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Let's Play Huayue!: Learning Traditional Chinese Musical Instruments Through Augmented Reality

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Abstract

Traditional Chinese musical instruments are a diverse range of instruments that have been used in China for thousands of years as a key component of Chinese music. As Western musical instruments become more prominent in the media and are more frequently exposed on radio and television, today's youth are becoming more interested in them. Besides, there are very few mobile applications regarding traditional Chinese musical instruments currently. Hence, the proposed mobile learning app "Let's Play Huayue!" aims to revitalize interest in traditional Chinese music and its instruments through 3D augmented reality and informative content. Multimedia Mobile Content Development (MMCD) methodology is deployed to develop this application on the Android platform. The application is designed to help users aged 10 and above to learn about traditional Chinese musical instruments without having to physically approach them, as well as build a respect for Chinese culture. The results of user testing demonstrate a greater acceptability level, with an average percentage of 77.75%.

1. Introduction

Traditional Chinese musical instruments play a vital role in Chinese music. They consist of a diverse range of instruments that have been utilized in China for centuries [1]. Today, young people are showing a growing interest in Western musical instruments as the instruments are more popular in modern music genres and frequently featured in the media, including radio and television, unlike traditional Chinese music [2]. As a result, the lack of exposure to traditional Chinese musical instruments has led to a weaker attraction among the younger generation, resulting in a limited understanding of these instruments.

In addition, as compared to modern musical instruments, there is a limited selection of mobile apps in the application store that specifically cater to traditional Chinese musical instruments. Instead of solely focusing on traditional instruments, most similar apps combine modern and traditional instruments. Furthermore, the majority of existing apps feature 2D graphics. Therefore, an interactive mobile learning app provided with sound called Let's Play Huayue! has been introduced, which focuses on traditional Chinese musical instruments and incorporates 3D augmented reality (AR).

The objective of this project is to design and develop the content of Let's Play Huayue! application on the Android platform. Utilizing the Unity and Vuforia technologies, an augmented reality approach will be employed. Users aged 10 and above will participate in user testing for the developed application. The subject matter expert for this project is Mr. Soh Eng Hwa from Muar Chung Hwa High School. This application will be delivered in English.

The application consists of three modules: Learn module, Quiz module and Mini Game module. In the Learn module, there will be a list of seven Chinese instruments. For each instrument, there will be a voiceover pronouncing the instrument's name, an accompanying image, and a detailed description. Moreover, user can access the AR scene to view the 3D representations of the instruments by tapping the AR button in the Learn module. The AR scene is marker-based which required users to scan the image provided. However, only two musical instruments, the Gu and Pipa could be played within the AR environment. Next, the Quiz module features two types of questions, with a total of 14 questions available. The final score will be shown at the end of the quiz. Lastly, the Mini Game module is a game where the user needs to match cards within a time limit. For this project, the Multimedia Mobile Content Development (MMCD) methodology will be applied.

The study is divided into five sections which are introduction, relevant work, methodology, results and discussion, and conclusion. In the second section, the literature review of the study and comparison of existing applications with the proposed application are discussed. The third section will explain the chosen methodology for this project, while the fourth section will present and analyze the results of the user acceptance test. Finally, the fifth section will provide a summary of the article. This section will also cover the advantages, limitations, and future work of the application.

2. Related Work

In this section, the study domain, technology used and the comparison between existing applications and Let's Play Huayue! are presented.

2.1 Traditional Chinese musical instruments

Long ago, people believed music started with flutes mimicking birdsong. These flutes, like other early instruments, played a special role in rituals, reflecting the idea of music connecting to the universe. In the Zhou Dynasty, fancy-looking instruments and orchestras emerged, showing how music grew [3]. Chinese orchestras, called Huayue tuan, are vital for keeping traditional Chinese music and instruments alive. They play at events and festivals, but many quit the band due to studies and work. Keeping instruments in top shape is also expensive [4]. Many worships Western music and hold negative stereotypes about the traditional Chinese musical instruments [5]. This lack of appreciation makes it hard for people to see the value and beauty of traditional Chinese music.

2.2 Technology Used

Alkhabra [6] stated that augmented reality (AR) is a technology that merges smart devices with specific software and programming to display virtual and real-world surroundings on smart devices. This technology utilizes different methods such as multimedia, 3D modeling, real-time tracking, and registration, among others. This integration enhances the real-world experience by adding virtual data [7]. This application implements marker-based AR, which is one of the two types of AR, the other being marker-less AR. Marker-based AR is an approach that utilizes physical objects known as markers or triggers as a frame of reference for the placement of AR content. It works by using cameras and the marker itself to function effectively [8]. The markers can be either paper-based or actual objects that exist in the physical world [9].

Besides, mobile learning technology is used in this project. Mobile learning, also known as M-learning, refers to a contemporary educational approach that utilizes mobile devices equipped with advanced communication technologies and user-friendly interfaces [10]. This innovative method of learning empowers students to actively participate in educational activities and access learning materials using their mobile devices, without being constrained by time or location. In contrast to the traditional classroom environment, M-learning offers students convenience and flexibility, enabling them to learn at their own pace. It plays a crucial role in enhancing the convenience and adaptability of the learning process. Consequently, numerous applications and services have emerged in recent years to support and enhance this technology [11].

2.3 Comparison Between Existing Applications and Proposed Application

The three existing applications which are Virtual Musical Instruments [12], Chinese Instruments [13] and Musical Instruments Sounds [14] are compared with the proposed application, Let's Play Huayue!. Table 1 is created to show the comparison between these applications.

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Table 1: *Comparison of existing applications with the proposed application*

Features	Virtual Musical Instruments [12]	Chinese Instruments [13]	Musical Instruments Sounds [14]	Let's Play Huayue!
Technology used	2D Approach	2D Approach	2D Approach	Marker-based AR with 3D approach
Mini game module	Do not provide mini game	Do not provide mini game	Provide jigsaw puzzle game	Provide pair matching card game
Platform	Android	iOS	Android	Android
Language	English	English	English, Spanish, Chinese, Japanese, German and Korean.	English
Modules	piano, drum, guitar, tablas, xylophone, pan flute, maraca, gong, Beat Maker, Instruments Slider, Saved Recordings and All Instruments	Contain learning module, music list module	Contain learning, quiz, and game module	Contain learning, quiz, and mini game module
Quiz mode	None	None	single mode	2 quiz mode
Description of instruments	Do not provide	Provide	Do not provide	Provide
Exit confirmation window	Provide	Do not provide	Do not provide	Provide
Strengths	• Able to create own music	• Consistent buttons. • Provide video	• Consistent buttons • Multiple language provided	• Consistent buttons • Interactive 3D models • 2 types of question
Limitation	• Cannot delete music recording • Lacks augmented reality technology	• Not available in Google Play Store • No sense of theme in application • Lacks augmented reality technology	• Lacks augmented reality technology • Does not provide exit button	• Only two instruments can be played

Based on Table 1, Let's Play Huayue! is the only app that uses augmented reality technology with a 3D approach. The other apps use a 2D approach. In terms of mini games, Let's Play Huayue! offers a pair-matching card game, while Musical Instruments Sounds offers a jigsaw puzzle game. The other two apps do not have mini games. Let's Play Huayue! also provides a description of the instruments, including their origin, category, construction, and playing technique. On the other hand, Chinese Instruments only provides background and category information. The other apps do not include any information about the instruments. Lastly, Let's Play Huayue! has two types of questions, whereas Musical Instruments Sounds only has one type of question.

3. Methodology

Multimedia Mobile Content Development (MMCD) is the methodology employed for this project to shorten the development activities and ensure the application is created within the specified schedule. Figure 1 shows the process of MMCD methodology [15].

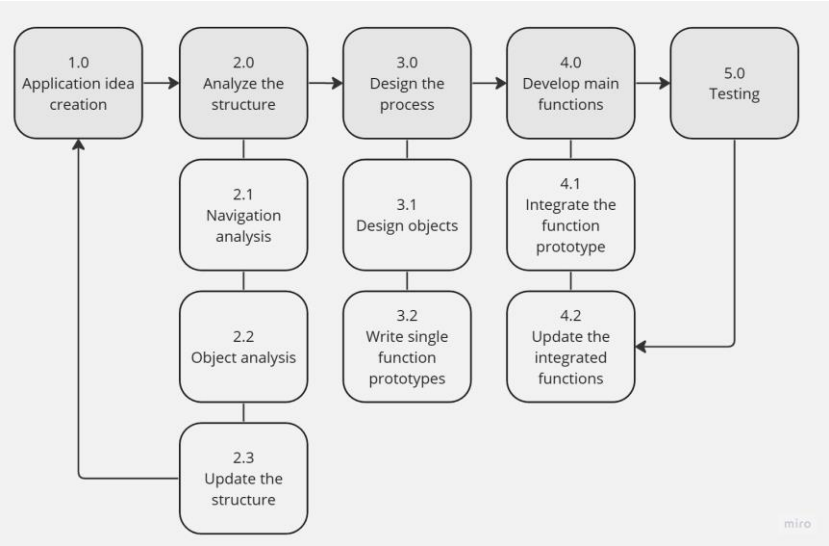


Fig. 1 *MMCD methodology [15]*

3.1 Application Idea Creation Stage

The MMCD approach starts by brainstorming the application concept, gathering crucial information, and then proceeding to analyse the structure, design, and development phases of the application [15]. The user analysis is conducted by interviewing the subject matter expert who teaches at Muar Chung Hwa High School. Table 2 shows the application idea creation checklist and Table 3 shows the user requirement analysis.

Table 2 *Application idea creation checklist*

Item	Description
Type of application	Mobile learning
Target device	Android OS Smartphone
Intended audience	General (Kids, teenagers, and adults)
User interface	Learning module, Quiz module, Mini Game module
Images	Background images of the homepage, Chinese musical instrument images
Video	None
Audio	Sound effect, sample audio clips, background music and voiceover for instruments
Application synopsis	Let's Play Huayue! is a mobile learning application that allows users to learn about traditional Chinese musical instruments that involve 3D augmented reality and recognize the sounds of each instrument. The application includes 7 musical instruments such as Pipa, Erhu, Xun, Guzheng, Guqin, Dizi (Chinese flute) and Drum.

Table 3 *User requirement analysis*

Stakeholder category	Role in product	Design implications	Actions needed
Subject Matter Expertise (SME)	Content consultant expert in the related field	Simple user interface design	• Use consistent color and button shape. • Use of a suitable font and font size. • Use icon-based button instead of text.
		Easy to navigate	• Provide the home button and back button. • Apply consistent button position such as back button located at upper left corner.
		Reliable content	• Use more graphical images to deliver content. • Offer correct information about instruments.
		Easy to learn	• Use simple words to deliver content. • The instruction of the game is clear and concise.

3.2 Analysis and Design

In this section, the application's navigation and object are thoroughly evaluated to prevent any negative impact on the rest of the development process. The functional and non-functional requirements of the application are tabulated in Table 4 and Table 5, respectively. Appendix A contains the flowcharts, content structure and navigation structure of the applications.

Table 4 *Functional requirements*

Functional requirements	Module	Description
User Interaction	Main interface	• The system shall provide users with the ability to start the application. • The system shall provide users with the ability to exit the application. • The system shall provide users with the ability to adjust the sound and music volume.
	Module selection interface	• The system shall provide users with the ability to select modules.
	Learn module interface	• The system shall provide users with the ability to click on the buttons to display the description of instruments. • The system shall provide users with the ability to interact with the 3D models. • The system shall provide users with the ability to press associated sound button to play the audio.
	Quiz module interface	• The system shall provide users with the ability to click on the button to answer the quiz.
	Mini Game module	• The system shall provide users with the ability to click the flipping cards.

Table 4 *Functional requirements (cont.)*

Functional requirements	Module	Description
Autonomous System Activities	Learn module interface	• The system should present 3D instruments models in the AR scene.
	Quiz module interface	• The system shall record the score obtained by the user. • The system shall move to the next question after the user answers.
	Mini Game module	• The application shall start counting down the time when the game begins. • The application shall show the success or failure interface after the game is ended.

Table 5: *Non-functional requirements*

Non-functional requirements	Description
Performance	• The time it takes to display the 3D model should not exceed three seconds.
Operational	• The application shall be run on any Android device with Android version 8 or higher.
Cultural	• The language utilized in this application shall be in English.
Legal	• The application restricts users from making any modifications to the information that is being displayed.
Usability	• The application should have a user-friendly interface that can be easily navigated.

3.3 Process Design

The main parts of this process design stage involve creating objects and writing single function prototype. In this project, Figma is used to design the buttons, Adobe Illustrator 2021 is used for designing the 2D graphics and the 3D models are created in Blender. Table 6 shows the button design in the application. In addition, the interface design also included in this stage which attached in Appendix B. Moreover, single function prototype is one of the major scripts in developing the proposed application. The code snippet for scene navigation is attached in Appendix C.

Table 6 *Button design*

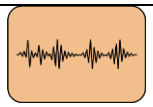
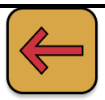
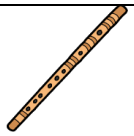
Button	Description	Button	Description
	This is the start button.		This is the close button.
	This is the setting button.		This is the sound button.
	This is the exit button.		This is the audio clip button in the quiz module.
	This is the Yes button.		This is the close button in description panel.
	This is the No button.		This is the voiceover button.

Table 6 *Button design (cont.)*

Button	Description	Button	Description
	This is the back button.		This is the home button.
	This is the replay button.		This is the learn module button.
	This is the AR button.		This is the quiz module button.
	This is the sample audio clip button.		This is the mini game module button.
	This is the Pipa instrument button.		This is the Xun instrument button.
	This is the Guqin instrument button.		This is the Gu instrument button.
	This is the Dizi instrument button.		This is the Guzheng instrument button.
	This is the Erhu instrument button.		

3.4 Main Function Development Stage

This section involves the development of assets such as asset development, 3D modelling, audio acquisition and editing. In addition, the key features of the integration of C# scripting in Unity will be described too as shown in Table 8.

Table 7 *Application asset development*

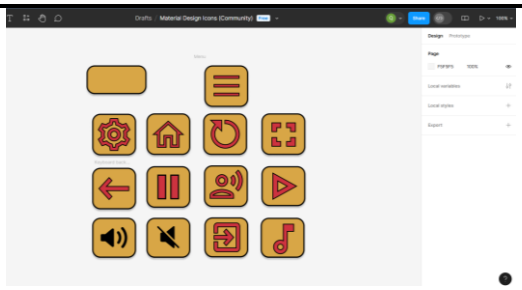
Assets	Development	Description
Graphics		The buttons icon design in the application are created in Figma online tool. Stroke effects are added to solidify the button.

Table 7 *Application asset development (cont.)*

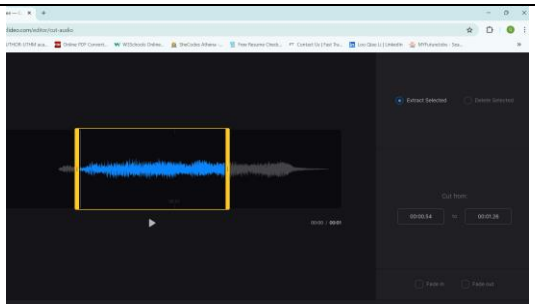
Assets	Development	Description
Audio		Audio such as background music, sample audio of the instruments and sound of the instruments are uploaded and edited in the online tool named Clideo.
3D models		3D models of instruments in the application are created using Blender. Some of the instruments are taken from online resource such as Sketchfab.

Table 8 *Integration of scripting in Unity*

Function	C# scripting	Description

Development of playable instrument	`void Update()`
	`{`
	`if (Input.touchCount > 0 && Input.touches[0].phase == TouchPhase.Began)`
	`{`
	`Ray ray = Camera.main.ScreenPointToRay(Input.GetTouch(0).position);`
	`RaycastHit Hit;`
	`if (Physics.Raycast(ray, out Hit)){`
	`btnName = Hit.transform.name;`
	`switch (btnName)`
	`{`
	`case "Front":`
	`myAudioSource.clip = aClips[0];`
	`myAudioSource.Play();`
	`break;`
	`case "Front1":`
	`myAudioSource.clip = aClips[0];`
	`myAudioSource.Play();`
	`break;`
	`case "Side":`
	`myAudioSource.clip = aClips[1];`
	`myAudioSource.Play();`
	`break;`
	`case "Side1":`
	`myAudioSource.clip = aClips[1];`
	`myAudioSource.Play();`
	`break;`
	`case "Side2":`
	`myAudioSource.clip = aClips[1];`
	`myAudioSource.Play();`
	`break;`
	`case "Side3":`
	`myAudioSource.clip = aClips[1];`
	`myAudioSource.Play();`
	`break;`
	`default:`
	`break;`
	`}`
	`}`
	`}`
	`}`
		When a touch is detected, a ray is cast from the camera to the touch position on the screen. This ray is used to determine if it intersects with any colliders in the scene. If the ray hits an object, the name of the object is retrieved. A switch statement is then used to decide which audio clip to play based on the object's name. This algorithm is implemented for both the Gu and Pipa instruments. In the case of the Gu, if the object's name is “Front” or “Front1“, the first audio clip “aClips [0]” is played. If the object's name is “Side,” “Side1”, “Side2“, or “Side3“, the second audio clip “aClips [1]” is played.

Answer checking in Quiz module	`public void UserAnswer(string answer)`
	`{`
	`StartCoroutine(AnswerCheck(answer));`
	`}`
	
	`IEnumerator AnwerCheck(string answer)`
	`{`
	`if (correctAnswer == answer)`
	`{`
	`currentScore = currentScore + correctScore;`
	`PlayerPrefs.SetInt("score", currentScore);`
	`sound.clip = correctSound;`
	`sound.Play();`
	`}`
	`else`
	`{`
	`sound.clip = wrongSound;`
	`sound.Play();`
	`}`
	`yield return new WaitForSeconds(1f);`
	`SceneManager.LoadScene(nextScene);`
	`}`
		The UserAnswer method initiates a coroutine named AnswerCheck to handle the user's response. Within the AnswerCheck coroutine, it verifies if the given answer matches the correct answer saved in the correctAnswer variable. If the answer is accurate, the player's score increases by the correctScore amount, and the new score is stored in PlayerPrefs with the key “score”.

Table 8 *Integration of scripting in Unity (cont.)*

Function	C# scripting	Description

Card Flipping	`public void PickAPuzzle()`
	`{`
	`if (!firstGuess)`
	`{`
	`firstGuess = true;`
	`firstGuessIndex = int.Parse(UnityEngine.EventSystems.EventSystem.current.currentSelectedGameObject.name);`
	`firstGuessPuzzle = gamePuzzles[firstGuessIndex].name;`
	`btns[firstGuessIndex].image.sprite = gamePuzzles[firstGuessIndex];`
	`}`
	`else if (!secondGuess)`
	`{`
	`secondGuess = true;`
	`secondGuessIndex = int.Parse(UnityEngine.EventSystems.EventSystem.current.currentSelectedGameObject.name);`
	`secondGuessPuzzle = gamePuzzles[secondGuessIndex].name;`
	`btns[secondGuessIndex].image.sprite = gamePuzzles[secondGuessIndex];`
	`countGuesses++;`
	`StartCoroutine(CheckIfThePuzzlesMatch());`
	`}`
	`}`
		The PickAPuzzle() function handles player interactions when choosing a puzzle card. It checks if it is the first or second guess using the boolean variables firstGuess and secondGuess. For the first guess, it sets firstGuess to true, finds the card's index, retrieves the puzzle name, and updates the button's image. For the second guess, it sets secondGuess to true, repeats similar actions, and increments the guess count. After both guesses, it starts the CheckIfThePuzzlesMatch coroutine to see if the puzzle cards match.

Countdown timer	`void Update()`
	`{`
	`if (timerIsActive)`
	`{`
	`currentTime -= Time.deltaTime;`
	`countdownText.text = currentTime.ToString("00") + "s";`
	`if (currentTime <= 10)`
	`{`
	`countdownText.color = new Color(0.5f, 0.0f, 0.0f);`
	`}`
	`if (currentTime <= 0)`
	`{`
	`currentTime = 0;`
	`countdownText.text = "00s";`
	`StopTimer();`
	`if (!gameController.IsGameCompleted())`
	`{`
	`GameOver();`
	`}`
	`}`
	`}`
	`}`
		The Update() function updates the countdown timer during gameplay. Time.deltaTime reduces the timer. When the timer is 10 seconds or less, the countdown text turns dark red to show the player time is almost up. When the timer hits zero, it stops counting down, signalling that time is up.

Instrument name panel	`IEnumerator CheckIfThePuzzlesMatch()`
	`{`
	`yield return new WaitForSeconds(.2f);`
	`if (firstGuessPuzzle == secondGuessPuzzle && firstGuessIndex != secondGuessIndex)`
	`{`
	`rightSound.Play();`
	`btns[firstGuessIndex].interactable = false;`
	`btns[secondGuessIndex].interactable = false;`
	`btns[firstGuessIndex].image.color = new Color(0, 0, 0, 0);`
	`btns[secondGuessIndex].image.color = new Color(0, 0, 0, 0);`
	`if (instrumentNames.TryGetValue(firstGuessPuzzle, out string instrumentName))`
	`{`
	`gametime.StopTimer();`
	`instrumentNameText.text = instrumentName;`
	`instrumentNamePanel.SetActive(true);`
	`yield return new WaitForSeconds(2);`
	`instrumentNamePanel.SetActive(false);`
	`gametime.StartTimer();`
	`}`
	`CheckFinished();`
	`}`
	`else`
	`{`
	`wrongSound.Play();`
	`yield return new WaitForSeconds(.3f);`
	`btns[firstGuessIndex].image.sprite = bgImg;`
	`btns[secondGuessIndex].image.sprite = bgImg;`
	`}`
	`firstGuess = secondGuess = false;`
	`}`
		The CheckIfThePuzzlesMatch function checks if two specific puzzle cards are matched. If they are matched, the countdown timer stops and the instrument name panel is displayed for a few seconds. After that, the panel is disabled by using instrumentNamePanel.SetActive(false), and the countdown timer starts again.

3.5 Testing

There are two types of testing that will be done in the final stage of the MMCD methodology: functional testing and user acceptance testing. Functional testing is conducted by the developer during the development process. For user acceptance testing, a collection of questions was published on a Google Form and distributed to 30 target users after the project was completed. The questionnaire assessed User Acceptance Level and Learning Outcome Acquisition to determine user acceptance of the created application.

4. Results and Discussion

In this section, the results of functional testing and user acceptance testing will be covered. Table 9 shows the expected result, actual result, and correction for each relevant test in the application. The modifications required were done to fix any issues and guarantee the buttons function properly.

Table 9 *Functional Testing*

Test	Expected Result	Actual Result	Correction
Start button	Navigate to the module selection interface.	Works well as expected.	Not needed.
Close button	Close the panel.	Works well as expected.	Not needed.
Sound button	Mute and unmute the background music.	While the background music is muted, the sound effects are also muted.	backgroundMusicSource is assigned in the Inspector to ensure it controls only the background music.
Back button	Navigate to the previous scene.	Works well as expected.	Not needed.
Replay button	Retry the mini game module	Works well as expected.	Not needed.
AR button	Navigate to the AR scene.	Works well as expected.	Not needed.
Sample audio clip button	Plays the sample audio of the instruments in AR scene.	Works well as expected.	Not needed.
Learn module button	Navigate to the Learn module.	Works well as expected.	Not needed.
Quiz module button	Navigate to the Quiz module.	Works well as expected.	Not needed.
Mini Game module button	Navigate to the Mini Game module.	Works well as expected.	Not needed.
Scan the instrument's target image	3D instrument model is displayed on the target image.	Works well as expected.	Not needed.

Based on Table 9, most of the functional testing results related to button functionality and the AR scene in the app worked well. The only problem encountered was that the sound effects were muted when the sound off button, meant for muting background music only, was pressed. To fix this, the backgroundMusicSource in the Inspector was assigned to only manage the background music.

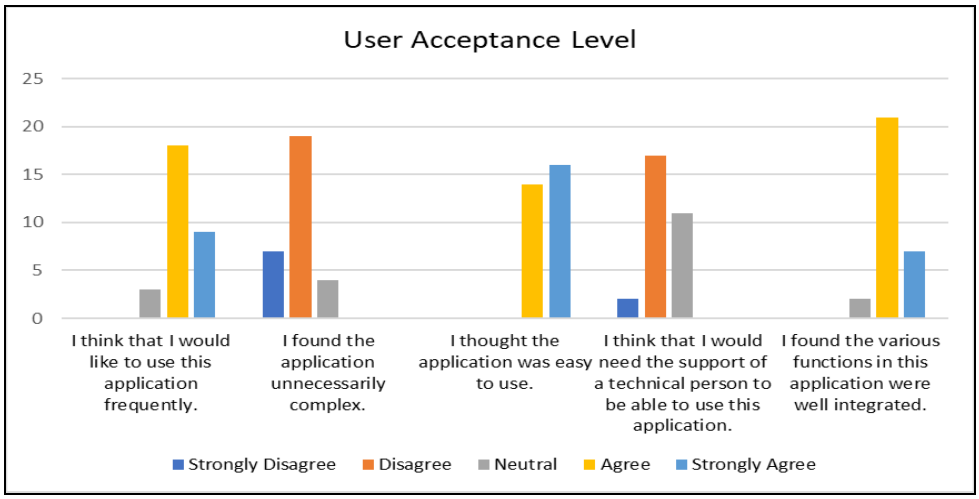


Fig. 2 *Results of questionnaire from Question 1 to 5*

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Based on Figure 2, the data reveals that most respondents (60%) expressed their agreement with the statement that they would like to use this application frequently. Following this, 30% of respondents strongly agreed, while 10% remained neutral. Turning to the statement regarding the application's complexity, most respondents (63.33%) disagreed, with 23.33% strongly disagreeing and 13.33% remaining neutral. Moving on to the next question, participants were asked about their perception of the application's ease of use. A significant majority (53.33%) strongly agreed that it was easy to use, while 46.67% simply agreed. Subsequently, respondents were asked if they required technical support to utilize the application. The majority (56.67%) disagreed with this statement, 36.67% remained neutral, and only 6.67% strongly disagreed. Lastly, when asked about the integration of various functions within the application, 70% of respondents agreed that they were well integrated. Additionally, 23.33% strongly agreed, and 6.67% remained neutral regarding this statement.

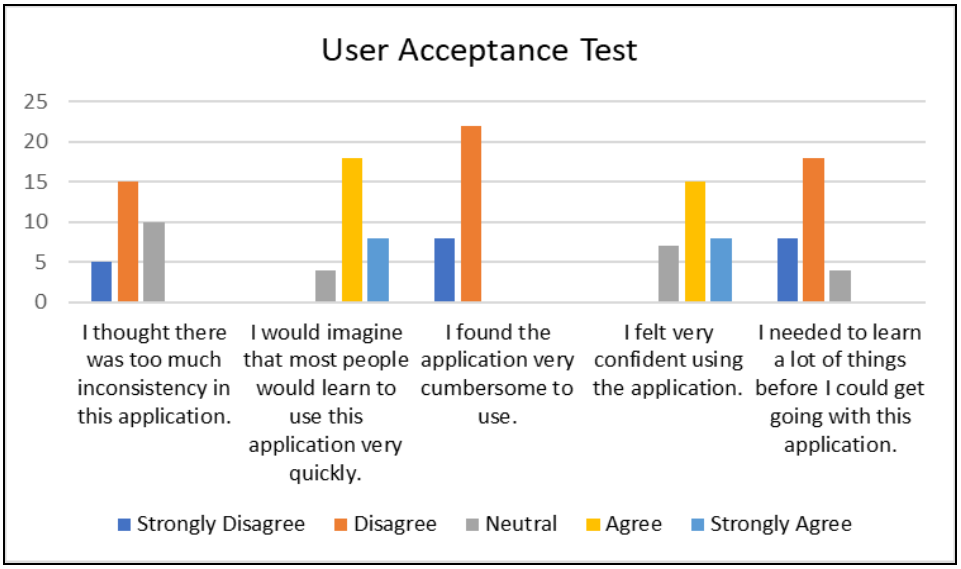

Fig. 3 *Results of questionnaire from Question 6 to 10*

The findings of the user acceptance test results for Questions 6 to 10 are illustrated in Figure 3. It shows that 15 respondents (50%) expressed disagreement with the statement of excessive inconsistency in the application, while 10 respondents (33.33%) remained neutral, and 5 respondents (16.67%) strongly disagreed. Subsequently, the survey questioned whether most individuals would learn to use this application quickly. Most respondents (60%) agreed, with 26.67% strongly agreed, and the remaining 13.33% maintaining a neutral answer. Regarding the claim of the application being overly cumbersome to operate, 73.33% of respondents disagreed, whereas 26.67% strongly disagreed. The subsequent query aimed to gauge users' confidence levels in utilizing the application. The results shows that 15 respondents (50%) agreed, 8 respondents (26.67%) strongly agreed, and 7 respondents (23.33%) chose the neutral option. Lastly, 60% of respondents disagreed the necessity of extensive learning prior to using the application, with 8 respondents (26.67%) strongly disagreeing, and only 13.33% remained neutral with the statement.

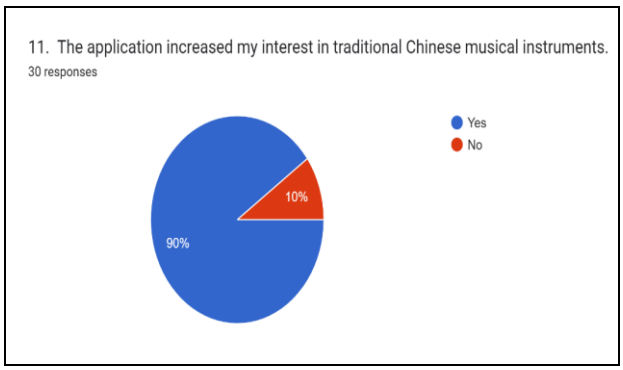

Fig. 4 *Learning outcome acquisition on increased interest in traditional Chinese instruments*

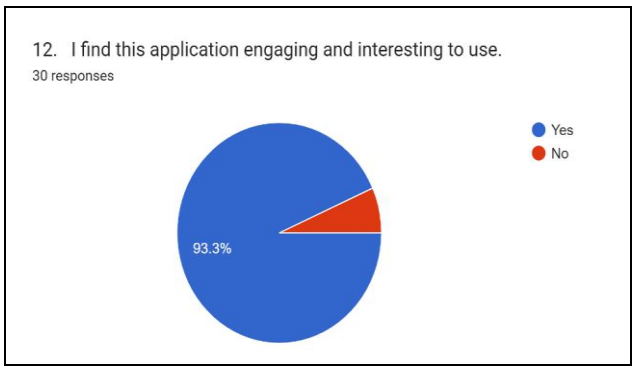

Fig. 5 *Learning outcome acquisition finding this application engaging and interesting to use*

Regarding the learning outcome acquisition based on Figure 4, 90% of respondents felt that the application increased their interest in traditional Chinese musical instruments, while only 10% disagreed. This indicates that the application successfully achieved its goal of boosting interest in these instruments. According to Figure 5, 93.3% of respondents found the application engaging and interesting, with only 6.7% disagreeing, showing that it effectively delivers an engaging user experience.

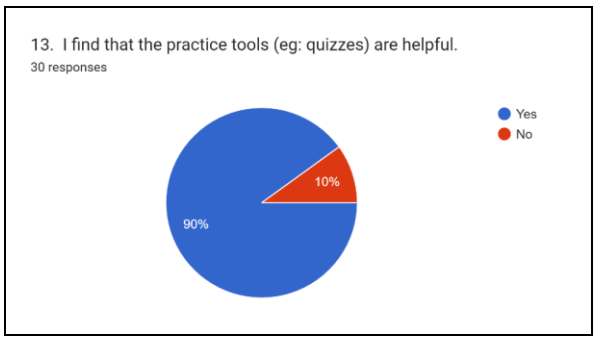

Fig. 6 *Learning outcome acquisition* on *finding the practice tools are helpful*

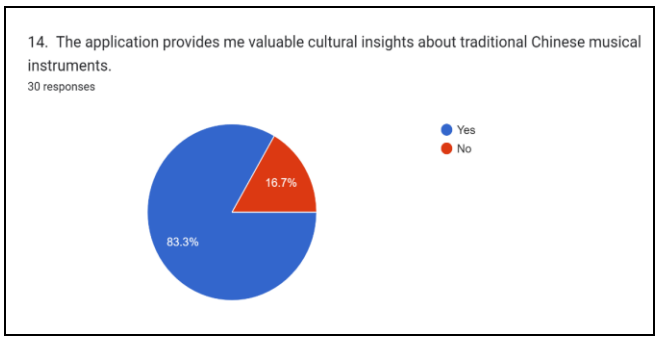

Fig. 7 *Learning outcome acquisition on providing valuable cultural insights about traditional Chinese musical instruments*

Figure 6 reveals that 90% of respondents found the practice tools helpful, with 10% disagreeing, suggesting the tools effectively assess users' understanding of traditional Chinese musical instruments, especially in recognizing them by sound. Lastly, Figure 7 shows that 83.3% of respondents agreed the application provides valuable cultural insights about traditional Chinese musical instruments, while 16.7% disagreed, indicating it effectively offers culturally enriching content.

The outcomes of the user acceptance testing were favorable, suggesting that the application is widely accepted as an educational tool for learning about traditional Chinese musical instruments.

5. Conclusion

In conclusion, the application Let's Play Huayue! achieved its objective based on the positive feedback from testing phase results. It is believed that the application could help users to learn about traditional Chinese musical instruments and spark their interest. One of the objectives is met by using a marker-based technique to show 3D instruments. Several online resources were employed to ensure the success of the Android development project. During development, functionality and user acceptance tests were performed on the intended user for running the application. The project followed the Multimedia Mobile Content Development (MMCD) methodology, ensuring timely completion. The application offers several benefits, such as the inclusion of interactive 3D instruments within the augmented reality (AR) scene. Additionally, it provides educational information that allows users to acquire knowledge about traditional Chinese instruments. Moreover, the application showcases realistic 3D models of these instruments, eliminating the requirement for physical viewing. However, there are certain limitations to the application. Firstly, it only offers two playable 3D instruments within the AR scene. Secondly, it is exclusively compatible with the Android platform. Lastly, the application features a limited selection of only seven instruments. For future improvements, it is recommended to add more Chinese instruments in the Learn module and expanding to iOS platform.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Loo Qiao Li, Rahayu A Hamid;* ***data collection:*** *Loo Qiao Li;* ***analysis and interpretation of results:*** *Loo Qiao Li, Rahayu A Hamid;* ***draft***

manuscript preparation: *Loo Qiao Li, Rahayu A Hamid. All authors reviewed the results and approved the final version of the manuscript.*

Appendix A

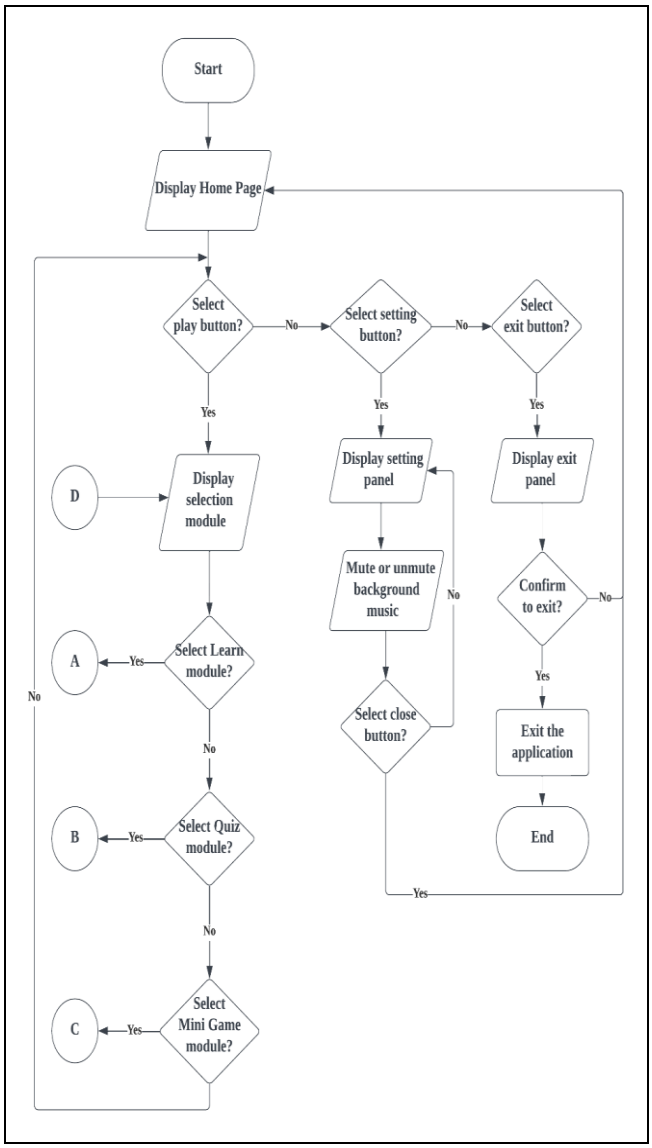

Fig. A1 *Main flowchart*

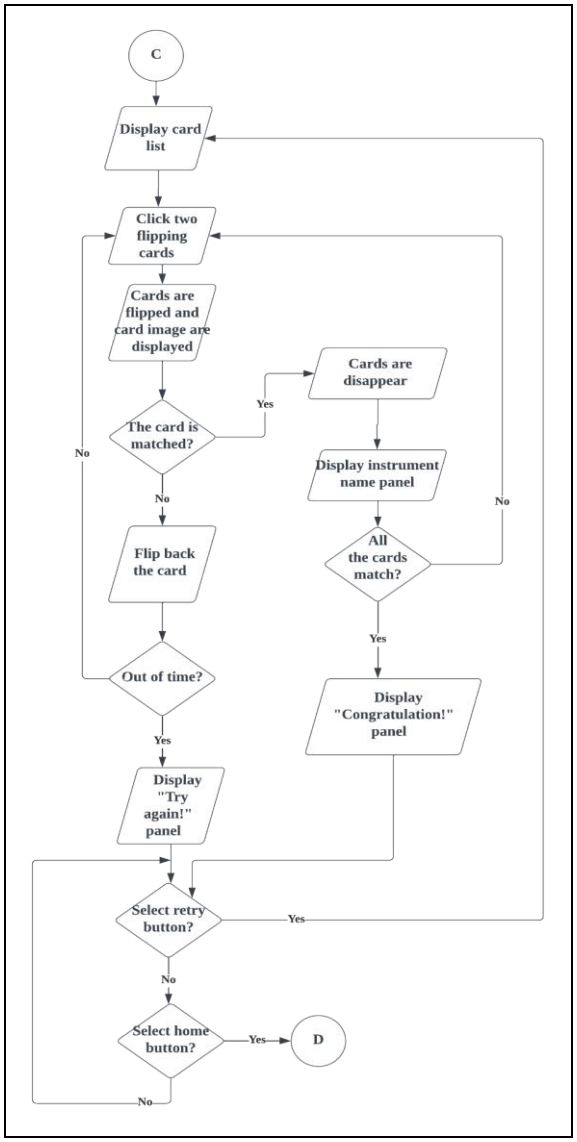

Fig. A2 *Flowchart of Mini Game Module*

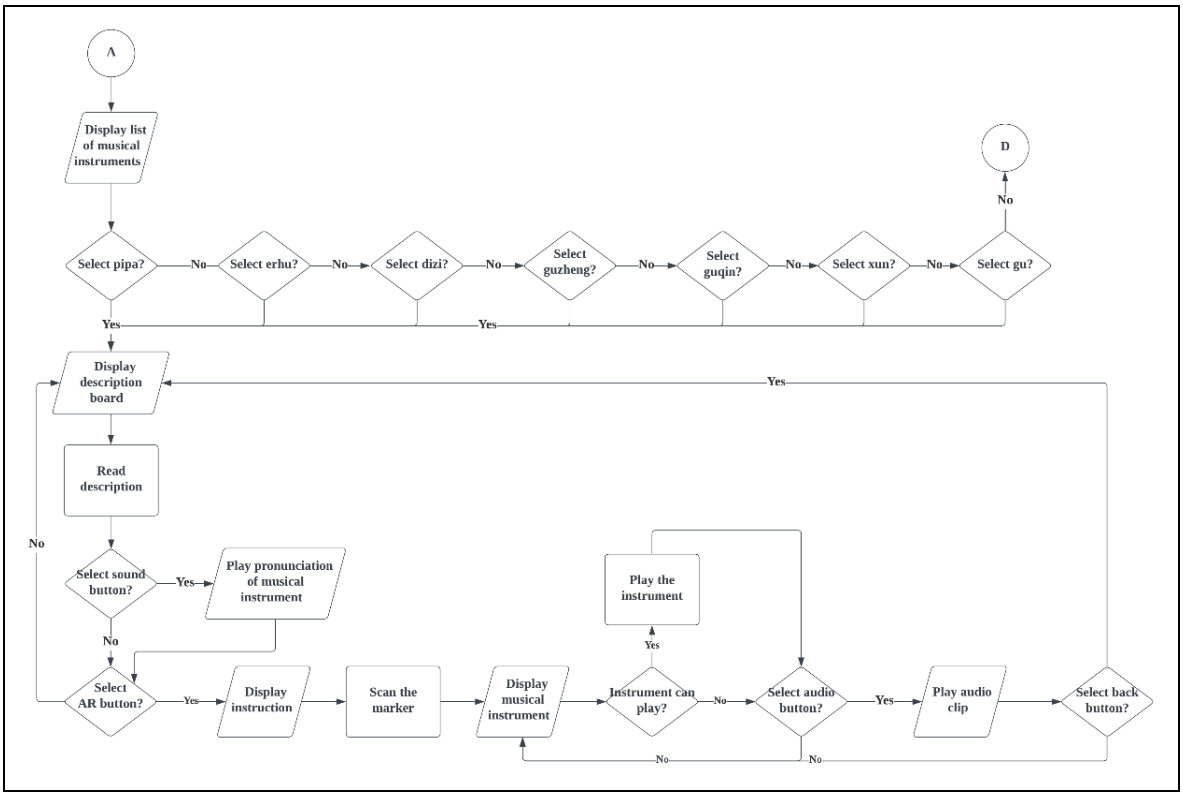

Fig. A3 *Flowchart of Learn Module*

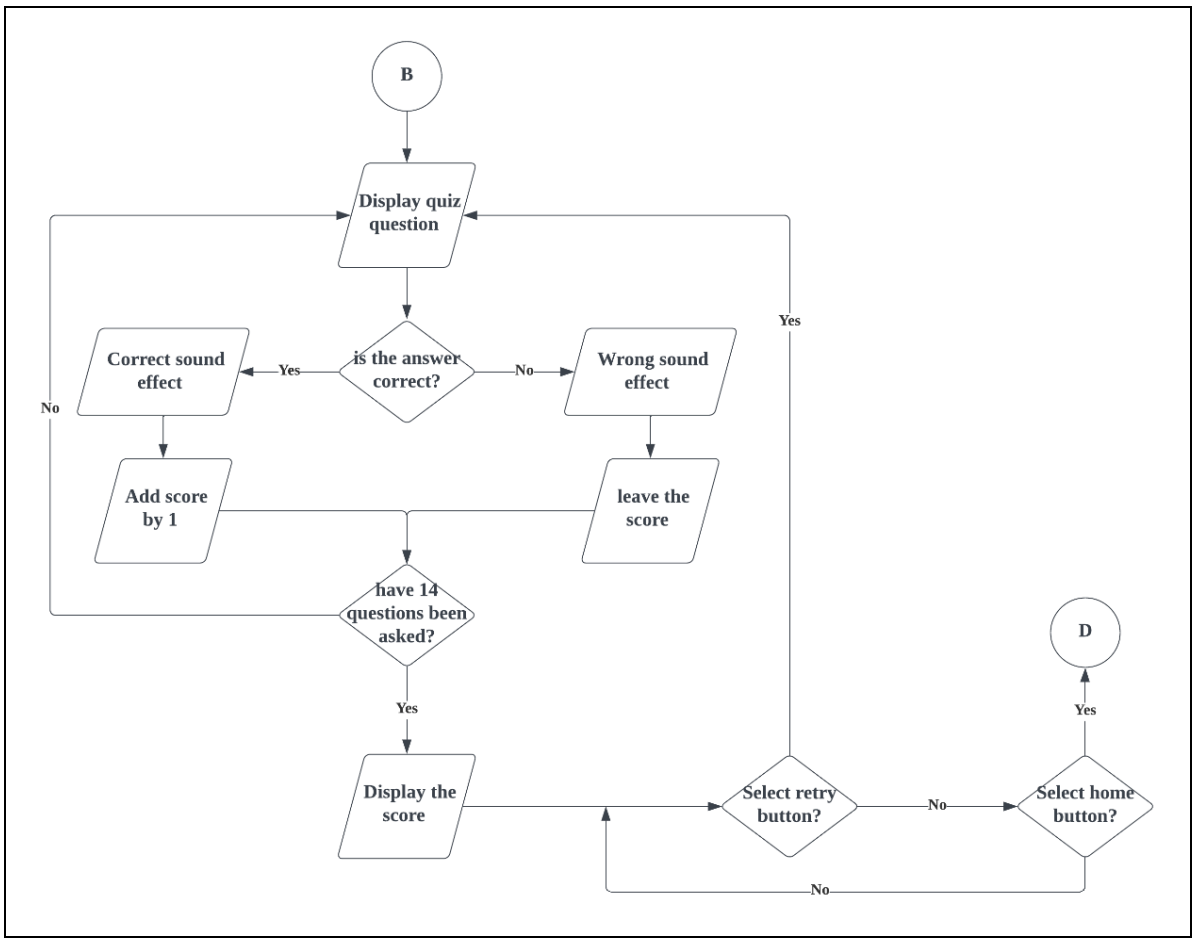

Fig. A4 *Flowchart of Quiz module*

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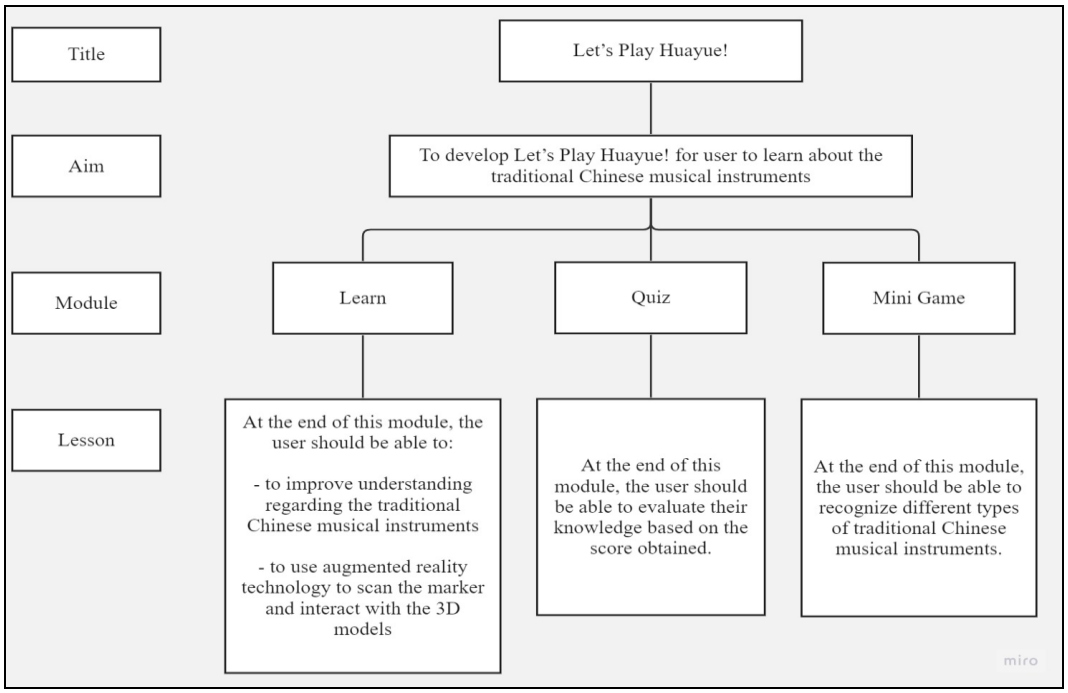


Fig. A5 *Content Structure*

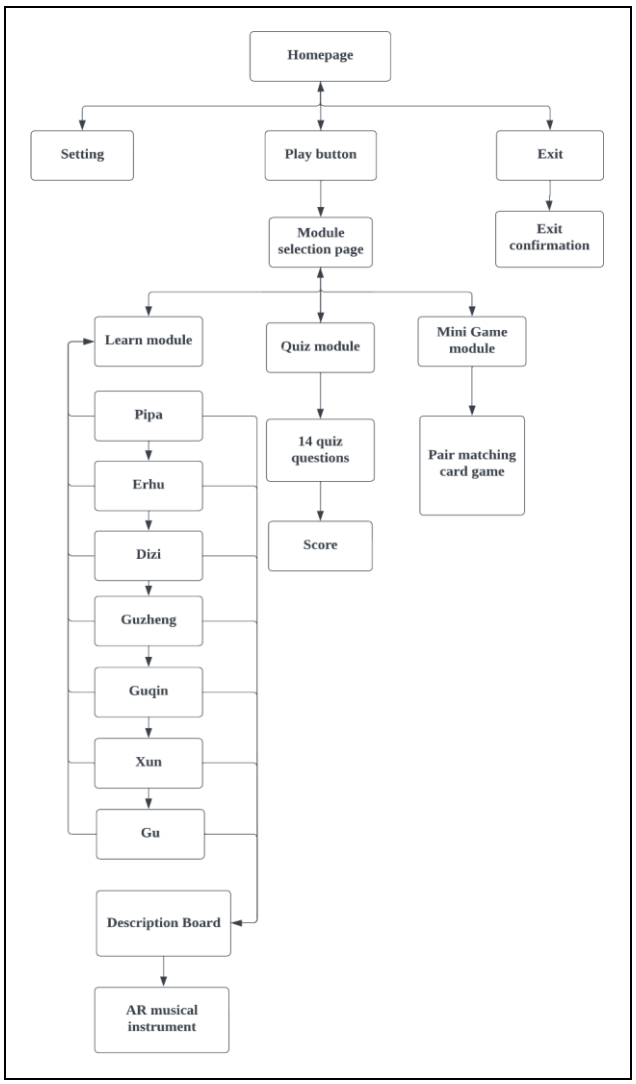
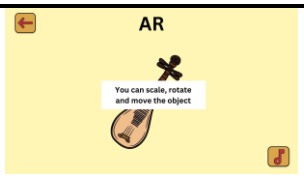
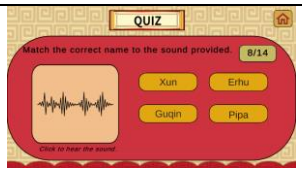
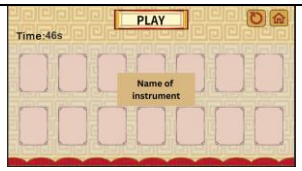
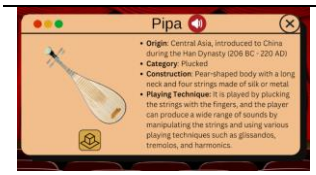


Fig. A6 *Navigation Structure*

Appendix B

Table 11 *Interface Design*

Interface	Description	Interface	Description
	This is the home page.		This is the AR scene.
	This is the setting page.		This is the Quiz module.
	This is the exit confirmation panel.		This is the Quiz module
	This is the module selection page.		This is the Score panel.
	This is the Learn module page.		This is the Mini Game module.
	This is the description panel.		This is the “Congratulations!” Panel.
	This is the “Try Again!” Panel		

Appendix C

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine.SceneManagement;
using UnityEngine;

public class ChangeScene : MonoBehaviour
{
    public void Scene(int sceneID)
    {
        SceneManager.LoadScene(sceneID);
    }
}
```

Fig. C1 *Code snippets for scene navigation in single function prototype*

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