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Mobile Learning for Manually Coded Malay Sign Language using Augmented Reality

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Abstract: Deaf children have difficulty in reading comprehension and are significantly lagging in education as compared to their hearing peers. This can affect their communication skills, and in turn affect their academic achievement. However, the existing applications developed for sign language education have a few drawbacks such as it only consists of 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, KTBM AR also included Augmented Reality (AR) as interactive learning medium to engage users more into learning. The methodology used in developing this application is ADDIE model which comprises five main phases which are analysis, design, development, implementation and evaluation phase. The result from testing shows that the application was successfully developed with a range of 94% acceptable according to 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

In order to be successfully 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 were significantly behind hearing peers [2]. Currently, to assist deaf students in class, sign interpreter is used. Deaf students are depending on sign interpreter to facilitate communication and to provide access to the auditory features of the school environment. This dependency on sign interpreter makes the deaf students constantly need the sign interpreter to help them in various situation [3]. Unfortunately, during this pandemic time, students are required to learn

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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 application available in app store, there are a few shortcomings from the application. 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 are lack of interactivity for the user to interact with. Other than that, most of the applications are using American Sign Language (ASL) as the chosen language [5]. However, the only form of sign language recognised 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 available application only provides Learning Module without any Activity Module [6]. Thus, users unable to do any interactivity activities to test their capabilities in signing and reading.

Hence, KTBM AR is developed as an alternative learning aids for deaf children. There are a few objectives that lead to the development of KTBM AR application. The first objective is to design an Augmented Reality application that displays 3D sign language animation on image target. This application provide user an Augmented Reality application that can scan the specially designed flash cards which serves 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 on Augmented Reality environment. KTBM AR are developed using Unity and plugged-in with Vuforia Engine as the platform for the Augmented Reality development. Lastly, to test the functionality of the application on the deaf students aged seven. This mobile learning application is tested on 10 selected deaf students aged seven to measure the System Usability Scale (SUS) of this application. The application consists of two module namely Learning Module that have Augmented Reality features and also Activity Module that consists of three different activities for user to choose from. Each modules developed by referring to the *Modul Pengajaran (Masalah Pendengaran) Bahasa Malaysia Tahun 1* as to deliver an interactive learning experience for students.

This proceeding paper consists of five sections that covers 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 functionality 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 analysed. It is important to identify the shortcomings of the equivalent application before starting to develop our own application so that the improvement can be made. Table 1 shows the comparative analysis of the existing applications.

Table 1: Comparative analysis between existing application

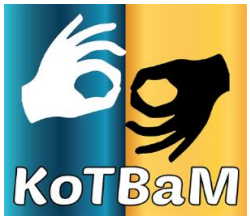
Application	Description
 KoTBaM [4]	• This application includes several basic syllabi of Manually Coded Malay such as alphabet, numbers, colors, animals, and date. • Each sign languages are shown through learning videos by the sign interpreter. • This application is available on Google Play and developed for Android version 4.0 and above

Table 1 (continued)

Application	Description
 StorySign [5]	• This application is available on Google play and Huawei's own AppGallery. • It uses marker-based AR to detect children's story books 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. • 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 represents a dynamic and flexible standard for developing efficient training and performance supporting tools. It is the most commonly implemented model for instructional design because of the positive impact towards multimedia teaching [9]. Figure 1 shows the ADDIE model.

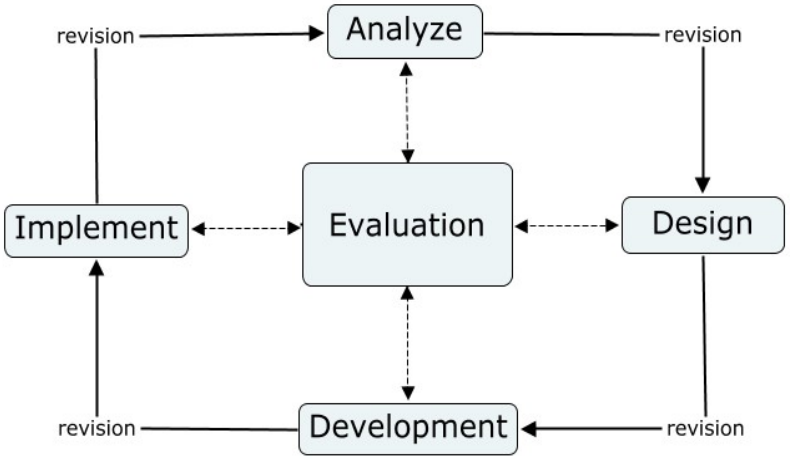


Figure 1: ADDIE Model [10]

3.1 Analysis Phase

In this initial phase, the main problem in the physic of the learning process were analysed. 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 article 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, software and hardware requirements. Next, the objectives of the whole project were decided.

Besides, the analysis of functional and non-functional requirements are 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 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 modules and interfaces while Table 3 shows the Non-functional Requirement Analysis that describes the important characteristics implemented on the application to deliver an application that are functioning well and meet the user's needs.

Table 2: Functional requirement analysis

Functional requirement	Description
Learning Module	• This system works by allowing users to scan the flash card 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 answer column to construct a sentence based on the image given.
- *Kuiz* – User is allowed to choose answer based on the sign language given.

Table 2 Functional requirement analysis (continued)

Functional requirement	Description
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 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 use anywhere at any time because it uses mobile platform hence, giving the users flexibility to access.
Performance	• The application shall operate completely offline. • The application shall be fast responding which is less than 1 second for most of Android mobile.
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 user aged 7.
Graphical User Interface Support	• The system shall support all components of the application such as animation, graphic, audio and text for different sizes of resolution on Android mobile.

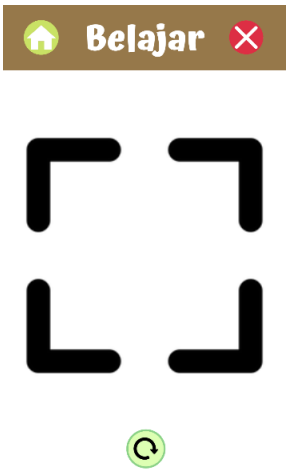
3.2 Design Phase

In this phase, tools to be used to gauge performance are gathered. The 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. 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.

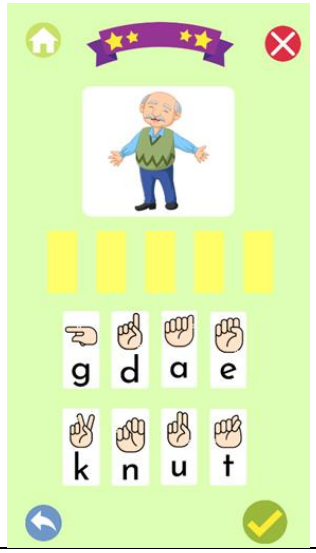
The most important step in this phase is to design the user interface as it will impact how the user engage in the application. A good user interface design will creates few problems, increases user involvement, enhances users satisfaction and attract more users. Table 4 shows the user interface design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

Table 4: User interface design

User interface	Description
	Home page • Consist of two main button that navigates user to Learning Module and Activity Module. • Also, have exit button for user to exit the application. • The logo of the application is shown in the middle of the page.
	Learning Module • This module requires user to give permission to use the camera function. • It allows 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 user to play the animation movement. • User can also exit or go to home page through exit and home button.

	Activity selection page • This page appears when user click on *Aktviti* button on home page. • It allows user to choose which activity they want to do. • The available activities are *Mari Mengeja*, *Susun Ayat* and *Kuiz.*

Table 4 User interface design (continued)

User interface	Description
	Instruction page • This page tells the user on 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 answer box to spell the word of the image given. • Then, they need to click on check button to see if the answer they made is correct or not. • If it was correct, marks will be given, and next question will appear. If the answer was incorrect, the answer column will reset so that user can try again.

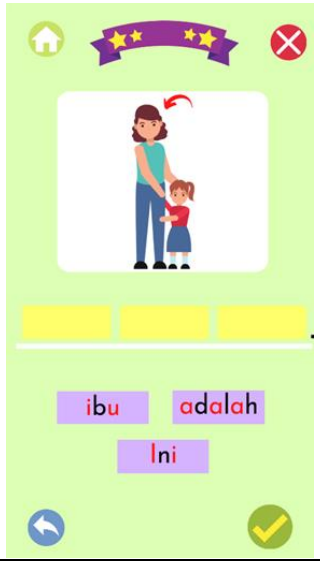
	*Susun Ayat* page • In this page, the users are required to drag the word to the answer column to construct a sentence based on the image given. • Then, they need to click on the check button to see if the answer they made is correct or not. • If the answer was correct, marks will be given, and next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

Table 4 User interface design (continued)

User interface	Description
	*Kuiz* page • In this page, the users are required to choose the answer based on the sign language given. • If the answer was correct, 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 is 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

In this stage, the application has fully developed and ready to be implemented on mobile platform. A few settings are made before publishing the application such as the application name, developers' profile and publishing settings are setup. 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 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 SME and target users to collect the feedback for this application.

4. Result and Discussion

4.1 Testing

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.

4.1.1 Alpha Testing

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 is the functionality of the buttons, 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 exit warning when clicked.	Works as expected.	Not needed.
Back button	Navigates to 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 activity page.	Works as expected.	Not needed.

Table 5 Result of alpha testing (continued)

Test	Expected Result	Actual Result	Corrective Action
Score	Add 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 user exits the activity page.
Drag and drop	Able to drag and drop answer selection to the answer box.	The letter or word cannot put back if it was drag from the answer column.	Make sure to click on 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 target that are look alike. Thus, it prompts out different audio.	Make sure to scan whole flash card so that it can display the correct output.

Based on Table 5, there are a few buttons and function 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.

4.1.2 Beta testing

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 System Usability Scale (SUS) to see if the application is acceptable 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

Table 6 The result of beta testing (continued)

No.	Question	Likert Points					Marks
		1	2	3	4	5	
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:

$$Y = \frac{P}{Q} \times 100\%$$

Where:

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

Therefore:

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

$$= 94\%$$

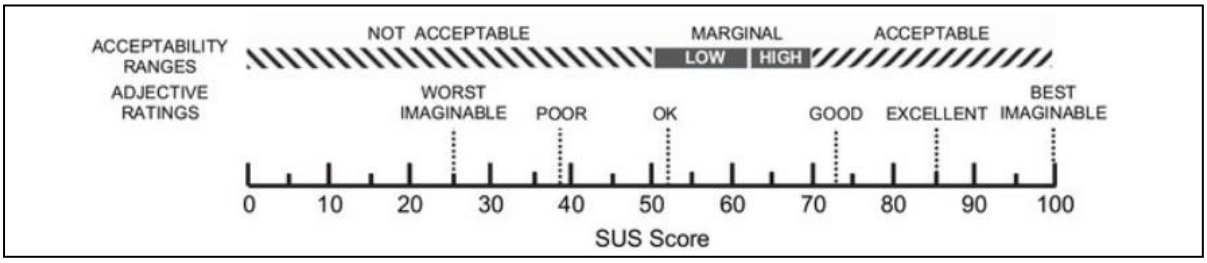


Figure 2: The scale of the SUS score [12]

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 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 ranges.

The three objectives stated in the beginning of this application development has been successfully achieved. The application was successfully published on Google Play for Android user with two modules namely Learning Module and Activity Module. The advantages and limitation of application have also been identified. Next, the application has also being 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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