ONLINE LEARNING PLATFORM FOR HEARING IMPAIRED PEOPLE

Project ID: TMP-22-177

Project Proposal Report

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Bachelor of Science (Hons) Degree in Information Technology

Specializing in Data Science

Department of Information Technology

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

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Signature of the supervisor Date

(Dr. Lakmini Abeywardhana)

…… …….

Signature of the Co-supervisor Date

(Mr. Yashas Mallawarachchi)

ABSTRACT

Numerous game based online systems are available in Sri Lanka as well as in the world for kids to help them gain knowledge and learn with entertainment. Nevertheless, less attention is traced on game-based learning systems for hearing impaired children to learn Sri Lanka sign language. The existing systems are only capable of asking questions using an avatar in sign language and detecting the sign language answer given by the student. In such systems, users will not be able to gain an opportunity to know the correctness of the answer and where they got wrong in case of a partially correct answer as in most regular learning platforms. This study attempts to bridge this gap between regular learning platforms and sign language-based learning platforms and the learning platform in is paper, is aimed to provide feedback on the correctness of the answer along the with correct percentage and must be corrected to make learning more effective to the users. The end product is intended to be a game-based web application to teach sign language to hearing impaired children interactively, with the use of a 3D avatar model. At the end of each level, questions will be asked by the avatar and feedback will be given with expressive emotions encouraging the child to correct mistakes.

Keywords: Sri Lankan sign language, online learning platform

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LIST OF ABBREVIATIONS

SLSL	Sri Lankan Sign Language
HIP	Hearing Impaired People
ASL	American Sign Language
UNICEF	United Nations Children's Fund
ISL	Indian Sign Language
BISINDO	Indonesian Sign Language
ArSL	Arabic Sign Language
API	Application Program Interfaces

LIST OF APPENDICES

1. INTRODUCTION

1.1 Overall Background

Refer to [1], it was evidential that 9% of Sri Lankans suffer from some sort of a hearing disorder. Sign Language is the main and official medium of Communication of such hearing-impaired individuals in the world as mentioned in [2]. As per [3], Sign language varies significantly depending on the factors as country, region and nation. Calling attention to the same reference [3], there exist several sign languages with slightly different regional accents even within the countries where one language is spoken. Similarly, several sign languages with minor variations can be found in Sri Lanka, as per the article [4]. Nevertheless, Sri Lankan Sign language (SLSL) can be recognized as an elementary attempt to standardize island wise sign language.

As per the findings of [5] , solid foundation mother tongue helps in improving literacy skills and acquiring academic skills easier than in any other language. Application of this finding to sign language depicts the importance of helping to learn SLSL to Sri Lankan hearing impaired students. Hence although there exist few learning systems for ASL and BSL, developing a learning system to learn SLSL correctly from ground level lays the foundation to improve skills of Sri Lankan hearing impaired students immensely.

1.2 Importance of online learning in education

A vast number of game-based learning systems and applications are available for kids to learn and improve skills in addition to the knowledge gained from school as can be seen in [6]. Nevertheless, learning platforms available to learn sign language are comparatively limited yet equally important. Development of learning platform for SLSL is paid further less attention [7]. The system developed for one sign language cannot be used by the users who are using another sign language similar to the spoken languages as discussed in [7]. Hence developing a separate learning system for SLSL with interactive features is essentially important. The limited number of available learning systems for SLSL lacks interactivity as most systems are only capable of teaching and recognizing the gesture and are not able to provide any feedback on the correctness of the answer as can be seen in papers [7] [8] [9]. Mitigating these barriers, developing a feedback enabled learning system for SLSL would help children with hearing impairments learn sign language interestingly.

1.3 Real-time video capturing methods

Detecting sign language correctly is important in learning platforms based on sign language. Sign language detection can be implemented mainly in two methods

1. Using wearable Armband

2. Using Computer vision

Using wearable armband is a sensor-based approach and Kinect sensor [10] and leap motion controller [11] are being used in implementing sign language detection systems in sensor-based approach. Image processing is used in computer vision-based approach. However, it is proven wearable armband is comparatively costly [12] as well as inconvenient [13]. Hence the computer vision-based image processing approach is comparatively cheaper and hence affordable. Despite the advantages, the computer vision approach is observed to produce relatively weak results in tricky real-world backgrounds [13].

1.4 Component Overview

Considering the above-mentioned factors, developing an interactive online learning system for HIP in SLSL is focused as the end product of the research. Hence, teaching content based SLSL in level-based game for kids with hearing impairments, using a 3D avatar, and evaluating the child with questions at the end of each level is focused on this research component. The evaluation will be conducted by detecting the answer given by the child using the normal camera in the device and comparing the correct answer against the given answer. In case of a partially correct answer, the correct percentage as well as what must be corrected to make the complete answer correct will be provided to the user as feedback through the avatar with expressive emotions. This is expected to encourage the user to learn SLSL with interest and to increase user engagement.

2. LITERATURE REVIEW

2.1 Background study

Pandemic situation raised with Covid 19 outbreak has now become new normal and with numerous challenges to daily routine, pandemic created a positive effect towards online education [14]. According to UNICEF [14], most learning systems gradually got transformed into the online mode. Figure 2.1.1 shows the statistics for implementation of digital and broadcast learning policies by educational level.

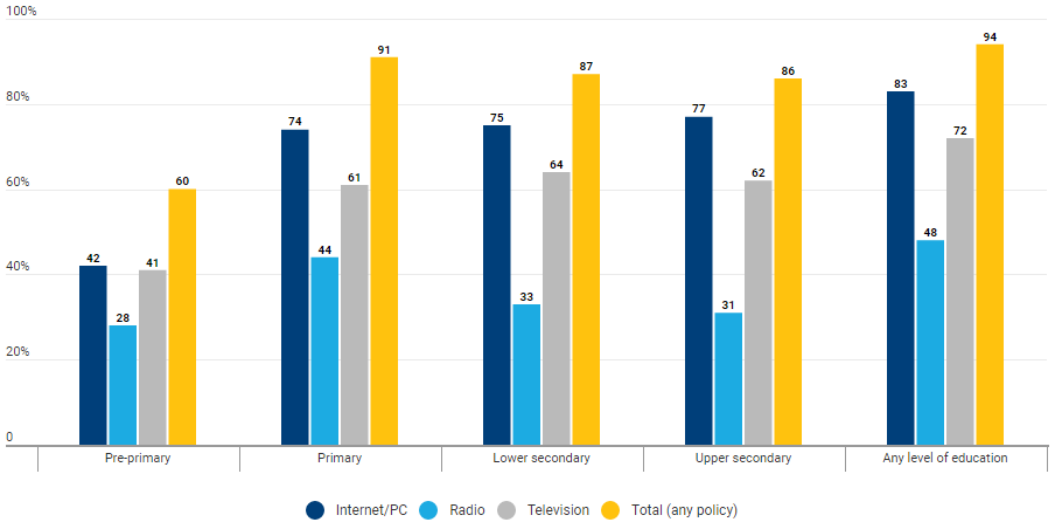

Figure 2.1 digital and broadcast remote learning policies

Sources: UNESCO-UNICEF-World Bank Survey on National Education Responses to COVID-19 School Closures (2020) and UNICEF country offices (2020).

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As per the above statistics, it is evidential the development of online learning system would not be waste of effort and same applies for the sign language. The uncertainty of continuous need for online platforms in future can be answered with the survey conducted by the research statistics conducted by [15] .

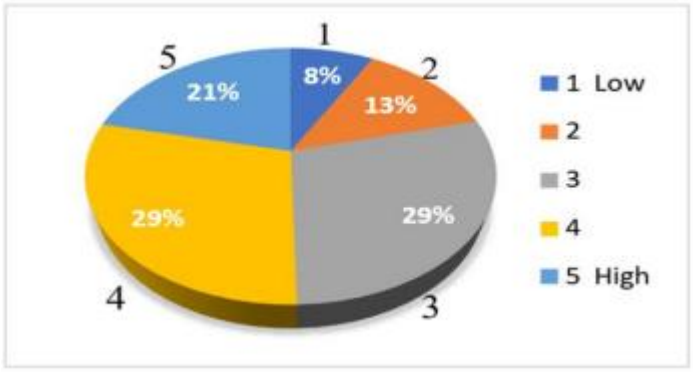

Figure 2.2 Student's preference for online learning in the future

As per the above survey results [15], students prefer proceeding with online learning for future studies and hence the commercial value for the e-learning system would not be degraded in future and would continue to provide benefits for Sri Lankan hearing impaired students.

In line with the research results of [4], the game-based learning approach is more efficient in terms of motivation to learn compared to traditional learning mechanisms. Nevertheless, comparatively less focus is subjected to making learning interesting through game-based approach for Sri Lankan sign language. Despite the fact the language is being taught to the students in physical and online environments, less attention is drawn to game-based learning system for Sri Lankan sign language.

Interactivity is a key feature in game-based learning systems. Interactivity is found to boost the interest of the students in learning as per the study of [16]. Hence, encouraging user interaction in online learning system for Sri Lankan sign language is essentially important to uplift the learning interest of hearing-impaired children. System being able to detect if the answer is correct or wrong as well as providing the feedback on the answer if the answer is given by the user is incorrect or partially correct would assist the user interactions in learning Sri Lankan sign language specially since most words in SLSL has multiple gestures to interpret a single word as can be found in [4]. This fact can be further clarified with the figures extracted from the source [17]

Figure 2.3 sign language representation 1

Figure 2.4 sign language representation 2

2.2 Literature Survey

Learning platform for hearing impaired kindergarten kids has been developed previously for Indonesian sign language with augmented reality in the research [9]. However, this application media was available only in offline mode and hence large RAM capacity and processor speed was required for fast video access. Mitigating this downside, an interactive online learning media for hearing impaired kindergarten children has been developed for Indonesian sign language [18]. Despite the speed access to the resources without requiring higher RAM capacity, this platform has only used flashcards for the teaching component, hence real-time user interaction is observed to be limited.

Static sign language detection mechanism has been implemented for SLSL based on conversational signs in an application called “Wadhan” [19]. In another work [8]Sign

language is recognized with template matching technique. In this study gestures are captured by the camera as images and are subjected to feature extraction with analysis, background removal and image smoothing. Then the image is compared against the dataset and respective sign alphabet symbol is displayed as the final result. Since the work is image based, interactivity in the system is observed to be limited.

Augmented reality-based system for Arabic sign language focusing on literacy development of hard hearing children is proposed at the conference [20], anyhow the research is still marked as ongoing, hence real implementation of the proposed system is not found to be available online.

According to J.R. Liddell [21], sign language can be described as a combination of three components.

1. Shape of hand
2. Position of hand
3. Movement of hand

Therefore, analysis of the above three components must be conducted in order to provide accurate feedback to the user. Considering these three factors to provide feedback, an interactive system to teach Irish sign language has been developed according to the research paper [22], Signs are demonstrated to the user using a virtual teacher and real-time feedback on the sign is given to the user evaluating user performance using colored gloves. The system is available as a software.

In [23], an online learning platform for HIP in ASL is developed. The teaching component in this platform is based on uploaded videos for teaching, and the platform can capture low light videos and enhance them using low light enhancement strategies. This enhancement is approached by converting the video to grey scale from RGB. Background removal and feature extraction methodologies have been followed in order to achieve the best results in capturing. The system is objected to teach basics of ASL such as ASL alphabet. Upon completion of each lesson, the user is asked to repeat the lesson as displayed in the tutorial and depending on the correctness of the answer, the user will be asked to repeat the task or will be given a new task. However, the user will not be given any feedback on the fault part in the answer in this approach.

3. RESEARCH GAP

As per the above literature survey, it can be observed that most learning platforms developed for sign language are not based on SLSL. Although comprehensive research studies have been conducted in research [10] [18] [20] [23] , they were not based on SLSL. As discussed in the background study sign languages are different from one language to another like spoken languages. Hence SLSL is different from ASL, ISL, ArSL, BISINDO and other sign languages and there exists a gap in implementing the advanced features in learning platforms for SLSL.

Although the application "Wadhan" in the research [19] is based on SLSL, the system is limited to static sign language detection based on images. Since interactivity is a key feature in teaching sign language as discussed above, implementation of dynamic capturing is important.

In the study [23], online learning system with dynamic capturing through visual computing is implemented. However, this application has been developed for ASL and although there exists a teaching component, knowledge evaluation to check if the user has learnt properly is not implemented in this system.

In the work of [22] , feedback enabled learning system is implemented for Irish Sign language as discussed in the literature review. Anyhow, the system requires additional colored gloves to be worn in order to detect the symbol. Further, it is not capable of providing feedback on the answer and is only capable of detecting if the answer is correct or wrong. In case of partially correct answer, user will not be educated on where they got wrong and what part of their answer is correct or wrong. Hence correcting the mistake from the user's side is tedious.

All the above systems do not implement an avatar with expressive emotions. Since the teaching component is mainly based on primary sign language teaching for hearing impaired kids, the expressions given by the avatar would encourage the child for learning and would make the learning interesting.

Table 3.1 Difference between existing studies and the proposed system

Feature / Research	Based on SLSL	dynamic detection of sign language enabled	Detect if the answer given is correct	Provides feedback on the answer	Available online	Exists an avatar with expressive emotions
Research A [7]	✓	✓	✗	✗	✓	✗
Research A [18]	✗	✓	✗	✗	✓	✗
Research B [19]	✓	✗	✗	✗	✓	✗
Research C [22]	✗	✓	✓	✗	✗	✗
Research D [23]	✗	✓	✗	✗	✓	✗
Proposed system	✓	✓	✓	✓	✓	✓

4. RESEARCH PROBLEM

Plenty of online resources including learning platforms are available for kids to learn spoken languages. However, availability of online resources for sign language, specifically SLSL, is limited as discussed above. Correcting mistakes is a key area in learning [24]. Unfortunately, out of the limited number of available learning platforms for SLSL, none provides the user with the opportunity of knowing the mistakes in their answers in sign language as justified in the literature survey. Further, it is possible to have partially correct answers in SLSL as it requires a series of gestures to represent one word as explained. Hence in case of the answer being partially correct, the user should be able to know what part of their answer is correct, where they got wrong and what to improve. Considering these factors, developing feedback enabled learning system for SLSL starting from basic signs for hearing impaired children is crucial. The survey results as per the survey conducted by the research team confirm this request, as can be seen in figure 4.1.

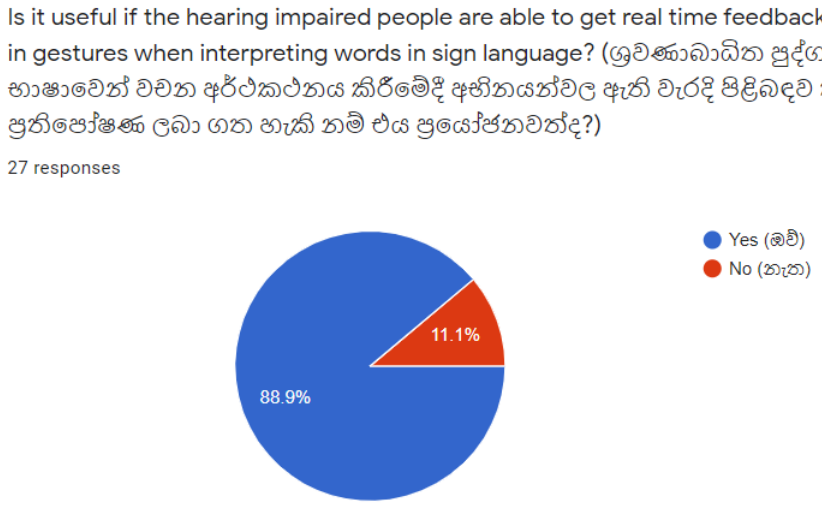

Figure 4.1 Response-real-time feedback on mistakes

As per the above survey results, more than 89% have stated that it is useful if the hearing-impaired people are able to receive real time feedback on their mistakes in the gestures when interpreting words in sign language. Hence this requirement will be addressed through the research.

In line with the survey results, it is evidential that most hearing-impaired people expect to state what percentage of their answer is correct or wrong along with the mistake they have done and the correct answer, since more than 77% of the responses have voted for that option. This can be seen in the figure below

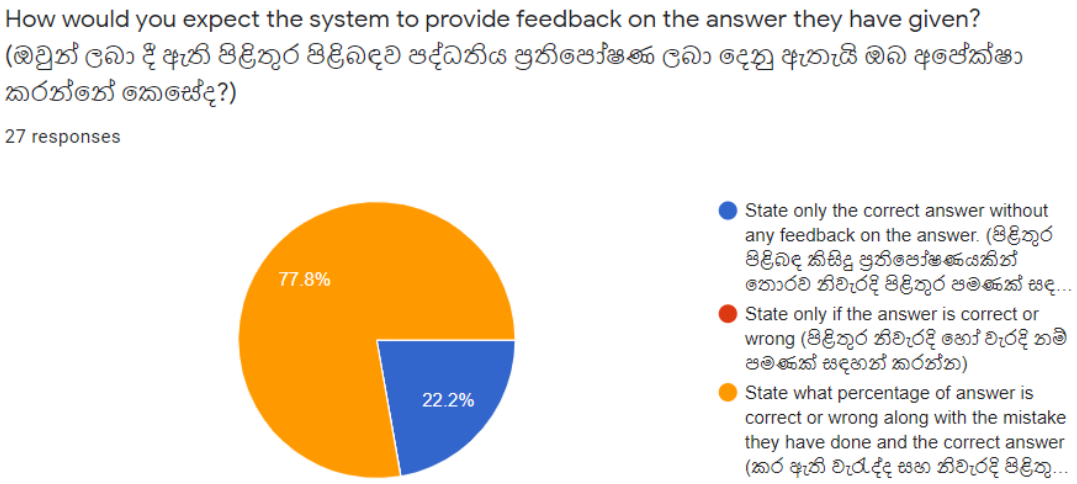

Figure 4.2 Response-feedback on the answer

Moreover, it is difficult for the teacher to pay individual attention to each student in the physical classroom. Feedback enabled learning systems bring individual attention to each child and hence provide a guaranteed quality education. However, Children learning SLSL lacks this opportunity as learning systems with proper feedback is not available for SLSL.

5. OBJECTIVES

5.1 Main Objective

The main objective of the research is to develop an interactive learning platform to help learning SLSL for hearing impaired children and to guide learning ASL for users who already know SLSL in Sri Lanka. The system is expected to provide additional learning recommendations that will be provided to outside videos by converting them into SLSL as well as to clear user doubts with an interactive Chabot.

5.2 Specific Objective

The objective of teaching research component is to provide a game-based teaching component with evaluations at each level to check if the user has grabbed the content as expected.

The sub objectives below will be accomplished in achieving the specified objective.

- **To clearly Teach sign language using Avatar with expressive emotions**

  One objective is to teach SLSL to the child with hearing impairments in an interesting way as a level-based game, using the avatar with expressive emotions.

- **To identify sign language Answer to the question**

  The level-based game will be followed by a quiz where at the end of each level knowledge evaluation is conducted. One of the objectives is to detect the answer given by the user/ child with a higher accuracy in order to provide effective feedback on the answer. Attached to this objective, the system is also intended to encourage child/user to provide completely correct answers by avatar with expressive emotions.

- **To provide Feedback on the answer**

  One of the important objectives is to compare the answer given by the user/child with the actual answer and provide feedback on what percentage of their answer is correct and what must be improved in order to make the answer completely correct. This would guarantee quality education to the Hearing-impaired kids in Sri Lanka since the child would be able to identify their mistakes.

6. METHODOLOGY

This component is objected to help HIP (specifically hearing-impaired children) in learning SLSL. As discussed above this will be achieved as a level base game where customized evaluation will be carried at the end of each level. The teaching can be done by the designed avatar using the content available in the database as the syllabus. The tedious task here is to provide feedback on the performance of the child against the questions being asked by the avatar at the end of each level in the game. Each answer given should be compared with the available answer in the database and the correct percentage will be displayed. In case of a partially correct answer, the mismatched section should be conveyed to the user, using the avatar.

6.1 System Architecture Diagram

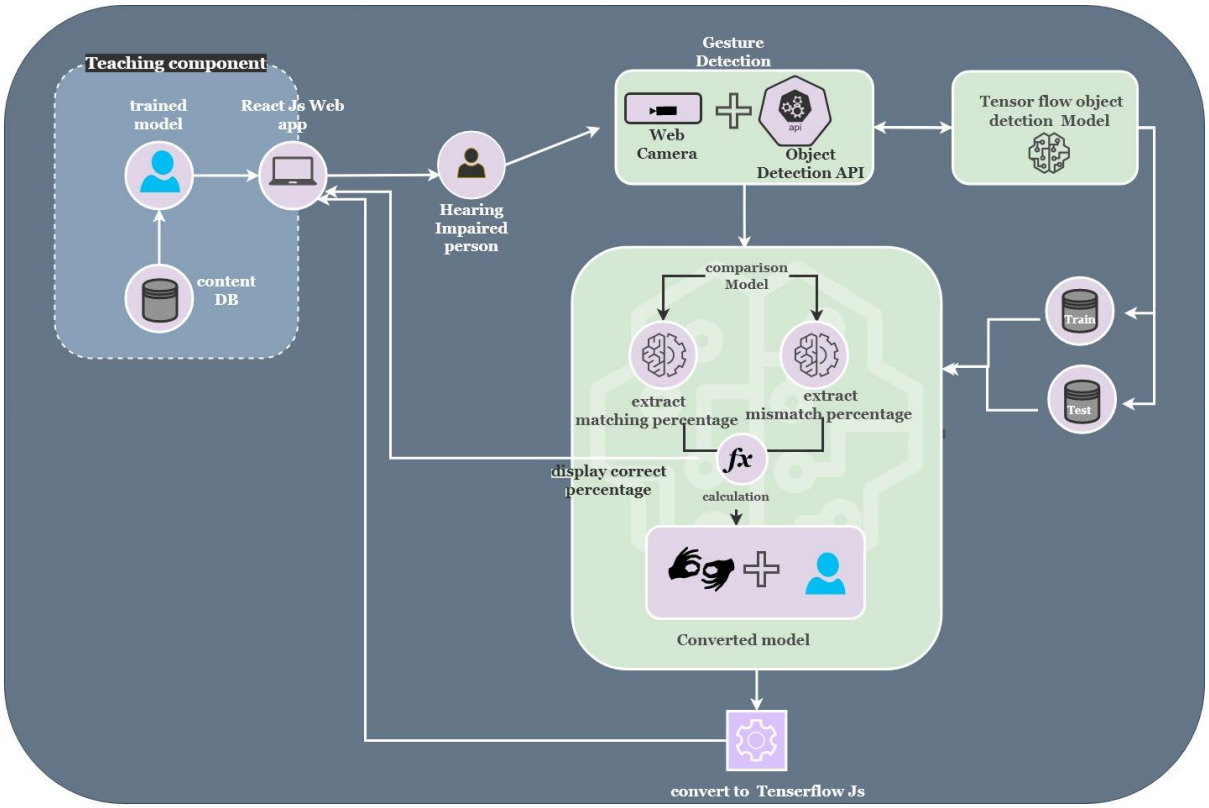

Figure 6.1 architecture diagram

6.2 Software Solution

Below phases would be followed in designing the software solution. Software development phases would help to achieve the goal of completing the product within the given period since it follows a step-by-step approach as can be seen in figure 6.2

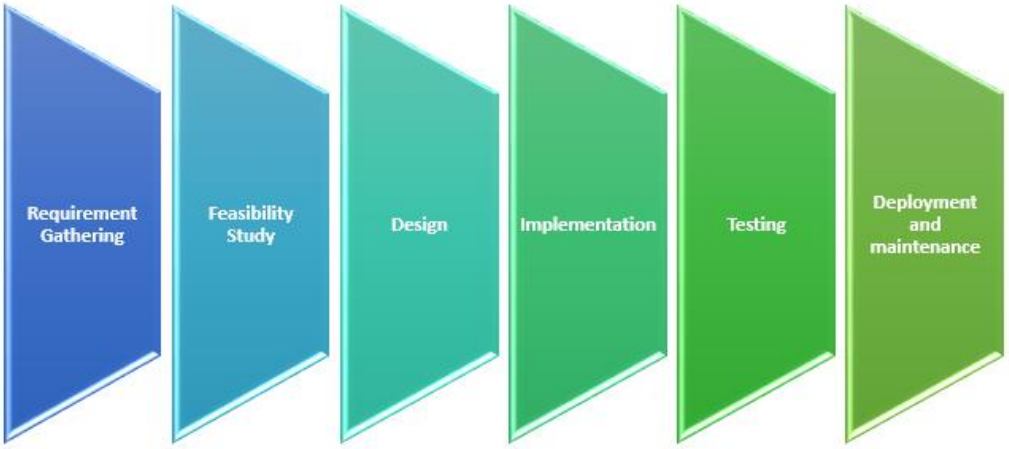

Figure 6.2 software solution

6.2.1 Requirement Gathering

This phase is focused to gather requirements from the users. The main mechanism is to gather the real requirements of hearing-impaired children. This is achieved by conducting a survey on set of hearing-impaired children in Sri Lanka. Further, the requirements pointed out by the previous research have been considered.

6.2.2 Feasibility Study

6.2.2.1 Schedule Feasibility

The solution should be completed within the given period with a quality and credible output. For this requirement, several plan charts including Gantt chart and work breakdown structure in order to ensure the smooth progress of work.

6.2.2.2 Technical Feasibility

The final product should be compatible with existing software and hardware that is available on an end user's device. Since the end user would be a hearing-impaired child or a person, the system would not be technically feasible if the system requires additional devices such as sensors and adapters.

Hence out of two main Sign language detection methods as discussed in the background study,

1. Using wearable Armband

2. Using Computer vision

The second approach mentioned in the introduction (computer vision approach) will be used since any additional sensors and adapters are not required in this approach.

Further, the end product would be a web application and therefore the dependencies issues in regular software installments would not occur. Only a web cam would be required as an additional device.

6.2.2.3 Economic Feasibility

Since minimum physical resources are involved, the end product would be available at a minimum cost and hence would be affordable for any user.

6.2.3 Design and Implementation

6.2.3.1 Generation of SLSL input for teaching

The sign language content will be stored in the database and 3D avatar model will be designed using the online tool called "Maya". 3D model will be developed with an attractive child face for this component and necessary orientation and viewpoint will be designed. Then the facial expressions will be embedded to the design. Model will be trained using a frame sequence to determine the movements using the content available in the database. A single will be involved with several gestures as discussed in the introduction and hence a file with "motion list" will be used to represent single gesture.

A detained version of the teaching component of the architecture diagram in figure 6.1 is given below figure 6.3

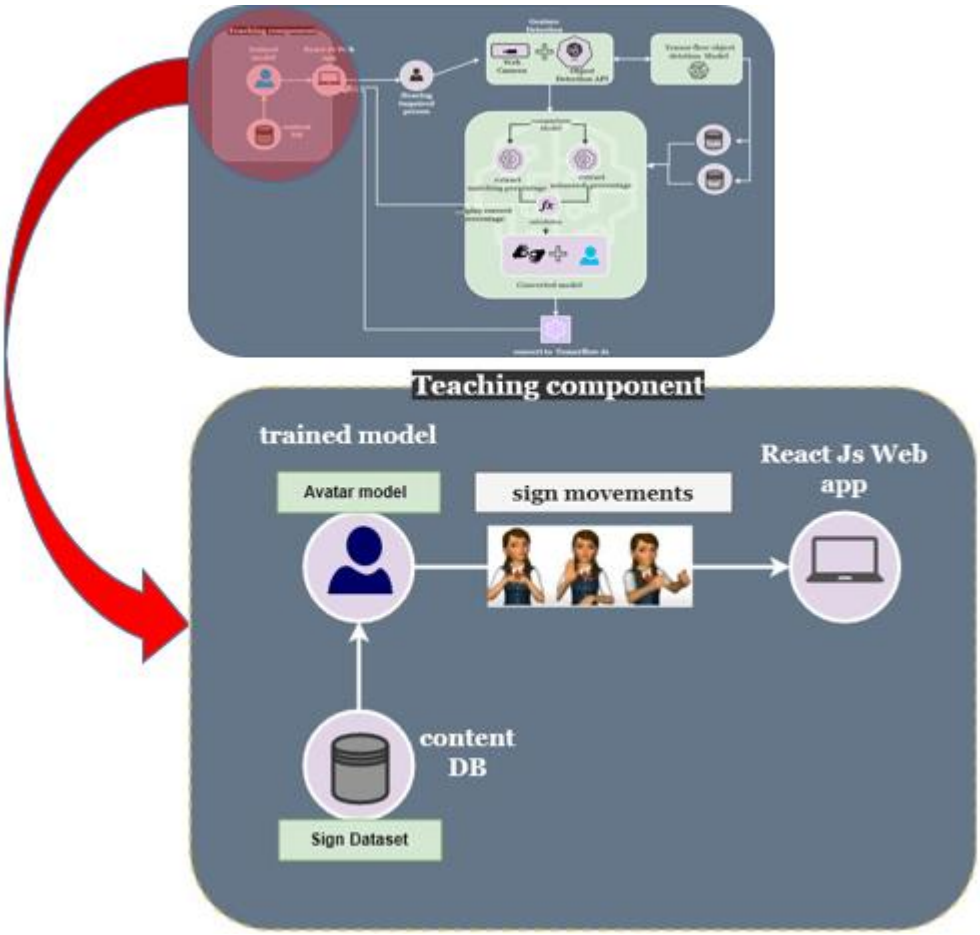

Figure 6.3 teaching component

6.2.3.2 Sign language answer detection

The sign language answer given by the child will be detected using TensorFlow object detection API and the read feed will be then converted to RGB color format to support processing in the tensor flow object detection model. Then it will be converted to original formal BGR and face, left hand, right hand, shoulder, elbow, nose, inner eye, outer eye, and other landmarks will be identified using media pipe.

A detailed version of object detection in the architecture diagram in figure 6.1 is displayed in the below figure 6.4

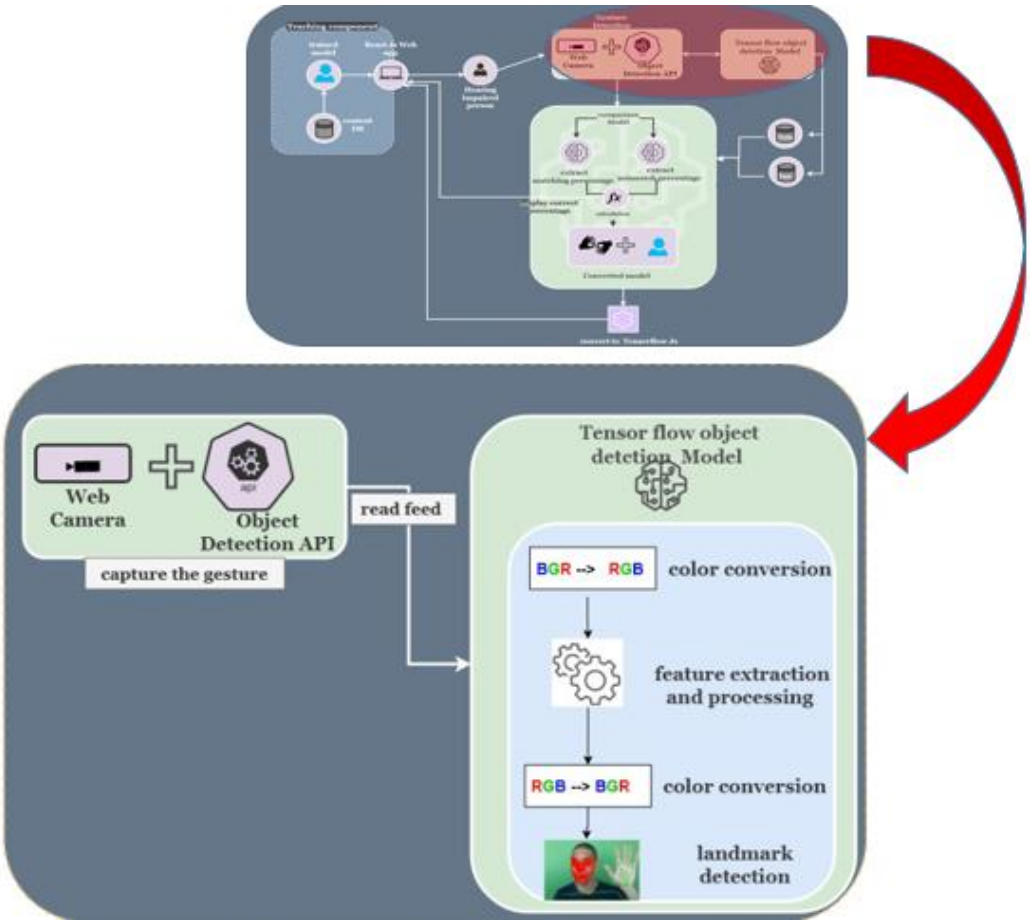

Figure 6.4 object detection

6.2.3.3 Feedback generation

The detected answer will be passed to the comparison model where the given answer will be compared against the correct answer and the correct percentage will be directly displayed. Then, what must be corrected will be displayed using the avatar model.

A detailed version of comparison model in the architecture diagram in figure 6.1 is given below figure 6.5

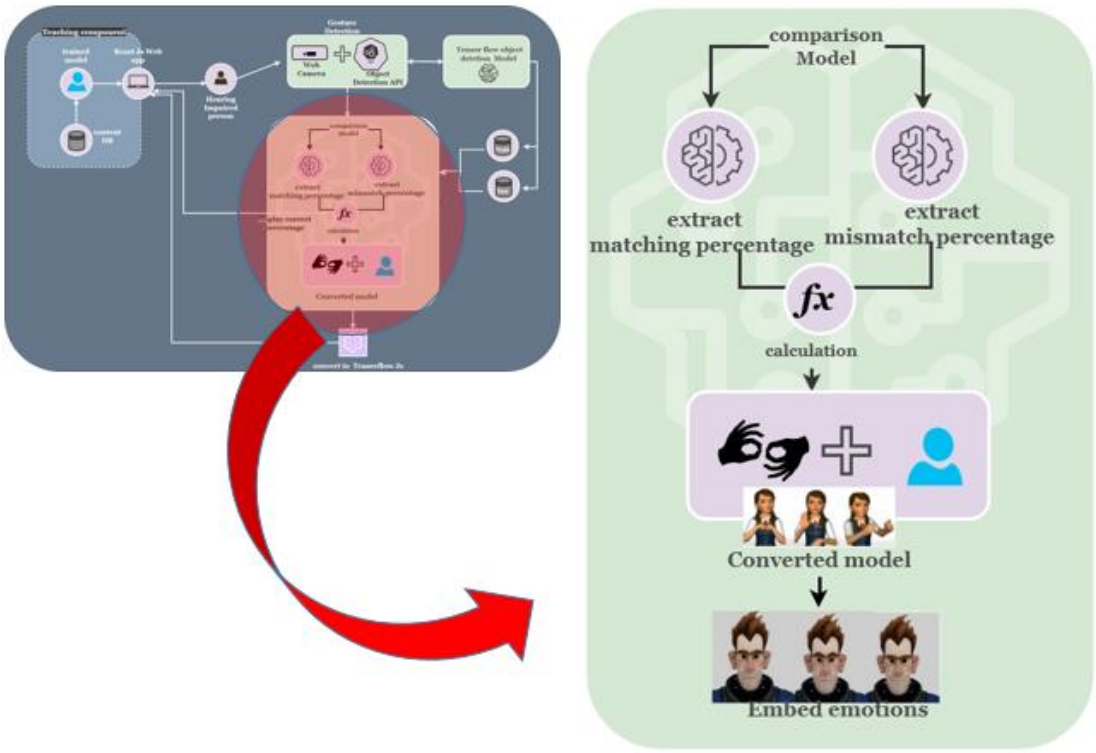

Figure 6.5 feedback

6.2.3.4 Final Output

The final output is a game-based system with an avatar model capable of teaching sign language starting from basic level. The game will be in levels and at the end of each level in the game, a quiz will be carried to evaluate the user. Then the answer given by the child/user will be captured and necessary feedback will be given using the avatar with expressive emotions.

6.2.3.5 Tools and Technologies

Technology stack:

- For Object detection -Tensor flow
- For Video processing -OpenCV
- For Version controlling-GIT
- Frontend-ReactJs

Programming Languages:

- Python –libraries: NumPy, sklearn, matplotlib

Tools:

- Google Colab
- Cuda Toolkit
- Media pipe

6.2.4 Testing

- **Unit Testing:** Teaching section, gesture detection section and feedback generation section will be tested separately

- **Component Testing:** All three sections will be combined and will be tested for errors

- **Integration Testing:** The teaching and monitoring component will be integrated with the system and error will be examined and fixed

- **System Testing:** Overall system will be checked to confirm it reform with expected results

- **Acceptance Testing:** The system will be checked by the end users/HIP to check if the performance is as intended.

6.2.5 Deployment and Maintenance

Upon successful completion of testing, the system will be deployed to the AWS could platform for better availability of the application. Once the system is successfully deployed it will be maintained for any updates and to fix issues by the team for smooth progress of end users.

6.3 Work Breakdown Structure

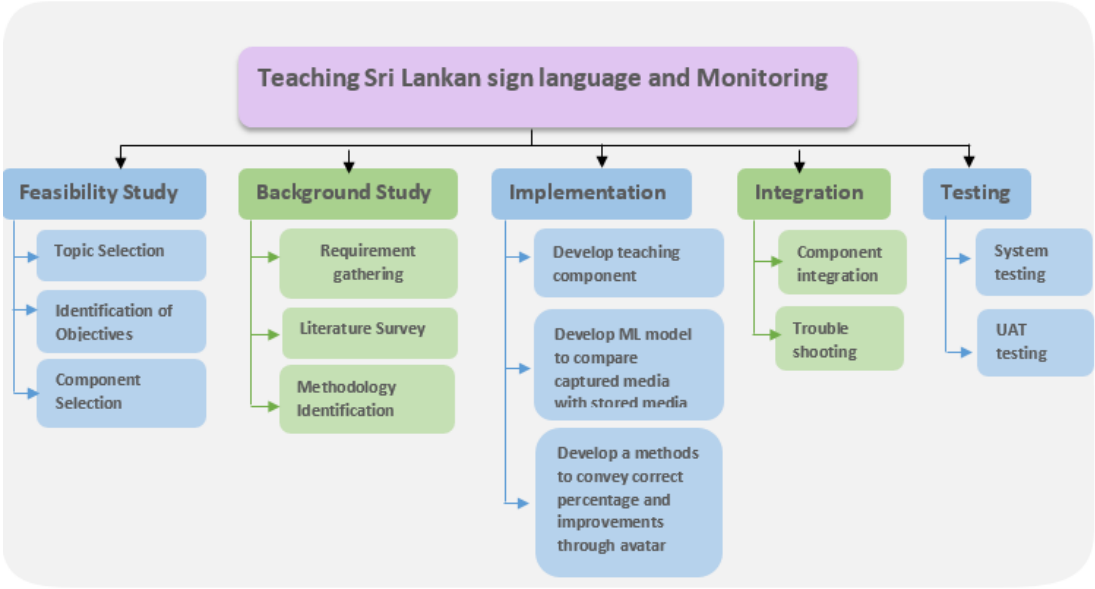

Figure 6.6 work breakdown structure

7. PROJECT REQUIREMENTS

7.1 Functional Requirements

- Teaching SLSL using the avatar
- Detect the answer using the webcam
- Display the correct percentage, fault part in the answer and correct answer in SLSL

7.2 Non-Functional Requirements

- User friendly interface
- Avatar with expressive emotions to encourage answering
- Fast loading of the web page and sign language display(teaching) without any lag
- Fast detection of answer detection and feedback generation

7.3 User Requirements

- Users should have moderate computer literacy

7.4 Technical Requirements

- User devices should have a web camera

8. GANTT CHART

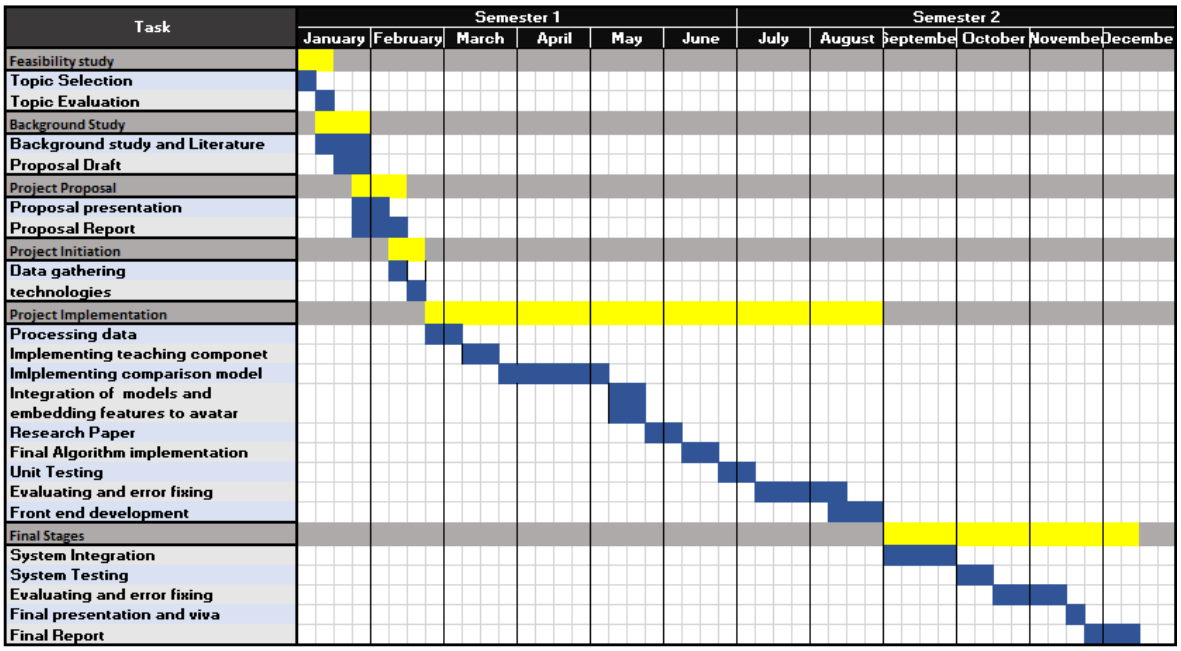

Figure 8.8.1 Gantt chart

9. COMMERTIALIZATION

Online learning platforms for kids are popular around the world for its ability to make learning interesting. Few such popular game-based learning systems are Encarta kids, PBS kids and national geography kids. Despite the high demand, minimal attention is drawn towards game-based learning systems for SLSL. Hence our system will be on demand. And Avatar with expressive emotions would grab the child's attention.

Despite the fact that the child might learn sign language at school, the teacher might not be able to pay attention to the child individually. Therefore, there might be some doubts or misunderstandings in learning. Since our approach monitors each child individually and provides customized feedback, this will be a particularly useful platform in learning SLSL and adding a comprehensive commercial value.

Further, System will be promoted through welfare organizations as feedback enabled learning system is still not available. Despite the unavailability, the system will be useful in learning SLSL from the beginning.

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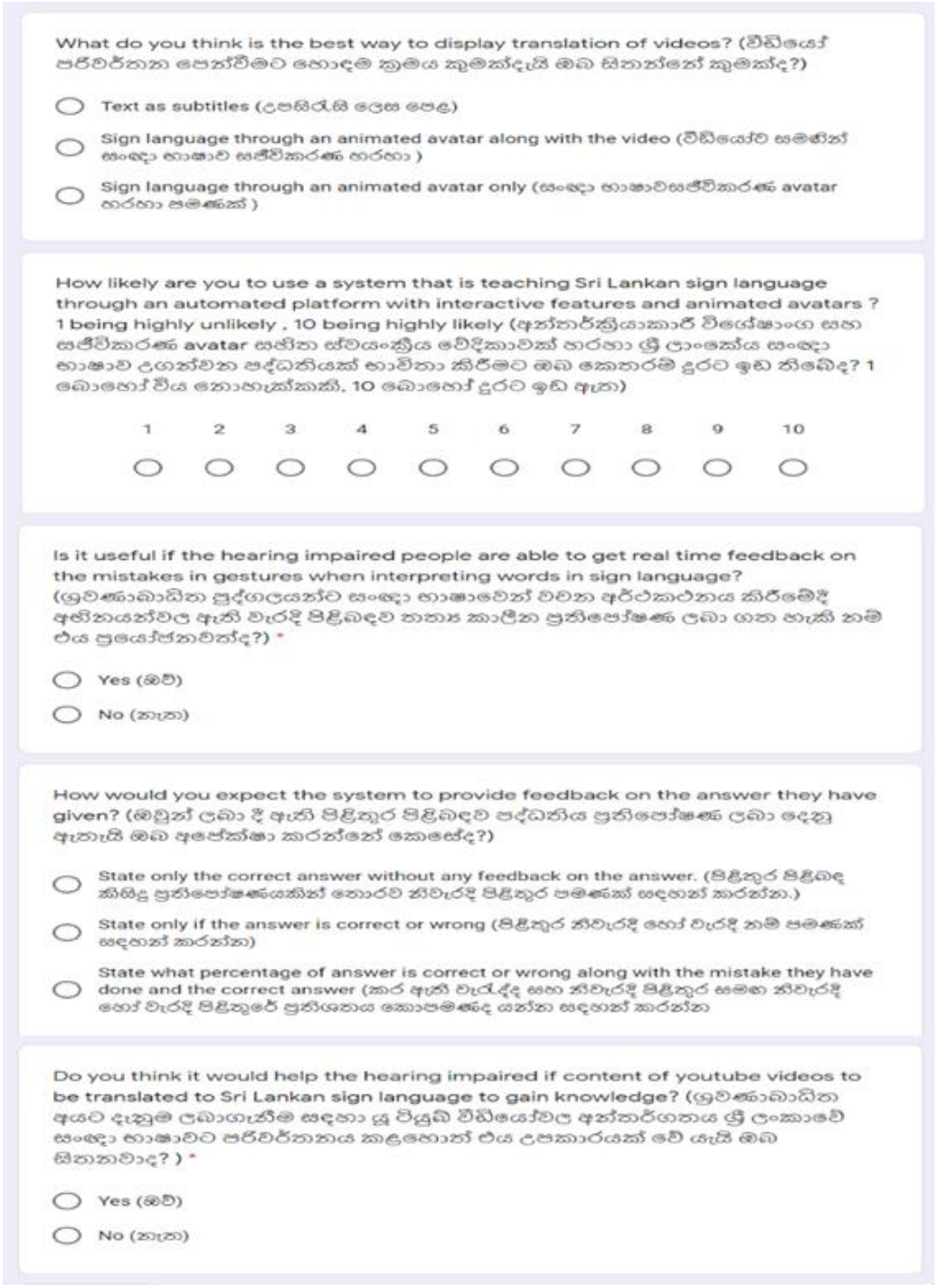
LIST OF APPENDICES

Appendix A : Survey Questions



What do you think is the best way to display translation of videos? (වීඩියෝ පරිවර්තනය පෙන්වීමට හොඳම ක්‍රමය කුමක්දැයි ඔබ සිතන්නේ කුමක්ද?)

- ◯ Text as subtitles (උපසිරැසි ලෙස පෙළ)
- ◯ Sign language through an animated avatar along with the video (වීඩියෝව සමඟින් සංඥා භාෂාව සජීවීකරණ හරහා)
- ◯ Sign language through an animated avatar only (සංඥා භාෂාවසජීවීකරණ avatar හරහා පමණක්)

How likely are you to use a system that is teaching Sri Lankan sign language through an automated platform with interactive features and animated avatars ? 1 being highly unlikely , 10 being highly likely (අන්තර්ක්‍රියාකාරී විශේෂාංග සහ සජීවීකරණ avatar සහිත ස්වයංක්‍රීය වේදිකාවක් හරහා ශ්‍රී ලාංකේය සංඥා භාෂාව උගන්වන පද්ධතියක් භාවිතා කිරීමට ඔබ කෙතරම් දුරට ඉඩ තිබේද? 1 බොහෝ විය නොහැක්කක්, 10 බොහෝ දුරට ඉඩ ඇත)

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Is it useful if the hearing impaired people are able to get real time feedback on the mistakes in gestures when interpreting words in sign language? (ශ්‍රවණාබාධිත පුද්ගලයන්ට සංඥා භාෂාවෙන් වචන අර්ථකථනය කිරීමේදී අඟතැන්වල ඇති වැරදි පිළිබඳව තත්‍ය කාලීන ප්‍රතිපෝෂණ ලබා ගත හැකි නම් එය ප්‍රයෝජනවත්ද?) *

- ◯ Yes (ඔව්)
- ◯ No (නැත)

How would you expect the system to provide feedback on the answer they have given? (ඔවුන් ලබා දී ඇති පිළිතුර පිළිබඳව පද්ධතිය ප්‍රතිපෝෂණ ලබා දෙනු ඇතැයි ඔබ අපේක්ෂා කරන්නේ කෙසේද?)

- ◯ State only the correct answer without any feedback on the answer. (පිළිතුර පිළිබඳ කිසිදු ප්‍රතිපෝෂණයකින් තොරව නිවැරදි පිළිතුර පමණක් සඳහන් කරන්න.)
- ◯ State only if the answer is correct or wrong (පිළිතුර නිවැරදි හෝ වැරදි නම් පමණක් සඳහන් කරන්න)
- ◯ State what percentage of answer is correct or wrong along with the mistake they have done and the correct answer (කර ඇති වැරැද්ද සහ නිවැරදි පිළිතුර සමඟ නිවැරදි හෝ වැරදි පිළිතුරේ ප්‍රතිශතය කොපමණද යන්න සඳහන් කරන්න

Do you think it would help the hearing impaired if content of youtube videos to be translated to Sri Lankan sign language to gain knowledge? (ශ්‍රවණාබාධිත අයට දැනුම ලබාගැනීම සඳහා යූ ට්‍යුබ් වීඩියෝවල අන්තර්ගතය ශ්‍රී ලංකාවේ සංඥා භාෂාවට පරිවර්තනය කළහොත් එය උපකාරයක් වේ යැයි ඔබ සිතනවාද?) *

- ◯ Yes (ඔව්)
- ◯ No (නැත)