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SIGN LANGUAGE LETTER LEARNING MEDIA

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Abstract

This research aims to build a sign language learning media, especially alphabet letters. Users can not only learn to act out the sign code but also train and test their understanding through question mode. The system will guide the user to act out the letters in sign language in the learning mode. After that, the user can practice in the practice mode, which is by acting out the sign code and the system will provide voice feedback. Meanwhile, with question mode, users can test their understanding of letters in sign language. In question mode, users will be asked to act out certain signs as instructed. The sign language used in this learning media is the Indonesian Sign Language System (SIBI). In question mode, users will act out the sign language with their hands and will be captured by the camera. In its development, the method used is the waterfall method with the stages of requirements, design, implementation, and testing. At the end of the stage, testing is done using the black-box method. Testing is done on the practice mode and question mode. The test results show that the learning media can work as expected.

Keywords: Indonesian sign language system, Learning media, Learning mode, Question mode, Sign language.

1. Introduction

Language is a tool to communicate between people. However, for those with disabilities such as the deaf, a special language is needed due to hearing limitations [1]. The language used by the deaf includes sign language [2]. Sign language can also be learned by anyone, not limited to teaching staff in a school environment for people with disabilities. To be able to use and understand sign language certainly requires sign language learning media.

Some research related to sign language recognition has been done. In 2017 a study produced a hand code object classification system on the introduction of Indonesian Sign Language (BISINDO) alphabet gestures [3]. In the study, the system will capture the sign language demonstrated by the user and then convert it into alphabet letters. However, in the study, not all letters can be translated by the system. Some letters that cannot be translated are the hand gestures of the letters J and R.

Research conducted in 2020, namely the development of sign language translation applications. This research produces an application to recognize hand gestures either captured by a camera or through image uploads [4]. Research in 2022 produced interactive sign language learning media to recognize letters and numbers for deaf students [5]. This learning media is built to facilitate students in learning sign language. The learning media will display sample images that demonstrate letters and numbers in sign language. Then in game mode, students will be asked to choose one of the right answers based on the numbers/letters displayed. This learning media is one-way.

Based on the description of the three studies, the sign language recognition system has not been able to recognize all letters because some of them are in the form of movements [3]. Meanwhile, the second and third studies do not have two-way learning features [4, 5]. The second study only translates the captured hand gestures, and the third study has not provided a question mode to ascertain whether the student can demonstrate the sign language according to the instructions given.

Therefore, the purpose of this research is to build a sign language learning media, especially alphabet letters, where users can not only learn to act out the sign code but also train and test their understanding through question mode. The system will guide the user to demonstrate the letters in sign language in the learning mode. After that, users can practice in the practice mode, which is by demonstrating the sign language code and the system will provide voice feedback. Not only learning and practice modes, but the system also provides a question mode. With question mode, users can test their understanding of letters in sign language. In question mode, users will be asked to demonstrate certain signs according to instructions. This research contributes to the world of education, especially helping users learn the letters of the alphabet in sign language. The sign language used in this learning media is the Indonesian Sign Language System (SIBI). In the question mode, the user will demonstrate the sign language with hand gesture and will be captured by the camera. For better recognition results, it is necessary for the camera to be able to capture images clearly, the light when taking pictures must be sufficient and the distance of taking pictures.

This research aims to build a sign language learning media, especially alphabet letters. Users can not only learn to act out the sign code but also train and test their understanding through question mode. Indeed, to be able to build this learning media requires several libraries and frameworks to produce letter learning web applications in sign language. In this research, the learning media built is a web application using the flask framework. Flask framework is chosen because it is lightweight and written in Python. Flask provides simple templates for web development. By using flask, web application development will be faster. The consideration for the use of the Python programming language is because Python is open source, relatively easy to understand, and has many additional libraries that can be used [6]. The Python programming language is open source and has many libraries that support system development [7-9]. With such specifications, this device is suitable for use in this study.

Meanwhile, so that the application can interact with the user, where the user will demonstrate the letter sign code and the system will evaluate whether the sign code demonstration performed by the user is correct or not, it requires OpenCV. OpenCV is useful for analysing and processing images [9-13]. OpenCV is used to capture images that come from live stream videos, where the video is taken through a camera that has been connected to a PC or laptop. OpenCV is a program package that contains many features related to image processing and analysis One of the functions of OpenCV is used to take an image from a webcam and then save the result to a variable [14-16]. OpenCV has a simple interface and is easy to use [17]. OpenCV is an open-source computer vision library for the C/C++ programming language and has been extended to the Python, Java, and MATLAB programming languages [10, 12, 18]. OpenCV focusing on real-time applications [12, 13]. Based on this, OpenCV is appropriate to be used in this case.

After the hand gesture demonstration is received by the system, then a function model is needed to be able to recognize human body parts, namely by using Media Pipe. Media Pipe is an artificial intelligence framework provided by Google [19]. Media Pipe is a service that provides a solution-type library so that the human body recognition function model in the image data can be developed, learned, and used easily. Media Pipe can detect human body parts accurately. Media Pipe has a large collection of human body detection and tracking models trained on a very large and diverse Google dataset [20]. Media Pipe supports various development environments such as web, Android, and iOS. The supported languages include Android, iOS, C++, Python, JS, and Coral. In addition, Media Pipe is also an open-source project so that it can be modified and developed according to needs [17].

This research also utilizes Support Vector Machine (SVM), which is a group of supervised learning methods capable of classification, regression, and detection [21]. With SVM, each image collection of sign language data is processed using Media Pipe and trained with SVM to classify the sign correctly [20]. SVM is an optimization-based learning technique that employs fictitious spaces represented as linear functions in high-dimensional data [22, 23]. SVM is widely used in binary classification and regression problems [24]. Additionally, SVM is a family of strong classifications that have proved effective in a variety of natural language processing tasks [25]. SVMs, or support vector machines, are efficient machine learning techniques. SVM uses a classification technique to group data into two categories. When given labelled training data, SVM can be used to classify new data. SVM is optimal when using limited data. The main function of SVM is to classify data that can be separated linearly and has better and more efficient performance than other methods such as Artificial Neural Network (ANN) when dealing with large data [26]. SVM is designed to determine the best line in ndimensional space to separate data into different groups, so that new data can be classified accurately in the future [27]. This method is a supervised machine learning approach used in pattern classification to enhance security and service quality. SVM proves to be effective in many classification cases by constructing an optimal hyperplane with maximum geometric margins [28-30].

For the question mode and the results of the examination of the sign code demonstration images performed by the user, the system will be delivered in the form of sound, namely by utilizing text-to-speech using Pygame. Pygame is a Python library for converting text into audio. Pygame is a cross-platform set of Python modules for creating audio. Pygame consists of computer graphics and sound libraries that have been designed to be used with the Python programming language.

This research contributes to the world of education, especially helping users to learn the letters of the alphabet in sign language. The system will guide the user to demonstrate the letters in sign language in the learning mode. After that, users can practice in the practice mode, which is by performing the sign language and the system will provide voice feedback. Not only learning and practice modes, but the system also provides a question mode. With question mode, users can verify their understanding of letters in sign language. In question mode, users will be asked to demonstrate certain signs as instructed. The sign language used in this learning media is the Indonesian Sign Language System (SIBI). In question mode, the user will act out the sign language with his/her hands and will be captured by the camera. The limitations of this research are that the shooting distance with the camera when demonstrating sign language is 30-60 cm and the lighting must be adequate.

2. Method

The system development method used in this research is waterfall. Waterfall consists of requirements, design, implementation, and testing as shown in Fig. 1.

requirements
design
implementation
testing

Fig. 1. Waterfall method.

The description of each stage is as follows:

2.1. Requirements

At this stage, the needs of the system to be built are analysed by evaluating the current system. To be able to analyse the needs of several things that are done including conducting literature studies through journals or proceedings related to learning letters in sign language. In addition, it is also necessary to understand how the current system is running.

In the current system, learning media for letters in sign language generally only shows pictures in the form of letter sign codes and checking the sign code that is demonstrated is what letter. The question mode given is only in the form of a sign code image and the user simply gives the answer what letter the code is. There is no direct and real time interaction between the user and the system, where the user directly demonstrates the sign code in front of the camera and the system responds in the form of sound from the letter being demonstrated. That way, users will be better at understanding letters in sign language because they act out the sign code directly. Table 1 shows the evaluation of the current system.

Table 1. Current system evaluation.

Current System	Actor	Solution
The current media for learning letters in sign language only shows pictures of sign codes and sign code checks that are demonstrated through a camera or uploaded images. The result of checking is in the form of text.	System	Build a learning media where users can practice by demonstrating the sign language in front of the camera and get audio feedback.
The question mode given is only in the form of a picture of a sign language and the user only needs to choose what letter the sign language is.	System	Build interactive learning media between the system and users to provide a better learning experience.

2.2. Design

The proposed system design is carried out at the design stage using an object approach. Based on the analysis results carried out in the previous stage, the use case design is shown in Fig. 2.

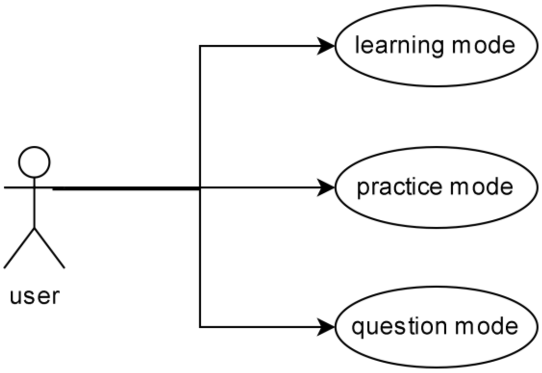


Fig. 2. Use case of learning media letters in sign language.

Users in this learning media are anyone who requires learning media letters in sign language. Users can access three modes in the learning media: learning mode, practice mode, and question mode. The next part is to design the flowcharts for these three modes. The flowchart design of the learning mode is shown in Fig. 3.

In learning mode, the system will display images of letter demonstrations in sign language starting from letters A to Z. The user will be allowed to follow the hand signal code that is demonstrated. If the user has been able to demonstrate the gesture code correctly, the image will change to the next letter demonstration. However, if the user is less precise in demonstrating the sign code that is exemplified, then the demonstration image will not move to the next image. The sign code demonstration will stop after reaching the letter Z. The flowchart design of the practice mode is shown in Fig. 4.

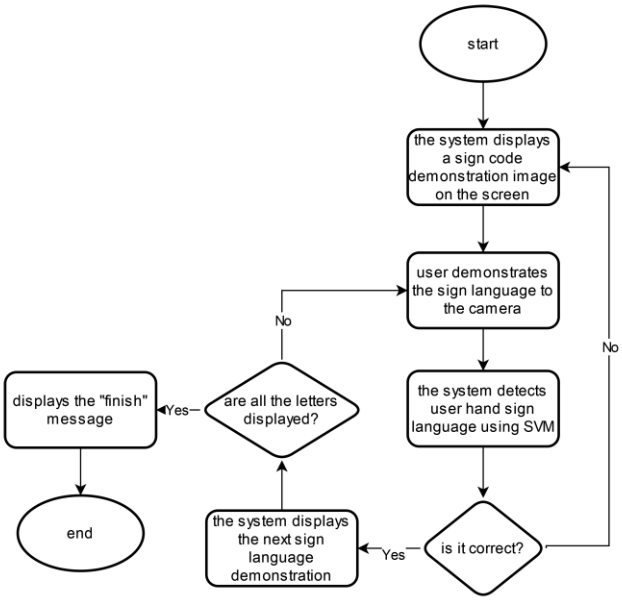

start
the system displays a sign code demonstration image on the screen
user demonstrates the sign language to the camera
the system detects user hand sign language using SVM
is it correct?
Yes
No
the system displays the next sign language demonstration
are all the letters displayed?
No
Yes
displays the "finish" message
end

Fig. 3. Learning mode flow diagram.

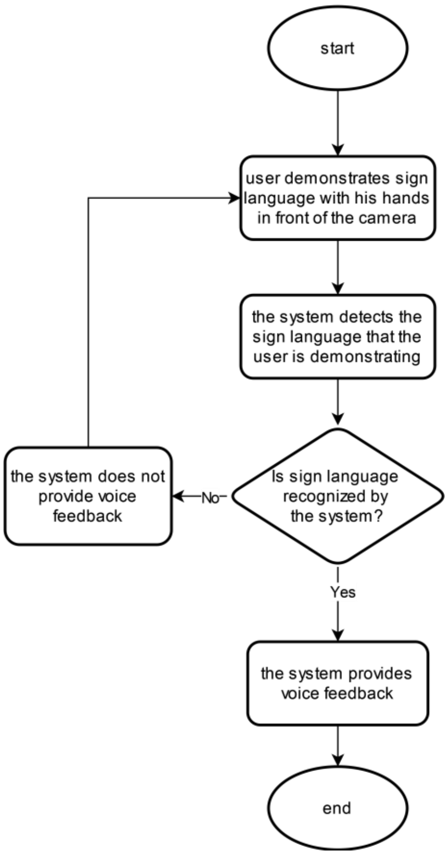

start
user demonstrates sign language with his hands in front of the camera
the system detects the sign language that the user is demonstrating
Is sign language recognized by the system?
No
the system does not provide voice feedback
Yes
the system provides voice feedback
end

Fig. 4. Practice mode flow diagram.

In the practice mode, the user can act out the sign code they are learning. The sign code will be captured through the camera then the system will provide feedback in the form of sound, which is the sound of the letter that is demonstrated by the user. This mode helps the user to practice and check whether the sign code he is demonstrating is correct or not. The flowchart design of the question mode is shown in Fig. 5.

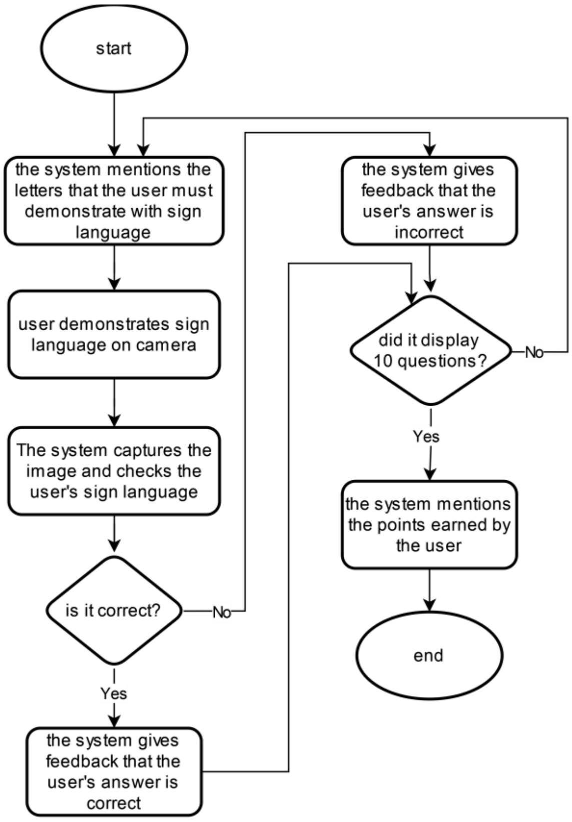

start
the system mentions the letters that the user must demonstrate with sign language
user demonstrates sign language on camera
The system captures the image and checks the user's sign language
is it correct?
No
Yes
the system gives feedback that the user's answer is correct
the system gives feedback that the user's answer is incorrect
did it display 10 questions?
No
Yes
the system mentions the points earned by the user
end

Fig. 5. Question mode flow diagram.

In question mode, the user will be given ten questions. The system will provide questions in the form of sound, and the user is asked to act out the sign code. The system will also provide feedback on whether the answer given by the user is correct or incorrect. At the end of the question mode session, the system will mention how many scores the user gets. Each correct question will get 10 points.

2.3. Implementation

The results of the proposed system design are then implemented into the form of a programming language. In this research, the programming language used is python. The first step is to create a dataset. The second step is to create a model and train the SVM model in Google Collab, and finally create a model, namely creating a learning media web application.

2.3.1. Creating a dataset

Two steps are taken in this stage, including:

(i) Capture images for training materials using OpenCV. The result of this process is an alphabet letter image containing 500 images for each letter stored in different folders.

(ii) Retrieve and convert all image data into csv form by utilizing OpenCV, Media Pipe, and NumPy.

2.3.2. Creating a model and train the SVM model

Several things are done in this stage, including:

(i) Import the necessary packages such as pandas, sklearn, seaborn, matplotlib and NumPy.

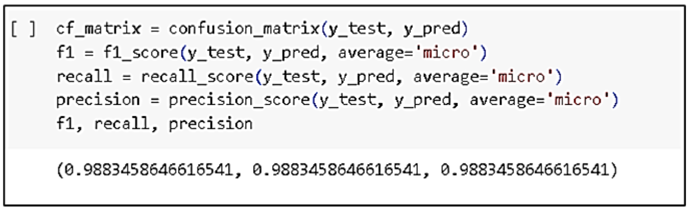
(ii) Create a data frame from the csv file that was created in the previous step.

(iii) Splitting the data into training and testing data (80% train data and 20% test data)

(iv) Trying the prediction using the test data.

(v) Finding the value of the confusion matrix for recall, f1, and precision. The values obtained at the time of making this model are shown in the Fig. 6.

(vi) Downloading the model file that has been created to be used in the web application to be built.



```
[ ]  cf_matrix = confusion_matrix(y_test, y_pred)
     f1 = f1_score(y_test, y_pred, average='micro')
     recall = recall_score(y_test, y_pred, average='micro')
     precision = precision_score(y_test, y_pred, average='micro')
     f1, recall, precision

     (0.9883458646616541, 0.9883458646616541, 0.9883458646616541)
```

Fig. 6. F1, recall, and precision value.

2.3.3. Learning media web application

The learning media web application was created using the Flask framework. The pages created include learning mode, practice mode, and question mode.

2.4. Testing

The next stage is testing, which is testing the system that was built. Testing is done using the black-box method. The black-box method is used to test the functionality of the system and ensure the system works and provides output as expected. The test scenario is carried out when the user demonstrates sign language in front of the camera to determine whether the system can recognize the sign code given by the user. In addition, the system is also tested whether it can provide sound output, namely mentioning the letters that the user demonstrates. The system was also tested for its ability to select in question mode, whether the sign code given by the user is correct or incorrect.

3. Results and Discussion

In this section, we will discuss the appearance of the learning media web application which includes the learning mode, practice mode, and question mode pages as well as the test results.

3.1. Learning mode

In learning mode, the system will show the hand sign code that must be followed by the user while mentioning the name of the letter. In this mode, the user practices to be able to demonstrate the letter sign code. When the user has been able to demonstrate the sign code well, the system will provide voice feedback and proceed to the next letter as shown in Fig. 7.

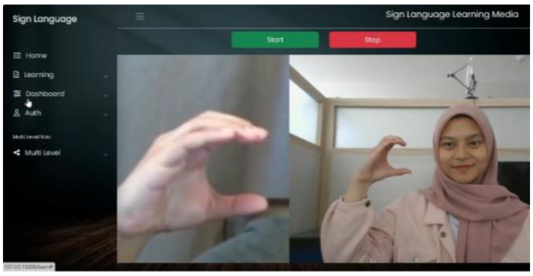


Fig. 7. A user demonstrates letter sign codes in learning mode.

In learning mode, it is tested whether the system can recognize the sign code demonstrated by the user. The test results are shown in Table 2. Tests were carried out on all letters.

Table 2. Learning mode test results on all letters.

Sign language letter symbol	User Hand Code	Recognized	Voice Feedback	Result
A	A	√	√	valid
B	B	√	√	valid
C	C	√	√	valid
D	D	√	√	valid
E	E	√	√	valid
F	F	√	√	valid
G	G	√	√	valid
H	H	√	√	valid
I	I	√	√	valid
J	J	√	√	valid
K	K	√	√	valid
L	L	√	√	valid
M	M	√	√	valid
N	N	√	√	valid
O	O	√	√	valid
P	P	√	√	valid
Q	Q	√	√	valid
R	R	√	√	valid
S	S	√	√	valid
T	T	√	√	valid
U	U	√	√	valid
V	V	√	√	valid
W	W	√	√	valid
X	X	√	√	valid
Y	Y	√	√	valid
Z	Z	√	√	valid

Based on the test results in Table 2, it can be concluded that the percentage of success in this mode is 100%, where this application can already guide users to demonstrate the form of sign language code and recognize the form of sign language code demonstrated by the user. In addition, the application has succeeded in providing feedback in the form of sound to the user either when the condition of the sign language code that is recognized is correct or incorrect.

3.2. Practice mode

The purpose of this test is to test the application in training mode, where the application must be able to recognize the form of sign language code demonstrated by the user. This mode helps users to practice and check whether the sign code they demonstrate is correct or incorrect. The sign code will be captured through the camera, and then the system will provide feedback resembling letter images and sound. The name of the recognized sign language character code becomes feedback in this mode. One of the snapshots of this testing mode is shown in Fig. 8.

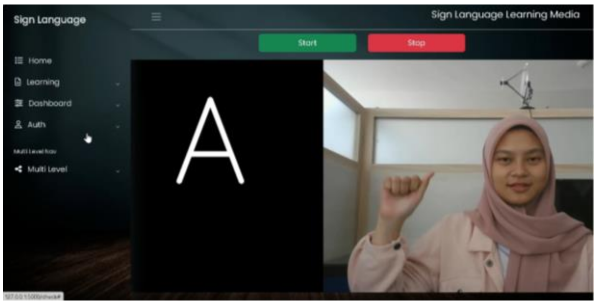


Fig. 8. A user demonstrates letter sign codes in practice mode.

This test was carried out 10 times for each letter code. The results of the tests performed in this mode are shown in Table 3.

Table 3. Practice mode test results on all letters.

No.	User	Detected sign language letter symbol	Voice and image feedback	Success percentage
1	A	A	√	100%
2	B	B	√	100%
3	C	C	√	100%
4	D	D	√	100%
5	E	E	√	100%
6	F	F	√	100%
7	G	G	√	100%
8	H	H	√	100%
9	I	I	√	100%
10	J	J	√	100%
11	K	K	√	100%
12	L	L	√	100%
13	M	M	√	100%
14	N	N	√	100%
15	O	O	√	100%
16	P	P	√	100%
17	Q	Q	√	100%
18	R	R	√	95%
19	S	S	√	100%
20	T	T	√	100%

21	U	U	√	95%
22	V	V	√	100%
23	W	W	√	100%
24	X	X	√	100%
25	Y	Y	√	100%
26	Z	Z	√	100%

Based on the test results in Table 3, it can be concluded that the application can already run following the initial objectives of the study, where the application can immediately recognize the sign language code demonstrated by the user and provide feedback in the form of letter names in the form of images and sounds. However, there are shortcomings in the recognition of the letters R and U, where the percentage of success is 95%. Apart from these two letters, the percentage of success is 100%. The average success percentage of this mode is 99.62%.

3.3. Question mode

The purpose of this test is to test whether the application is able to randomize questions, read questions, recognize user answers, provide correct or incorrect feedback regarding the answers of the user, and provide a total score at the end of this mode The number of questions given in this mode is 10 questions. Each correct question will get 10 points. The test results are shown in Table 4.

Table 4. Question mode test results.

No.	Question	User answer		Sound feedback	Status
		T	F		
1	Demonstrate the letter F	√		Your answer is correct, let's move on to the next question	valid
2	Demonstrate the letter M	√		Your answer is correct, let's move on to the next question	valid
3	Demonstrate the letter I	√		Your answer is correct, let's move on to the next question	valid
4	Demonstrate the letter K		√	Your answer is incorrect, let's move on to the next question	valid
5	Demonstrate the letter B	√		Your answer is correct, let's move on to the next question	valid
6	Demonstrate the letter P		√	Your answer is incorrect, let's move on to the next question	valid
7	Demonstrate the letter Y	√		Your answer is correct, let's move on to the next question	valid
8	Demonstrate the letter S	√		Your answer is correct, let's move on to the next question	valid
9	Demonstrate the letter A	√		Your answer is correct, let's move on to the next question	valid
10	Demonstrate the letter C	√		Your answer is correct, let's move on to the next question Congratulations, your score is 80.	valid

Based on the test results shown in Table 4, it can be explained that this application has successfully randomized and read the questions as seen in the user's question and answer columns. The application can recognize user answers captured through the camera. Besides, this application has provided feedback resembling sound on correct or incorrect answers and the total score achieved by the user. Snapshots of users doing the question mode test are shown in Figs. 9-11.

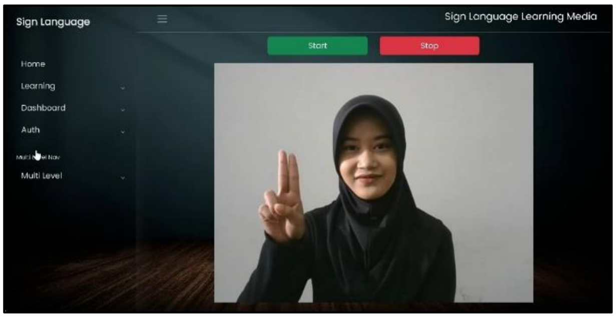


Fig. 9. Snapshot of user 1 doing the question mode test.

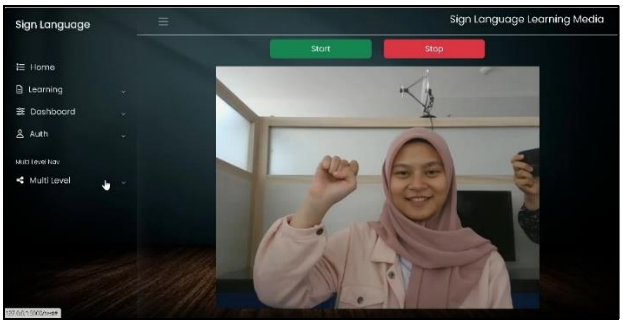


Fig. 10. Snapshot of user 2 doing the question mode test.

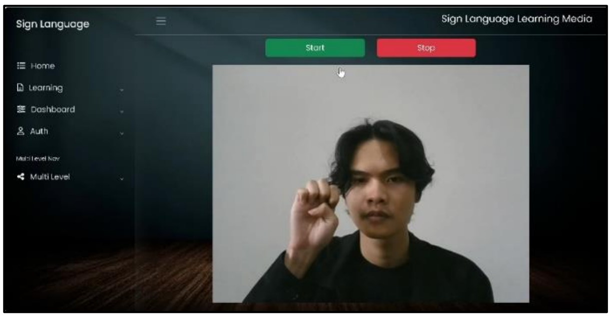


Fig. 11. Snapshot of user 3 doing the question mode test.

The Sign Language Letter Learning Media and the ICT application as a supervisory tool synergize to create an effective instructional delivery approach. The integration of Sign Language Letter Learning Media with ICT tools enhances the supervisory aspect, fostering a more efficient and interactive learning environment for sign language instruction [31].

4. Conclusion

This sign language learning media has been successfully created and runs in accordance with the objectives. Where this application is able to run learning mode with a success percentage of 100%, practice mode of 99.62%, question mode of 100%. For further development, it may be possible to add the number of images that will be used as models.

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