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Mobile Learning for Manually Coded Malay Sign Language Using Augmented Reality

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Abstract: lagging in education as compared to their hearing peers. This can affect their communication skills and affect their academic achievement. However, the existing applications developed for sign language education have a few drawbacks, such as only consisting of a Learning Module, and the media used was only learning videos. Hence, the Mobile Learning for Manually Coded Malay Sign Language using Augmented Reality (KTBM AR) is developed to provide users with Learning and Activity Modules where users can interact with and test their knowledge. Not only that, but KTBM AR also included Augmented Reality (AR) as an interactive learning medium to engage users more in learning. The methodology used in developing this application is the ADDIE model, which comprises five main phases: analysis, design, development, implementation, and evaluation. The result from testing shows that the application was successfully developed with a range of 94% acceptable according to the System Usability Scale (SUS). Thus, it can be concluded that KTBM AR is suitable to be implemented in sign language learning.

Keywords: Manually coded malay, mobile learning, Augmented Reality, ADDIE model, System Usability Scale (SUS)

1. Introduction

To be successful in functioning in today's society, reading is the most important skill to be acquired, and it is a skill that is very much taken for granted by hearing people [1]. Unfortunately, deaf students do not have that ability. Hence, it is hard for them to acquire those skills. As a result, their reading achievement was significantly behind their hearing peers [2]. Currently, to assist deaf students in class, a sign interpreter is used. Deaf students depend on a sign interpreter to facilitate communication and provide access to the auditory features of the school environment. This dependency on sign interpreters makes the deaf students constantly need the sign interpreter to help them in various situations [3]. Unfortunately, during this pandemic time, students are required to learn through Online Distance Learning (ODL) at home, where no sign interpreter is available. Hence, making it difficult and frustrating for them to follow and participate in the online class.

Even though there were plenty of sign language applications available in the app store, there are a few shortcomings. One of the shortcomings is that the available Manually Coded Malay application does not have the augmented reality (AR) features [4]. It only consists of sign language videos that lack interactivity for the user to interact with. Other than that, most of the applications use American Sign Language (ASL) as the chosen language [5]. However, the only form of sign language recognized by the Ministry of Education in Malaysia is Manually Coded Malay as the formal language of communication for the purpose of teaching and learning process in school. Next, the

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available application only provides Learning Module without any Activity Module [6]. Thus, users are unable to do any interactivity activities to test their capabilities in signing and reading.

Hence, KTBM AR is developed as an alternative learning aid for deaf children. A few objectives lead to the development of the KTBM AR application. The first objective is to design an Augmented Reality application that displays 3D sign language animation on an image target. This application provides users with an Augmented Reality application that can scan the specially designed flashcards that serve as the image target and prompt out 3D sign language animation on the screen. Next, to develop a mobile learning application for Manually Coded Malay Sign Language in an Augmented Reality environment. KTBM AR is developed using Unity plugged-in with Vuforia Engine as the platform for the Augmented Reality development. Lastly, to test the application's functionality on the deaf students aged seven. This mobile learning application is tested on 10 selected deaf students aged seven to measure this application's System Usability Scale (SUS). The application consists of two module name modules: The Learning Module, which has Augmented Reality features, and the Activity Module, which consists of three different activities for users. Each m module was developed by referring to the Modul Pengajaran (Masalah Pendengaran) Bahasa Malaysia Tahun 1 o deliver an interactive learning experience for students.

This proceeding paper consists of five sections that cover the project development. Section 1 describes the background of the project, such as the problem statement that led to the development of this project, the objectives achieved, and project scopes. Next, Section 2 covers a systematic analysis of scholarly articles and other sources related to the project topic such as the technology used and a comparison between equivalent applications that have been developed. While Section 3 discusses the phases of application development using the ADDIE Model. Furthermore, Section 4 describes the discussion results of the project through functional testing and user acceptance test. Finally, Section 5 discusses the final result of the developed application.

2. Literature Review

Before developing an application or system, the problems and difficulties faced by users are identified. The comparison of equivalent applications is also conducted and analyzed. It is important to identify the shortcomings of the equivalent application before starting to develop our own application so that improvements can be made. Table 1 shows the comparative analysis of the existing applications.

Table 1 - Comparative analysis between existing applications

Application	Description
 KoTBaM [4]	• This application includes several basic syllabi of Manually Coded Malay such as alphabet, numbers, colors, animals, and date. • Each sign language is shown through learning videos by the sign interpreter. • This application is available on Google Play and developed for Android version 4.0 and above
 StorySign [5]	• This application is available on Google Play and Huawei's own AppGallery. • It uses marker-based AR to detect children's storybooks and then translates the words into sign language through an avatar. • The sign languages supported by this app are British, French, Spanish, Portuguese, Belgian Flemish, Swiss German, Italian and Irish.
 Hand Talk [7]	• This application can automatically translate a spoken language in text and audio into sign language, such as Asl to Portuguese to Libras. • It uses an avatar called Hugo, an AI-powered character as the sign interpreter • Hand Talk is free and available for smartphones and tablets on Android and iOS. • It is suitable for three basic sources which are audio, text and images that users want to translate into sign languages.

KTBM AR	• KTBM AR is the developed application which uses Manually Coded Malay as the chosen language. • It consists of two modules which are Learning Module and Activity Module. • In Learning Module, user can scan the flash card provided to display the 3D sign language animation. • Activity Module consist of three activities such as spelling, sentence structure and quiz. 1. This application is available on Google Play for Android users.

3. Methodology

The methodology used in developing this application is the ADDIE model. ADDIE model is an iterative process used by instructional designers and training creators as a guiding framework for developing educational products and other learning resources [8]. It consists of five stages which are analysis, design, development, implementation, and evaluation that represent a dynamic and flexible standard for developing efficient training and performance support tools. It is the most commonly implemented model for instructional design because of its positive impact on multimedia teaching [9]. Figure 1 shows the ADDIE model.

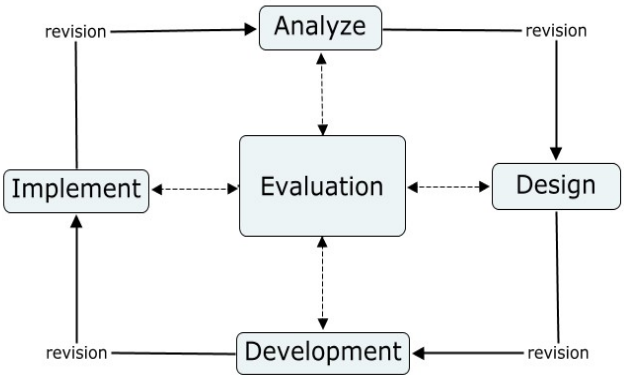


Fig. 1 - ADDIE Model [10]

3.1 Analysis Phase

In this initial phase, the main problem in the physic of the learning process was analyzed. The analysis was conducted through a discussion with the Subject Matter Expert (SME) which is Dr. Ruzimi Mohamed from Universiti Teknologi Malaysia (UTM). In addition, internet resources such as journal articles and *Modul Pengajaran (Masalah Pendengaran) Bahasa Malaysia Tahun 1* are used as references. During this stage, the related requirements are also determined such as the target users, the platform used, and software and hardware requirements. Next, the objectives of the whole project were decided.

Besides, the analysis of functional and non-functional requirements is conducted during this stage. This analysis is needed to identify the requirements needed to develop the application. Functional requirements are what an application is capable of doing while non-functional requirements can be defined as how the system shall do something [11]. Table 2 shows the Functional Requirement Analysis of the developed application that explains the functionality of each module and interface while Table 3 shows the Non-functional Requirement Analysis that describes the important characteristics implemented on the application to deliver an application that is functioning well and meets the user's needs.

Table 2 - Functional requirement analysis

Functional requirement	Description
Learning Module	● This system works by allowing users to scan the flashcard using Augmented Reality (AR) to display the 3D animation of the sign language.
Activity Module	● This system consists of three learning activities that users can do. The activities are *Mari Mengeja*, *Susun Ayat* and *Kuiz* activities. ● *Mari Mengeja* – User is allowed to drag and drop the letter into the answer column to construct a word based on the image given. ● *Susun Ayat* – User is allowed to drag and drop the word into the answer column to construct a sentence based on the image given. ● *Kuiz* – User is allowed to choose the answer based on the sign language given.
Menu interface	● Menu interface works by allowing users to change to different interfaces. By clicking the button, it will direct the users to their desired page. Users can also click on the exit button to exit the application and the replay button to play the 3D model animation.
Activity selection interface	● This interface allows users to choose which activity they want to do by clicking on the button.

Table 3 - Non-functional requirement analysis

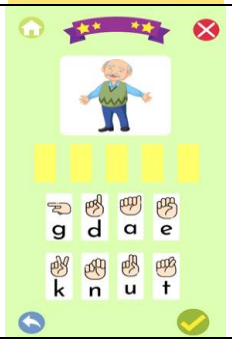
Non-functional requirement	Description
Mobility	● The application can be used anywhere at any time because it uses a mobile platform hence, giving the users flexibility to access it.
Performance	● The application shall operate completely offline. ● The application shall be fast responding which is less than 1 second for most Android mobiles.
Implementation	● The application shall operate on any Android mobile as long as it is Android version 7.0 and above.
Cultural	● This application uses fully Malay language. ● The application shall provide content that is suitable for users aged 7.
Graphical User Interface Support	● The system shall support all components of the application such as animation, graphics, audio, and text for different sizes of resolution on Android mobile.

3.2 Design Phase

In this phase, tools to be used to gauge performance are gathered. A few criteria are determined such as type of media being used, resources needed to complete the project, level and type of activity that will be implemented in the application development, and learner's evaluation method. The interface was designed first using a storyboard and presented to the supervisor to make sure it was acceptable and suitable for the target users. After the storyboard is approved, the assets, props, and animation needed for the application were created and implemented in Unity. The navigational structure was designed and used to provide an overview of how the entire system will link together and how the user is expected to navigate between different interfaces.

The most important step in this phase is to design the user interface as it will impact how the user engages in the application. A good user interface design will create few problems, increases user involvement enhances user satisfaction, and attracts more users. Table 4 shows the user interface design of KTBM AR.

Table 4 - User interface design

User interface	Description
	**Home page** • Consist of two main buttons that navigate the user to Learning Module and Activity Module. • Also, have an exit button for the user to exit the application. • The logo of the application is shown in the middle of the page.
	**Learning Module** • This module requires the user to give permission to use the camera function. • It allows the user to scan the image target to display the 3D sign language animation. • Once the image target is detected, the replay button will appear for the user to play the animation movement. • User can also exit or go to the home page through the exit and home button.
	**Activity selection page** • This page appears when the user clicks on the *Aktviti* button on the home page. • It allows users to choose which activity they want to do. • The available activities are *Mari Mengeja*, *Susun Ayat* and *Kuiz.*
	**Instruction page** • This page tells the user how to do the activity that they have chosen. Each activity will have its own instruction page.
	***Mari Mengeja* page** • In this activity page, users are required to drag the letter into the answer box to spell the word of the image given. • Then, they need to click on the check button to see if the answer they made is correct or not. • If it was correct, marks will be given, and the next question will appear.

	If the answer was incorrect, the answer column will reset so that user can try again.
	***Susun Ayat* page** • In this page, the users are required to drag the word to the answer column to construct a sentence based on the image given. • Then, they need to click on the check button to see if the answer they made is correct or not. • If the answer was correct, marks will be given, and the next question will appear. • If the answer was incorrect, the answer column will reset so that the user can try again.
	***Kuiz* page** • In this page, the users are required to choose the answer based on the sign language given. • If the answer was correct, the next question will appear and marks will be given. If the answer is incorrect, the marks will not be given.

3.3 Development Phase

During this stage, the planning and design made in the previous stage are put into action. In this stage, the lesson materials for the application are generated. The predetermined modules that have been planned in the design phase are made into reality using several software applications like Unity and Blender. Canva is used to design the interface, background image, button assets, and the application logo while the 3D model was animated using 3D Blender. Next, the sound for each animation was recorded using the Voice Recorder App. Lastly, all the assets are integrated using Unity with Vuforia SDK.

3.4 Implementation Phase

At this stage, the application has fully developed and is ready to be implemented on the mobile platform. A few settings are made before publishing the application such as the application name, developers' profile and publishing settings are setups. After completing all the settings, the application is then built as an executable file (APK files). The application is released to Google Play so that users can download it and provide feedback for future improvements.

3.5 Evaluation Phase

The last stage in the ADDIE model is the evaluation. In this stage, the application is tested to see if the objectives of the whole project are accomplished or not. After the implementation process is over, a summative evaluation is conducted for instructional improvement. Throughout the evaluation phase, the problems relevant to the program are solved and the objectives are made sure to be achieved. The evaluation form was created in Google Form and was distributed to SMEs and target users to collect the feedback for this application.

4. Result and Discussion

In order to make sure that the application is functioning well, alpha testing and beta testing were carried out. Alpha testing was done by the developer throughout the development process until the project was completed whereas beta testing was done by involving targeted users after the project was completed.

Alpha testing was conducted throughout the development process until the project was completed to test the functionality and the effectiveness of the application. Things that are being tested during alpha testing are the functionality of the buttons, the output of the image target scanned, score as well as drag and drop functionality in the Activity Module. Table 5 shows the result of the Alpha testing based on all the functionalities stated in KTBM AR.

Table 5 - Result of alpha testing

Test	Expected Result	Actual Result	Corrective Action
Home button	Navigates to Home Page.	Works as expected.	Not needed.
Exit button	Shows an exit warning when clicked.	Works as expected.	Not needed.
Back button	Navigates to the previous page.	Works as expected.	Not needed.
Belajar button	Navigates to Learning Module.	Works as expected.	Not needed.
Aktiviti button	Navigates to Activity Module.	Works as expected.	Not needed.
Replay button	Play the 3D animation.	The button is not in a fixed position.	A canvas is created for the button.
Check button	Check the answer.	Works as expected.	Not needed.
Mari Mengeja button	Navigates to *Mari Mengeja* instruction page.	Works as expected.	Not needed.
Susun Ayat button	Navigates to *Susun Ayat* instruction page.	Works as expected.	Not needed.
Kuiz button	Navigates to *Kuiz* instruction page.	Works as expected.	Not needed.
Next button	Navigates to the activity page.	Works as expected.	Not needed.
Score	Add a score for each correct answer.	The score is not reset after the user exit the activity page.	A line of coding was added to reset the score every time the user exits the activity page.
Drag and drop	Able to drag and drop answer selection to the answer box.	The letter or word cannot be put back if it was a drag from the answer column.	Make sure to click on the check button to reset the answer column.
3D animation displays output	Display correct 3D model, animation, and audio for each image target scanned.	There are a few images targeted that look alike. Thus, it prompts out different audio.	Make sure to scan the whole flashcard so that it can display the correct output.

Based on Table 5, there are a few buttons and functions that are not functioning as expected. The corrective actions are taken, and the errors are fixed before the application is released to the users. The testing was done to ensure the quality of the prototype before proceeding to the next stage.

Beta testing was conducted by involving deaf students after the project was completed. This testing is to get feedback from target users based on their experience when using the KTBM AR application. A set of questionnaires was prepared on Google Form so that the auto-generated figures and charts can make the analysis of the data easier. The test is conducted by distributing the questionnaire to the selected 10 deaf users aged seven with 15 questions. The data collected from the questionnaire is then measured using the System Usability Scale (SUS) to see if the application is accepted or not. The score is shown in Table 6.

Table 6 - The result of beta testing

No.	Question	Likert Points					Marks
		1	**2**	**3**	**4**	**5**	
1.	*Pautan dan Navigasi.*	0	0	0	3	7	47
2.	*Reka Bentuk Antara Muka.*	0	0	0	5	5	45
3.	*Susunan Menu.*	0	0	0	4	6	46
4.	*Gaya Teks dan Butang.*	0	0	0	2	8	48
5.	*Reka Bentuk 3D.*	0	0	0	5	5	45
6.	*Pemilihan Warna Aplikasi.*	0	0	0	4	6	46
7.	*Tahap Mesra Pengguna.*	0	0	0	2	8	48
8.	*Butang pada halaman utama berfungsi dengan baik.*	0	0	0	3	7	47
9.	*3D model dipaparkan dengan betul.*	0	0	1	3	6	45
10.	*Halaman Aktiviti "Mari Mengeja" berfungsi dengan baik.*	0	0	0	4	6	46
11.	*Halaman Aktiviti "Susun Ayat" berfungsi dengan baik.*	0	0	0	1	9	49
12.	*Halaman Aktiviti "Kuiz" berfungsi dengan baik.*	0	0	0	1	9	49
13.	*Animasi bahasa isyarat yang dipaparkan senang untuk diikuti.*	0	0	1	2	7	46
14.	*Arahan pada halaman aktiviti adalah jelas dan mudah untuk difahami.*	0	0	0	2	8	48
15.	*Markah pada halaman aktiviti berfungsi dengan baik.*	0	0	0	0	10	50
					TOTAL		705

The formula used to get the usability result based on SUS is:

$$Y = \frac{P}{Q} \times 100\% \quad (1)$$

Where:

P = Total scores of respondents for each question.
Q = Total maximum of respondents scores.
Y = Percentage score.

Therefore:

$$Y = \frac{705}{750} \times 100\%$$

$$= 94\%$$

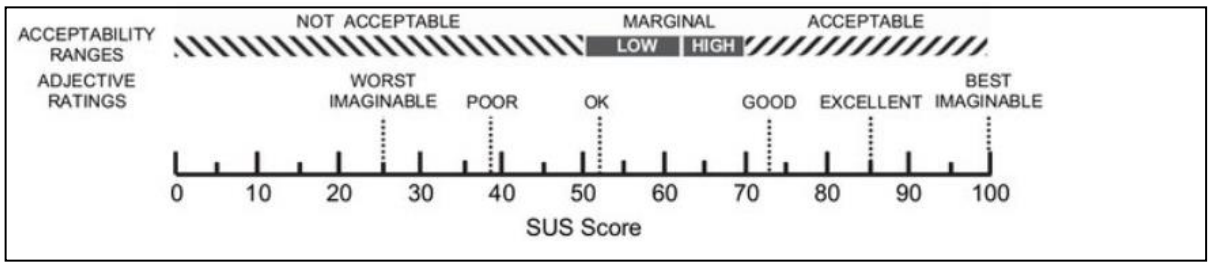


Fig. 2 - The scale of the SUS score [12]

Based on the scale of the SUS score shown in Figure 2, the proposed application SUS score which is 94% acceptable.

5. Conclusion

Based on the results, it can be concluded that the KTBM AR application has been successfully developed which covers the Learning and Activity Module. The result from Alpha testing shows that most of the system is working well, only a few improvements needed to be taken into consideration for future improvements. Also, the result of Beta testing using SUS got 94% which is in the acceptability range. The three objectives stated at the beginning of this application development have been successfully achieved. The application was successfully published on Google Play for Android users with two modules namely the learning module and activity module. The advantages and limitations of the application have also been identified. Next, the application has also been tested on target users successfully. In conclusion, it is hoped that this application can continue to be better in the future.

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