et al. "Ear Hear Android Application for Specially Abled Deaf People." *International Journal of Computer Science and Engineering* 3.3 (2015): 1108-1114.G.V.S.
- [13] Abdallah, Emad E., and EbaaFayyumi. "Assistive Technology for Deaf People Based on Android Platform." *Procedia Computer Science* 94 (2016): 295-301.
- [14] Gandhi, Pruthi, et al. "Image based sign language recognition on android." *International Journal of Engineering and Techniques* 1.5 (2015): 55-60.
- [15] Ouellette, G. P. (2006). What's meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psychology*, 98(3), 554.
- [16] Jones, S. & Murphy, M. (2005). Using corpora to investigate antonym acquisition. *International Journal of Corpus Linguistics*, 10, 401-422.
- [17] Novogrodsky, Rama, et al. "The development of antonym knowledge in American Sign Language (ASL) and its relationship to reading comprehension in English." *Language Learning* 64.4 (2014): 749-770.
- [18] Arnold, Paul. "Deaf children and mathematics." *Hrvatska revija za rehabilitacijska istraivanja* 32.1 (1996): 65-72.
- [19] Hyde, Merv, Robyn Zevenbergen, and Des Power. "Deaf and hard of hearing students' performance on arithmetic word problems." *American Annals of the Deaf* (2003): 56-64.
- [20] Kritzer, K. L. & Pagliaro, C. M. (2013). An intervention for early mathematical success: Outcomes from the hybrid version of the building math readiness parents as partners (MRPP) project. *Journal of Deaf Studies and Deaf Education*, 18(1) 30-46. Doi: 10.1093/deafed/ens033.
- [21] Edwards, A., Edwards, L., & Langdon, D. (2013). The mathematical abilities of children with cochlear implants. *Child Neuropsychology*, 19(2), 127-142. doi:10.1080/09297049.2011.639958
- [22] Zeshan, Ulrike, Madan N. Vasishtha, and Meher Sethna. "Implementation of Indian Sign Language in educational settings." *Asia Pacific Disability Rehabilitation Journal* 16.1 (2005): 16-40.
- [23] Bangla Ishara Vashar Abidhan, Edited by Bangladesh Sign Language Committee: <https://dokumen.tips/documents/bangla-sign-language-dictionary.html>.