JOURNAL OF INFORMATION TECHNOLOGY AND ITS UTILIZATION, VOLUME 7, ISSUE 2, DECEMBER 2024
EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

An Assistive Technology for A Deaf Student: Many-to-One System Using Button Board Speech-to-Image Based on Microcontroller ESP8266

Kristian Dame[1], Lianly Rompis[2], Julie Rante[3], Ryan Singgeta[4]

[1,2,3,4]Universitas Katolik De La Salle Manado, North Sulawesi - Indonesia
kdame@unikadelasalle.ac.id[1*], lrompis@unikadelasalle.ac.id[2], jrante@unikadelasalle.ac.id[3], rsinggeta@unikadelasalle.ac.id[4]
*Corresponding author

***Abstract*--Education is the right of every nation and society including disabled students. In an effort to facilitate proper education for students with special needs, especially deaf students, it is very important to care and commit for conducting research on assistive technology for deaf students. This research designed and created a Button Board Speech-to-Image tool based on the ESP8266 microcontroller which is intended for deaf students to make it easier for them to communicate and interact with teachers while in the classroom, especially during exams or learning process activities. The research method was experiment by system design and data mining. The assistive technology development method was Research and Development (R&D). The inputs on the button board were processed into sound (speech) which was sent to the recipient wirelessly so that what the deaf student wants to convey in class can be understood by the teacher through the speaker or text display. The technology operates well with WiFi network and well accepted for learning process and communication.**

Keywords: Assistive, button board, deaf, many-to-one, microcontroller.

I. INTRODUCTION

A. Background

Based on Law of the Republic of Indonesia Number 23 of 2002, every child, particularly disabled children, has the right to receive special-needs education. Normally in education, learning process is the important matter and nowadays, it refers to interactive learning or interactive communication [11].

Communication is very essential in children education, especially in their development age where they slowly and wisely learn to create their critical thinking naturally through learning media and visual technology. The non-disabled children are not difficult to communicate with other people, but the communication process of the disabled who came with hearing loss will be harder so these difficulties will ultimately hinder the child in developing learning science, understanding science, skills in dealing with the surrounding environment and learning new things.

Interactive learning media is one of the most effective ways that can be used to help deaf children to learn. It should be specifically designed to offer a more interesting, fun, easy-to-understand and clear lesson delivery. Interactive learning media is designed to clarify the presentation of messages and information. It can overcome the limitations of the senses, space, time, and objects. Objects can be presented with the help of slides, or images. These conditions will improve their ability to analyze, criticize, and reach conclusions based on critical thinking skills [11].

Sensory and behavior are interrelated. The senses of deaf friends affect their daily activities and movement. It is necessary to build an effort to combine aspects of deaf space, which focus more on visual and auditory, with other sensory senses [12]. Based on those reasons, it needed research in an assistive technology for a deaf student, a Many-to-One System using Button Board Speech-to-Image based on Microcontroller ESP8266, which can be used to make it easier for them to communicate and interact when study in the classroom.

The designed and developed assistive technology is an embedded system consist of microcontroller ESP8266 as data processing, input to output, where the input is from Many-to-One System using button board image and processed become voice (speech) and go through the speaker wirelessly (Bluetooth technology). This makes teachers are able to understand what disabled students exactly want to communicate

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

during class. It is expected that this technology can operate well and used by deaf students to learn and communicate in class.

B. Basic Theory

Literature study was conducted to support research activities, i.e., finding few good references from journals and textbooks. Each selected reference was related to the developed system. Ideas and the achieved development were analyzed for research process.

Based on reference [1], deaf person is a person who lost his hearing ability, part or whole, and hinders the language information process through his hearing. Hearing loss can be caused by several factors such as genetical, infections in the mother such as chicken pox during pregnancy, complications during childbirth, or early childhood illnesses, such as mumps or chicken pox.

Assistive technology is a term that covers aid tool, adaptive, and rehabilitation for individuals that have disabilities and lack of specific [2]. Some assistive technology for deaf technology has been created and developed, e.g., Android application name So-Ice that functions as a communication tool with sign language (BISINDO) [3], assistive technology for calling the deaf using Android based Library Pocketsphinx as a voice to text changer [4]. The other technology is a bracelet Gyroscope for helping the deaf people to follow priest moving instructions when doing congregational prayer [5] and bracelets based on the Internet of Things (IOT) [6] for the deaf as warning of guests, rain warning, fire warning, and warning of thieve.

The research that has been carried out previously regarding deaf people includes the development of a tool for calling deaf people using the Android-based Pocketspinx library which makes it easier to call deaf people. This application will work if a voice calls the deaf person's name and then the deaf person's cellphone will vibrate and display the text. This research gave very good results so it is recommended that it will be developed [9].

Apart from that, there is also research on the development of a media literacy development program for deaf students. The results of the research obtained are that the media literacy development program is highly recommended to be applied to every lesson for deaf students so that they can enhance their learning experience by collaborating language skills and media technology [10].

A sign language interpreter device with voice output in the form of an ATMega328 microcontroller-based voice speaker module also has ever been built focuses on the translation of 16 words that have been predetermined in Indonesian Sign Language [13].

For safety listening, standards were created by US organizations such as the National Institute for Deafness and Communication Disorders (NIDCD), the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Administration (OSHA) to promote safe listening and reduce the risk of noise-induced hearing loss (NIHL). The NIOSH standard recommended exposure level is 85 dBA over 8 hours daily.

C. Roadmap

This research is the first assistive technology basic research of Electrical Engineering Study Program lecturers. Although this is the first research but in the middle of year 2023 the lecturers together with students have already frequently done experiments using Microcontroller Arduino Uno in Electrical Engineering laboratory. Some lecturers also have scientific publications that cover wireless control system and microcontroller.

This research was also part of the assistive technology development program that our study program had been conducted for disabled Students in SMA Kristen Permata Hati Manado. Winning the grant from Indonesia Government, we created a button board image to text for disable students so they could communicate well in class and easily explain what actually they want to do. A simple technology but it was a basic one for further technology development. For this research, the technology thinking framework for deaf students are described in Fig. 1.

A. Solution

From our observation and literature study, a deaf student has difficulty to communicate, so the solution is an image-aid-technology.

B. Input

The input of our technology is several buttons from a board, or we can call it a button board which is designed with an image as a label.

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

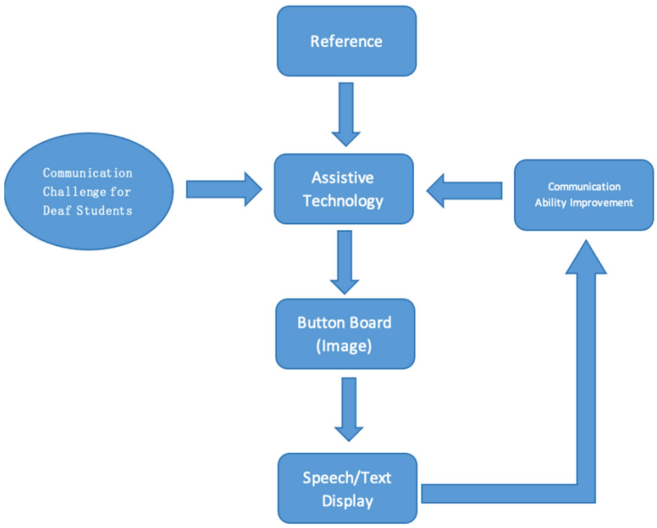

Fig. 1. The diagram of technology concept

C. Process

The process is the conversion of signal from the image-button to speech or text display.

D. Output

The output of our technology is on the LED screen and speaker.

E. Outcome

The outcome of our technology is the communication improvement of the deaf student.

II. METHOD

This research is a quantitative research, conducted an experiment method and used data measurement. It developed and evaluated the effectiveness of the assistive technology system for deaf students. This experiment method was chosen because of its capability to equip us to test the distance and signal strength when the button was activated. The assistive technology development method was Research and Development (R&D). This research aims to test how far the developed system can help deaf students to communicate using microcontroller ESP8266. The experiment was designed to test the system performance with several steps as follows:

A. Choosing the Research Parameter

Author selected the pilot distance and bandwidth reference that would be used so the design of assistive technology could be developed in proper and effectively used in communication.

B. System Design

The used system was tools and devices consist of button board as the input and microcontroller ESP8266 as data processor, which then the output was a speech and text according to images. This system was tested in a controlled condition and was guaranteed with the right input processing of the microcontroller.

C. Data Mining

The experiment process was conducted in 4 (four) sessions, i.e. WiFi network distance testing, WiFi testing with spectrum analyzer, power testing and calculation in dBm, and speaker testing. All data were measured using measurement devices. For the calculation of Power in Watt, a RSS (Receive Signal Strength) formula has been used, as shown in equation 1.

$$1\ dbm = 10\ log * (P/1mW) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The system has 4 (four) transmitters and 1 (one) receiver with WiFi symbol. It is described in Fig. 2. This shows that there is a communication system which is built inside a building system. The developed communication system is a wireless network. From the button board side, we modified using microcontroller ESP8266 and made it able to send data image-to-speech when the button was pushed. From receiver, it will be ready to accept data using wireless network as well. The used protocol was ESP8266 or ESP. Now that was used to display the short transmission data packet, and mode Many-to-One that made possible for many senders with one receiver. The figure shows that sender is equipped with push buttons that will send data in a form of speech signal to the receiver. The speech signal will receive voice through the speaker.

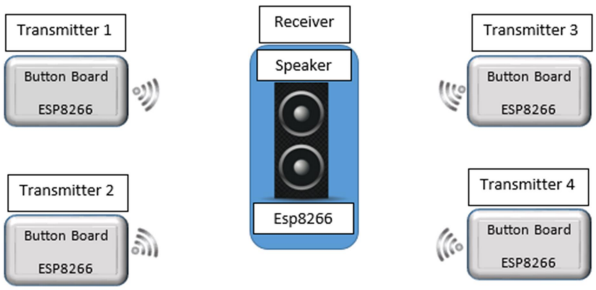

Fig. 2. The design of Many-to-One system using ESP protocol

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

III. RESULT AND DISCUSSION

Tools and materials needed for the system were microcontroller ESP8266, power supply 3-9 Volt, push-button modul, LED, resistor, speaker/headset/headphone, jumper, MP3 modul, decibel meter, spectrum analyzer, and SD card modul. Each tool and material were well checked before used. The process of checking lasted for one week. For system design, there are two parts of research activities: hardware design and software design.

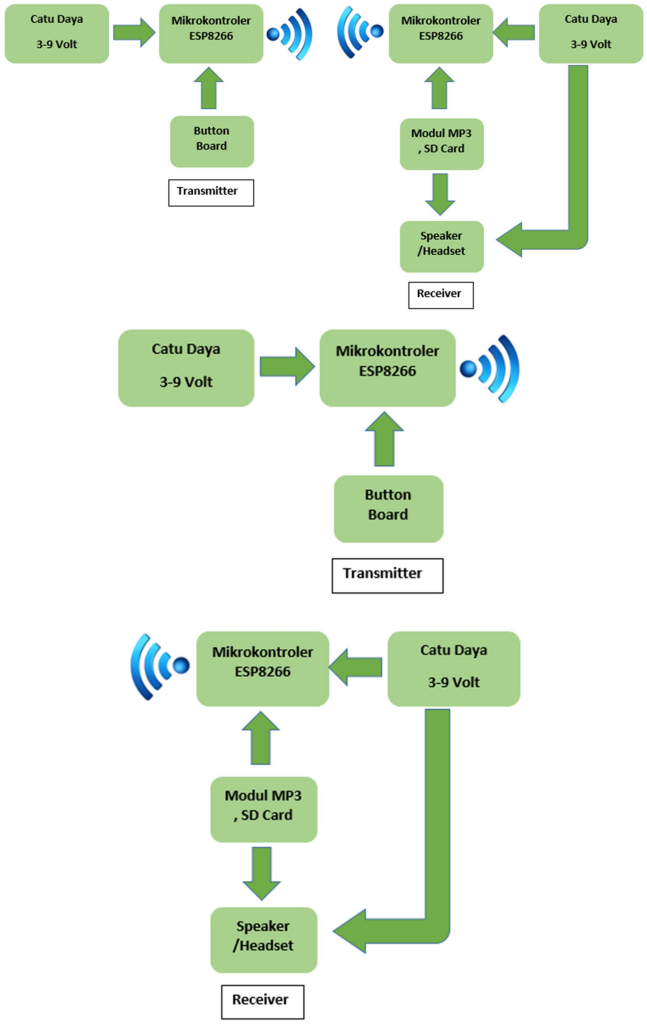

Fig. 3. Block diagram of Many-to-One system

A. Hardware Design

Hardware design of Many-To-One system is shown in Fig. 3.

B. Software Design

Software design of Many-To-One system is shown in Fig. 4. At the beginning of the program, the button board is being initiated, continued with inserting input or pushing the button. The data sent from the button will be processed and can be read. If it is succeed, then the system will emit sound and be received by speaker, headset, or headphone. If the data from the button could not be read, system must return the input or push again the button until it can be read again. The looping system is working continuously.

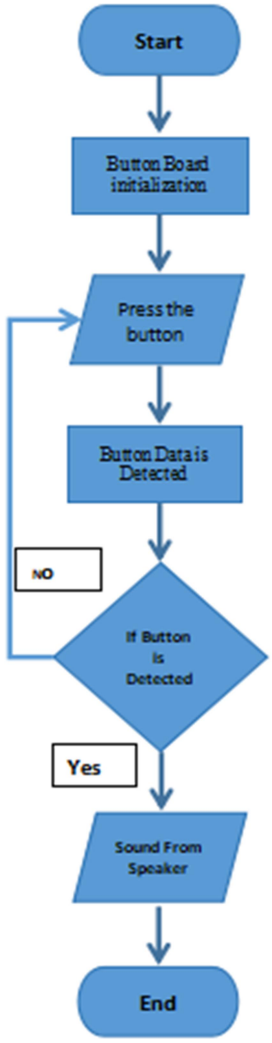

Fig. 4. Flowchart of software design

C. WiFi Network Testing with Datasheet 2.4 GHz

Our team used spectrum analyzer to check the frequency value in microcontroller ESP8266 datasheet and in real environment. The testing data can be seen in Table 1. It is described in it that the testing was conducted from distance 0.6 to 5 meters. After checking using spectrum analyzer, the measured frequency still accurate because the error only between 0.02–0.03 GHz. Table I displays some distances and frequencies from datasheet and measurement. Fig. 5 shows the line chart of frequency 2.4GHz testing.

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

TABLE I
Frequency Testing

No.	Distance	Frequency (from datasheet)	Frequency (from measurement)
1	60 cm	2.40 Ghz	2.43 GHz
2	200 cm	2.40 Ghz	2.43 GHz
3	300 cm	2.40 Ghz	2.43 GHz
4	400 cm	2.40 Ghz	2.43 GHz
5	500 cm	2.40 Ghz	2.43 GHz

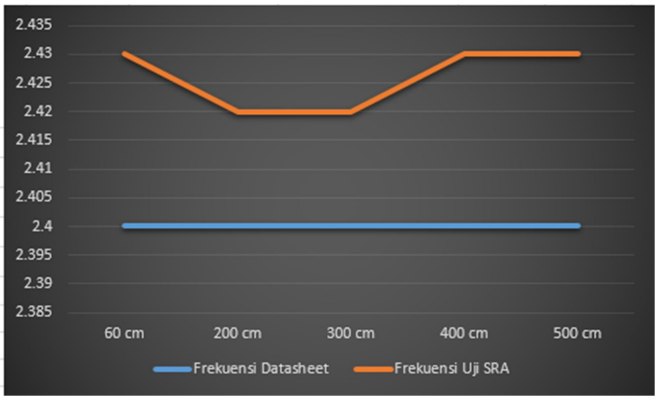

Fig. 5. Graph of frequency 2.4 GHz testing

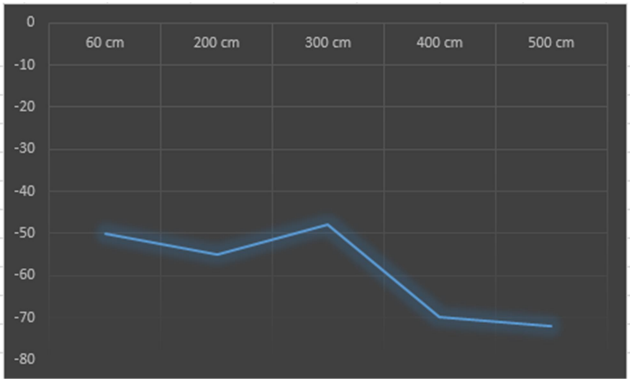

Fig. 6. Graph of line chart of distance testing with dBm value

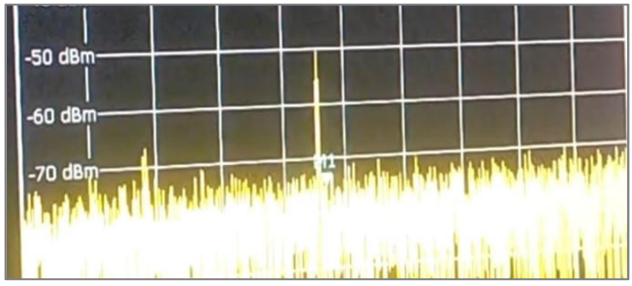

Fig. 7. dBm testing with Spectrum Analyzer

D. WiFi Network Testing with Spectrum Analyzer

The next testing was measuring the power in the network (dBm). Knowing dBm will make it easier to convert into watts. The testing can be seen in Table II.

TABLE II
Testing Power in Network (dBm)

No.	Distance	Frequency (Datasheet-Mode Bluetooth)	Frequency (measurement)	dBm
1.	60 cm	2.40 Ghz	2.43 Ghz	-50
2.	200 cm	2.40 Ghz	2.42 Ghz	-55
3.	300 cm	2.40 Ghz	2.42 Ghz	-48
4.	400 cm	2.40 Ghz	2.43 Ghz	-70
5.	500 cm	2.40 Ghz	2.43 Ghz	-72

The testing for power run well and show significance change from -50 dBm until -72 dBm (the measurement value was related with the theory), the farther the transmitter from receiver the greater the value of dBm and the greater also the minus value of dBm. Fig. 6 is a graph of dBm value from 0.6-5-meter distance. Fig. 7 is the result of dBm using SRA (Spectrum Analyzer).

E. Testing and Calculating Power in Watt

In this testing, using the equation (1), power in dBm was converted into watts so it could be easy to read. Based on Table III which covers the whole testing using WiFi, we can see that signal is well detected from distance 60-500 cm and the measured frequency average using Spectrum Analyzer is 2.43 GHz with the highest power 15.85 nW at 300 cm.

TABLE III
RSS Power Calculation

No.	Distance	Freq (datasheet)	Freq (measurement)	dBm	Power (nW)
1	60 cm	2.40 Ghz	2.43 Ghz	-50	10
2	200 cm	2.40 Ghz	2.42 Ghz	-55	3.16
3	300 cm	2.40 Ghz	2.42 Ghz	-48	15.85
4	400 cm	2.40 Ghz	2.43 Ghz	-70	100 pW
5	500 cm	2.40 Ghz	2.43 Ghz	-72	63,1 pW

F. Speaker Testing

Testing for speaker output aims to know if the output or voice from the system run well, using dB so it can be in accordance with the speech strength level and do not affect the ears. The result for the testing can be seen in Table IV.

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

TABLE IV
Speaker Output Testing

No.	Speaker Status	dB Value
1	Inactive	51 dB
2	Active	83 dB

Fig. 7 shows the value of dB from the speaker. It is well seen that both in Table IV and Fig. 8, the result value is 51 dB and 83 dB. For inactive speaker or unsounding speaker, the result is 51 dB while for active and sounding speaker the result is 83 dB. The value of 83 dB is in the safe condition for ears based on reference [14], because the safe value limit for hearing according to the NIOSH standard is 85 dB. The level of sound however can be adjusted based on demand and specific purposes.

Fig 8. dB testing on speaker

The testing in WiFi mode is related with Table III. It is shown that all the connection works well for all pilot distance, and this is proven by the measured frequency average 2.43 GHz. The highest power is 15.85 nW with a distance of 300 cm. This means that the signal in that distance can be well accepted and good for communication. The speaker emits a sound in safe category, i.e. 83 dB. The microcontroller ESP8266 testing has already included Many–to–One system, because the input program for every microcontroller is the same except the IP address and has one receiver.

IV. Conclusion

The frequency stability of the system is good. The average frequency for all pilot distance is 2.43 GHz which shows that the system can maintain its frequency stability although in various distances. This proves that the system runs well for communication purpose with a very minimum interference from other devices.

For signal strength, out test showed that a signal strength of 15.85 nW at 300 cm distance can be well received. This proves that at that distance the system has enough transmission power for effective communication.

In relation to our research objective, it can be said that this system can be applied for disable children, especially the deaf ones, and the technology was using a speaker with output level of 83 dB which is safe and can be heard by users and send a text or message to be displayed in LED screen. Besides that, this Many-to-One system is using ESP8266 that functions well and compatibly integrated with the system, with the same input for every microcontroller that proves the proper technology application.

This system not only effective in supporting communication, but also gives opportunity to children who has hearing disability so they can improve better skills and knowledge, build more understanding about their world, and enrich their learning experience.

For future work, this research can be developed into a database system so the data can be analyzed further and developed using machine learning method. This system can also be made in two directions.

V. References

[1] F. N. Rahmah, “Problematika Anak Tunarungu dan Cara Mengatasinya,” Quality, vol. 6, no. 1, p. 1, doi: 10.21043/quality.v6i1.5744, Jun. 2018.

[2] Eviani Damastuti, Teknologi Asistif, Cetakan Pertama., vol. 1. Jl. Sokajaya No. 59, Purwokerto Perum New Villa Bukit Sengkaling C9 No. 1 Malang: IRDH (International Research and Development for Human Being), 2021.

[3] M. Luter, K. Frehadtomo, R. N. Dayawati, S. Si, and F. N. Prawita, “Application as A Communication Tool for The Deaf Speech”.

[4] N. H. Abdullah, M. T. Ananta, and R. K. Dewi, “Pengembangan Alat Bantu Pemanggil Penyandang Tunarungu Menggunakan Library Pocketsphinx Berbasis Android (Studi Kasus PSLD Universitas Brawijaya)”.

[5] H. Heriyadi, H. R. Fajrin, and W. Kartika, (2022), “Prayer Guide Gyroscope Bracelet for The Deaf Using MPU6050 Sensor,” Indones. J. Electron. Electromed. Eng. Med. Inform., 4(1), 36–40, doi: 10.35882/ijeeemi.v4i1.6

EISSN 2654-802X ; PISSN 2985-4067
DOI: https://doi.org/10.56873/jitu.7.2.5865. SUBMITTED: OCTOBER 25, 2024; REVISED: DESEMBER 3, 2024; ACCEPTED: DESEMBER 11, 2024

[6] A. W. Susanto, I. Piscesa, and R. Widianingsih, (2019), "Gelang bagi Tunarungu Berbasis Internet of Things".
[7] R. L. Singgeta and P. Manembu, (2018), "Sistem Pengamanan Pintu Rumah dengan RFID Berbasis Wireless ESP8266," Open Science Framework, preprint, doi: 10.31219/osf.io/9q4z7.
[8] R. L. Singgeta, I. R. Honandar, and P. D. K. Manembu, "Pemanfaatan Alat Dispenser Pakan Ikan Otomatis Berbasis Internet Of Things oleh Kelompok Masyarakat Kaweruan Kabupaten Minahasa Utara dalam Meningkatkan Efektivitas dan Produktivitas Budidaya Ikan Mujair," 4(1).
[9] P.E. Prasetyo, and A.E. Susetyo, (2020), "Analisis Kebutuhan Alat Bantu Berkendaraan Sepeda Motor Tunarungu dengan Metode *Quality Function Deployment*", Jurnal Taman Vokasi, 8(1), 7-15.
[10] R.D. Kurniawati, A. Wijiastuti, and Yuliati, (2020),"Pengembangan Program Pembinaan Literasi Media Bagi Siswa Tunarungu", Jurnal Teknologi Pendidikan, Vol. 8, *online* ISSN:2622-4283, Print ISSN: 2338-9184.
[11] M.R. Runtulalo, Y.D. Rindengan, and A.S.M. Lumenta, (2019), "Aplikasi Media Pembelajaran Interaktif Pengenalan Komputer bagi Anak Tunarungu". Jurnal Teknik Informatika, 14(2), 209-220.
[12] S.F. Collin, and D. Husin, (2024). "Pengalaman Multisensor Teman Tuli dalam Perancangan Edukasi-Hiburan di Kembangan", Jurnal Sains, Teknologi, Urban, Perancangan, 6(1), 509-522.
[13] I.W. Sukadana, I.N.A.M. Adnyana, and E.M. Sartika, (2021), "Indonesian Sign Language Interpreter Device Based on ATMega328 Microcontroller for Bali Deaf Community Denpasar", Jurnal of Innovation and Community Engagement, 1(2), 88-101.
[14] F. Chen, H. Xue, M. Wang, Z. Cai, and S. Zhu, (2023), "Hearing Care: Safe Listening Method and System for Personal Listening Devices", *International Journal of Environmental Research and Public Health*, 20(3), 2161, https://doi.org/10.3390/ijerph20032161.