

# Development of Volleyball Learning Application: Fun Volley by Using Augmented Reality Technology

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**Abstract:** Volleyball is one of the sports included in secondary school physical education (PE) subjects, specifically in Form 1 and Form 4 syllabi. However, the limited media in textbooks causes the loss of student interest in learning theoretical volleyball knowledge while the limited content cannot ensure the effectiveness of delivery of the whole subject matter. Therefore, this project proposes the development of a volleyball learning application named Fun Volley. The purpose of this Fun Volley application is to help volleyball learners to learn the fundamentals of volleyball using markerless augmented reality (AR) technology. Multimedia Mobile Content Development (MMCD) approach is used to develop the Fun Volley application. The user acceptance test shows a 72.98% average score for the developed application based on the System Usability Scale and more than 70% of positive feedback with the Technology Acceptance Modal. The future works included adding more AR elements and additional exercise modules.

**Keywords:** Volleyball, Mobile learning application, Augmented Reality, Markerless AR

## 1. Introduction

Volleyball is one of the most popular sports in the entire globe, second only to soccer [1]. It was invented in 1895 by William G. Morgan and was named mintonette initially [2]. In fact, volleyball is also included in the syllabus of physical education (PE) subjects in local secondary schools, specifically in Form 1 and Form 4. However, the time limitation of physical education classes and the static information in textbooks are insufficient to deliver the entire subject matter of volleyball. This is because the monotonous learning model with limited learning material and deficient supporting learning media reduce volleyball learners' interest in learning volleyball [3]. Furthermore, existing volleyball-related applications on the market focus more on volleyball training and gaming purposes but pay less attention to its theoretical content even though they are as important as volleyball skills to master this sport since volleyball games cannot be played without volleyball rules [4]. Science and technology can be applied to develop an interactive multimedia-based learning resource to provide a more fascinating learning experience while learning volleyball [5], for example, Augmented Reality (AR) technology.

In recent years, AR has been successfully applied in several sectors, including education, to improve the quality or user experience [6]. The application of AR in education may provide new learning environments and experiences while encouraging an interactive learning process since it integrates the actual world with digital content [7]. Nevertheless, the researchers show less interest in implementing AR in PE than in other subjects [8] even though it can enhance motivation, academic achievement, and receptivity in the subject matter [9]. Therefore, the volleyball learning application, Fun Volley is developed to deliver theoretical content of volleyball by using the AR approach.

The objectives of this project are to design the Fun Volley learning application using the visual and aural (VA) learning style, to develop Fun Volley by implementing AR technology on the Android platform, and to perform functional testing and user acceptance test on the target user for the developed application. The application is developed for volleyball beginners or players as self-learning material to help them learn the theoretical content of volleyball and enhance the learning experience with the AR approach. Among the two modules of the application, which are the Learn module and the Quiz module, only parts of the Learn module are integrated with the AR technology. The application is designed in English and supports Android-based mobile with Android 7.0 and above operating system.

The rest of the paper is organized as follows: Section 2 discusses the literature review of the related work and existing applications. Next, the methodology used to develop the application including the analysis and design is described in Section 3. Then, the implementation and testing are explained in Section 4. Finally, the last section concludes the current work and highlights the advantages, limitations, and suggestions for improvement in future work.

## **2. Related Work**

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

### **2.1 Volleyball**

Volleyball is a sport that is played between two competing teams consisting of six members on each side of the net where grounding balls on the opposite team's court will win them a score. The volleyball rules are approved by FIVB (Fédération Internationale de Volleyball) Congress, and it has always been evolving. The latest edition of official volleyball rules is the Official Volleyball Rules 2021-2024 which has been commissioned by the 37th FIVB World Congress [10]. The Rally Point System is implemented in volleyball where the team who wins the rally will gain a point. A team needs to obtain 25 scores with at least 2 points lead to win a set while winning three sets means winning the match. Besides, volleyball is a team sport where each player has their own role, which is known as position. Only when the learners truly understand the theories of volleyball, they will be able to immerse themselves in a volleyball game.

### **2.2 Technology Utilized**

Augmented Reality (AR) technology can combine the real-world environment with virtual information. Azuma [11] has defined AR with three characteristics, which are "combine real and virtual", "interactive and real-time", and "registered in 3D". The commonly used AR types are marker-based AR, and marker-less AR. Marker-based AR involves the process of a camera recognizing the markers in the real-world scene to render the virtual objects on top of the marker [12]. In contrast, markerless AR depends on the environment's real features to generate the overlaying virtual content on a flat surface. Hence, markerless AR provides more flexibility and a higher motion range than marker-based alternatives but with higher production costs and lower accuracy.

On the other hand, Visual and aural (VA) learning styles are used to develop the proposed application. The VA learning style is included as one of the bimodal learning styles in VARK modalities that were suggested by Fleming and Mills in 1987. It includes four sensory modalities in processing

information, which are Visual, Aural, Read or Write, and Kinesthetic. A learner can prefer one of the modalities or more than one modality whereas those who have more than one modality are known as multi-modal, which means they can alter their learning style depending on the situation [13]. Based on the research article by Joshi and Palkar [14], 61% of students be more partial to the multimodal learning style, while 31.50% of them prefer the VA bimodal learning style. Hence, Fun Volley aims to focus on visual and aural modalities only. It displays the information through graphics, animation, and audio to provide an interactive learning experience to volleyball learners.

### 2.3 Comparative Analysis

In this section, a comparison has been made between existing applications, namely, Learn Volleyball Techniques [15], Volleyball Dictionary [16], and What Sport is it? AR [17], and the proposed application. Table 1 compares the existing applications and the proposed application in terms of AR type, operating system, payment charges, multimedia elements, and the quiz module.

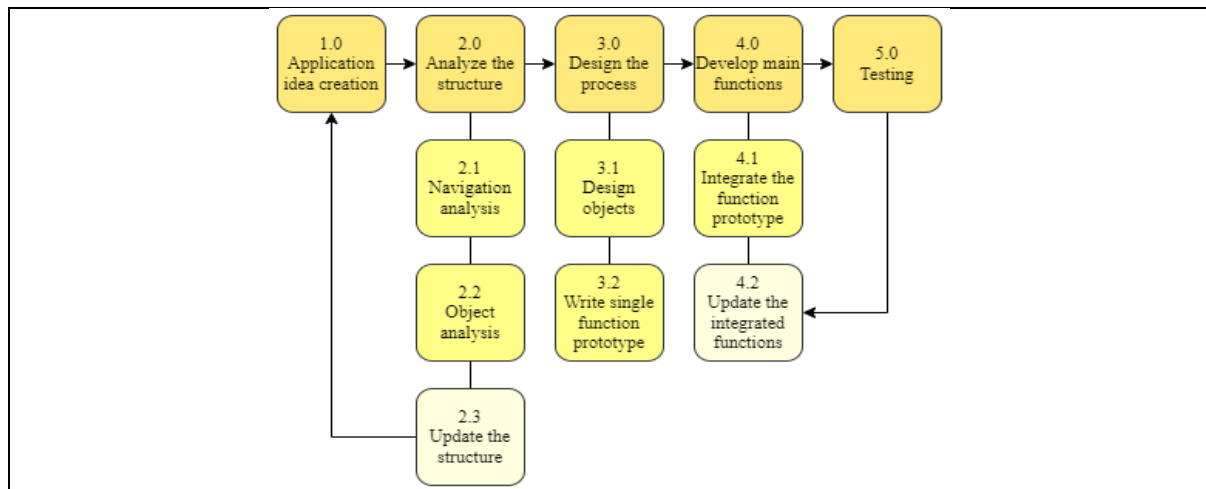
Based on Table 1, only the proposed application applies markerless AR technology. What Sport is it? AR application contains rich multimedia elements while Volleyball Dictionary contains a Quiz module. By combining the strengths, the proposed application will include rich multimedia elements, namely text, images, audio, and animation, and a quiz module with three different sets of questions.

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

Features	Learn Volleyball Techniques	Volleyball Dictionary	What Sport is it? AR	Fun Volley
Type of AR	Does not apply AR technology	Does not apply AR technology	Apply marker-based AR	Apply markerless AR
Operating system	Support Android 5.0 and above	Support Android 4.1 and above	Support iOS 9.0 and iPadOs 9.0 and later	Support Android 7.0 and above
Payment charges	Free to use	In-app purchase	Free to use	Free to use
Multimedia elements	Text and images are used	Text, images, and audio are used	Text, images, audio, and animation are used	Text, images, audio, and animation are used
Quiz modules	Does not contain any quiz module	Contain a Quiz module	Does not contain any quiz module	Contain a Quiz module

### 3. Methodology

Multimedia Mobile Content Development (MMCD) is chosen as the methodology to develop the proposed application as it is presented for the development of a multimedia mobile learning application that focuses on user needs [18]. Figure 1 illustrates the main phases of the MMCD methodology.



**Figure 1: MMCD Methodology**

### 3.1 Application Idea Creation

The first stage of MMCD methodology is the application idea creation stage. It gathers the required data before entering the design and development stages. In this stage, the user analysis was done by interviewing the Subject Matter Expert (SME), Miss Chung Huei Nian, an elementary school teacher experienced in volleyball. The result of the user analysis is tabulated in Table 2. Besides, Table 3 shows the application idea checklist.

**Table 2: User Analysis**

Stakeholder Category	Role in product	Design implications	Actions Needed
Subject Matter Expert (SME)	Content consultant expert in the volleyball	Consistency in user interface design	<ul style="list-style-type: none"> <li>• Same theme font used in button design.</li> <li>• Consistent button size and shape.</li> </ul>
		Simple navigation	<ul style="list-style-type: none"> <li>• Contains back button and main menu button.</li> <li>• Simple navigational structure to lead the user to the particular scene.</li> </ul>
		Easy to learn	<ul style="list-style-type: none"> <li>• Straightforward instructions are given.</li> <li>• English is used.</li> </ul>
		Simple word choice	<ul style="list-style-type: none"> <li>• Use general and suitable vocabulary for volleyball beginners.</li> </ul>

**Table 3: Application Idea Creation Checklist**

Item	Description
Type of application	Mobile Learning
Target device	Android Smart Phone
Target users	Volleyball beginners and players
Software	Unity, Blender, Adobe Photoshop
GUI	Main interface, submodule menu, Ball, Court, Quiz, Hand Signals, Position, Rules
Images	Icons
Video	None
Audio	Voice-over audio
AR	Markerless AR

### 3.2 Structure Analysis Stage

The second stage of MMCD methodology involves the analysis of the navigation and objects of the application. Functional and non-functional requirements are listed in Table 4 and Table 5. In addition, Figure 2 illustrates the navigation structure. Besides, Figure 3 shows the main system flowchart while the remaining flowcharts that show the system flow of each module and the content structure are attached in Appendix A.

**Table 4: Functional Requirements**

Functional Requirements	Description
Autonomous System Activities	<ul style="list-style-type: none"> <li>• The system should ask for camera permission when the AR feature is first used</li> <li>• The system should display the 3D volleyball equipment models when the camera detects a flat surface.</li> <li>• The system should generate quiz questions randomly.</li> <li>• The system should check the user input when answering the quiz and play sound effects based on it.</li> <li>• The system should calculate the total score of the quiz</li> </ul>
User Interaction	<ul style="list-style-type: none"> <li>• The system should enable the user to select a module through button clicks.</li> <li>• The system should enable the user to navigate the application using the appropriate buttons.</li> <li>• The system should pop up an exit confirmation message when the exit button is pressed.</li> <li>• The system should display a pop-up panel when the text button is pressed.</li> <li>• The system should play narration when the sound button is pressed.</li> <li>• The system should enable the user to zoom the 3D models through a finger pinch.</li> <li>• The system should enable the user to rotate the 3D models through finger slides.</li> <li>• The system should enable the user to drag the 3D models through finger press and hold.</li> <li>• The system should enable the user to give input by clicking one of the answer choices to answer the quiz.</li> <li>• The system should enable the user to redo the quiz when the replay button is pressed.</li> </ul>

**Table 5: Non-functional Requirements**

Non-functional Requirements	Description
Performance	<ul style="list-style-type: none"> <li>• The application should operate completely offline.</li> <li>• The application should respond within 2 seconds.</li> </ul>
Operational	<ul style="list-style-type: none"> <li>• The application should be able to operate on any Android device with Android version 7.0 and above.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>• The application should display in English.</li> </ul>
Usability	<ul style="list-style-type: none"> <li>• The application should have a user-friendly interface that is easy to use.</li> </ul>

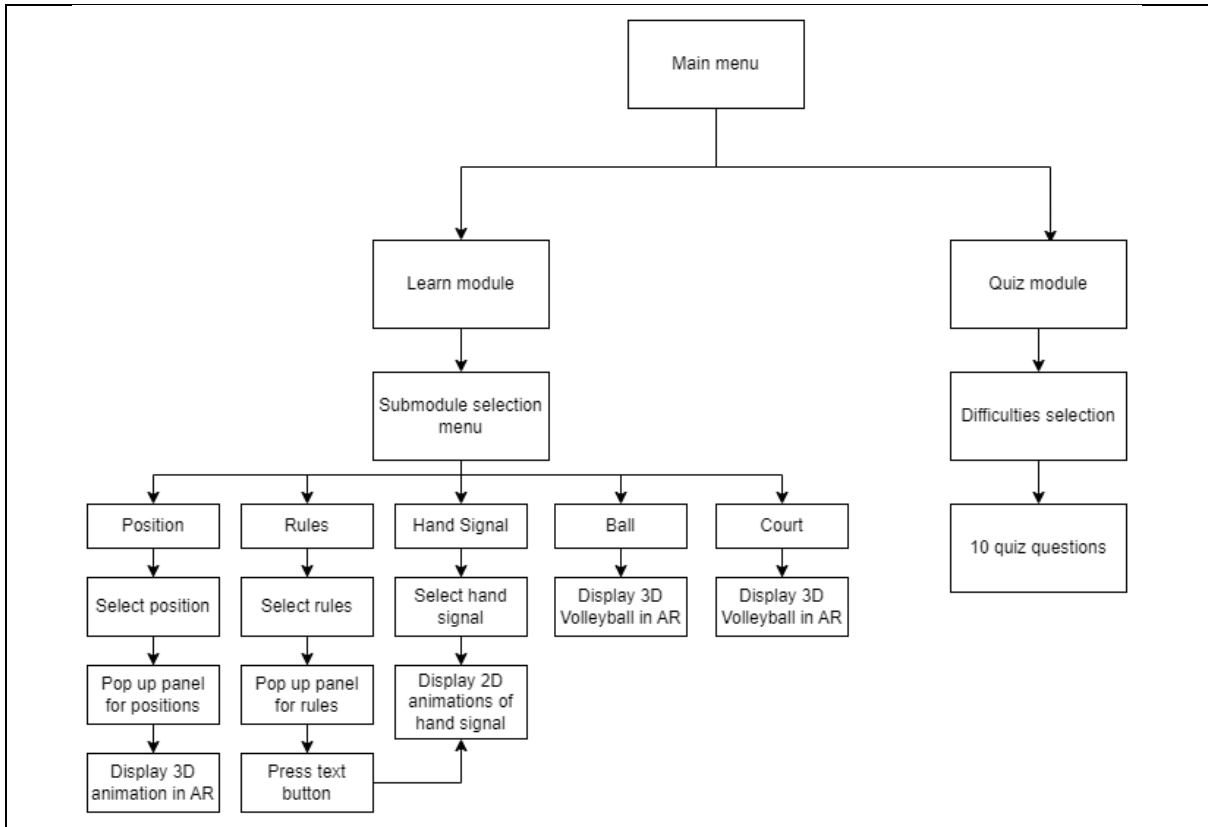


Figure 2: Navigation structure

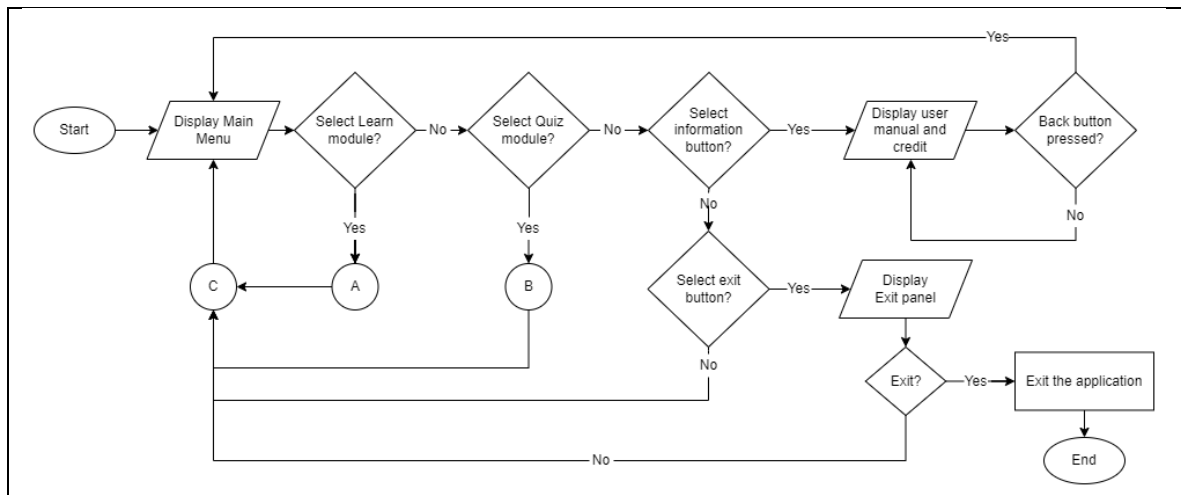




Figure 3: Main system flowchart

### 3.3 Process Design Stage

This stage involves object design and writing a single-function prototype. The application logo, buttons, and images are created by using Adobe Photoshop. Besides, the 3D graphics are created and modified through Blender software, which is open-source software that supports modeling, sculpting, and UV as one of its features. Table 6 shows the button design.

Table 6: Button Design

Button	Description	Button	Description
	This is a Home button.		This is a Learn Module button.



















Button	Description	Button	Description
	This is a Quiz Module button.		This is a Ball submodule button.
	This is a Court submodule button.		This is a Position submodule button.
	This is a Rules submodule button.		This is a Hand Signal submodule button.
	This is a quit button.		This is a sound button.
	This is a back button.		This is an information button.
	These are the control buttons, namely, the play button, the pause button, and the stop button.		This is an ask-for-help button.
	This is a camera button.		This is a skip button.
	This is a close button.		These are the next and previous buttons.
	This is one of the text buttons for Learn module.		These are the yes and no buttons.

Figure 4 demonstrates the single function prototype from the developed application. This prototype aims to navigate the users between scenes based on the build index since the navigation in the application plays a huge role in the developed application. The `LoadScene` function is inherited from the `SceneManager` library, hence, the `SceneManager` library needs to be included in the scripting in order to access the `LoadScene` function. In Figure 4, the `LoadScene` function takes an integer variable as a parameter for the scene build index to direct the navigation of the scenes.

```

using UnityEngine.SceneManagement;

Unity Script (39 asset references) | 0 references
public class ChangeScene : MonoBehaviour
{
    int previousScene;

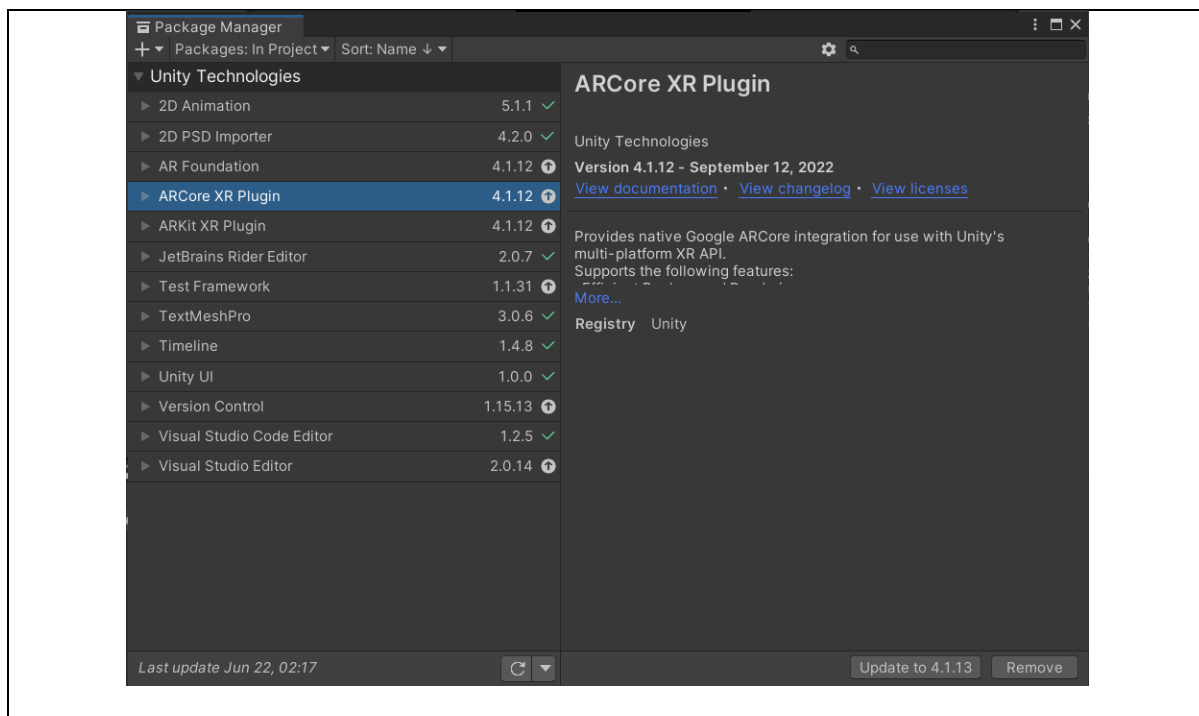
    0 references
    public void SceneLoad (int SceneNumber)
    {
        SceneManager.LoadScene(SceneNumber);
    }
}

```

**Figure 4: Single Function Prototype**

### 3.4 Main Function Development Stage

The development of the application involves two major stages, which are the development of application assets and the integration into Unity Game Engine through scripting. On top of that, the markerless AR functions in the AR scene require ARCore XR as a plugin in Unity to display the virtual 3D object in a real-world environment, and the installation of the ARCore XR plugin in Unity is shown in Figure 5.



**Figure 5: Import ARCore XR Plugin**

Besides, the Quiz module requires functions to calculate scores, answer checking, and question generation. Other than that, a timer is added in the Quiz module to increase the challenge of the second and third stages, where the user will fail the quiz if they could not complete the quiz before the timer ran out of time. Table 7 describes the methods that are responsible for 3D object spawning, timer implementation, generating quiz questions randomly, and scene navigation. These functions require the integration of C# script to work.

**Table 7: Integration in Unity with Scripting**

Functions	Scripts	Description
3D object spawning (AR)	<pre> void Update() {     // Check no 3Dmodel has been spawned, flat surface, and user touch input     if (spawnedObject == null &amp;&amp; placementPoseIsValid         &amp;&amp; Input.GetTouch(0).phase == TouchPhase.Began)     {         // Spawn 3D model         ARPlaceObject();     }      UpdatePlacementPose();     // Check whether to display the indicator     UpdatePlacementIndicator(); }                 </pre>	<p>This is the Update method in the ARPlacement.cs script. In this method, the application ensures that there is no 3D object spawned, a flat surface has been detected, and there has a touch input from the user before instantiating the 3D model in any AR scene.</p>
Timer (Quiz)	<pre> void Update() {     if (timeLeft &gt; 0)     {         timeLeft -= Time.deltaTime; // Reduce the time         timerBar.fillAmount = timeLeft / maxTime; // Reduce timeline          int minute = (int)(timeLeft / 60f);         int second = (int)(timeLeft - minute * 60f);          timerText.text = string.Format("{0:0}:{1:00}", minute, second);     }     else     {         timerText.text = "00:00"; // Reset time         failedPanel.SetActive(true); // Pop up scoreboard         Time.timeScale = 0; // Stop the timer     } }                 </pre>	<p>This is the Update method in the NewTimer.cs script. It controls the timer in the Quiz module. It keeps the timer running when the time left is larger than 0 and constantly reduces the timer fill. It also helps to pop up the scoreboard when the time ran out and display the current score.</p>

Functions	Scripts	Description
Generate questions in random order. (Quiz)	<pre>void generateQuestion() {     if (QnA.Count &gt; 0)     {         // Generate question randomly         currentQuestion = Random.Range(0, QnA.Count);         QuestionTxt.text = QnA[currentQuestion].Question;         SetAnswer(); // Check answer     }     else     {         // End of the quiz         Debug.Log("Finished.");         GameOver();     }     // Indicates the number of question left     questionLeft.text = questionNumber + " / " + totalQuestions; }</pre>	This method in the QuizManager.cs script helps to generate the questions from the quiz set randomly and set the correct answer for that question when it is generated.
Scene Navigation	<pre>public void SceneLoadforRulesAndHS(int SceneNumber) {     // Assign previousScene with the build index of current scene     previousScene = SceneManager.GetActiveScene().buildIndex;     // Save the build index with PlayerPrefs     PlayerPrefs.SetInt("previousScene", previousScene);     // Go to another scene     SceneManager.LoadScene(SceneNumber); }  0 references public void HSback() {     // Assign SceneNumber with the value retrieved from PlayerPrefs     // (Default value is 10)     int SceneNumber = PlayerPrefs.GetInt("previousScene", 10);     // Go back to the previous scene by passing SceneNumber as parameter     // inside the LoadScene method     SceneManager.LoadScene(SceneNumber); }</pre>	These methods are used for navigation between the Hand Signal submodule and Rules submodule which are interrelated. This is because the Rules submodule provides certain buttons for the user to navigate to scenes in the Hand Signal submodule. This method is written to ensure that user can go back to the previous scene depending on where they come from. This is achieved by saving the build index of the previous scene with PlayerPrefs and retrieving it to be set as the parameter for the build index.

### 3.5 Testing Stage

The testing stage is the last stage of the MMCD methodology. The testing stage involves two types of testing, which are alpha testing and beta testing. Alpha testing is conducted by the developer to test the functionality of the application. On the other hand, beta testing, or user acceptance testing, is conducted on the target users, which are volleyball beginners and players to test the user acceptance level towards the developed application. The received feedback through beta testing can help to identify the weakness of the application and provide suggestions for future improvement. The result of alpha testing is tabulated in Table 8 while the result for beta testing is discussed in the next chapter.

**Table 8: Results of alpha testing**

Test	Expected Output	Actual Output	Correction Action
Home button	Navigates to Main Menu scene	Works well as expected.	Not required.
Learn Module button	Navigates to Learn menu scene	Works well as expected.	Not required.
Quiz Module button	Navigates to Quiz menu scene	Works well as expected.	Not required.
Ball submodule button	Navigates to Ball AR scene	Works well as expected.	Not required.
Court submodule button	Navigates to Court AR scene	Works well as expected.	Not required.

Test	Expected Output	Actual Output	Correction Action
Position submodule button	Navigates to Position menu scene	Works well as expected.	Not required.
Rules submodule button	Navigates to Rules menu scene	Works well as expected.	Not required.
Hand Signal submodule button	Navigates to Hand Signal menu scene	Works well as expected.	Not required.
Quit button	Displays the Exit Panel	Works well as expected.	Not required.
Sound button	Plays voice-over audio	Works well as expected.	Not required.
Back button	Navigates to the previous scene	May navigate to the wrong scene when the current scene can be accessed from two different scenes.	Save the build index of the previous scene in Player Preferences and assign it as the parameter of LoadScene.
Information button	Displays user manual and credit scene	Works well as expected.	Not required.
Control buttons	Play, pause, and stop both animation and audio simultaneously	Animation stops when the audio is still playing.	Use a Boolean in animator to control the animation after checking if audio is playing
Ask-for-help button	Displays user manual in AR scene	Works well as expected.	Not required.
Camera button	Navigates to AR scene	Works well as expected.	Not required.
Skip button	Skips the user manual in AR scene	Works well as expected.	Not required.
Close button	Close pop-up panel	Works well as expected.	Not required.
Next and previous buttons	Navigates between pop-up panels	Works well as expected.	Not required.
Text buttons	Plays animation, answers quiz questions, or navigates to Hand Signal animation scene	The animation is played in the wrong order after closing and reopening the panel.	Add more keyframes in the animations.
Yes and No buttons	Yes to confirm exit and No to close Exit Panel	Works well as expected.	Not required.

#### 4. Results and Discussion

The beta testing is conducted and evaluated by using two tools, which are the System Usability Scale (SUS) and Technology Acceptance Model (TAM). The feedback is collected through an online Google Form that is distributed to the target user through the hands of two subject matter experts, who are Mr. Muhammad Uzma bin Radzi, the coach of the UTHM volleyball community, and Miss Chiung Huei Nian. There are a total number of 30 respondents who participated in this survey, including the volleyball community of University Tun Hussein Onn Malaysia (UTHM). The questionnaire included 10 questions that are to be measured with the System Usability Scale (SUS) and 6 questions to be measured with the Technology Acceptance Model (TAM).

#### 4.1 System Usability Scale (SUS)

The System Usability Scale (SUS) is a Likert scale that measures the usability of a system through a ten-item questionnaire that requires the respondent to express their degree of agreement or disagreement with the question [19]. The ten-item questionnaire is constructed with five positive-toned questions on odd numbers, namely the first question, third question, and so on, and five negative-toned questions on even numbers, such as the second question, fourth question, and the continuing even-numbered questions. The analysis of the result for positive-toned questions from the SUS questionnaire is shown in Figure 6 while the analysis of negative-toned questions is illustrated in Figure 7. The overall result of the beta testing shows positive feedback from the users as most of the users strongly agreed with the positive-toned questions as shown in Figure 6. For example, 26 respondents out of 30 respondents agreed that the various function in the developed application were well integrated.

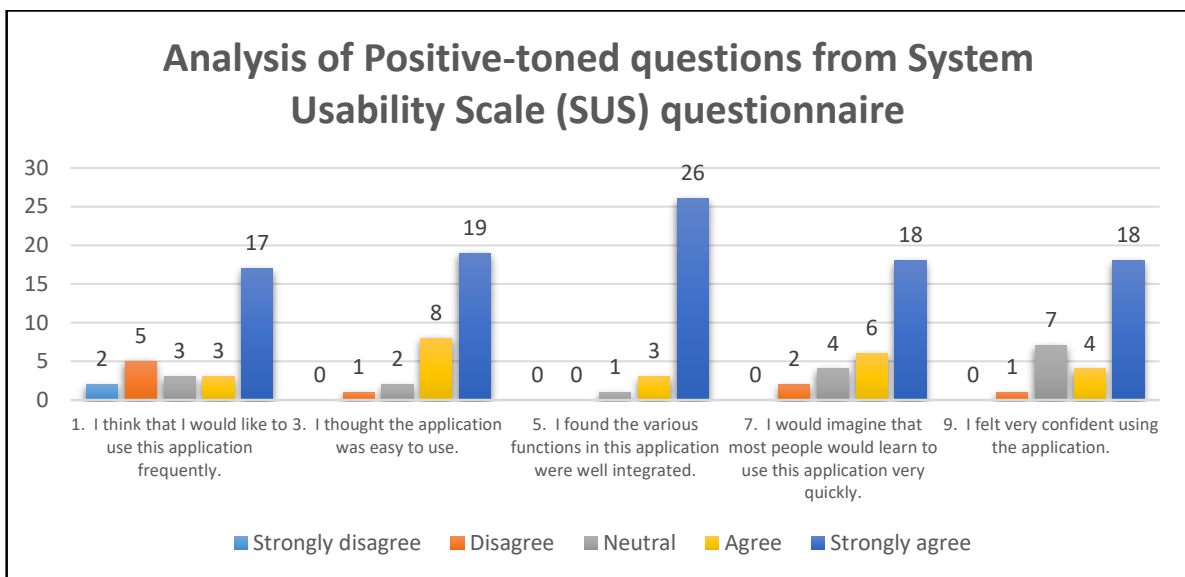


Figure 6: Chart of Analysis of positive-toned questions of the SUS questionnaire

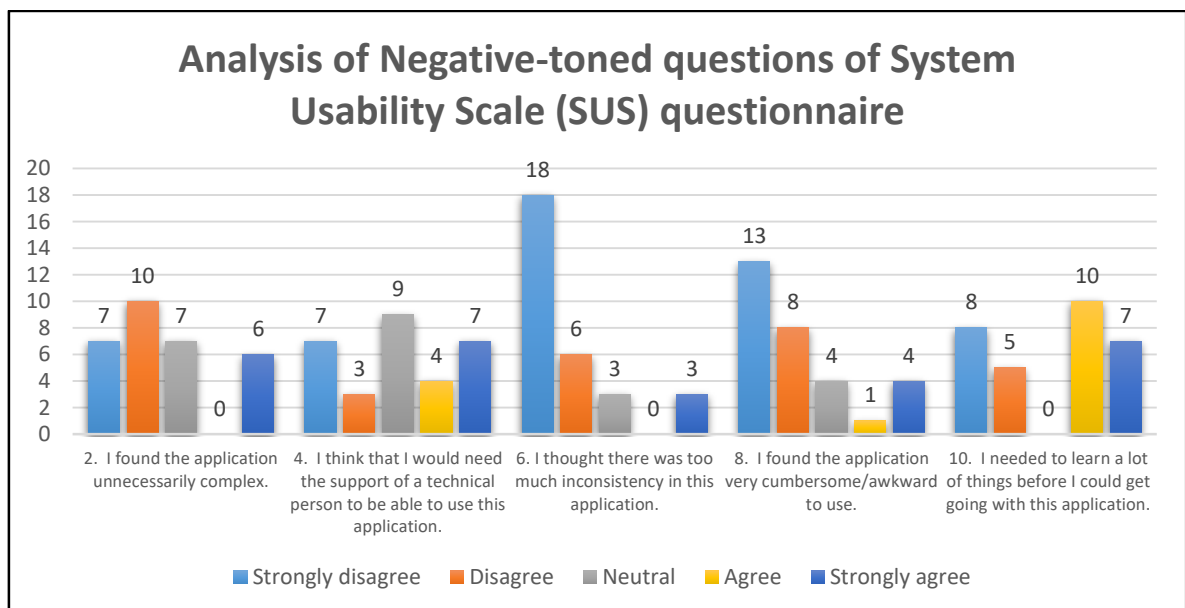
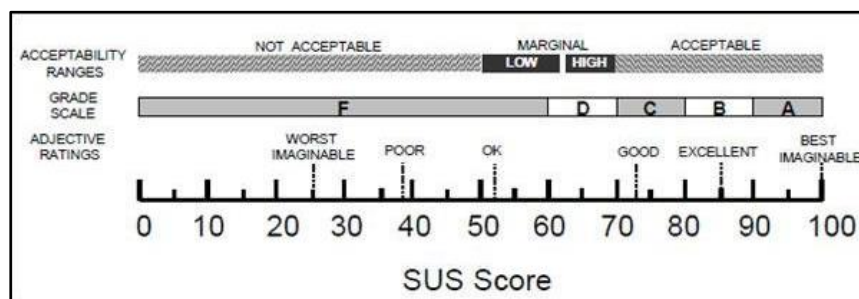


Figure 7: Chart of Analysis of negative-toned questions of the SUS questionnaire

**Table 9: Total score of System Usability Scale testing**

Respondent	Score										Odd-number questions' score	Even-number questions' score	Total
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10			
R01	5	5	5	5	5	5	5	5	5	5	15	0	37.5
R02	5	3	5	1	5	1	5	1	5	1	20	18	95
R03	5	5	5	5	5	1	5	3	5	1	20	10	75
R04	4	3	4	2	4	2	4	2	5	2	16	14	75
R05	3	2	5	3	5	1	5	2	5	4	18	13	77.5
R06	5	5	5	5	5	5	5	5	5	5	20	0	50
R07	5	5	5	5	5	5	5	5	5	5	20	0	50
R08	1	5	5	5	5	3	2	1	5	5	13	6	47.5
R09	4	2	4	3	5	2	2	2	4	4	14	12	65
R10	5	1	5	1	5	1	5	2	5	2	20	18	95
R11	5	1	3	3	5	1	4	1	5	1	17	18	87.5
R12	5	1	4	3	5	1	5	4	5	5	19	11	75
R13	5	2	5	4	5	1	5	1	5	2	20	15	87.5
R14	5	3	4	1	5	1	5	3	4	4	18	13	77.5
R15	5	2	5	4	5	3	3	1	5	1	18	14	80
R16	5	1	5	1	5	1	5	1	5	1	20	20	100
R17	5	3	5	5	5	2	5	1	5	1	20	13	82.5
R18	1	3	5	2	3	3	4	3	3	4	11	10	52.5
R19	3	2	5	3	5	1	5	1	3	4	16	14	75
R20	2	2	5	5	5	1	5	1	3	5	15	11	65
R21	5	2	2	1	5	2	3	5	3	5	13	10	57.5
R22	5	3	4	3	4	1	5	2	5	4	18	12	75
R23	2	3	5	1	5	1	5	1	4	1	16	18	85
R24	4	2	5	2	4	2	4	2	4	1	16	16	80
R25	2	1	3	3	5	1	4	1	2	4	11	15	65
R26	5	5	4	1	5	2	3	1	3	4	15	12	67.5
R27	3	2	4	4	5	1	3	2	5	4	15	12	67.5
R28	2	1	4	4	5	1	5	3	5	2	16	14	75
R29	5	2	5	3	5	1	4	1	3	4	17	14	77.5
R30	2	1	5	3	5	1	5	2	3	2	15	16	77.5
Average Score (%)													72.98

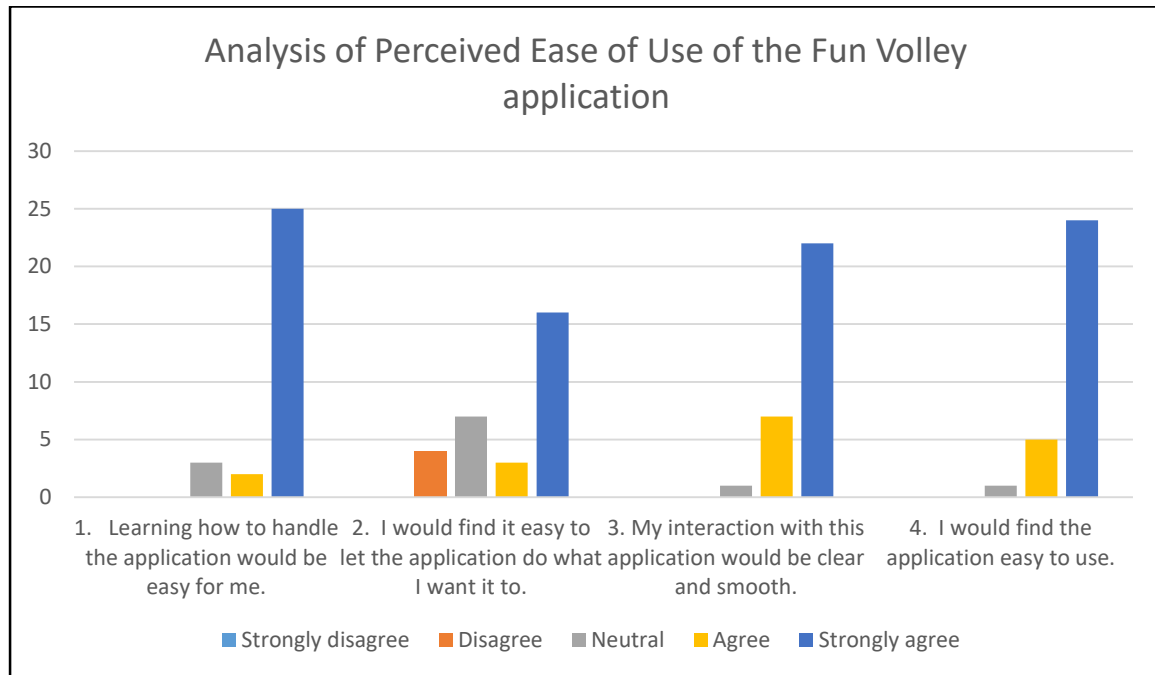


**Figure 8: Grade ranking of SUS scores [20]**

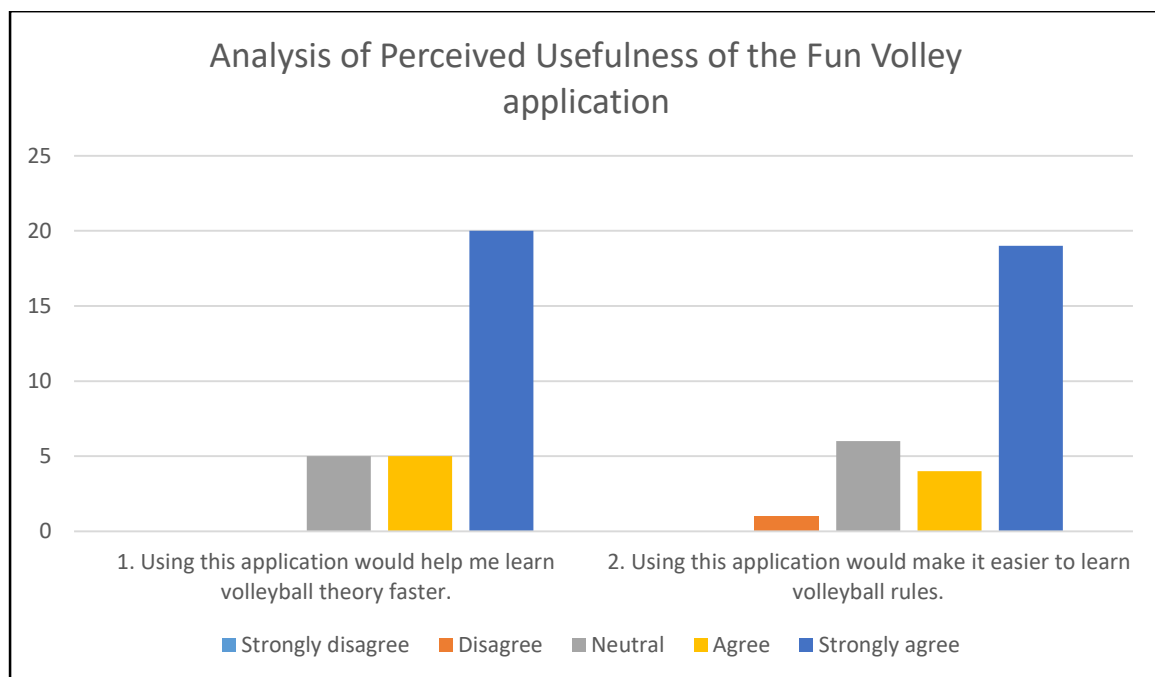
Furthermore, Table 9 shows that the developed application has successfully achieved an average score of 72.98% for beta testing with the System Usability Scale. Therefore, it has a good adjective rating with a “C” grade and is highly acceptable based on the SUS grading and acceptability range [20] as in Figure 8.

#### 4.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a framework used to determine user acceptance by examining two constructs, which are perceived ease of use and perceived usefulness [21]. The beta testing collected user feedback on these two constructs with four questions related to the perceived ease of use and two questions related to the perceived usefulness. The questionnaire items were measured with a 5-point Likert scale as in SUS, where scale 1 represents strongly disagree while scale 5 stands for strongly agree. The analysis of the beta testing regarding the perceived ease of use of the developed application, Fun Volley, is illustrated in Figure 9. On the other hand, Figure 10 shows the analysis of the perceived usefulness of the developed application.



**Figure 9: Chart of analysis of perceived ease of use of the Fun Volley application**



**Figure 10: Chart of analysis of perceived usefulness of the Fun Volley application**

Based on Figure 9, an average of 72.5% of respondents strongly agreed with the perceived ease of use of the developed application. Nevertheless, there is a minority of respondents (13.33%) reported their disagreement with the statement that it is easy to let the application do what they want to do. This is due to the user are not familiar with markerless AR and they cannot easily find a flat surface to display the virtual content in the AR scene. On the other hand, the TAM testing also shows positive feedback in terms of the perceived usefulness of the developed application according to Figure 10 where there are 20 respondents strongly agreed that the application can help them learn volleyball theory faster. On the other hand, even though 19 respondents strongly agreed that the application would make it easier to learn volleyball rules, 3.33% of respondents disagreed with this statement. This may be due to the lack of AR implementation in the Rules submodule. Hence, the implementation of AR in the Rules submodule can be the solution for future work.

## **5. Conclusion**

In conclusion, the Fun Volley application has been successfully developed with two main modules, which are the Learn module and the Quiz module, while the Learn module has been integrated with AR technology to enhance the volleyball learning experience. At the end of the study, the three objectives listed have been achieved successfully. Firstly, the Fun Volley learning application is designed using the visual and aural (VA) learning style with the integration of voice-over audio and 3D models in the developed application. Besides, the Fun Volley application is developed by implementing AR technology on the Android platform and the functional testing and user acceptance test have been conducted on the target user for the developed application. The result of the user acceptance test shows more than 70% of positive feedback for TAM and the application has gained an average of 72.98% score with SUS, proving that the application is applicable in the volleyball learning process even for beginners.

Fun Volley provides advantages in volleyball learning. The use of multimedia elements within the developed application can ease the visual and aural learners to understand volleyball theory. For example, it applies 2D graphics and animations in the Hand Signal submodule with voice-over audio to help the learners easily visualize the movement of the referee in real life. Through user testing, most of the users are attracted to the developed application thanks to the implementation of AR technology that displays interactable 3D animation in the AR environment where the user can scale, rotate, and drag the augmented virtual content. However, only limited modules are integrated with AR technology and the interaction with the animation is limited. Hence, it is suggested to apply the AR features in other modules as well for future improvement and to add interactable functions for the animations of 3D models in AR scenes. Furthermore, the application is also suggested to provide more exercise modules to check user understanding in addition to the Quiz module and to increase language options, such as Malay and Chinese, in Fun Volley as future work.

## **Acknowledgment**

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Appendix A

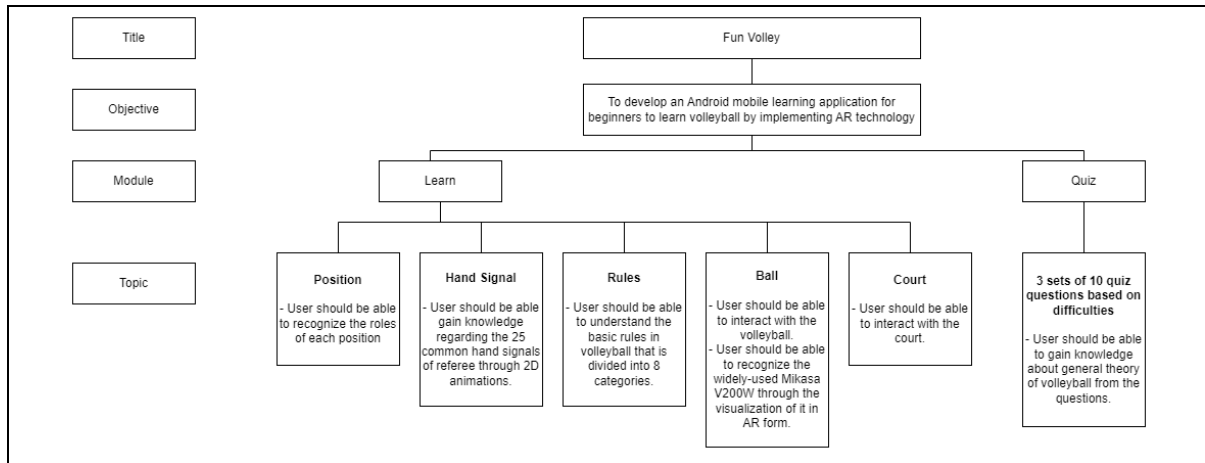


Figure 11: Content Structure

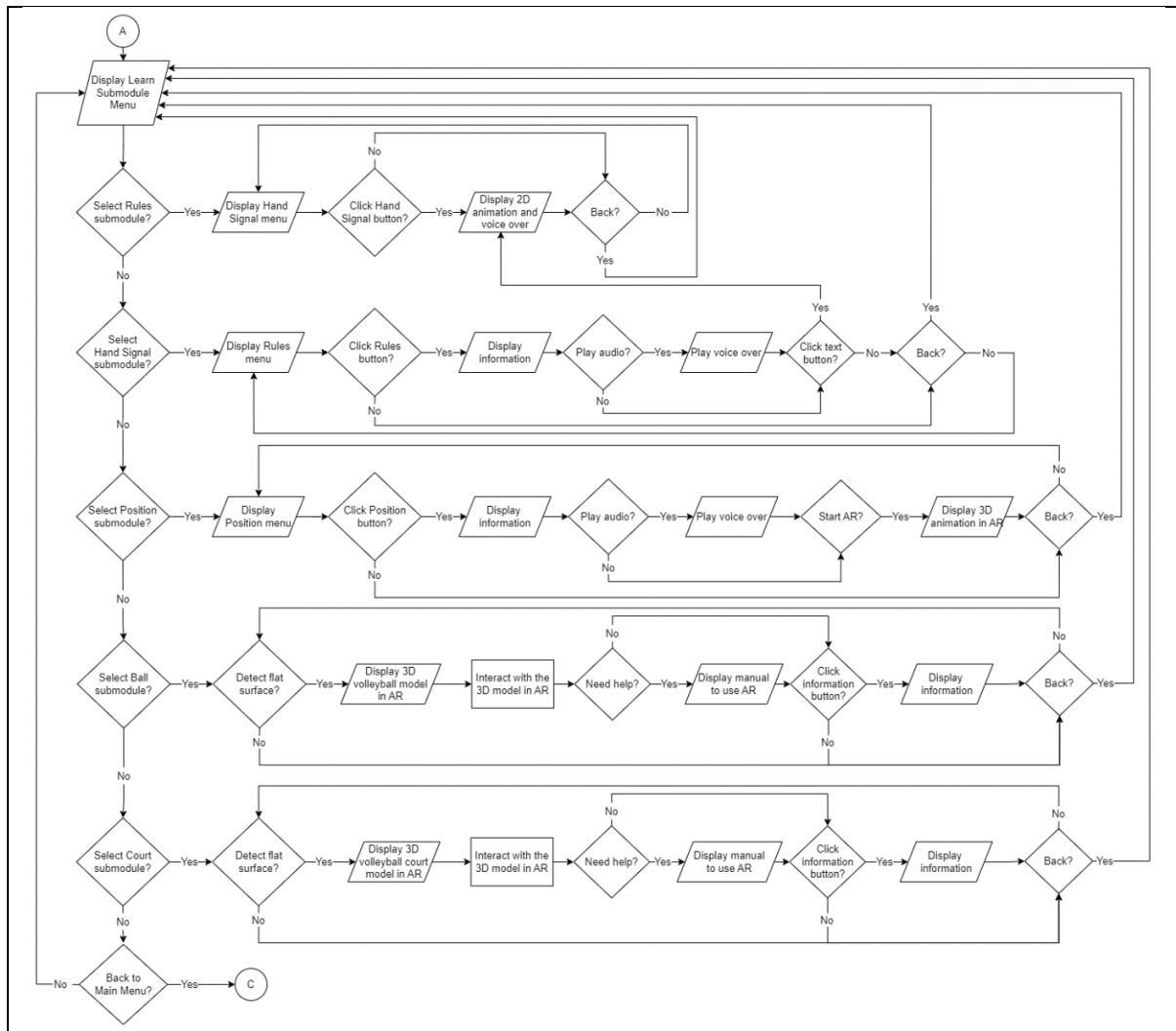


Figure 12: Flowchart for Learn module

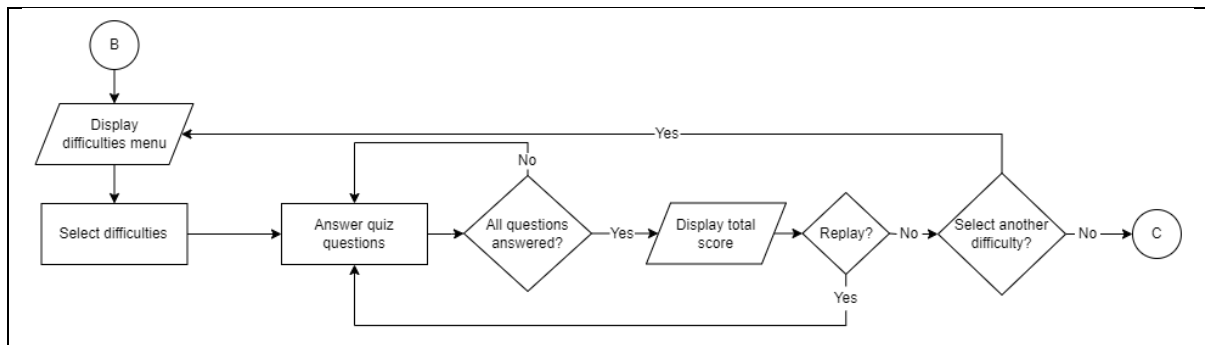


Figure 13: Flowchart for Quiz module

Appendix B

Table 10: Sample output of Fun Volley

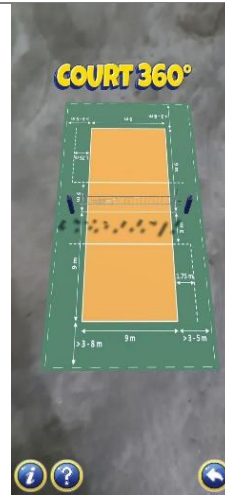
Main menu	Information and credit	Learn menu	Rules menu
Pop-up panel in Rules submodule	Position menu	Pop-up panel in Position submodule	AR scene in Position submodule



Indicator in AR scene



User manual in AR scene



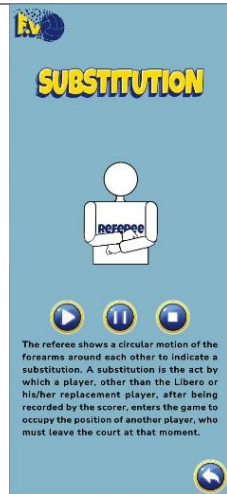
AR scene in Court submodule



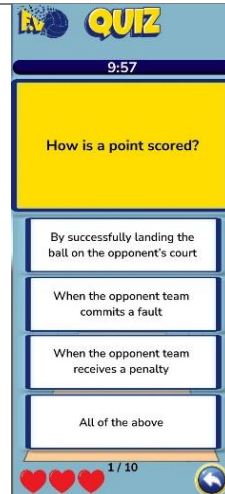
AR scene in Ball submodule



Hand Signal menu



2D animation in Hand Signal submodule



Quiz module



Score panel in Quiz module

## Appendix C



**Figure 14: User testing with target users (UTHM's volleyball coach and players)**

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