INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 14, Issue 2, (2024) E-ISSN: 2222-6990

Assistive Technology for The Deaf: A Literature Review

Nur Amiratul Amira binti Nor Rashid, Asmak binti Asaari @ Kamaluddin, Syar Meeze Mohd Rashid

Faculty of Education, The National University of Malaysia (UKM)

Corresponding Author Email: cikgumeeze@ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v14-i2/20828 DOI:10.6007/IJARBSS/v14-i2/20828

Published Date: 11 February 2024

Abstract

Technology is advancing rapidly with various conveniences, tools, and aids to enhance the quality of human life. This also applies to the deaf community, who are not exempt from embracing and utilizing technology to facilitate their daily affairs, especially in terms of communication. Assistive technology is a supportive technology that can meet the needs of the deaf community in enhancing their abilities to perform daily tasks, regardless of the disabilities they may experience. Therefore, this literature review aims to identify relevant literature sources related to assistive technology developed for the deaf community. The study has analyzed 20 articles from the Google Scholar and Scopus databases. The research findings reveal that there are five mediums for developing assistive technology for the deaf community, including augmented reality, software, websites, mobile applications, and touch devices.

Keywords: Assistive Technology, Deaf, Innovation

Introduction

OKU (Persons with Disabilities in hearing)

The definition of "Orang Kurang Upaya" (OKU) is an individual who has a long-term limitation in terms of physical, mental, intellectual, or sensory abilities, which may hinder their full and effective participation in society (OKU Act 2008). Specifically, "Orang Kurang Upaya" (OKU) pendengaran, also known as the deaf or hard of hearing, refers to individuals who have lost their ability to hear, whether their level of hearing loss is severe or moderate (Norakyairee, et al., 2020). According to the Department of Social Welfare (2023), there are 42,652 individuals with hearing impairments in Malaysia based on the current registration status of OKU.

Furthermore, individuals with hearing impairments are divided into two groups: the deaf and those who have experienced difficulty hearing. According to the Department of Social Welfare (2023), hearing impairments are categorized into five levels based on the degree of hearing loss, which are: Normal (20 dB and below), Mild (21-40 dB), Moderate (41-70 dB), Severe (71-90 dB) and Profound (91 dB). The following are the levels of hearing according to Aznan (2010):

Table 1
Reference for Levels of Hearing Loss

Levels of Hearing Loss	Categories of Deafness	Effects of Hearing Loss
20dB - 40dB	Mild	Experiencing difficulty in hearing speech and conversations.
41dB – 55dB	Moderate	Experiencing speech difficulties, especially when there is loud background noise.
56dB - 70dB	Moderately severe	Experiencing speech and vocabulary difficulties.
71dB - 90dB	Severe	Unable to hear normal speech sounds.
90dB and above	Profound	Experiencing significant difficulty in hearing speech sounds.

The deaf use hearing aids to assist them in hearing sounds and speech. Those who have significant hearing difficulties at this stage require Special Education, hearing aids, as well as speech and communication training. The next stage is profound deafness, where the level of hearing loss is more than 90dB (Zuri & Aznan, 2019). Individuals experiencing hearing problems at this stage require hearing aids and speech therapy.

Moreover, the challenges faced by individuals with hearing impairments lead them to use sign language as a means of communication. According to Grushkin (2006), sign language is one of the communication forms utilized by those experiencing hearing problems or hearing disabilities. Mohd. Huzairi, Hajarul Bahti, and Syar Mezee (2019) suggested that since children with hearing impairments are more visual in nature, teachers should present clear visuals to explain concepts during teaching, accompanied by explanations using sign language.

In the current technological era, individuals who are deaf are not exempt from accepting and utilizing technology to assist them in communication and ease their daily activities. According to Izzati (2021), the rapid development of technology can help humans interact without boundaries. Additionally, Aderonke et al (2020) state that the advancement of digital and wireless technology has greatly aided the deaf community in communication and engagement in activities, irrespective of differences and backgrounds. Technology can also facilitate the affairs and communication of individuals in their surroundings. There are various forms of technology involving the deaf community, including technology for testing, exercises, hearing aids, and so forth (Rehabtool, 2014).

Assistive Technology for the Deaf Community

The definition of assistive technology is a kind of assistance technology which introduced as adaptive technology. However, assistive technology has become a more widely used term. Assistive technology is provided to help individuals with various cognitive, sensory, physical,

communication, learning, and other challenges to overcome barriers to more effective participation and learning opportunities.

Therefore, Assistive Technology (AT) for the deaf community is a term that encompasses all accessibility tools developed to facilitate their lives. They promote greater autonomy in carrying out activities that involve sound or dialogue with those who hear their language. For example, parents who are deaf, could be in the living room and receive a notification on their smartphones warning that their baby is crying in the bedroom. Similarly, individuals who are deaf participate in video conferences with those who can hear during work meetings.

Problem Statement

According to Basak et. al (2018), when it comes to education and training, those with hearing impairments who have a different prescription among disabled individuals face numerous challenges. These pupils are studying at least five years behind because children born with hearing loss does not develop language and communication abilities for a variety of reasons, including not hearing enough voices, not detecting verbal cues, and not being able to utilize their mother tongue on a daily basis. Therefore, lack of hearing power or deafness creates difficulties to speak and understand what others are saying.

Besides that, it is particularly useful in the education of hearing-impaired children to complement knowledge and skill training with visual methods as much as possible, to design educational settings, and to allow peer interaction. According to Karal et. al (2008), emphasis is placed on the fact that paintings and animations, which are front panel content, visual rich media or games based graphics, should be an effective material to prepare for hearing impaired persons. Furthemore, Linsday et. al (2013), state that in medication field, hearing-impaired people have limited access to health information, which can jeopardize their well-being and make them vulnerable to preventable adverse events. Most specialists in this field are not fluent in sign language, a form of communication that uses visual movements and has its own grammatical structure (Kolberg, 2014).

According to Alejandro and Marta (2022), technology plays a crucial role for individuals with disabilities. Technology enables those with disabilities to engage in activities without limitations. However, the deaf community faces challenges in utilizing technology due to a lack of technology knowledge, and some technologies are not suitable for their disabilities. According to Wehmeyer et al (2008), exposure to technology can enhance the skills of the deaf community. Therefore, appropriate assistive technology can help facilitate their daily affairs and improve their quality of life. For these reasons, in this study, aims to identify relevant literature sources related to assistive technology developed for the deaf community.

Objective

This study aims to identify literature sources related to assistive technology developed for the deaf community.

Research Questions

What specific studies are related to assistive technology within the deaf community?

Methodology

This study employs a qualitative research design utilizing the literature review method. The aim is to analyze articles from previous studies related to assistive technology for the deaf community. Additionally, the literature review method in this study encompasses the research

title, authors and publication year, objectives, and study findings. There are three stages in selecting articles related to the writing objectives. The first stage involves selecting articles through Google Scholar and Scopus. According to Joklitschke et al (2018), the most crucial aspect in the article selection process is the terms and keywords used.

Table 2
Criteria for Accepted Articles

Criteria	Accepted Articles
Year of Publication	2018 - 2023
Language	Malay and English
Type of Reference	Articles
Related field	Technology and innovation for the deaf community

Based on Table 2, the selected articles for this writing are from the years 2018 to 2023. Furthermore, in terms of language, accepted articles are those written in Malay and English only. The types of materials and related fields for these articles are within the domain of technology and innovation used for the hearing-impaired community. In the second stage, articles obtained from the Google Scholar and Scopus databases were filtered according to the specified criteria as outlined in Table 2. In the article selection stage, there were 50 articles related to the objectives of this writing. However, upon examination, only 20 articles were chosen and analyzed because they met the established criteria.

Research Findings
Here are 20 articles that have been analyzed

Table 3
List of analyzed Articles

No.	Articles Title	Author, year, and country	Research Objectives	Research Findings
1.	Interactive Multimedia Games to Enhance the Emotional Intelligence of Deaf and Hard of Hearing Adolescents	• Nakpong & Chanchalor (2019) • Thailand	Designing and testing the effectiveness of interactive multimedia to enhance emotional fitness in deaf students.	The interactive multimedia running test indicates that users are satisfied with the developed application.
2.	HearASL: Your Smartphone Can Hear American Sign Language	• Y.Wang et al (2023) • China	Implementing a prototype and testing the system's functionality.	Attained 97.2% accuracy in interpreting words and a 0.5% error rate in sentence structure.

3.	Basic Skills in Sign Language Code with the Assistance of Augmented Reality Mobile Application for Hearing-Impaired Students and the General Public.	• Maisarah & Suhazlan (2021) • Malaysia	Testing the functionally of the Let's Learn Sign Language module	80% of users say that this application makes it easier for them to understand sign language.
4.	Gesture Based Virtual Assistant for Deaf Mutes using Deep Learning Approach	• Bhat (2023) • India	Assisting the deaf community in communicating with typical individuals.	The application can achieve a 99.9% effectiveness in the usability test.
5.	Application of Machine Learning in Malaysia Sign Language Translation	• Muhammad Nazmi and S.K.Yee (2023) • Malaysia	Development of a machine learning system to collect a dataset of 24 sign language alphabet images captured by a camera.	This machine enables accurate recognition of all alphabets. If there is an error in any alphabet, the dataset will be recaptured and restored.
6.	Development of Prayer Mobile Application Software for The Hearing Impaired (Deaf) Based on Malaysian Sign Language	• Abdul Rakim et.al (2021) • Malaysia	Easy Prayer Application Software based on Malaysian Sign Language.	An engaging mobile application tailored to the learning needs of individuals with hearing impairments.
No.	**Articles Title**	**Author, year, and country**	**Research Objectives**	**Research Findings**
7.	Intelligent gloves: An IT intervention for deaf-mute people	• Amal Babour (2023) • Arab Saudi	Developing gloves capable of detecting sign language movements.	Users are satisfied with the developed smart gloves.
8.	Development of a Prototype Mobile Application for Special Needs Students in Fashion and Clothing Design at Polytechnics	• Noorhati, Saadah and Suhaili, (2020) • Malaysia	Developing the FasTep Application using Adobe Animate.	The development of this prototype will be continued in the next phase.
9.	Measuring based on the Technology Acceptance Model (TAM) for the Special Needs Deaf and	• Che Wan Shamsul (2018) • Malaysia	Measuring the level of Augmented Reality (AR) technology	The AFSO application can assist deaf and speech-impaired individuals in understanding and

	Speech Impairment Prayer Jurisprudence Application (AFSO).		acceptance in the prayer Fiqh application for Deaf and Speech Impaired Persons with Disabilities (OKU).	mastering every fiqh rule in prayer.
10.	Sign Language Technologies and The Critical Role of SL in View Future Internet Accessibility Services	• Eleni et al., (2019) • Greece	Collecting Greek Sign Language materials on a single website.	52.78% of users are satisfied with the functions developed within the website.
11.	Alarm Technologies to Wake Sleeping People Who are Deaf or Hard of Hearing	• Erik et al., (2022) • Amerika Syarikat	To review the opinions of the deaf community regarding the alert system.	The study found that the alert system is effective for all age groups within the deaf community, helping them stay aware of their surroundings.
12.	MudahKIU Education Software	• Siti Zaharah & Nor Azan (2019) • Malaysia	Development of Malay Language Speech KIU Course-ware.	This software enables hearing-impaired children to acquire literacy skills such as reading, writing, and arithmetic.
No.	**Articles Title**	**Author, year, and country**	**Research Objectives**	**Research Findings**
13.	Measuring Satisfaction on Augmented Reality Courseware for Hearing-Impaired Students: Adjustment Formula form System Usability Scale	• Norzila et. al., (2021) • Malaysia	Conducting a usability test for the PekAR - Microorganism Courseware.	The average satisfaction score of participants using the PekAR Microorganism course software is 87.8 percent.
14.	Sign L-The Development of Sign Language System for Primary School Student	• Alyaa & Azizul (2023) • Malaysia	They design the Sign L E-learning Web System.	This project can enhance smart learning that enables acquiring basic knowledge and aids in communicating with deaf individuals.

15.	Development of Augmented Reality Learning Materials for the Hearing-Impaired Students in Primary 1	• Umaporn (2023) • Thailand	Developing a sign language book using Augmented Reality.	The usability test results found that this book achieved an effectiveness level of 85.33%.
16.	The Design of Sign Language Module Application (m-Isharah) Content for Special Education Undergraduate Students	• Syar Meeze et. al., (2020) • Malaysia	Learning Module Application (M-Isharah)	This application learns sign language based on themes that are suitable for students and enhances students' self-awareness in learning sign language.
17.	Hear IT- A Mobile Assistive Technology for Hearing Impaired People in Slovak	• Jan Stas. et. al., (2023) • Slovakia	Developing an application that interprets words into sentences to assist the deaf community in communication.	The usability test results found that this application can achieve 80%-95% accuracy even in noisy conditions.
No.	**Articles Title**	**Author, year, and country**	**Research Objectives**	**Research Findings**
18.	The Use of Video Remote Interpreting (VRI) in a Medium Secure Psychiatric Setting During the Covid-19 Lockdown	• Aile Trumm et al., (2023) • England	Providing online sign language interpretation services to assist the deaf community in psychiatric wards.	Study participants are dissatisfied with the services provided because they are not suitable for the current situation.
19.	IRDC-Net: An Inception Network with a Residual Module and Dilated Convolution for Sign Language Recognition Based on Surface Electromyography	• Xiangrui et al., (2023) • Switzerland	To develop software that can detect hand movements (sign language) and interpret them into words and sentences.	The usability test results found that the developed software achieved 91.70% accuracy in interpreting hand movements into words and sentences correctly.
20.	Measuring Effectiveness of Mobile Application in Learning Basic Mathematical	• Komal Parvez et al., (2019) • Pakistan	Testing the effectiveness of the basic Mathematics learning	The experimental group scored higher in the quiz compared to the control group.

Concepts Using Sign Language	application for deaf students.

Discussion

Based on the analyzed articles, it was found that there are five themes related to assistive technology for the hearing-impaired. These include augmented technology, websites, software, mobile applications, and touch devices.

Theme 1: Augmented Reality Technology

Augmented Reality (AR) is a type of visual effect generated by a computer where computer-generated visual objects are added to the view of the real world displayed on the screen. As a result, users looking at the real world through the computer screen will perceive the existence of various objects in addition to the existing reality.

The findings from four previous studies indicate that the *AR-Assisted Fiqh Solat for the Deaf and Speech-Impaired* (Che Wan Shamsul, 2018) is designed to help deaf and speech-impaired individuals understand and master each Fiqh rules in prayer. The *AR-Book application* (Umaporn, 2023) focuses on assisting hearing-impaired students in learning independently through videos or finger spelling and can be used to enhance learning in more challenging content. As a result, most hearing-impaired students prefer the design of the book program because the AR-Book content is colourful. *VRI in a Medium Secure Psychiatric Setting* (Trumm et al., 2023) involves face-to-face meetings between sign language interpreters and deaf individuals through video during the Covid-19 pandemic.

However, the results led to misunderstandings and video-related issues in sign language communication with deaf individuals. Moreover, *PekAR-Microorganism* (Norziha et al., 2021) also focuses on studying the recognition of microorganisms using sign language in AR technology. The findings indicate that the use of AR can ensure equality in education for the hearing-impaired to understand specific topics. The impact of AR on the deaf community is found to be positive as it significantly helps in capturing interest and can be used anytime and anywhere.

Theme 2: Websites

A website is an electronic information document that uses a web browser and can be accessed on the internet network. It is created in HTML or XHTML format and has the ability to access links to other pages (Faridawati et al., 2022).

Referring to previous studies, websites such as *Sign L* (Al'adwiyah & Azizul, 2023), *Application of Machine Learning in Malaysia Sign Language Translation* (Nazmi & Yee, 2023), and *Sign Language Technologies* (Eleni et al., 2019) have been developed as communication tools used in sign language widely across the world. These websites serve as interpreter services to enhance communication skills between the normal community and the hearing-impaired.The impact of websites on the deaf community is found to enhance performance and interest in learning, solve tasks, and provide communication facilities across long distances. The use of websites is more time-saving without the need for lengthy processes.

Theme 3: Application Software

Software is a set of complete instructions in the form of procedures and procedures that control, manage, and support computer systems and information processing activities. There are five studies on software development, namely *Interactive Multimedia Games to Enhance*

Emotional Intelligence (Nakpong & Chanchalor, 2019), *Gesture-Based Virtual Assistant* (Bhat, 2023), *Prayer Mobile Application* (Abdul Rakim et al., 2021*), EasyKIU Education Software* (Zaharah & Azan, 2019) and *IRDC-Net* (Xiangrui et al., 2023).

In order to help the hearing-impaired communicate, five software programs have been developed with the goal of translating hand gestures into words and sentences. Chat log recording, storing, deleting, and searching features are also included in this software. By using this software, hearing-impaired people can communicate with members of the general public without the need for a sign language translator. The impact of application software on the deaf community is that each software installation requires a minimum based on the specifications of the computer used. It aims to perform various tasks related to or according to the requirements of the application software. Moreover, application software needs to be licensed as it can use data for a maximum period.

Theme 4: Mobile Applications

Mobile applications, or mobile apps, are computer programs or software applications designed to run on mobile devices. By using these application platforms, users can easily find comprehensive information. These applications can be used online or installed directly in the mobile devices.

Based on the findings from the six previous studies, the *FasTep application* (Noorhati et al., 2020) was developed using Adobe Animate software. This application includes videos and visuals to explain the use of sign language among lecturers and students in the field of fashion design as a reference. The *Learn Sign Language application* (Maisarah & Suhazlan, 2021) is designed to help users learn and memorize hand sign language codes correctly. This module is equipped with Augmented Reality so that users can see virtual objects. The *HearASL applicatio*n (Wang et al., 2023) is created to translate and communicate sign language into spoken language on smartphones. This application focuses on helping normal people understand the sign language conveyed by the hearing-impaired.

In addition, the *M-Isharah application* (Meeze et al., 2020) aims to help prospective Special Education teachers learn sign language and prepare early to become Special Education teachers for deaf students regarding the needs, methods, and ethics of sign language. The *Learning Basic Mathematical Concepts Using Sign Language application* (Parvez et al., 2019) was developed for deaf students to learn basic mathematics using sign language. The results show that they are very interested in the application due to its background, color scheme, font, videos, and images that are easy to read and clear. The *HearIT application* (Jan Stas et al., 2023) was developed with similar objectives as the HearASL product. All six applications were designed to assist those learning and understanding sign language at the early stages, as well as providing exposure to those familiar with sign language. The positive impact of mobile applications on the deaf community is evident in facilitating the rapid and widespread dissemination of information across various countries.

Theme 5: Touch Devices

Touch devices or touch screens are a type of input and output device that allows a user to interact with a system by touching the screen, and the system responds to this input through specific gestures or touches on the screen, either with a special stylus or using one or more fingers.

Two studies focus on touch devices, namely *Alarm Technologies to Wake Sleeping People Who Deaf* (Erik et al., 2019) and *Intelligent Gloves for Deaf* (Babour et al., 2023). The Alarm

Technologies to Wake Sleeping People Who Deaf study discusses vibrating alarm devices designed to wake up individuals with hearing impairments from sleep. These devices are found to be effective for individuals with hearing impairments and also for the elderly. However, there is a need for further research on the effectiveness of bed/pillow shakers, especially for the elderly.

Furthermore, the Intelligent Gloves for Deaf device is a smart glove designed to translate sign language movements into audible speech and sentences that can be heard by individuals without hearing impairments. This device also enables two-way interaction and communication between individuals with hearing impairments and typical individuals. The impact of touch devices on the deaf community is found to allow users to interact directly with what is displayed rather than indirectly through touch-controlled pointers. However, the cost of such devices is high.

Implications and Reserves

Based on the studies that have been carried out, it has been found that there is a positive effect of the use of assistive technology on the deaf which is undeniable. This is because assistive technology gives a lot of exposure and new experiences to the deaf. However, the findings clearly show that this technology has some limitations that make it unsuitable for the deaf and pose challenges for them to learn how to use it.

Therefore, the government can provide allocation for the deaf in the development of technology to help facilitate their daily activities. The assistive technology tools provided by the government for the use of the deaf can also be categorized as technology in terms of education, medicine and so on. Some examples of this tools are sign language model, smartphone, tables, software and so on that can improve skills, knowledge and help the deaf more effectively.

Conclusion

Assistive technology for the deaf refers to tools such as mobile application, sign language interpretation software, and communication devices that use text or graphics to facilitate communication. These technologies help individuals who are deaf or hard of hearing to communicate, access information, and perform tasks independently. The aim is to enhance their quality of life and promote independence. The deaf community is not exempt from the need for this technology. The deaf communicate differently from other people, yet their objectives are the same as those of people who lead regular lives. With the advancement of assistive technology, it can attract the interest of the deaf community to use interactive visual images and moving visuals as an additional method in teaching and learning (Aidah et al., 2016). Through the analysis of the literature review conducted, it is found that the developed technology is well-received and effective for users, especially the deaf community. Therefore, the produced technology can assist the deaf community in improving sign language communication skills, language proficiency, religious understanding, and more.

Reference

Aderonke, P. B., Burnett-Zeigler, I., Fokuo, J. K., Wisner, K. L., Zumpf, K., Oshodi, Y. (2020).Mental health stigma among university health care students in Nigeria: a cross-sectional observational study. *Pan Afr Med Journal*.

Edries, A. A. M., & Ramli, A. A. (2023). Sign L- the development of sign language system for primary school student. *Applied Information Technology and Computer Science,* 4(1), 1419-1433.

Babour, A., Bitar, H., Alzamzami, O., Alahmadi, D., Barsheed, A., Alghamdi, A., & Almshjary, H. (2023). Intelligent gloves: An IT intervention for deaf-mute people. *Journal of Intelligent Systems*, 32(1).

Baglama, B., Haksiz, M., & Uzunboylu, H. (2018). Technologies used in education of hearing impaired individuals. *International Journal of Emerging Technologies in Learning (iJET)*, 13(09), 53–63.

Jairam, B. G., and Ponnappa, D. (2023). Gesture Based Virtual Assistant for deaf-mutes using deep learning approach. *29th International Conference on Advanced Computing and Communication Systems (ICACCS)*, India

Ramones, F. A., Del-Rio-Guerra, M. S. (2023). Recent development in haptic devices desugned for hearing impaired people: a literature review*, MDPI*

Grushkin, D. A. (2006). The more things change the linguistics of American sign language: an introduction. *The Journal of Deaf Studies and Deaf Education*, 11(2): 269-272

Efthimiou, E., Fotinea, S., Goulas, T., Vacalopoulou, A., Vasilaki, K., & Dimou, A. (2019). Sign language technologies and the critical role of sl resources in view of future internet accessibility services. *Technologies*

Department of Social Welfare. (2023). The distribution of registered people with disabilities across states and categories until 31 January 2023. Access from https://www.jkm.gov.my

Kolberg, M. W. (2014). Hard of hearing is not deaf. Access from http://journals.lww.com/ajnonline/Fulltext/2014/02000/Hard_of_Hearing_Is_Not_Deaf.

Parvez, K., Khan, M., Iqbal, J., Tahir, M., Alghamdi, A., Alqarni, M., Alzaidi, A. A., & Javaid, N. (2019). Measuring effectiveness of mobile application in learning basic mathematical concepts using sign language. *Sustainability*, 11, 3064.

Joklitschke, J., Rott, B., & Schindler, M. (2018). Theories about Mathematical creativity in contemporary research: a literature review. *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education*, pp. 171–178. PME.

Lindsay, G. J., Nakaji, M., Harry, K. M., Gallegos, N., Malcarne, V. L., Sadler, G. R. (2013). Ovarian Cancer: deaf and hearing women's knowledge before and after an educational video. *J Cancer Educ.*

Mamat, M., & Suhaimi, S. (2021). Basic skills of sign language assisted by Augmented Reality (AR) mobile application for students with hearing problems and the general public. *Journal of ICT in Education*, 8(3), 117-125.

Huzairi, M. A., Bahti, H. Z., & Meeze, S. R. (2019). Teaching methods of Fardhu Ain, to students with special needs. *Seminar on Basic Class on Al-Quran and Fardhu Ain teaching (KAFA) education awareness*.

Ramli, M. N., & Yee, S. L. (2023). Application of machine learning in Malaysia Sign Language Translation. *Emerging Advances in Integrated Technology,* 4(1), 1-6.

Nakpong, N., & Chanchalor, S. (2019). Interactive multimedia games to enhance the emotional intelligence of deaf and hard of hearing adolescents. *International Journal of Instruction*, 12(2), 305-320.

Izzati, N. (2021). MyKamus application as a facilitator of basic sign language learning. *E-Prosiding Konvensyen Kearifan Nusantara Ke-3 Arif 2021: "Memartabatkan Kearifan Melayu Islam Nusantara*.

Ramli, M. N., & Yee, S. K. (2023). Application of machine learning in Malaysia Sign Language translation. *Emerging Advances in Integrated Technology*

Razalli, A. R., Mamat, N., Razali, N. A., Yasin, M. H., Lakulu, M., Hashim, A. T., & Ariffin, A. (2021). Development of prayer mobile application software for the hearing impaired (deaf) based on Malaysian Sign Language. *International Journal of Academic Research in Business and Social Sciences.*

Rehabtool. (2014). Sciences and technology in the education of people with special needs. *Journal of Sciences and Technology in Special Education*, 2:143-158

Soetan, A. K., Onojah, A. O., Alaka, T. B., & Aderogba, A. J. (2020). Hearing impaired students' self-efficacy on the utilization of assistive technology in Federal College of Education (Special) Oyo. *International Journal for Cross-Disciplinary Subjects in Education*, 11, 4245-4252.

Smedberg, E., Ronchi, E., & Hutchison, V. (2022). Alarm Technologies to wake sleeping people who are deaf or hard of hearing. *Fire Technology,* 58, 2485-2507.

Mohid, S. Z., & Zin, N. A. M. (2019). Education Software (Mudahku). *Malaysian Journal of Information and Communication Technology*, 4(2), 121-136.

Trumm, A., Lau, E. J. S., Farthing, S., & Breen, K. (2023). The use of video remote interpreting (VRI) in a medium secure psychiatric setting during the COVID-19 lockdown. *The Journal of Forensic Practice*, 25(3), 263-273.

Wang, X., Tang, L., Zheng, Q., Yang, X., & Lu, Z. (2023). IRDC-Net: an inception network with a residual module and dilated convolution for sign language recognition based on surface electromyography. *Sensors*, 23