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# Pocket Music Theory: The Development of Augmented Reality (AR) Basic Music Theory Learning Mobile Application

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**Abstract**: Augmented reality (AR) technology is widely used for educational purposes including music theory learning. However, in some music schools, for instance, The Sea Music Studio, the main music theory education material is still paper-based which causes issues like an inconvenience to carry, easy getting dirty and damage, especially for children. Hence, the basic music theory learning mobile application, namely Pocket Music Theory is developed on the Android platform to overcome the problems and allow the user to carry out music theory learning at any time anywhere. Multimedia Mobile Content Development (MMCD) is used as the methodology for developing the application. This application allows users to scan and learn music theory with marker-based AR and provide quiz and summary modules for practice and revision. Positive results are obtained from alpha and beta testing. According to the feedbacks in testing phase, future works should include more AR elements and higher music theory learning.

**Keywords**: Music theory, Mobile learning application, Augmented Reality

## 1. Introduction

Early research shows that music helps in child development such as empathy, emotional, certain complex locomotor skills and others [1]. Music can be categorized into practical skills and theory learning. Practical skills refer to the skill of an individual in playing a musical instrument while music theory acts as a language of music that allows the musicians to understand the music structure in a song. In 21-century, augmented reality (AR) technology is widely used in various industries including education fields. It is commonly implemented into electronic learning (e-learning) or mobile-based device learning (m-learning) and explains the entities or abstracts with the help of three-dimensional (3D) models.

In recent years, the m-learning application is especially common in education fields including music theory learning. However, in The Sea Music Studio, Seremban, Negeri Sembilan, the music theory learning materials, provided are still paper-based. Music theory books are prepared for every student according to their grades. The content in those music theory books only included static two-dimensional

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(2D) images and texts. According to research, the static content is less attractive compared to the dynamic content [2]. Moreover, paper-based learning materials are inconvenient in the carriage, and easily get dirt and damaged especially for children. Hence, a basic music theory learning application namely Pocket Music Theory is developed to allow the music theory beginners, especially kids to learn basic music theory. To achieve the aim above, several objectives had been set as follows. To design a basic music theory learning mobile application by implementing a visual learning style. The targeted user for the developed application is music theory beginner from age 7 to 9 years old. The application is developed in English and consists of three modules which are learning module, quiz module and summary module. Each module includes 4 topics. Marker-based AR technology is implemented only in the learning module. 3D models will be displayed once the user scans the marker.

## 2. Literature Review

The literature review is important in researching a particular topic. The comparison of several similar existing applications will be discussed in this section for analysis and reference purposes.

### 2.1 Basic Music Theory

Basic music theory is the starting lesson for a beginner with zero basic understanding of music theory. According to the reference books recommended by the Subject Matter Expert (SME) named Music Theory to Beginners Level A and Level B by Lee Ching Ching, the learning topics can be divided into 4 topics which are music clefs, notes values and rests, time signatures and music symbols. At the end of the session, the user will be able to recognize the music notes and symbols and understand their functions and usage [3].

In addition, both the music theory books provided several practice and exercises for each topic which aimed for supplementary revision after the basic music theory lesson [3]. The questions are presented in various presentation ways to lay a secure foundation in the learning of the basic music theory [3]. For example, name the music notes or symbols, count the beat in a bar, state the music notes values and others.

Music theory is a new language for beginners. Thus, it may be hard for them to understand and recognize the music notes and symbols, especially for children. According to research, dynamic reading materials are more attractive to children [2]. By using the implementation of augmented reality (AR) technology, it will more focus on interactivity using an image, animation, sound, and interaction mechanism, to make the concept easier to comprehend [4]. So, the user gets to learn in a more interactive and fun way which helps in increasing a user's learning effort and enthusiasm [5]. Hence, the use of AR technology in learning should be beneficial.

### 2.2 Marked-based Augmented Reality Technology

The early stages of augmented reality (AR) technology were based on markers. It is also known as marker-based AR. Marker-based AR needs an image to serve as a marker for camera recognition to show the digital virtual objects in the real-world environment and is used by software to pinpoint the virtual objects in a scene [6]. The marker is the most important thing in marker-based AR technology. A marker can be either a 2D picture such as banners, clear images, logos or pictures with easily derived visual attributes or natural things found in the actual world [7]. The most basic sorts of augmented reality markers are in black and white where a white square with a black border on the inside symbols or letters were written on it [8]. They can accommodate a wide range of different pictures while being quite easy to adjust. However, the program has limitations on the types of augmented reality markers that may be used, because certain algorithms are required to extract characteristics from the marker.

## 2.3 Comparison Between Existing Application and Proposed Application

Three existing applications are described in this section. These existing applications include Music Theory Helper [9], MyMusicTheory [10] and Learn Music Theory with Sonid [11]. Several elements of these existing applications are compared as shown in Table 1.

The proposed application (Pocket Music Theory) contained three types of modules, which are the learning module, a quiz module and a summary module. Features such as background music, the sound of musical instruments and tutorials are included in the proposed application to improve the user experience. The design theme of the application is suitable for the children (target users) with colourful and cartoons included.

**Table 1: Comparison between existing application and proposed application**

| Elements/ Applications | *Music Theory Helper* | *MyMusicTheory* | *Learn Music Theory with Sonid* | *Pocket Music Theory* |
|---|---|---|---|---|
| Operating systems | Android | Android and iOS | Android and iOS | Android |
| Target user | Not specific | Theory learners from grade 1 to 5 | Not specific | Beginner learners from age 7 to 9 years old |
| In-app purchases | In-app purchases | In-app purchases | In-app purchases | Free to use |
| Language | English, Italian, Russian, German, Swedish | English, German, Slovak | English, German | English |
| Internet connection | Not require | Not require | Require for certain functions | Not require |
| Background music | Not available | Not available | Not available | Available in quiz module |
| Tutorial guidance | Not available | Not available | Available | Available |
| Button Design | Consistent and clear to recognize the function | | | |
| Font | Easy to read as all text in sentence case | | | |
| Advertisements (Ads) | Not included | Advertisements included | | Not included |
| Augmented reality (AR) technology applied | No augmented reality (AR) technology is used | | | Marker-based AR technology is used |
| Strength | • Provide multi-languages<br>• Simple user interface | • Provide multi-languages<br>• Simple user interface | • Provide multi-languages<br>• Provide statistical record | • Free to use<br>• AR interaction in learning |

**Table 1: (continued)**

| | | | | |
|---|---|---|---|---|
| Weakness | • In-app purchase needed<br>• Less guidance provided | • Contain ads cause distraction<br>• In-app purchase needed<br>• Less guidance provided | • Complex user interface<br>• Contain ads cause distraction<br>• In-app purchase needed | • Only suitable for beginners<br>• Only provide single language |

## 3. Methodology

In this section, the chosen methodology that has been utilized for the proposed project will be discussed. Multimedia Mobile Content Development (MMCD) [12] was chosen to be the methodology of the development process for the proposed project. The stage of MMCD methodology is shown in Figure 1.

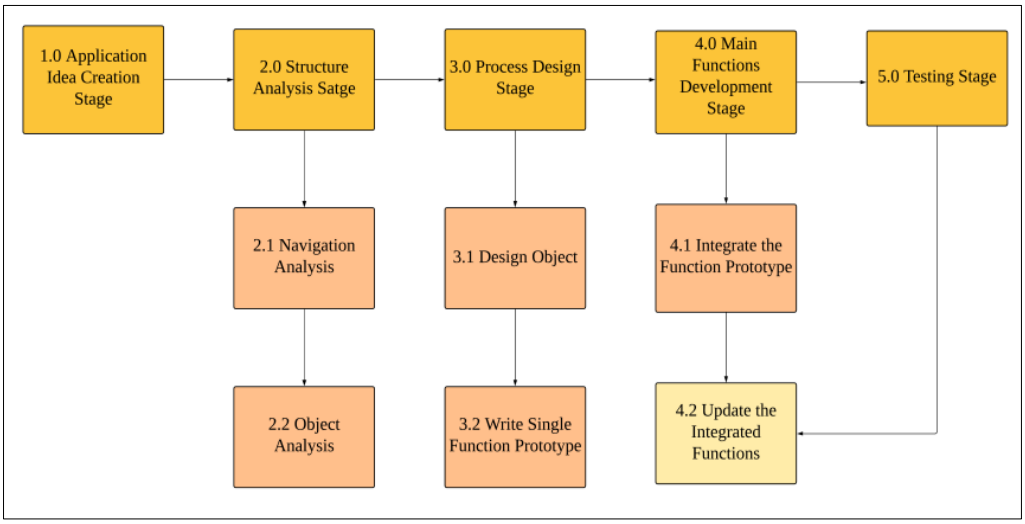



**Figure 1 : Multimedia Mobile Content Development (MMCD) model [12]**

### 3.1 Application Idea Creation

The application idea creation stage is the first stage of the Multimedia Mobile Content Development (MMCD) methodology. The main activities in this stage are identifying requirements and information needed in the developing process such as the user and application requirements. The application idea creation list is shown in Table 2 and the user analysis of subject matter experts and target users is in Table 3.

**Table 2: Application idea creation checklist**

| Item | Description |
|---|---|
| Type of application | • Mobile learning application |
| Target device | • Android mobile platform |
| Subject Matter Expert (SME) | • Madam Angeline Poon Ngan Yee, piano teacher and director of The Sea Music Studio |
| Unity 2020 | • Unity: 2020. 3. 12f1<br>• For application development |
| Blender | • For 3D modelling |

**Table 2: (continued)**

| | |
|---|---|
| Visual Studio 2019 | • For script writing |
| Canva | • For designing background images and button icons |

**Table 3 : User analysis**

| Stakeholder Category | Role in Product | Design Implications | Actions needed |
|---|---|---|---|
| Subject Matter Expert (Piano teacher with 25 years of teaching experience) | Content and design consultant expert in related field | Based on the interview, Easy to navigate | • Buttons shall be in combinations of text and icons.<br>• Contains simple and easy-to-understand navigation buttons such as home and back buttons.<br>• Buttons size shall be consistent. |
| | | Simple user interface | • Theme shall be attractive to children such as colourful and cartoon.<br>• The arrangement of content and buttons shall be neat and clean. |
| | | Easy learn | • Use simple English as required.<br>• Provide simple and clear tutorials and instructions.<br>• Clear graphics shall be provided as aids for better understanding.<br>• Provide a summary for each topic for revision. |
| | | Reliable content | • Use the suitable content as taught to music theory beginners.<br>• Avoid complex words.<br>• Add some extra notes such as italic terms that are common on music scores. |
| General user (Music theory beginners from age 7 to 9 years old) | End-user of the application | Based on the questionnaire, High mobility that can be used at any time anywhere. | • The application shall be able to be used offline.<br>• The application shall be able to download and use on the mobile phone.<br>• The application shall be implemented with augmented reality (AR) technology. |
| | | With the implementation of technology. | • The application shall be implemented with augmented reality (AR) technology. |

## 3.2 Structure Analysis Stage

The second stage in MMCD methodology is the structure analysis stage. The main activities in this stage are navigation analysis and object analysis. Navigation and object are both key characteristics of a well-structured MMCD. The failure of both these characteristics might cause problems in the design stage and delay the development progress. Figure 2 shows the navigation structure of Pocket Music Theory and the object checklist of the content structure shown in Table 4.

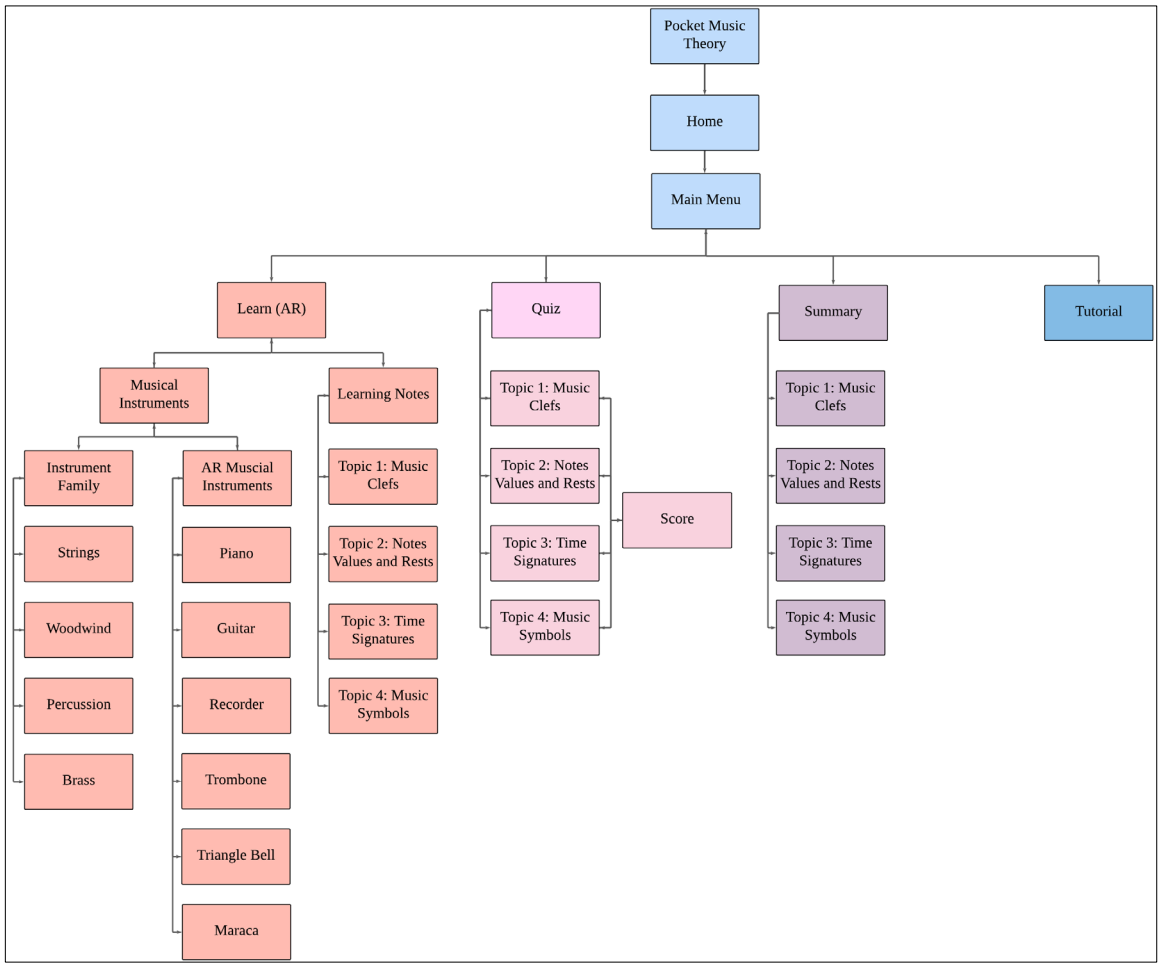



**Figure 2 : Navigation structure**

**Table 4 : Object checklist**

| Elements | Descriptions |
|---|---|
| GUI (Graphical user interface) | • Start interface, main menu interface, learn module interface, quiz module interface, summary module interface, tutorial interface, AR interface |
| 2D Images | • Button icons, background images, application logo, static images for note and quiz |
| 3D Images | • Musical instruments 3D models in Learn module (AR) |
| Audio | • Background music, musical instruments and beat counting audio |
| Writing | • Arial, Cheque |
| Colour | • Light colour (pink, purple, blue and orange) |

## 3.3 Process Design Stage

The third stage in MMCD methodology is the process design stage. The main activity in this stage is to prepare all the objects needed according to the checklist in section 3.2. The two sub-topics under this stage are designing an object and writing a single function prototype. Several tools such as Unity, Blender, Canva, and Visual Studio are used to design the object and script writing. Table 5 shows the button design used for the proposed application. All the buttons are designed using Canva, an online designing tool. Meanwhile, Table 6 shows the 3D models and augmented reality (AR) markers of musical instruments. The 3D models of the musical instruments are modelled using Blender 3D whereas

the AR markers are created using Canva. Both the 3D models and AR markers will be imported into Unity for the AR environment development. The flowchart of the application is shown in Appendix A.

**Table 5 : Button design**

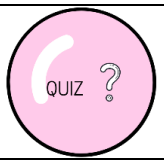
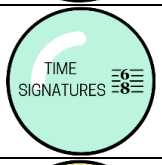
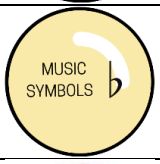
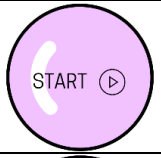
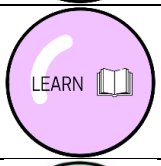
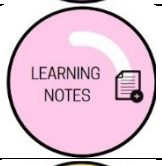
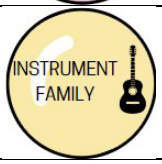
| Button | Function Description | Button | Function Description |
|---|---|---|---|
|  | This is the home button for navigating to the start interface. |  | This is the quiz button for navigating to the quiz module. |
|  | These are sound buttons for mute or unmute background music. |  | This is the summary button for navigating to the summary module. |
|  | This is the next button for navigating to the next page. |  | This is the topic 1 (music clefs) button. |
|  | This is the tutorial button. |  | This is the topic 2 (notes values and rests) button. |
|  | This is the back button for navigating to the main menu. |  | This is the topic 3 (time signatures) button. |
|  | This is the retry button for navigating to the previous quiz. |  | This is the topic 4 (music symbols) button. |
|  | This is the start button for navigating to the main menu |  | This is the AR button for navigating to the AR musical instruments menu. |
|  | This is the learn button for navigating to the learn module. |  | This is the learning notes button for navigating to the topic menu. |
|  | This is the musical instrument button for navigating to the musical instrument's menu. |  | This is the instrument family button for navigating to the instrument family menu. |

**Table 5 : (continued)**

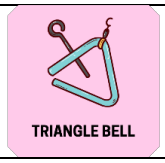
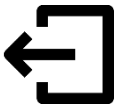
| | | | |
|---|---|---|---|
|   | This is an AR musical instrument button for navigating to the AR scene. |   | This is a musical instrument sound button to play the musical instrument's sound clip. |
|  | This is a time signature sound button to play the beat counting in time signature. |  | This is an exit button to display the exit panel. |
|   | This is a no button that hides the exit panel and returns to main menu. |   | This is a yes button that exits the application. |

**Table 6 : 3D models and AR makers of musical instruments**

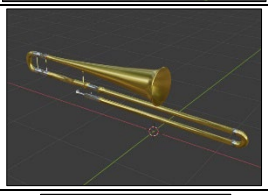
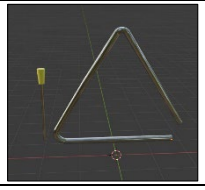
| 3D Models | Augmented Reality (AR) Makers | Result of 3D Modeling |
|---|---|---|
| Guitar |  |  |
| Recorder |  |  |
| Piano |  |  |
| Trombone |  |  |
| Triangle Bell |  |  |

**Table 6 : (continued)**

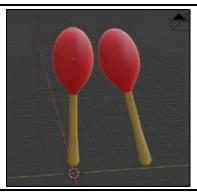
| | | |
|---|---|---|
| Maraca |  |  |

Figure 3 shows a single function prototype which includes in the proposed application. Since Pocket Music Theory is mainly about changing scenes by interacting with the navigation buttons, therefore, the prototype for scene loading should be written under a single function prototype. In the prototype, `UnityEngine.SceneManagement.` is added for writing the single function prototype. It is a library that handles the object `SceneManager` to control the behaviour of `LoadScene` with a parameter `scene_name`. For example, Home, MainMenu and others.

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

public class NextScene : MonoBehaviour
{
    // Start is called before the first frame update
    public void goToHome()
    {
        SceneManager.LoadScene("Home");
    }
    public void goToMain()
    {
        SceneManager.LoadScene("MainMenu");
    }
```

**Figure 3 : Single function prototype**

## 3.4 Main Function Stage

The implementation is discussed in this section. There are 2 main functions in this proposed application which are the application assets development and integration with scripting in Unity. The application assets development including 3D models, AR marker, Vuforia database and AR environment development in Unity. The script makes the application assets function well and perfectly linked to each other. Table 7 shows the application assets development in Pocket Music Theory. Sample scenes of the application are shown in Appendix B.

**Table 7 : Application assets development**

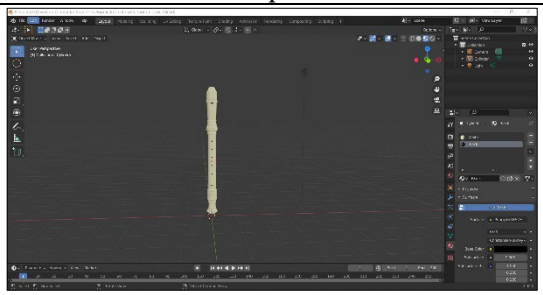
| Assets | Development | Description |
|---|---|---|
| 3D Models (Musical instruments) |  | The musical instrument models are created using Blender 3D by editing a 3D mesh. Then, material assigned with texture will be added to the edited mesh to make it look more realistic. Lastly, the 3D models will export into an fbx file and imported to Unity. |

**Table 7 : (continued)**

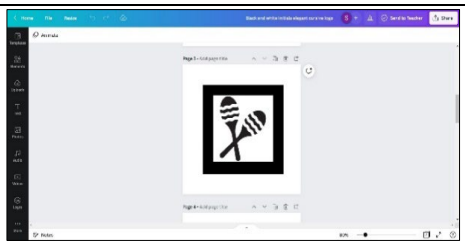
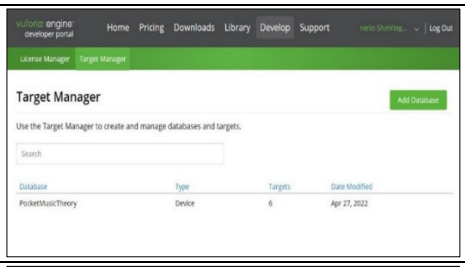
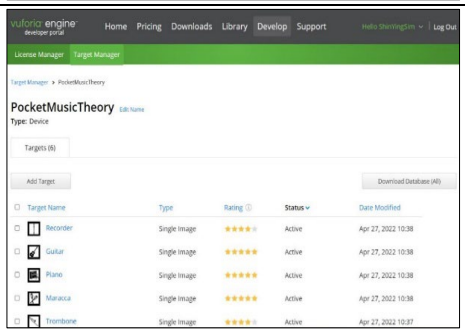
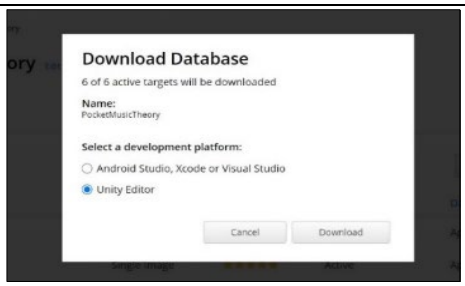
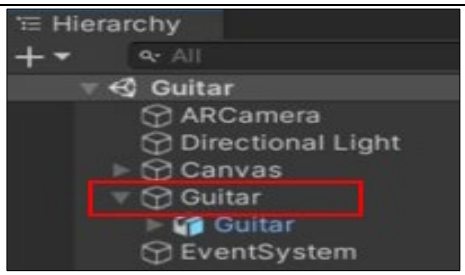
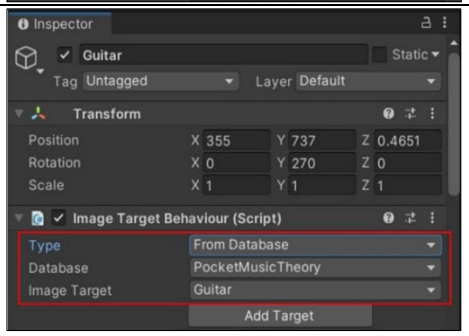
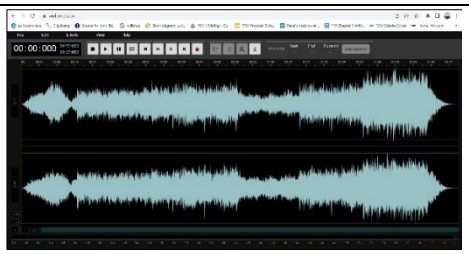
| | | |
|---|---|---|
| AR Markers |  | The AR marker is designed in black and white by using Canva. The AR marker is then downloaded as png file and converted to 8-bit grayscale images before uploading to Vuforia database. |
| Create Vuforia Database Account |  | Register an account and create a new device database under Target Manager. |
| Upload AR markers to Vuforia Database |  | The AR marker should be in 8-bit grayscale or 24-bit RGB of file type Joint Photographic Expert Group (jpg) or Portable Network Graphic (png) and the graphic file size should not be more than 2MB. The width of the uploaded graphic files should be on the same scale as the augmented virtual content and name the image target with a unique name. The target images will be rated by the Vuforia system. The higher the rating of the target image, the stronger the detection and tracking ability it contains. Thus, the target images must be 4 stars or above, so it is easier for the Vuforia to recognize and track this target. |
| Download Vuforia Database and Import into Unity |  | Download the Vuforia database in Unity Editor development platform and import the downloaded database into Unity. |
| Create Image Target Prefab |  | The AR scene in Unity should include AR camera and image target prefab. Game object with complete components and properties could be store in a prefab. The main camera will be deleted and replace with an AR camera. Meanwhile, image target prefab is used to store 3D models and act as AR maker. |

**Table 7 : (continued)**

| | | |
|---|---|---|
| Apply Vuforia App License Key into Unity |  | To allow the connection between Vuforia and Unity, App License Key is needed. The App License Key should be copied and pasted under Vuforia Configuration under Inspector of AR camera. |
| Inspector Setting of Image Target Prefab |  | In the Inspector of the image target prefab, change the database type under image target behaviour to 'from database' and select the Vuforia database that was downloaded from Vuforia earlier. Thus, different image targets could be selected from the Vuforia database, and the image targets will be displayed in the Unity scene. To add the 3D model onto the image target, the 3D model is exported from Blender 3D in Flimbox (fbx) file and imported into Unity Assets. The 3D model should be store in the image target prefab. Finally, the 3D model will show when the user scan on the image target which also known as AR marker to trigger augmented experience. |
| Background Music (Quiz Module), Sound of Musical Instruments and Beat Counting |  | The audio clips for musical instruments and beat counting are recorded using a phone recorder. All the audio clips are then uploaded to AudioMass for online editing which includes trimming and adding effects. The audio clips are then exported and imported to Unity Assets. |

Scripting is used to control some important functions that contain in Pocket Music Theory. For example, show and hide panel, quiz respond to selected option, update quiz score and question arrangement.

**Table 8 : Integration with scripting in Unity**

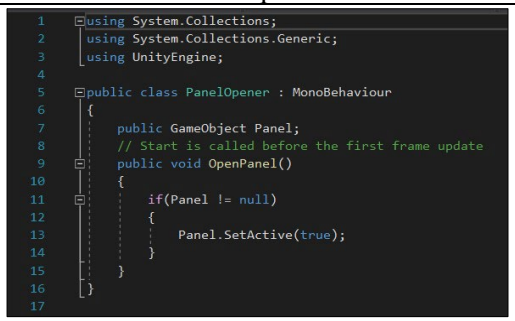
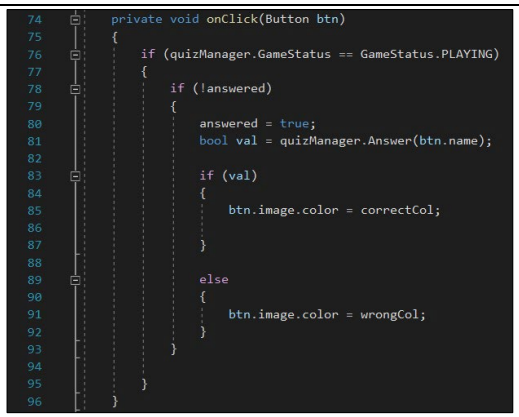
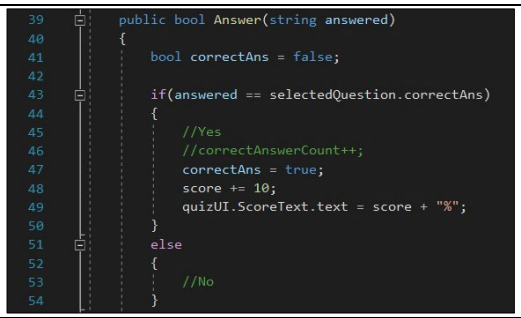
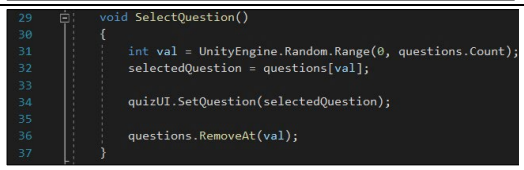
| Functions | Scripts | Descriptions |
|---|---|---|
| Show and Hide Panel (Exit Panel) |  | `PanelOperator.cs` is created for this function. A script is attached to the exit button where the `OnClick()` function is assigned with the runtime game object of Exit Panel. The exit button invokes the function of `OpenPanel()` where `Panel.SetActive(true);`. This indicates that once the exit button is clicked, the exit panel becomes active and visible. |

**Table 8 : (continued)**

| | | |
|---|---|---|
| Quiz Module<br><br>Quiz Respond to Selected Option |  <br>```<br>private void onClick(Button btn)<br>{<br>if (quizManager.GameStatus == GameStatus.PLAYING)<br>{<br>if (!answered)<br>{<br>answered = true;<br>bool val = quizManager.Answer(btn.name);<br><br>if (val)<br>{<br>btn.image.color = correctCol;<br><br>}<br><br>else<br>{<br>btn.image.color = wrongCol;<br>}<br>}<br><br>}<br>}<br>``` | The function only occurs when the game status is set to be `GameStatus.PLAYING`. if the question is answered and the answer is correct `btn.image.color = correctCol` will display green colour on the selected option button else `wrongCol` will display red colour on the option button. |
| Update Quiz Score |  <br>```<br>public bool Answer(string answered)<br>{<br>bool correctAns = false;<br><br>if(answered == selectedQuestion.correctAns)<br>{<br>//Yes<br>//correctAnswerCount++;<br>correctAns = true;<br>score += 10;<br>quizUI.ScoreText.text = score + "%";<br>}<br>else<br>{<br>//No<br>}<br>``` | The script that updates the quiz score is under `QuizManager.cs`. If the user picks the correct answer, it will trigger the statement of `score +=10`. Meanwhile, if the user picks the wrong answer, no marks will be recorded. |
| Question Arrangement |  <br>```<br>void SelectQuestion()<br>{<br>int val = UnityEngine.Random.Range(0, questions.Count);<br>selectedQuestion = questions[val];<br><br>quizUI.SetQuestion(selectedQuestion);<br><br>questions.RemoveAt(val);<br>}<br>``` | `SelectQuestion()` function controls the display of the quiz questions in random arrangement and removes the questions after they had been shown once. It provides all the questions with an integer using `int val`. |

## 3.5 Testing Stage

The proposed application was nearly completed for development. Testing was needed to be conducted to test the functionality of application elements and technology acceptance of the user on the proposed application. 2 testing involved in this stage is Alpha and Beta-testing.

Alpha testing is conducted throughout the development process by the developer to determine the functionality and effectiveness of the application. In Alpha testing, the developer tested the function of buttons, AR system and audio. The error will be fixed once it is found during the testing phase to ensure all the elements work well as expected. The results of alpha testing based on function of buttons, AR system and audio are shown in Table 9.

**Table 9 : Results of alpha testing**

| Test | Expected Result | Actual Result | Correction Action |
|---|---|---|---|
| Start button | Navigates to Main Menu scene. | The application successfully navigates into the Main Menu scene. | Not needed |
| Learn Module Button | Navigates to Learn Module scene. | The application successfully navigates into Learn Module scene. | Not needed |

**Table 9 : (continued)**

| | | | |
|---|---|---|---|
| Quiz Module Button | Navigates to Quiz Module scene. | The application successfully navigates to the Quiz Module scene. | Not needed |
| Summary Module Button | Navigates to Summary Module scene. | The application successfully navigates to the Summary Module scene. | Not needed |
| Tutorial Button | Navigates to Tutorial scene. | The application successfully navigates to the Tutorial scene. | Not needed |
| Exit Button | Shows the exit warning when clicked. | The application successfully shows the exit warning. | Not needed |
| Musical Instrument Sound Button | Plays the sound of a selected musical instrument. | Two sounds play at the same time when both buttons are clicked. | Make sure only one sound will be played at a time. |
| Musical Instrument Selection | The selected musical instruments will go to the AR camera scene to display the 3D models. | AR camera not functioning on mobile devices. | Make sure the API level and other Player Settings meets the requirement of the Vuforia AR Toolkit. |

## 4. Results and Discussion

This section presents the analysis of the testing phase. The testing phase is conducted in Alpha and Beta testing. Technology Acceptance Model (TAM) is applied in Beta testing to test the technology acceptance of the target user. Alpha testing is conducted by the developer whereas Beta testing involves the target user which is the beginner learners in music theory from age 7 to 9 years old.

Before the testing is conducted, the target user is asked to use the proposed application. A set of questionnaires is prepared according to the TAM concept that includes 4 different sections which are perceived ease of use, perceived of usefulness, attitude and behavioural intention. According to TAM research mode, the user's behavioural intention can be affected by the user's attitude which could be enhanced by focusing on the usefulness and ease of use of the application. As the target users are young and may not clearly understand the questions, they are asked to answer the questionnaires under the guidance of music teachers. The target user will only allow to fill in the questionnaires after they had experienced the application. In Appendix C shows that the application interface installed in different Android mobile phone.

Figure 4 shows the overall survey results collected for Section B, perceived of ease use in Beta testing. There are 4 questions in this section. Perceived ease of use refers to the level of easiness for the user to use the application. From the result of the survey, most of the user feels that Pocket Music Theory is ease of use. 14 respondents feel that Pocket Music Theory is easy to use. Learning to use Pocket Music Theory is easy which was supported by 14 respondents. Besides that, almost all of the respondents (14 users) also feel that Pocket Music Theory provide clear guidance on how to use the application. All the users feel that the operation of Pocket Music Theory does not require too much time.

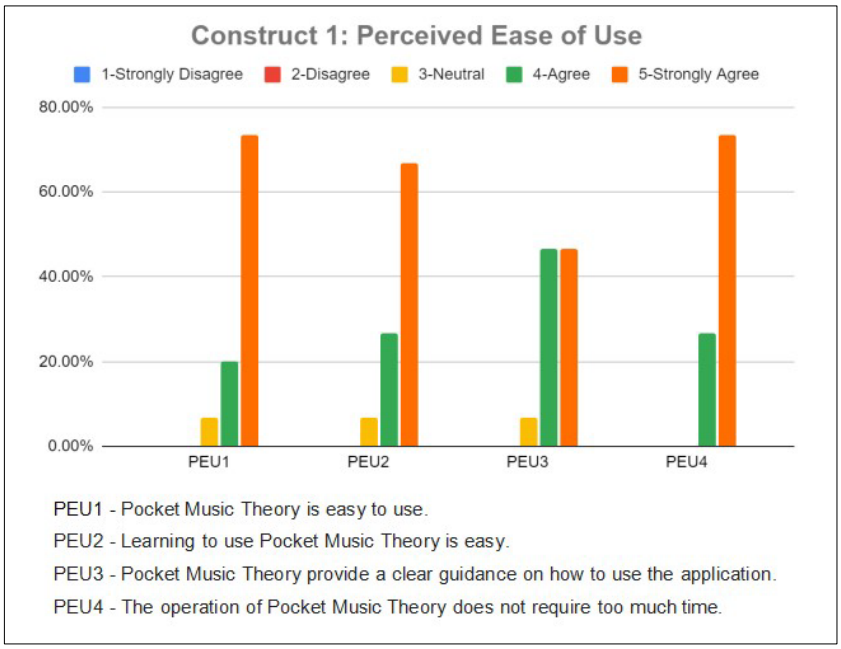



**Figure 4 : Analysis Section B: perceived ease of use**

Figure 5 shows the overall survey results collected for Section C, perceived of usefulness in Beta testing. There are 5 questions in this section. Perceived of usefulness refer to whether the application could help the users in learning basic music theory using Pocket Music Theory. According to the survey result, all the respondents (15 users) agreed that Pocket Music Theory helps them to recognise music clefs, music notes, time signatures and music symbols. Many respondents (13 users) feel that the application helps in learning the sound of different musical instruments. 12 respondents agreed that Pocket Music Theory helps in learning beating counting in various time signatures. Almost all the respondents (14 users) agreed on the application helps in increasing the proficiency in basic music theory and with the aid of Pocket Music Theory helps them to learn better.

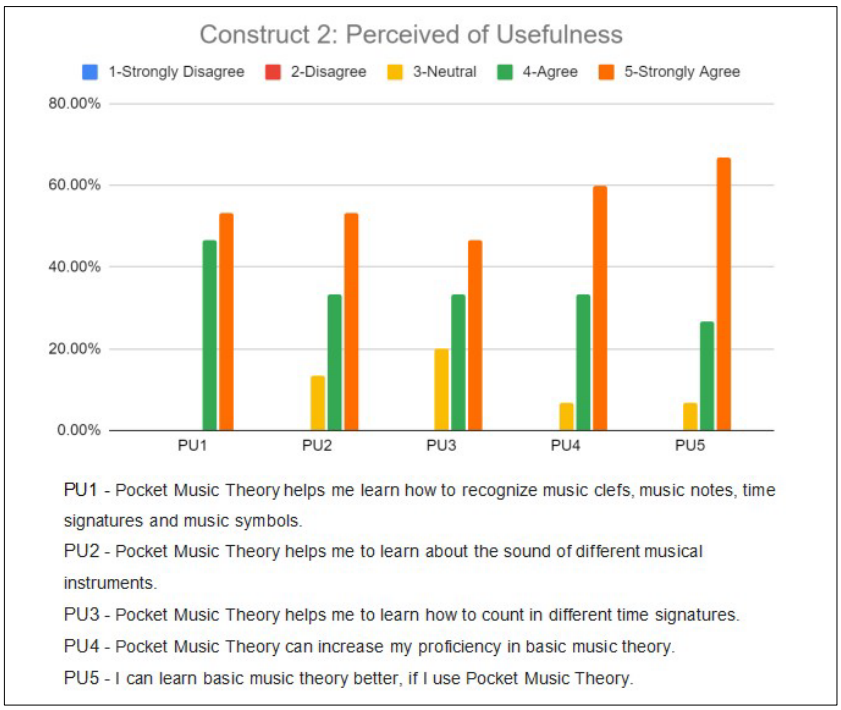



**Figure 5 : Analysis Section C: perceived of usefulness**

Figure 6 shows the overall survey results collected for Section D, attitude towards use in Beta testing. There are 3 questions in this section. Attitude toward use refer to the satisfaction level of the user when using the application in basic music theory learning. 14 respondents agreed that Pocket Music Theory is fun. Most of the respondents (13 users) agreed that the application provide a more interesting learning experience and they prefer to use Pocket Music Theory in basic music learning.

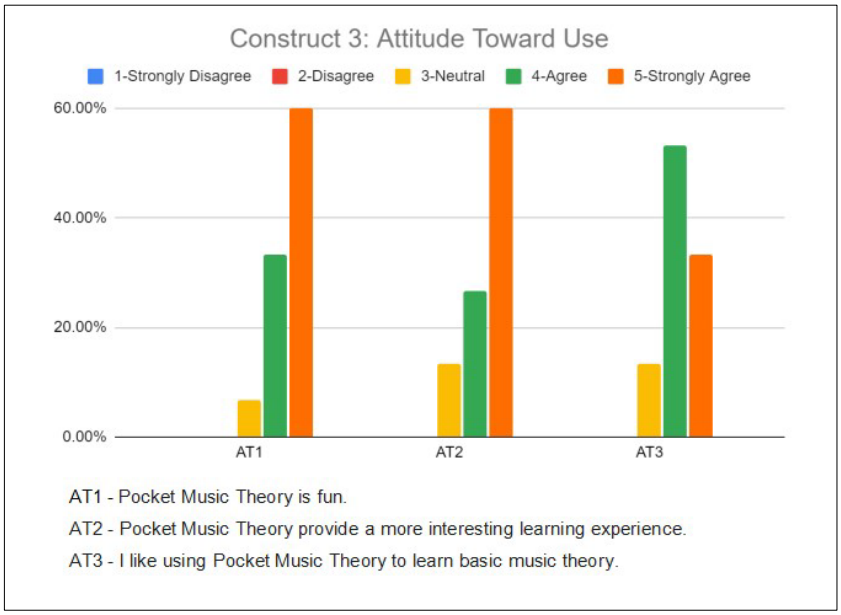



**Figure 6 : Analysis Section D: attitude towards use**

Figure 7 shows the overall survey results collected for Section E, behavioural intention in Beta testing. There are 2 questions in this section. Behavioural intention refers to the studies of users' intention to use Pocket Music Theory on a long-term basis. 13 respondents plan to use Pocket Music Theory in their basic music theory learning in the next 6 months and all the respondents would like to recommend this application to their friends.

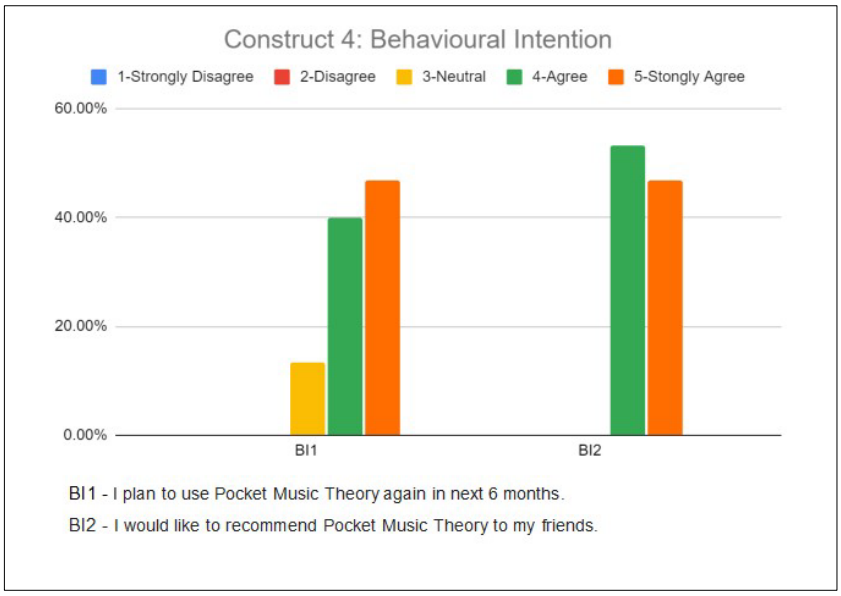



**Figure 7 : Analysis Section E: behavioural intention**

## 5. Conclusion

The last stage of Multimedia Mobile Content Development (MMCD) which is the testing phase is completely done. The survey results collected from the testing phase, show positive feedback from the target users. This indicates Pocket Music Theory could provide a positive outcome in learning basic music theory. Furthermore, the 3 main objectives of developing this application had been achieved.

Pocket Music Theory is a mobile learning application that is implemented with augmented reality (AR) technology which allows the users to learn basic music theory. Thus, the user can view the musical instrument in 3D models by using AR technology which provides a realistic effect. Besides, Pocket Music Theory provides a fun learning environment to the users compared to the traditional paper-based learning methods. It also provides the user with high multimedia interaction with the graphical response, textural instructions, and marker-based AR. Moreover, all the functionality of Pocket music Theory works well, and the user could carry out learning progress at any time anywhere.

Other than advantages, Pocket Music Theory has limitations too. Pocket Music Theory only covered the basics of music theory which is only suitable for theory beginners and grade 1. Besides, the quiz questions on each topic are limited to only 10 questions which could be finished within 10 minutes. In addition, the 3D models would disappear once the target is lost and the appearance of 3D models in the AR environment is not smooth. To improve the application, an update should be provided to increase the lesson content, and quiz levels which cover music theory grade 2 and above. Furthermore, the application is also suggested to be developed on other platforms such as iOS mobile and desktop platforms and apply animation in learning modules in the future. Lastly, hopes that the suggestions for future work discussed and listed could help to improve the applications and continue to do better in the future.

**Acknowledgment**

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

## Appendix A

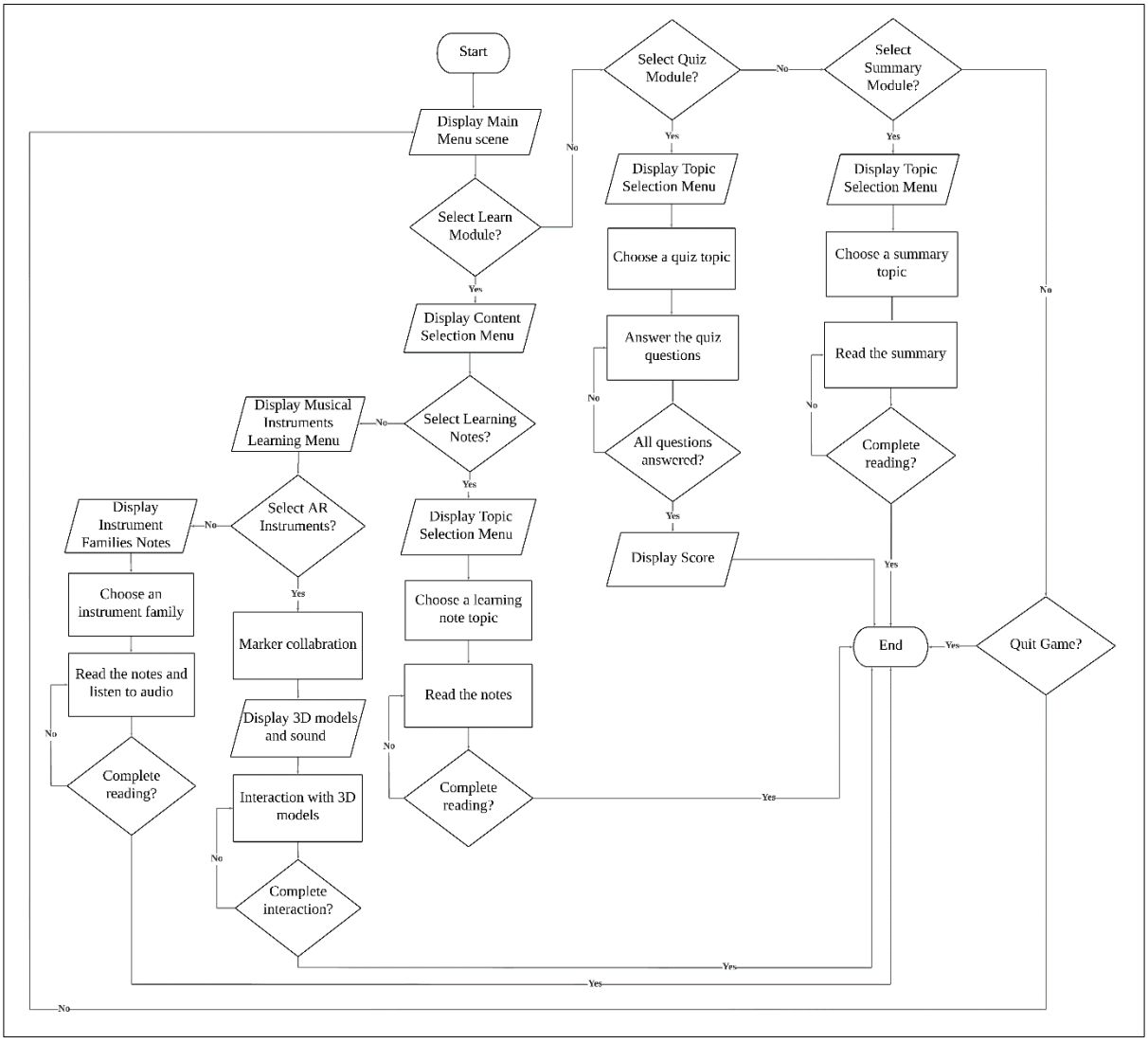



**Figure 1 : Flowchart**

## Appendix B

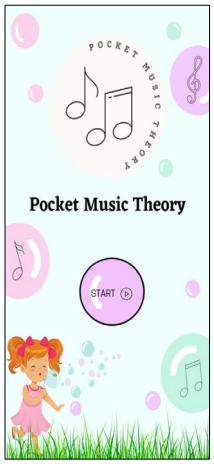



**Figure 2 : Start**

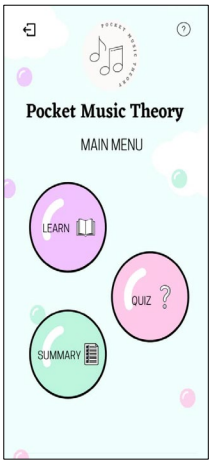



**Figure 3 : Main menu**

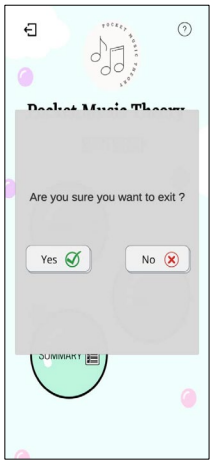



**Figure 4 : Exit Panel**

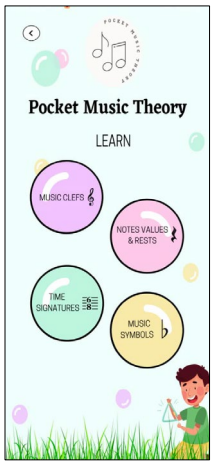



Figure 5 : Lesson Module

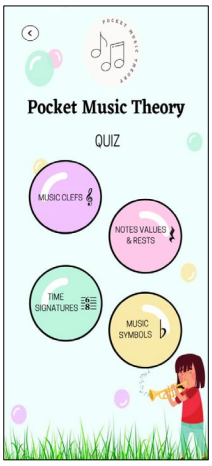



Figure 6 : Quiz Module

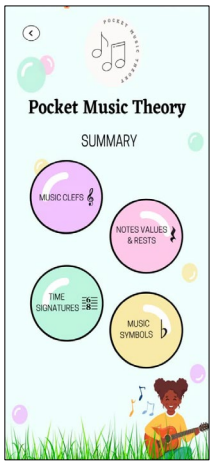



Figure 7 : Summary Module

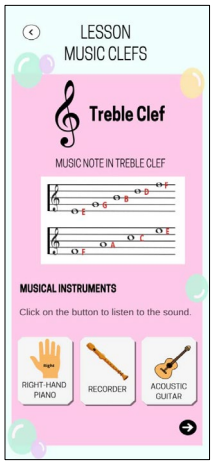



Figure 8 : Learning Note

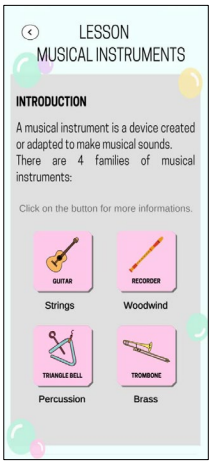



Figure 9 : Instrument Family

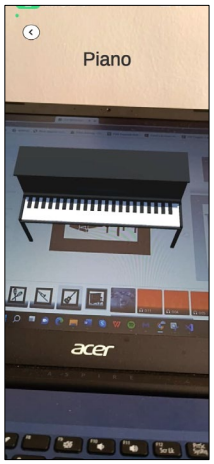



Figure 10 : AR Musical Instrument

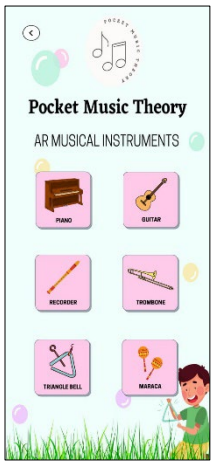



Figure 11 : AR menu

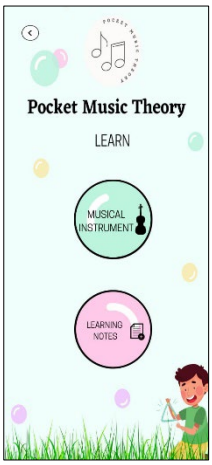



Figure 12 : Learn selection menu

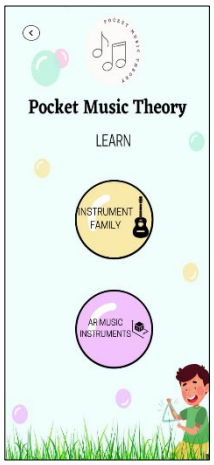



Figure 13 : Musical instrument menu


**Figure 14 : Quiz scene**

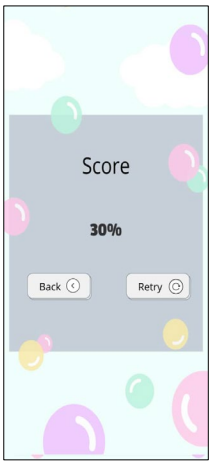



**Figure 15 : Score panel**

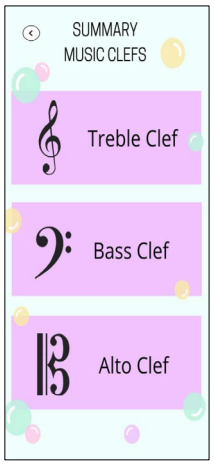



**Figure 16 : Summary scene**

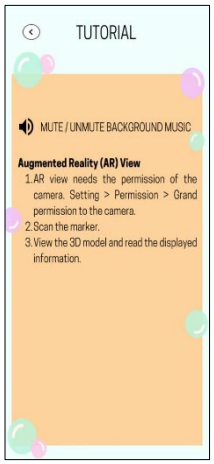



**Figure 17 : Tutorial**

## Appendix C

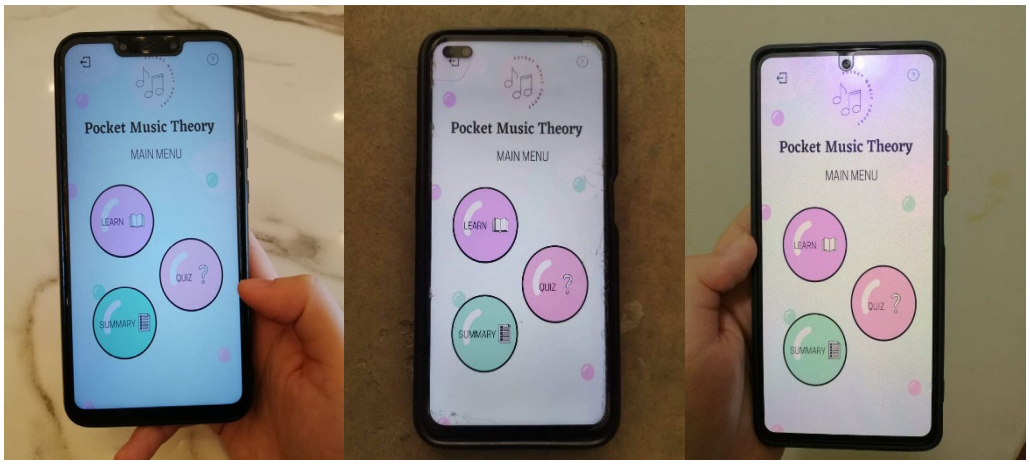



**Figure 18 : Application installed on different Android device**

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