



The Development of Mobile Augmented Reality Korean Language Learning Application: KoreAR

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Abstract: Korean language is the official language of South Korea and North Korea, and Hangul is used as the alphabet and writing system. Hangul helps in the learning and comprehension of the Korean language for both native and non-native Korean speakers. However, the existing Korean language learning applications for learning Hangul lacks interactive elements, and only few are implemented with augmented reality (AR) technology. Therefore, this objective of this project is to develop an augmented reality mobile Korean language learning application that helps to learn Hangul. The target users for this project are university students. The development of KoreAR application is based on the Multimedia Mobile Content Development (MMCD) methodology. Besides, based on the user acceptance test, an average score of 88.42 were obtained, which is within the acceptable range according to the System Usability Scale (SUS). To sum up, the application is expected to help target users learns the basic of Hangul, by implementing markerless AR technology.

Keywords: Mobile Learning Application, Korean Language, Hangul, Augmented Reality

1. Introduction

Learning the Korean language is becoming increasingly popular, and the demand is high these days. As stated by the language learning application Duolingo [1], Korean is the fastest-growing language in Japan, Brazil, France, Germany, India, and Mexico, and it is the seventh most popular language to study globally. The Korean language is the official language of both South Korea and North Korea. The Korean alphabet is known as Hangul in South Korea or *Chosŏn'gŭl* in North Korea and was invented by King Sejong the Great in 1443 [2]. Korean alphabet or Hangul is made up of 24 basic letters: 14 consonants and 10 vowels. In Korean, the consonants and vowels are combined to form syllable blocks and each syllable block will have an initial consonant and final consonants.

In recent years, the use of augmented reality technology is expanding and becoming increasingly common across a diverse variety of applications. Augmented reality has blended the physical environment with virtual data, with the principle of applying computer-generated virtual data, such as text, images, 3D models, music, and video, to the real world after simulation [3]. Unlike virtual reality

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which requires an expensive headset to operate, augmented reality does not require a headset, hence making it more accessible to casual users. In short, augmented reality technology is an effective way to deliver learning content.

Furthermore, there are limited sources to learn the Korean alphabet. Secondly, there are quite a few language learning applications that failed to provide users with appealing interfaces and interactive features. Lastly, the unattractive features of some applications cause a lack of user acceptance. Therefore, the mobile learning application, KoreAR is proposed to be developed.

The objectives of this study are to design KoreAR mobile learning application using an augmented reality approach, to develop KoreAR mobile learning application on the Android platform using the Unity game engine, and to test the functionality of the developed application and user acceptance test on the target user. The proposed application is developed for university students that are interested in the Korean language to learn the consonants, vowels, basic vocabulary and the correct pronunciation of the Korean alphabet. The subject matter expert of this project will be Mr. Muhammad Syahid bin Hasan, a freelance Korean language teacher.

Two educational modules, including ones on vowels and consonants, may be found in the KoreAR application, along with one AR module that makes use of markerless AR technology. All navigational buttons in the application are expected to perform well. Sound buttons will be provided as part of the learning content. Clear and accurate pronunciation of the Korean alphabet and vocabulary would be provided to ease the user to follow the learning content. Lastly, the AR mode of the application is expected to display the 3D model of the corresponding vocabulary of the consonants and vowels using plane detection. Then, the user can drag, rotate, and scale the 3D model displayed within the plane.

The rest of the paper is organized as follows: Section 2 discusses the domain of study, the technology used, and the result of the comparative analysis. Next, the Multimedia Mobile Content Development (MMCD) methodology used to develop the application and the output of each phase of this project is described in Section 3. Furthermore, Section 4 presents the results and discussion, and Section 5 states the conclusion of the project.

2. Related Work

In this section, the study domain, technology used, and results of the comparative analysis are discussed.

2.1 Korean Language Learning

Even though English, Mandarin, and Japanese are widely used and understood, Korean is the official language of both South Korea and North Korea. Korean is a language isolate, which means that it is distinct from all other languages and has its own language family [4]. Therefore, Korea has its vocabulary, grammar system and alphabet. The Hangul, or Korean alphabet, consists of 24 basic letters: 14 consonants and 10 vowels. Since Korean is an isolated language, studying it may be challenging for people who are not native Korean speakers. Based on a survey conducted to determine the general difficulties learners have faced when studying Korean [5], many of them felt difficulty in having little interaction with native Koreans, which accounts for 39.5%, followed by having no idea of how to study (27.9%), and having difficulty in choosing helpful materials (23.3%). Additionally, most Malaysian universities offer courses in foreign languages such as Japanese, Chinese, Spanish, and French. However, due to the lack of Korean teachers, only some universities offer Korean language courses, despite the high demand and interest from the students. Thus, most students choose to learn Korean on their own or participate in Korean language courses outside of school. The next subsection explains the technology applied in the proposed application.

2.2 Mobile Learning

In this project, two technologies have been used. First, mobile learning, or m-learning for short. The phrase "m-learning" refers to the use of mobile and portable IT devices, such as tablet PCs, laptops, PDAs, and mobile phones, in training, education, and research [6]. Learning through language learning applications has also become one of the major trends, especially since university students are the main users of mobile applications. The portability of m-learning improves the effectiveness and attractiveness of the learning process since learning activities can be accessed anytime and anywhere without being limited by traditional places and time. In addition, A study conducted by [7] found that Korean language learners at universities in China typically had good reactions to mobile learning. They used mobile learning for real-time streaming content (70.2%) and claimed that the use of mobile devices largely stimulated two skills, which are listening (61.6%) and vocabulary (61.6%). Duolingo, Memrise, LingoDeer, and HelloTalk are few examples of popular mobile learning applications that are commonly used for Korean language learning.

2.3 Augmented Reality

Augmented reality is often outlined as a system that comes with 3 basic features: a mix of real and virtual worlds, allows for real-time interaction, and accurately registers 3D models of virtual and real objects [8]. It involves enhancing a representation of the real world with digital data and computer-generated pictures. There are several forms of augmented reality technology that are suitable for various purposes. The two main types of augmented reality that are commonly used are Marker-based AR and Markerless AR. In this project, the proposed application is developed using the markerless method. Markerless AR does not require any marker and it enables users to insert virtual objects or contents without having to move any background elements. In markerless AR, the virtual object is positioned in the geometry produced by SLAM (Simultaneous Localization and Mapping), which uses the camera feed to produce a 3D mesh of the surroundings and stores them into a 3D model [9]. Consequently, a virtual object is placed in its 3D model so that even if the camera loses track, the virtual object will still be found at the same location. The comparative analysis of existing applications and the proposed application are discussed in the next subsection.

2.4 Comparative Analysis

In this section, a comparison has been made between the existing applications, such as Korean Hangul [10], Learn Korean [11], and LearnHangul [12], and the proposed application. Figure 1 shows the main interface of the three existing applications. Meanwhile, 10 features have been discussed, as shown in Table 1. It includes language, supported platform, content, application approach, exit pop-up, target user, access modes, learning module, instructions, and purchasing.

Based on Table 1, several strengths and limitations of the proposed application can be concluded. Firstly, markerless augmented reality (AR) technology will be applied to the proposed application. Secondly, the proposed application will provide two learning modules and 1 AR module. The learning modules include the consonants and vowels of the Korean alphabet. Besides, the proposed application also includes the learning of some basic vocabulary and the learning of correct pronunciation. Thirdly, the existing applications do not provide instructions to guide the users to use the application. Therefore, video-based and text-based instructions are provided to improve users' understanding of the application's functionality. On the other hand, the proposed application does not support iOS devices and only supports mobile devices with Android version 8.0 and above. Furthermore, a game module is not included in the proposed application. Instead, it only provides the learning modules and AR modules.

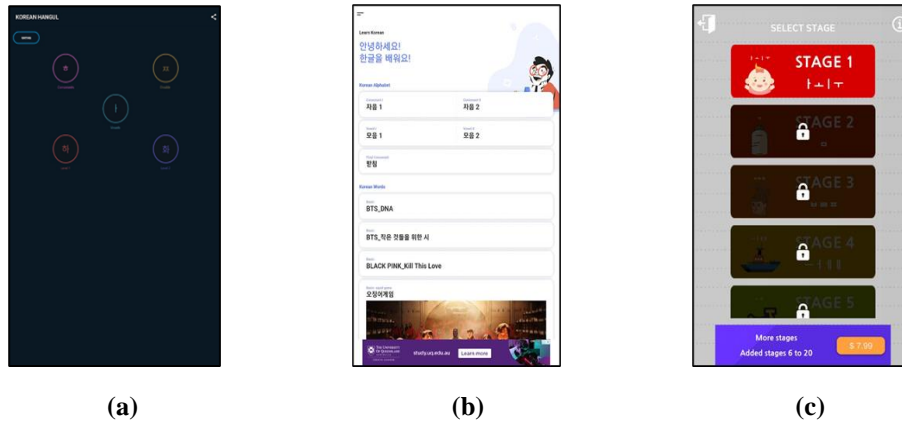


Figure 1(a): Korean Hangul [10] Figure 1(b): Learn Korean [11] Figure1(c): LearnHangul [12]

Table 1: Comparison between existing applications and proposed application

Features	Korean Hangul	Learn Korean	LearnHangul	KoreAR
Language		English		English, Chinese
Supported Platform	Android.	Android.	Android and iOS.	Android.
Content	Consonants, double consonants, vowels, level 1, level 2 chart	Consonants, vowels, basic vocabulary	Consonants, vowels	AR, vowels, Consonants, basic vocabulary
Application Approach		2D		Markerless Augmented Reality
Exit Pop up	Exit only.		Exit after confirming at the popup.	
Target User	Beginners.	Beginners.	Not mentioned.	University students.
Access Modes	Offline but required internet connection for some parts.		Offline.	
Learning Module	5 learning modules.	2 learning modules.	Not available.	2 learning modules.
Instructions	Not available.	Not available.	Adequate in text.	Text aided with narration.
Purchasing	Free to use.	Free to use.	In-app purchasing.	Free to use.

3. Methodology

The proposed application, KoreAR is a mobile learning application designed as a tool to learn the Korean alphabet. Meanwhile, the Multimedia Mobile Content Development (MMCD) approach is used to create mobile learning (m-learning) applications [13]. Therefore, it is chosen to apply to this project. The 5 phases of the MMCD methodology are shown in Figure 2. Next, each phase of the MMCD is discussed in the following subsections.

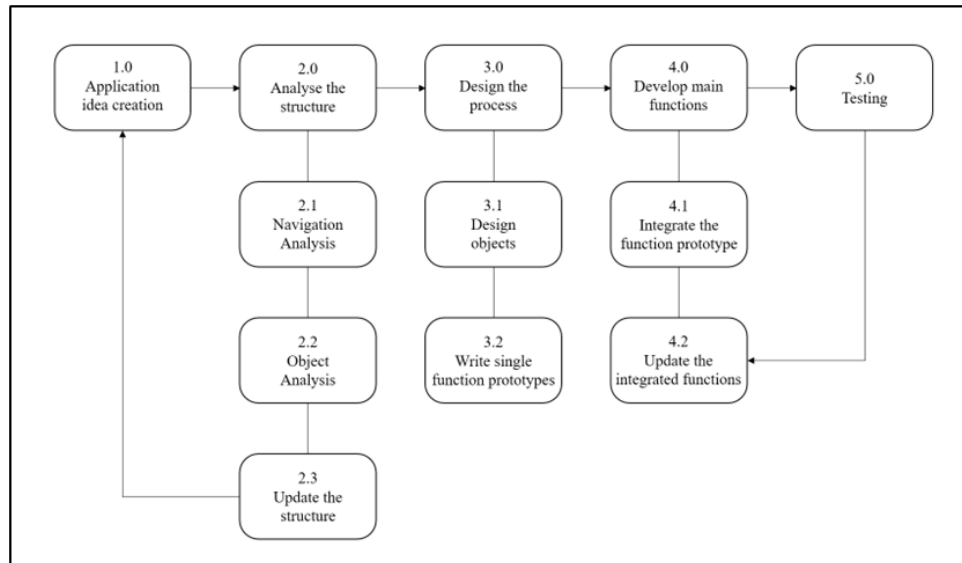


Figure 2: MMCD Methodology

3.1 Application Idea Creation

Application idea creation is the first phase of MMCD methodology. In this phase, the information required before the design and development of the KoreAR is determined. Two information-gathering methods have been used to identify user requirements. Firstly, an interview session was conducted with the Subject Matter Expertise (SME), Mr. Muhammad Syahid bin Hasan, a freelance Korean language teacher. In addition, A questionnaire survey was distributed to the target users via Google Forms. A total of 30 responses from university students aged between 18 to 26 have been collected as attached in Appendix B. The results obtained from the target users are attached in Appendix A. The results of the user analysis are tabulated in Table 2. Table 3 shows the application idea creation checklist.

Table 2: User analysis

Stakeholder Category	Role in Application	Design Implication	Action Needed
Subject Matter Expert (SME)	Content consultant expert in related field	Easy to navigate	<ul style="list-style-type: none"> Simple navigational structure. Contain back, exit, guide and settings buttons. Use a consistent size for all buttons based on their category.
		Simple user interface design	<ul style="list-style-type: none"> Use icon-based buttons rather than text-based buttons. Use a suitable font style and size for content.
		Simple but reliable content	<ul style="list-style-type: none"> Provide correct pronunciation for the Korean alphabet. Include Korean language vocabularies that are suitable to learn. The content should be simple and easy to understand.
		Ease of use	<ul style="list-style-type: none"> Avoid using unnecessary buttons that might be confusing. Provide clear instructions.

Stakeholder Category	Role in Application	Design Implication	Action Needed
General User	End-user of the application	Based on the questionnaire, the user preferences	<ul style="list-style-type: none"> The application should be created as a free-to-download mobile learning application. The application should be developed in offline mode which allows users to access it anywhere, anytime on a mobile device. The interface design of the application should be simple and clean. A sound button with clear pronunciation should be included in the application.

Table 3: Application idea checklist

Item	Description
Type of application	Mobile Learning application
Target device	Android-based smartphone.
Target users	University students
Unity2020	- Version: 2020.3.32f1 - Resolution: Free aspect
Adobe Photoshop CC 2020	Design application assets
User interface	Background (main page, sub-page)
Images	Icons, buttons, and backgrounds.
Application synopsis	KoreAR is a Korean language learning application for university students in Malaysia which allow students to learn the Korean alphabet such as consonants and vowels. The application is designed with an interactive AR module to enhance the interaction and bring motivation to learn the language to the students.

3.2 Analyze the Structure

In the second phase of the MMCD methodology, the structure of the application to be developed is analyzed. The object and navigation analysis has been conducted. Figure 3 shows the navigational structure. The system flowcharts are shown in Figure 4. The content structure can be referred to in Appendix B. Functional and non-functional requirements are listed in Table 4 and Table 5.

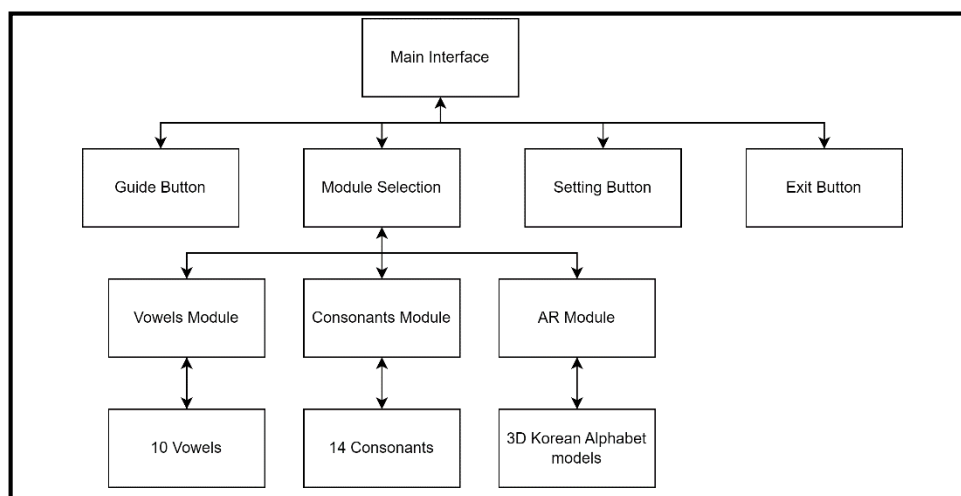


Figure 3: Navigational Structure

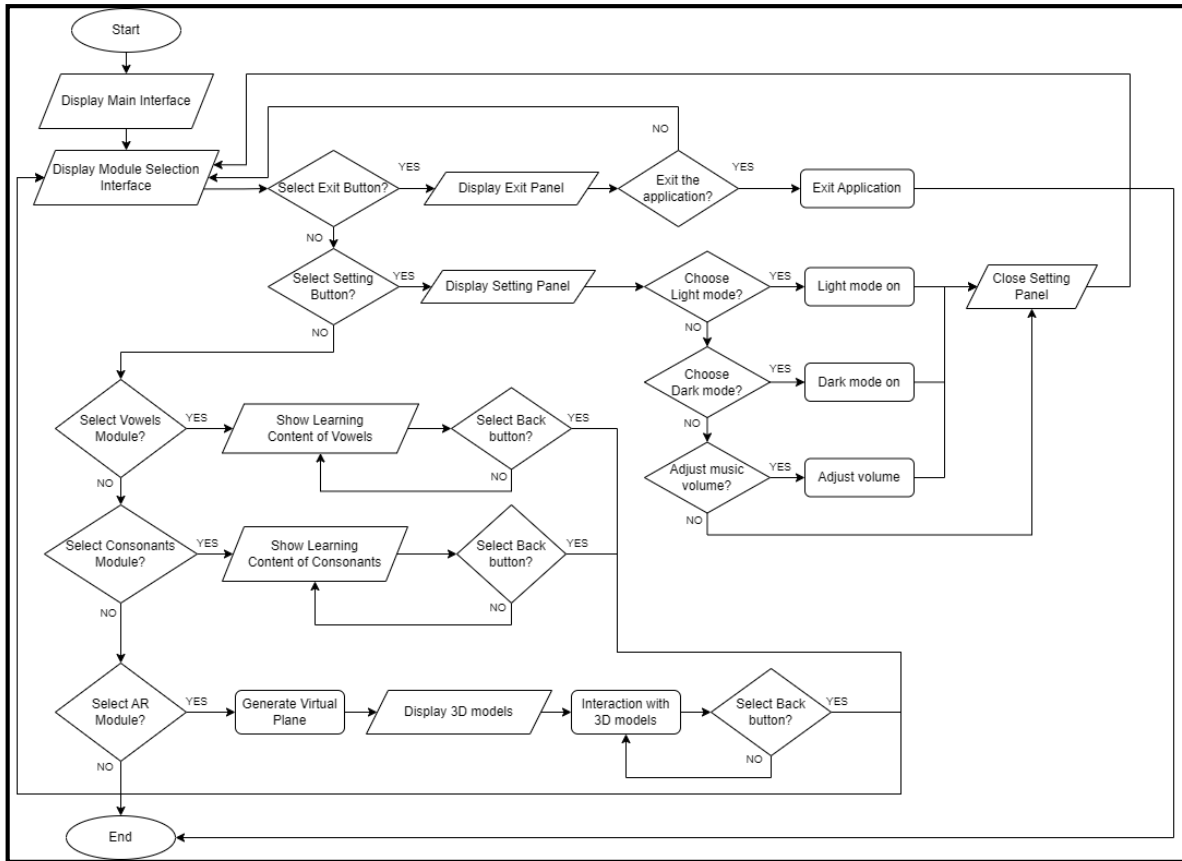


Figure 4: System flowchart

Table 4: Functional requirements

Functional Requirement	Explanation
User Interaction Support	<ul style="list-style-type: none"> The application should allow users to give their input by touching the screen of mobile devices. The application should allow users to switch between different interfaces of the application by pressing the appropriate navigational buttons. The application should allow users to click on the sound button to listen to the pronunciation in the modules.
Provide Learning Module	<ul style="list-style-type: none"> The application should allow users to learn the vowels and consonants of the Korean alphabet. The application should allow users to learn and understand the meaning of Korean vocabulary. The application should allow users to recognize the pronunciation of the Korean alphabet and vocabulary through an audio form.
Autonomous Application Activities	<ul style="list-style-type: none"> After the user enters the Vowels and Consonants modules, the animation of the moving down arrow indicator should play automatically. The application should ask the new users for their camera permission. The application shall display the 3D Korean alphabet model after the camera detects a flat surface.













Table 5: Non-functional requirements

Non-functional Requirement	Explanation
Performance	<ul style="list-style-type: none"> The application shall operate completely offline. The application should be able to operate at the fastest speed for most Android mobile that fulfills the application requirement. The time to display the 3D model should not be more than 3 seconds.
Implementation	<ul style="list-style-type: none"> The application shall be able to operate on any Android device as long as it is Android version 8.0 or above.
Usability	<ul style="list-style-type: none"> Users should be able to access the application anywhere and anytime if they have a mobile device with this application installed. The application should be simple, effective to use and provide a pleasant user experience.
Legal	<ul style="list-style-type: none"> Users of the application can only view but have no right to modify the information that is displayed in the application.
Cultural	<ul style="list-style-type: none"> English language and Korean language are used in this application, along with some Chinese language as the learning content.
Graphical User Interface Support	<ul style="list-style-type: none"> The application should support all multimedia elements such as graphics, animation, video, text and audio for different sizes of display resolution on Android devices.

3.3 Design the Process

Designing the process is the third phase of the MMCD approach. Design objects and write single function prototype scripting are two subphases in this stage. The prototype should be completed in terms of graphics and object designs that are making up the AR framework of this proposed application. In this project, authoring tools such as Adobe Photoshop, Blender, and PowerPoint are used to create graphics, 3D models, and storyboards. Meanwhile, Unity software is used to compile and integrate all the assets along with scripting. Table 6 shows the button design, whereas Table 7 shows the interface design.

Table 6: Button Design

Button	Description	Button	Description
	Vowels Module button		Guide Text button
	Consonants Module button		Application Info button
	AR Mode Module button		Sound on button
	Yes button		Sound off button
	No button		Next button
	Guide Video button		Pronunciation Audio button












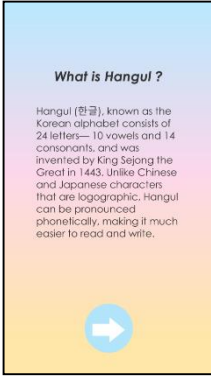

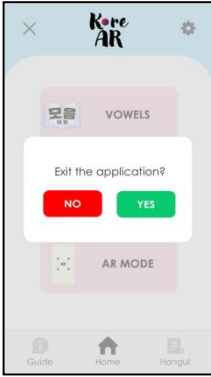
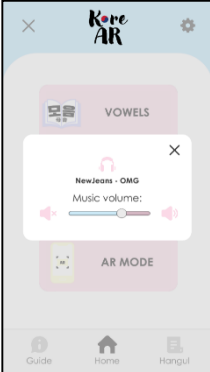


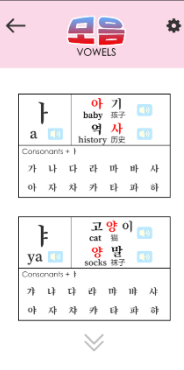




Button	Description	Button	Description
	Home button		Setting button
	Guide button		Close button
	Hangul chart button		AR Building Placement button
	Back button		AR Vowels button
	AR Consonants button		AR Object Placement button

Table 7: Interface Design

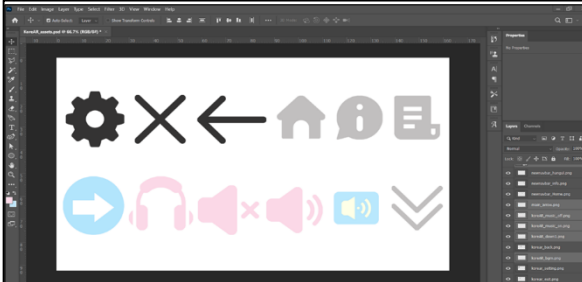
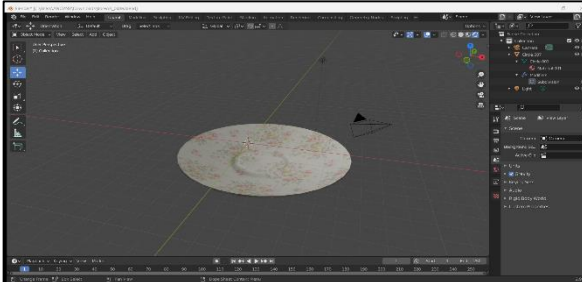
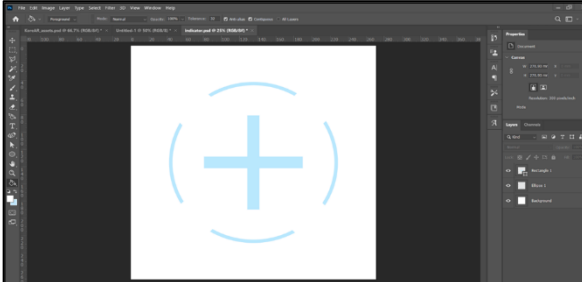
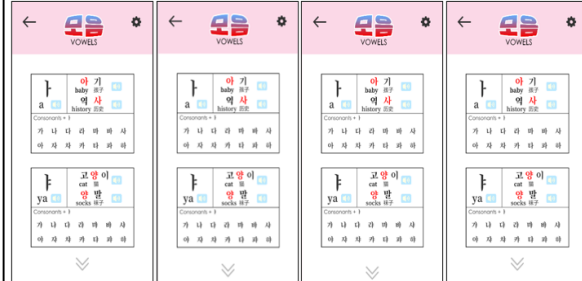
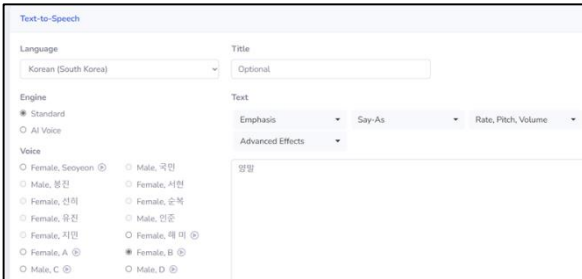
Interfaces	Description	Interfaces	Description
	This is the startup interface of the proposed application. The user clicks the next button to go to the introduction scene.		This is the introduction interface. Users can get to know some of the information on Hangul before starting the application. The user clicks the next button to go to the module selection scene.
	This is the module selection scene that contains three buttons including the Vowels module, Consonants module, and AR mode module. Each button navigates to each module, respectively.		This is the exit confirmation panel. If pressing “Yes”, users will exit the application, if press “No”, it denies the decision of the users for exiting the application and close the exit confirmation panel.
	This is the setting panel. It displays the name of the background music. Volume can be adjusted using the slider bar, drag to the right to increase the volume or to the left to decrease the volume.		This is the guide interface where users can view the instructions of the application in video or text. Application info can be viewed by clicking the application info button.

Interfaces	Description	Interfaces	Description
	<p>This is a Hangul Chart interface. It displays all the 10 vowels and 14 consonants of the Korean alphabet.</p>		<p>This is a scrollable interface of the Vowels module. It includes the 10 vowels of the Korean alphabet as well as the example vocabulary. Pronunciation audio buttons are provided.</p>
	<p>This is a scrollable interface of the Consonants module. It includes the 14 consonants of the Korean alphabet as well as the example vocabulary. Pronunciation audio buttons are provided.</p>		<p>This is the AR Mode module. AR placement indicator will be generated when the camera detects a flat surface. A 3D model of the gwanghwamun building will be displayed. Users can drag, rotate, and scale the 3D models.</p>
	<p>This is the AR Vowels module. 3D models of the corresponding vowels will be displayed. Users can drag, rotate, and scale the 3D models.</p>		<p>This is the AR Consonants module. 3D models of the corresponding consonants will be displayed. Users can drag, rotate, and scale the 3D models.</p>

3.4 Develop Main Function

In this phase, the main functions of the proposed application are developed. It involved developing assets for the application and the integration of the assets into Unity software. There are 5 multimedia elements developed as assets of the application. It consists of graphics, 3D models, AR placement indicators, animations and audio, as listed in Table 8.

Table 8: Application Assets Development

Assets	Development	Description
Graphics		<p>Storyboards of the application are created using PowerPoint. Adobe Photoshop is then used to develop the application icons and interfaces. The background of the elements is set to transparent.</p>
3D Models		<p>All 3D models are created using Blender software or downloaded from online resources like BlenderKit and Sketchfab. Each vowel or consonant has a model corresponding to the vocabulary.</p>
AR placement indicator		<p>AR placement indicator is used as a cursor that solves the lack of precise location information provided by the AR Raycast. It was created using Adobe Photoshop. The 3D models will be placed above the '+' symbol.</p>
Animations		<p>The moving down animation in the Vowels and Consonants module of KoreAR is created using the DOTween package installed in Unity Assets Store. The animation will loop four times and then stops.</p>
Audio		<p>The audio files in the KoreAR application are in the Moving Picture Experts Group Layer-3 Audio (MP3) format. It is generated using the Text-to-Speech tool to ensure the accuracy of the pronunciation.</p>

Furthermore, the C# scripts are developed to enable the main functions of the application. Such functions include typewriter effect, background music sound manager, AR place indicator, and AR place multiple object manager. These functions are explained in Table 9, whereas the interfaces of the developed application are displayed in Table 10.


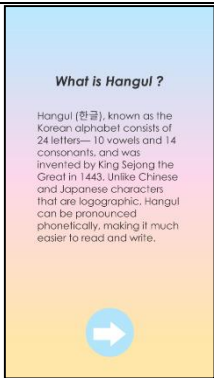
Table 9: Integration in Unity


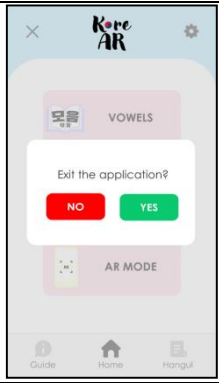
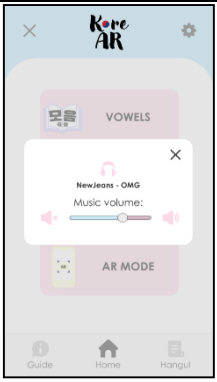


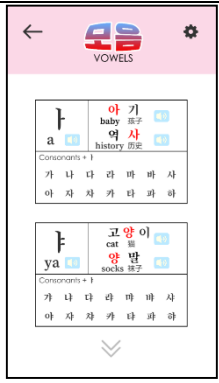


Functions	C# Scripts	Description
<p>Typewriter effect (Introduction)</p>	<pre>public class TypeWriterEffect : MonoBehaviour { public float delay = 0.1f; public string fullText; private string currentText = ""; void Start () { StartCoroutine(ShowText()); } IEnumerator ShowText(){ for(int I = 0; I <= fullText.Length; i++){ currentText = fullText.Substring(0,i); this.GetComponent<Text>().text = currentText; yield return new WaitForSeconds(delay); } } }</pre>	<p>The typewriter effect is used to gradually reveals text character by character as if it were being typed. It is used in the introduction scene, which briefly explains Hangul to the users. The ShowText() is defined as an IEnumerator, which allows for yielding control during its execution. The yield return new WaitForSeconds(delay) introduces the desired delay before the next character is revealed.</p>
<p>Background music sound manager (All interfaces)</p>	<pre>public class SoundManager : MonoBehaviour { [SerializeField] Slider volumeSlider; void Start() { if(!PlayerPrefs.HasKey("musicVolume")) { PlayerPrefs.SetFloat("musicVolume", 1); Load(); } else { Load(); } } public void ChangeVolume() { AudioListener.volume = volumeSlider.value; Save(); } private void Load() { volumeSlider.value = PlayerPrefs.GetFloat("musicVolume"); } private void Save() { PlayerPrefs.SetFloat("musicVolume", volumeSlider.value); } }</pre>	<p>The background music sound manager is used to handle volume control using a slider component and it saves the volume level using PlayerPrefs. PlayerPrefs is a class in Unity that saves and retrieves player preferences between game sessions. In the Start() method, if the musicVolume key exists, the script will call the Load() method directly, to ensure the volume slider reflects the previously saved volume level. Moreover, ChangeVolume() will update the AudioListener.volume property to the value of the volume slider. After updating the volume, the Save() method is called to save the new volume level in PlayerPrefs.</p>

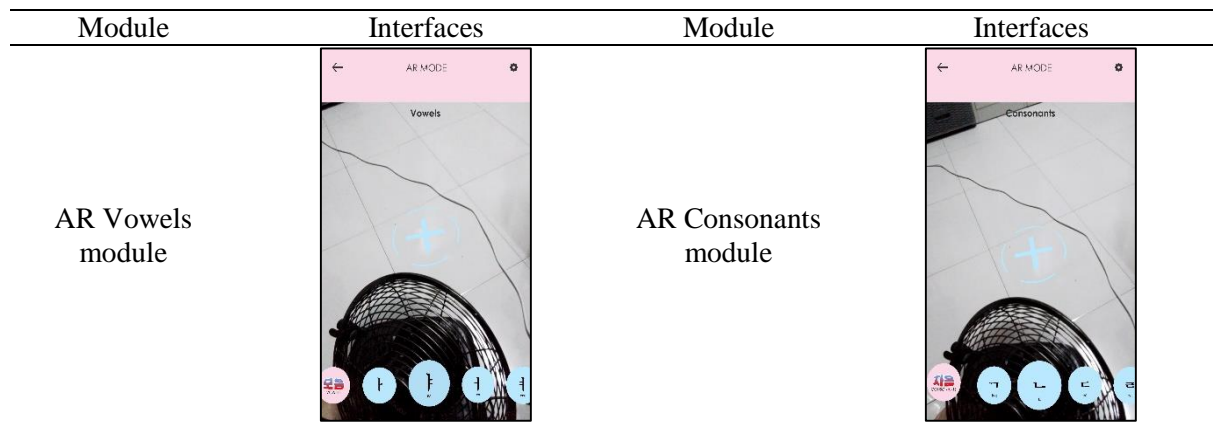
Functions	C# Scripts	Description
<p>AR place indicator (AR Mode module)</p>	<pre> using System.Collections; using System.Collections.Generic; using UnityEngine; using UnityEngine.XR.ARFoundation; using UnityEngine.XR.ARSubsystems; public class PlaceIndicator : MonoBehaviour { private ARRaycastManager raycastManager; private GameObject indicator; private List<ARRaycastHit> hits = new List<ARRaycastHit>(); // Start is called before the first frame update void Start() { raycastManager = FindObjectOfType<ARRaycastManager>(); indicator = transform.GetChild(0).gameObject; indicator.SetActive(false); } // Update is called once per frame void Update() { var ray = new Vector2(Screen.width / 2, Screen.height / 2); if (raycastManager.Raycast(ray, hits, TrackableType.Planes)) { Pose hitPose = hits[0].pose; transform.position = hitPose.position; transform.rotation = hitPose.rotation; if (!indicator.activeInHierarchy) { indicator.SetActive(true); } } } } </pre>	<p>This AR place indicator uses AR Foundation and AR subsystems and is responsible for placing the indicator on the detected flat surfaces in the AR environment, as well as updating its position and rotation based on the ray cast hits. The indicator is initially deactivated using SetActive(false). The Update() method starts by creating a Vector2 ray representing the center of the screen. The raycastManager then performs a ray cast from the ray onto detected planes. If a ray cast is detected, the hit pose of the first hit in the hits list is obtained. The position and rotation of the game object with the place indicator script are set to match the hit pose, aligning the object with the detected plane. Also, if the indicator is not active in the hierarchy, like it is not visible, it is activated using SetActive(true).</p>
<p>AR places multiple object manager (AR Mode module)</p>	<pre> public class PlaceMultipleObject : MonoBehaviour { private PlaceIndicator placeIndicator; public GameObject objectFirst; public GameObject objectSecond; public GameObject objectThird; private GameObject objectToPlace; </pre>	<p>AR place multiple managers are used to place different 3D models of the corresponding vowels and consonants vocabulary. First, the variables wanted to be used are declared beforehand.</p>

Functions	C# Scripts	Description
AR place multiple manager (AR Mode module)	<pre> void Start() { placeIndictor = FindObjectOfType<PlaceIndicator>(); } public void InstantiateObject() { Instantiate (objectToPlace,placeIndictor.transform.position, placeIndictor.transform.rotation); } public void ClickToPlaceFirst() { objectToPlace = objectFirst; InstantiateObject(); } public void ClickToPlaceSecond() { objectToPlace = objectSecond; InstantiateObject(); } public void ClickToPlaceThird() { objectToPlace = objectThird; InstantiateObject(); } } </pre>	<p>InstantiateObject() method is used to instantiated an object at the position and rotation of the place indicator. The instantiate function creates a new instance of the objectToPlace prefab, while being determined by the place indicator's position and rotation. The ClickToPlace() method is called when a button is clicked. For example, in ClickToPlaceFirst() method, it assigns objectFirst to objectToPlace variable, then then InstantiateObject() method is called. By using this AR place multiple object manager, different objects can be placed in the scene using the place indicator's position and rotation in which the specific object to place is determined by which button is clicked.</p>

Table 10: Interfaces of the developed application

Module	Interfaces	Module	Interfaces
Startup interface		Introduction interface	

Module	Interfaces	Module	Interfaces
Module selection		Exit confirmation panel	
Setting panel		Guide interface	
Hangul chart interface		Vowels module	
Consonants module		AR Mode module	



3.5 Testing

In the last phase of the MMCD methodology, two types of testing will be performed, including functional testing and user acceptance testing. If any bugs are detected in this phase, the project will return to the previous state to update the integrated functions to fix the bugs. The functional testing is tabulated in Table 11, while the user acceptance testing is discussed in Section 4.

Table 11: Functional Testing

Test	Expected Result	Actual Result	Corrective Action
Navigation button	Navigates to each interface.	Works well as planned.	Not needed.
Close button	Close the pop-up panel.		
Setting button	Open the setting panel.		
Sound button	Mute and unmute background music.		
Guide button	Show application guide in video or in text.		
Application info button	Show information of application.		
Pronunciation audio button	Play pronunciation audio.	Audio clips will adjust its volume according to the volume slider.	Add <code>ignoreListenerVolume()</code>
AR building placement button	Show the Gwanghwamun 3D model.	The model is out of the screen.	Add Canvas and new Camera to show the 3D model.
AR object placement button	Show the corresponding vocabulary 3D models.		

Table 11 shows that some errors were spotted. Corrective actions are then taken to fix the errors found in order to obtain the expected results. In the Vowels and Consonants module, all audio clips of the pronunciation audio buttons will adjust its volume according to the volume slider in the setting panel. Therefore, `ignoreListenerVolume()` is added to the script that controls all audio clips so that the audio source will ignore the volume of the audio listener and does not modify both the volume of the background music and pronunciation audio. Additionally, the 3D model that should be displayed in the AR Mode module is out of the screen. To solve this, new Canvas and Camera are added to show the 3D models.

4. Results and Discussion

This section shows data and analysis of user acceptance testing. The testing is performed to assess user acceptance of the developed application. In this project, System Usability Scale (SUS) [14] is adopted and applied. The application was distributed to target users aged 18 to 23 years old via Google Drive, along with a Google Form questionnaire. The questionnaire consists of 10 questions, which the respondents are required to answer the questionnaire using a 5-point Likert scale, and the options range from ‘strongly agree, to ‘strongly disagree’. A total of 30 respondents were collected and the results were analyzed.

In the SUS questionnaire, odd-numbered questions represent a positive expression on the usability of the application while even-numbered questions indicate a negative expression of application’s usability. Based on Figure 5(a), all respondents answering the questionnaire gave a score between strongly agree, agree, and neutral. None of them have chosen strongly disagree and disagree options on the positive statement of the application’s usability such as they would like to use the application frequently, the application was easy to use, or they would image that most people would learn to use this application very quickly. This might be due to the useful information provided for the learning content as well as the high level of multimedia engagement in the application. Therefore, the usability of the KoreAR application is acceptable.

Based on Figure 5(b), almost all respondents strongly disagree and disagree on the negative statement of the usability of the application such that the application was unnecessarily complex or there was too much inconsistency in the application. Only a few respondents were neutral about the negative statements about the application’s usability. Thus, it can be said that the users did not encounter any issues when using the application. Lastly, the user acceptance test’s average usability score of 88.42 falls into the ‘Acceptable’ range on the SUS scoring scale, which can be concluded that KoreAR has completed user acceptance testing with positive responses from the target users.

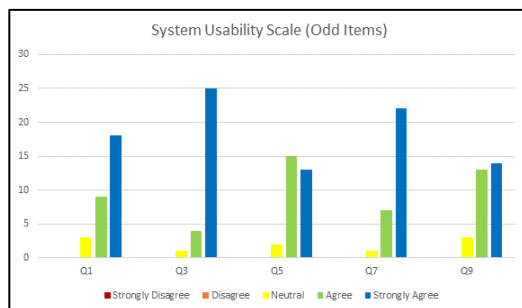


Figure 5(a): Analysis of positive questions

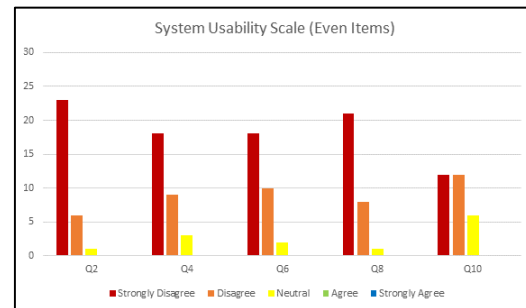


Figure 5(b): Analysis of negative questions

5. Conclusion

Based on the results analyzed from the testing phase, the KoreAR application is suitable for the target users to learn Korean alphabet. The three objectives of this project were fully accomplished by first implementing the augmented reality approach in designing KoreAR mobile learning application. Second, successfully developing KoreAR mobile learning application on Android platform using Unity game engine. Lastly, performing the functional and user acceptance testing after the development phase was completed. Multimedia Mobile Content Development (MMCD) methodology assisted this project to be completed on time. Additionally, the advantages and limitations of the KoreAR application are tabulated in Table 12. Last but not least, for future work, it is suggested that the additional Hangeul characters such as the compound vowels and double consonants can be included in the learning module. Moreover, a quiz module can be added to the application to increase the engagement of the users. Also, language selection function can be provided to let the application more applicable to other ethnic groups in Malaysia and around the world.

Table 12: Advantages and Limitations of the KoreAR Application

Advantages	Limitations
<ul style="list-style-type: none"> • Provides useful information for learning components of Korean alphabet, such as vowels, consonants, and vocabulary. • Compose of a high user acceptance level, where the target users agreed that the application is easy to use. • Provides high multimedia interactivity such as AR environment experience, 3D models interaction, textual instruction, and pronunciation audio. • Provides interactions such as drag, rotate and scale the 3D models. • Completely offline and no network connection required. 	<ul style="list-style-type: none"> • Does not include all vowels and consonants such as the compound vowels and double consonants. • There is no quiz module in the application. • Provides only a 3D model for each corresponding vowels and consonants vocabulary.

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Appendix A

Appendix A shows the results of the questionnaires for user analysis and user preferable features.

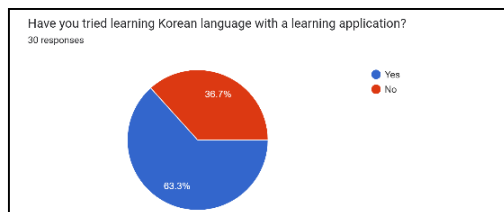


Figure 6(a): User experience analysis

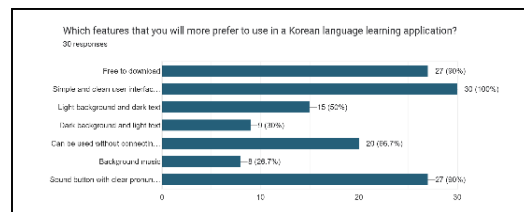


Figure 6(b): Preferable features

Appendix B

This section presents the content structure mentioned in section 3.2.

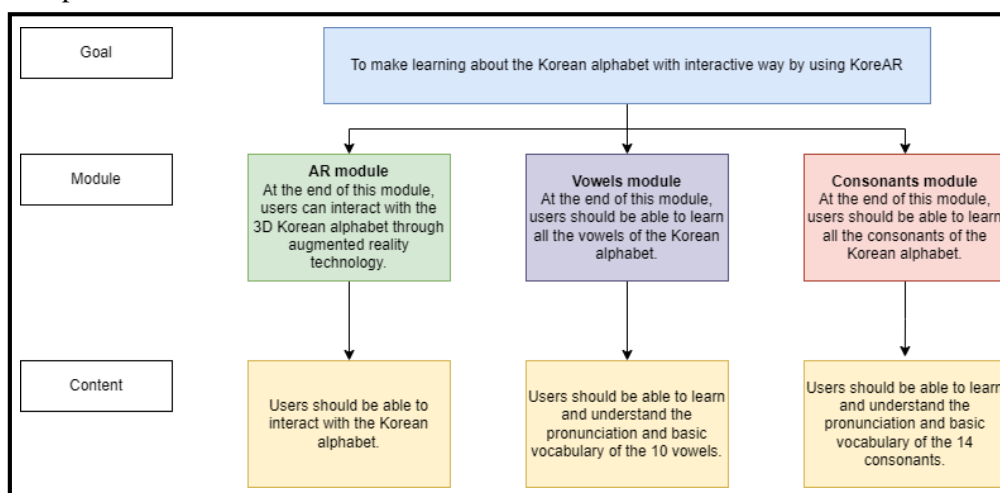


Figure 7: Content Structure

References

- [1] C. Blanco, “2021 Duolingo Global Language Report,” Duolingo Blog, December 6, 2021. [Online]. Available: <https://blog.duolingo.com/2021-duolingo-language-report/>. [Accessed Nov. 10, 2022].
- [2] I. Lee and S. R. Ramsey, *The Korean language*. Albany: State University Of New York Press, 2001.
- [3] Y. Chen, Q. Wang, H. Chen, X. Song, H. Tang, and M. Tian, “An overview of augmented reality technology,” *Journal of Physics: Conference Series*, vol. 1237, no. 2, p. 022082, Jun. 2019, doi: 10.1088/1742-6596/1237/2/022082.
- [4] A. Martín, “What Is An Isolated Language?,” Lingo Press Books, October 10, 2020. [Online]. Available: <https://www.lingopressbooks.com/blog/what-is-an-isolated-language/>. [Accessed Nov. 10, 2022].
- [5] S. Y. Choo, *Age and Korean Language Learners’ Use of Mobile Applications*. University of Hawai’i at Mānoa, 2021.
- [6] M. Sarrab, “Mobile Learning (M-Learning) and Educational Environments,” *International Journal of Distributed and Parallel systems*, vol. 3, no. 4, pp. 31–38, Jul. 2012, doi: 10.5121/ijdps.2012.3404.
- [7] A. Kim, “A Study on the Status Quo and Perception of Mobile Learning by Korean Language Learners in Chinese Universities.”, *Bilingual Research*, 81(0), 35-57, 2020, doi: 10.17296/korbil.2020..81.35.
- [8] H.-K. Wu, S. W.-Y. Lee, H.-Y. Chang, and J.-C. Liang, “Current status, opportunities and challenges of augmented reality in education,” *Computers & Education*, vol. 62, pp. 41–49, Mar. 2013, doi: 10.1016/j.compedu.2012.10.024.
- [9] K. Ahir, “What is the difference between Marker based and Markerless AR?,” Medium, September 6, 2021. [Online]. Available: from <https://kumarahir.medium.com/what-is-the-difference-between-marker-based-and-markerless-ar-192fb9fa09c5>. [Accessed Nov. 10, 2022].
- [10] (2018). *Korean Hangul (Version 1.6.4)* [Mobile app]. Retrieved from Google Play Store. <https://play.google.com/store/apps/details?id=com.korean.alphabet>.
- [11] (2021). *Learn Korean (Version 1.4.0)* [Mobile app]. Retrieved from Google Play Store. <https://play.google.com/store/apps/details?id=kr.co.noobee.hunmin>.
- [12] (2022). *LearnHangul (Version 1.10.5)* [Mobile app]. Retrieved from Google Play Store. <https://play.google.com/store/apps/details?id=com.evst.LearnHangul>.
- [13] W. S. N. S. Saifudin, S. Salam, and M. H. L. Abdullah, “Multimedia mobile content development framework and methodology for developing m-learning applications,” *Journal of Technical Education and Training*, vol. 4, no. 1, pp. 15-21, 2012. [Online]. Available: <https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/481>.
- [14] J. Brooke, “SUS : A Retrospective,” vol. 8, no. 2, pp. 29–40, 2013.