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Learning Application for Slow Learner Children Using Gamification Approach: Matematik Pintar

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Abstract: In this globalized era, learning using mobile devices has become a trend. Mobile devices have become a complete set of applications to help the education field. Additionally, gamification technology has been growing famous nowadays. Students can understand the learning better with the help of animation and gamification technology. Therefore, the contents of the learning application for slow learner children are developed using a gamification approach to present the learning materials. The methodology used in developing this proposed application is Multimedia Mobile Content Development (MMCD). The total of 31 respondents have performed user acceptance test. This application is to assist the user to learn about basic mathematics with the help of multimedia elements.

Keywords*: Slow Learner, Gamification, learning application*

1. Introduction

Slow learners are those who score below average on intelligence tests, and their mental abilities grow far more slowly than ordinary children their age [1]. These children have specific difficulties based on their learning ability, which affects their development progress. A developmental gap will always exist between the child's potential and attainment. As nowadays, the learning system for normal children is using books as a reference and notes. Children will learn to recognize numbers then they will be taught how to spell the syllables. However, this method is difficult for slow learners because they face problems in the normal learning process compared to the normal children. Thus, specialized attention from teachers with experience and training is required to help the slow learners in the learning process. Applying the gamification on learning process is a good delivery technique for children with learning abilities. This is because gamification in education has massive positive benefits on user engagement, motivation, and social dynamics [2].

Furthermore, slow learners usually do not like assignments or exercises in the form of worksheets and easily get bored for extended periods of time. Children are easily bored and teachers sometimes have to change exercises in the form of games or activities. Meanwhile, worksheets or teaching material on the internet are too high level for slow learners. Thus, the teachers have to make their own worksheets

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to meet the standards of the children. Therefore, the mobile learning application, Matematik Pintar is proposed to be developed.

The objectives of this study are to design the content of *Matematik Pintar*, an interactive learning application for slow learner children using the VARK learning model, to develop an interactive learning application using gamification approach and to conduct functional and user acceptance tests on the developed application to the target user. The proposed application is developed for slow learners' students in pre-school between the age of five to six years old. The subject matter expert (SME) participating in this project is Puan Ummi Wahida Binti Ghazali, an experienced teacher at special Education School, SK Putrajaya Presint 16(2). Furthermore, the learning model that will be implemented in this project will only focus on kinaesthetic or tactile style.

The Matematik Pintar application will contain two learning modules which are Number 1-10 and Pengiraan. All interactive buttons in the application are expected to perform well. The sound buttons will be provided as part of the learning content. Clear and simple instructions would be provided to ease the user to understand and follow the learning content.

2. Related Work

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

2.1 Slow Learner

Slow learners are students who can acquire required academic abilities but at a slower and depth rate than other students who are their age [3] Raji. The child will progress through the same developmental phases as normal children, but at a slower rate. Academically slow learners tend to be identified based on intelligence test scores ranging from 75 to 89 [4]. Therefore, they need special attention and care compared to normal children. This is because, slow learners face challenges related to their cognitive and sensory abilities, communication skills, social behavior, and physical attributes [5]. They normally have problems in collecting and processing information in their memory because they are unable to focus on learning for too long. Slow learners often struggle with maintaining focus, leading to a propensity for errors caused by negligence and they find it challenging to successfully finish tasks and manage subsequent ones [6]. Therefore, these children require special attention and method from the teacher in order to enhance their interest and help them get involved in the learning process.

2.2 Tactile Learning Style

Learning preferences and learning styles may be used to categorise how students learn. In order to facilitate better learning results, the teacher must consider the learner's specified learning style. Based on the study, the chosen learning style for slow learner is by applying kinaesthetic or tactile learning style [7]. Kinaesthetic-tactile learners thrive when information is presented through touch and movement. This implies that the more opportunities the learner has to physically interact with and manipulate the materials used for information delivery, or utilize body movements, the more accessible the learning process becomes for them [8]. The tactile technique fosters a scientific learning attitude in students and enhances cognitive and psychomotor domains that help in learning and retention [9]. This dynamic type of learning will attract interest in the students and improve their analytical abilities.

A tactile learner prefers to engage in physical activity to learn something rather than simply listening to a lecture or watching a demonstration. They learn better through hands-on activities such as taking notes and highlighting notes with bright colours to attract and engage their attention while learning new knowledge. That is why getting hands on the things that want to study is the greatest method to learn them.

A previous work has been done before about how a slow learner are affected with tactile learning. The previous work involved the development of an android mobile application for slow learner with

tactile learning style. One of the objectives of the previous work is to study how an Android mobile application may be utilised to improve the learning process of slow learners with tactile learning styles. The previous work addressed that a study needs to be done in order to acknowledge and differentiate style of learning [10]. The objective of the previous work was successfully achieved at the end of the work as the mobile application received a good response. Based on the study, 83.33% of students has proved that this mobile application can help to improve the learning experience of slow learners with tactile learners in schools [9]. Therefore, it is proved that slow learners respond well to tactile learning.

2.3 Gamification

According to Kapp, gamification is defined as game mechanics, aesthetics, and game thinking are used to engage people, encourage action, increase learning, and solve issues [11]. Traditional educational approaches have alienated many children, and gamification in an educational context provides some relief. Thus, gamification might be a potential solution to the existing education system's loss in student motivation and engagement.

Traditional educational approaches have alienated many children, and gamification in an educational context provides some relief. Thus, gamification might be a potential solution to the existing education system's loss in student motivation and engagement. the features that may be included in gamification for education to make the learning process exciting for students are achievement, rewards and storyline. It will give students an enjoyable and interactive learning experience. Aside from that, as traditional methods of teaching become less successful, the use of modern technology in teaching and learning can be an effective solution. Lastly, the learning system uses gamification as a teaching aid has received attention and attracted the interest of many students and teachers. This gamification can be used as an exercise or activity extra in the class to diversify the approach used in class. Besides that, this gamification allows students to learn and practice in a conducive manner where they can continue learning wherever they are.

2.4 Comparative Analysis

In this section, a comparison has been made between existing applications such as Todo Math [12], Kids Math [13] and Math Joy [14], and the proposed application. Figure 1 shows the main menu interface of the three exciting applications. Meanwhile, 7 features have been discussed as shown in Table 1. It includes a learning module, target user, video tutorial, payment charges, user interface design, supported platform and gamification elements. Table 1 shows the comparison between existing applications and proposed application.

Figure 1(a): Todo Math

Figure 1(b): Math Kids

Figure1(c): Math Joy

Table 1: Comparison between existing applications and proposed application

Features	Todo Math	Math Kids	Math Joy	Matematik Pintar
Learning Module	Does not provide any learning module			Provide learning module which are Basic Number and Simple Calculation
Target User	Slow learner children	Normal children		Slow learner children
Video Tutorial	Does not provide a tutorial.	Provide a tutorial but only to show the function for each button	Does not provide a video tutorial	Provide a video instruction before starting the activity with clear and simple instructions.
Payment Charges	Partially free of charge and need to pay to upgrade to the premium	Free of charge		
User Interface Design	Suitable for kids and preschool student	A little bit crowded on the main menu interface	Simple and suitable slow learner children because the design is very simple	
Supported platform	iOS and Android		iOS only	Android
Gamification elements	Badges, level selection, timers, and personalization	Rewards		Level and rewards

3. Methodology

The project system development methodology that will be used for the process of developing Matematik Pintar learning application is the Multimedia Mobile Content Development (MMCD) model. MMCD methodology consists of five main components which are application idea creation stage, structure analysis stage, process design stage, main function development stages, and testing stage [15]. The 5 phases of the MMCD methodology are shown in Figure 2. This methodology helps in the improvement and acceleration of the application development process, hence reducing data and mobile processing utilization.

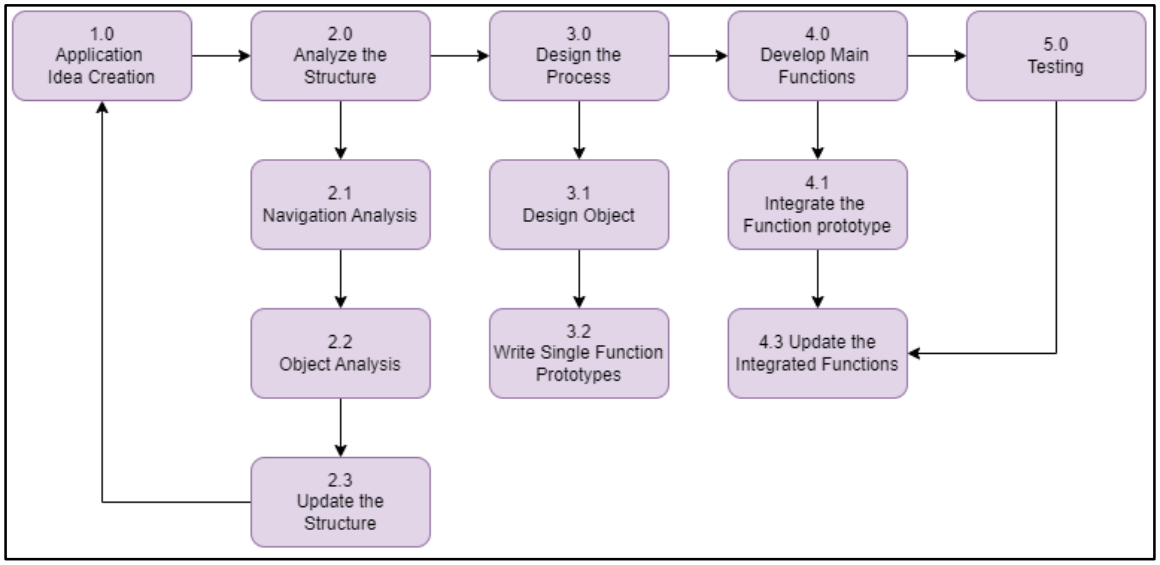


Figure 2: MMCD Methodology

3.1 Application Idea Creation

The application idea creation provides the information required before the design and development of the Matematik Pintar learning application begins. In this phase, the ideas and concept for the application are defined where the application will be in 2D and the target users are for slow learner children in preschool. The scope is Mathematics learning which covers basic number, addition and subtraction. The proposed idea is discussed with the supervisor first to get ideas and suggestions before implementing the project. A subject matter expert (SME) named Puan Ummi Wahida Binti Ghazali from SK Putrajaya Presint 16(2) as a special education teacher is also being interviewed to have more understanding of a particular topic. The transcript is attached in Appendix A. the results of the user analysis are tabulated in Table 2. Table 3 shows the application idea creation checklist.

Table 2: User analysis

Stakeholder Category	Role in Product	Comment Received	Action Needed
Subject Matter Expertise (SME)	Content Consultant expert in special education field	Simple while colorful user interface	• Prevent complicated design on interface while offering colorful elements to catch children's attention • Use font types that are easy to read.
		For the exercise module, it must be in activity or games instead of a plain worksheet	• Adding activities to strengthen the knowledge.
		Simple but reliable content	• Clear learning module and contents. • Avoid complicated work.
		Easy to navigate	• Navigation buttons should be consistent in terms of size and shapes.

Stakeholder Category	Role in Product	Comment Received	Action Needed
		Multimedia content	● Use audio, background music, and pictures to attract children's attention.
General Users	Target users of the application	Colorful interface	● The interface should be filled with colorful elements.
		Usage of graphics	● More graphics should be used instead of texts.
		Offline feature	● The application should be able to access anywhere, anytime on mobile devices.

Table 3: Application idea checklist

Item	Description
Type of application	Mobile learning application
Platform	Android mobile
Target User	Slow learners' students in pre-school between the age of five to six years old.
Target device	Android platform.
Graphical User Interface	Learning module and exercise module.
Images	Icons, image of the learning material and exercise module
Video	Instruction video in form of 2D video.
Audio	Background music and instructions audio in exercise module
Application Synopsis	Matematik Pintar is a learning application for slow learners that cover Mathematic syllabus which are basic numbers that cover number one until ten and simple calculation that includes addition and subtraction. The application provided audio and animation to deliver the learning content

3.2 Analyze the Structure

In the second phase of the MMCD methodology, the structure of the application is analyzed. The object and navigation analysis has been conducted. Functional and non-functional requirements are listed in Table 4 and Table 5. Figure 3 shows the navigation structure while Figure 4 shows the system flowcharts of the Matematik Pintar. The content structure shown in Appendix A.

Table 4: Functional requirements

Functional Requirements	Module	Description
User Interaction	Main Interface	The system provides users with the ability to start the application.
	Main menu	The system provides users with the ability to select the modules.
	Learning module	The application provides users with the ability to choose from number one until ten for the basic number module.
	Activity module	The application provides users with 3 sets of activities for each module and users should be able to go to the previous interface with a back button.
	Instruction Video	The application be able to provide an instruction video before the users start the activities module.

Functional Requirements	Module	Description
Autonomous system activities		• After users launch the application, the landing page will be displayed.

Table 5: Non-functional requirements

Non-Functional Requirements	Description
Performance	• The application should be able to load all the modules. • The average response time between click and reaction is less than 3 seconds • The application shall be available every time.
Legal	• The system should provide users with the ability to select the modules. • Users cannot modify the content of the application
Usability	• The application is easy to use. • The application would be an offline-based application. • Simple words is used to deliver the learning content
Operational	• The application is be able to operate on any Android device.
Cultural	• The application is applying Malay language as suitable contents based on the needs. • The application is using familiar symbols or text that is understandable by the target users.

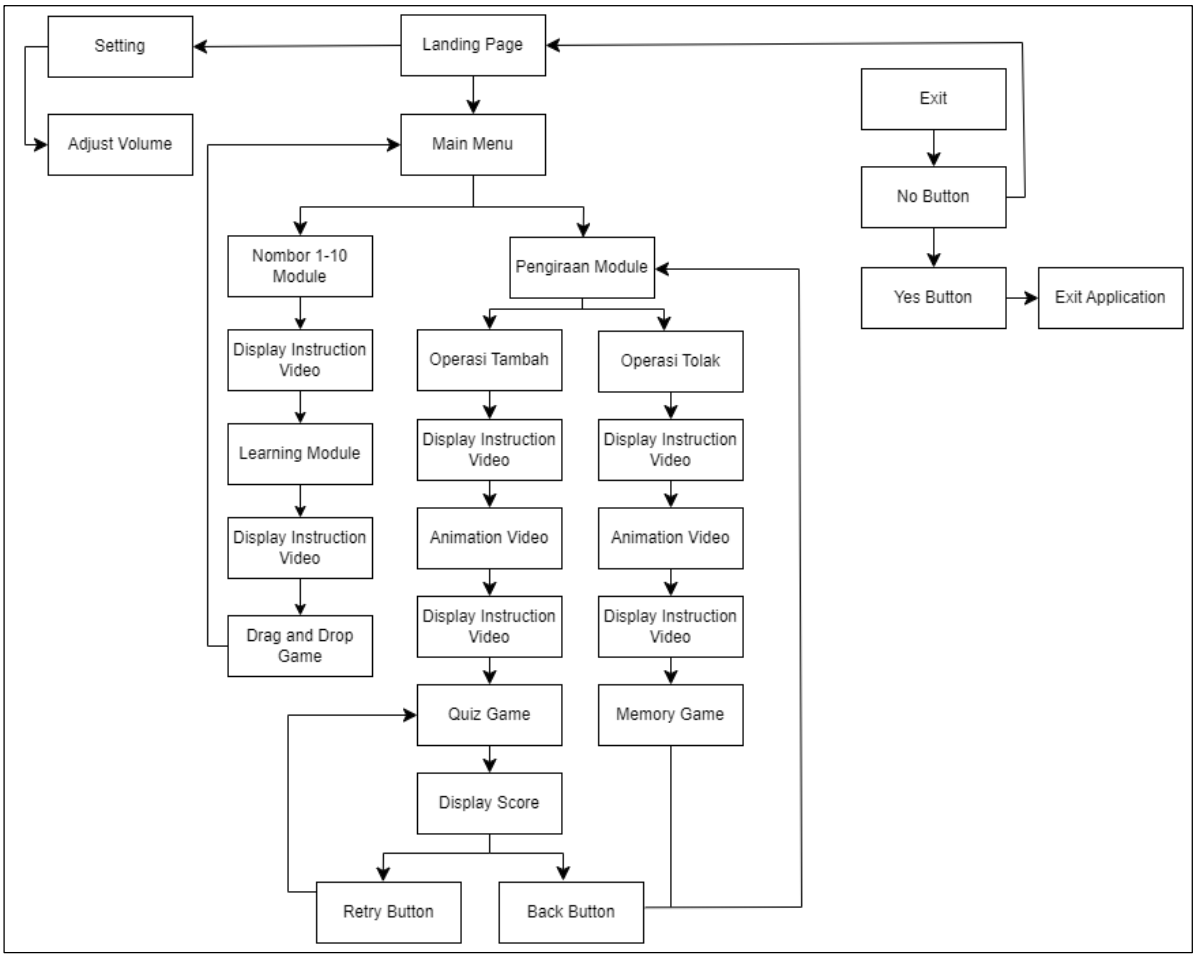


Figure 3: Navigation structure

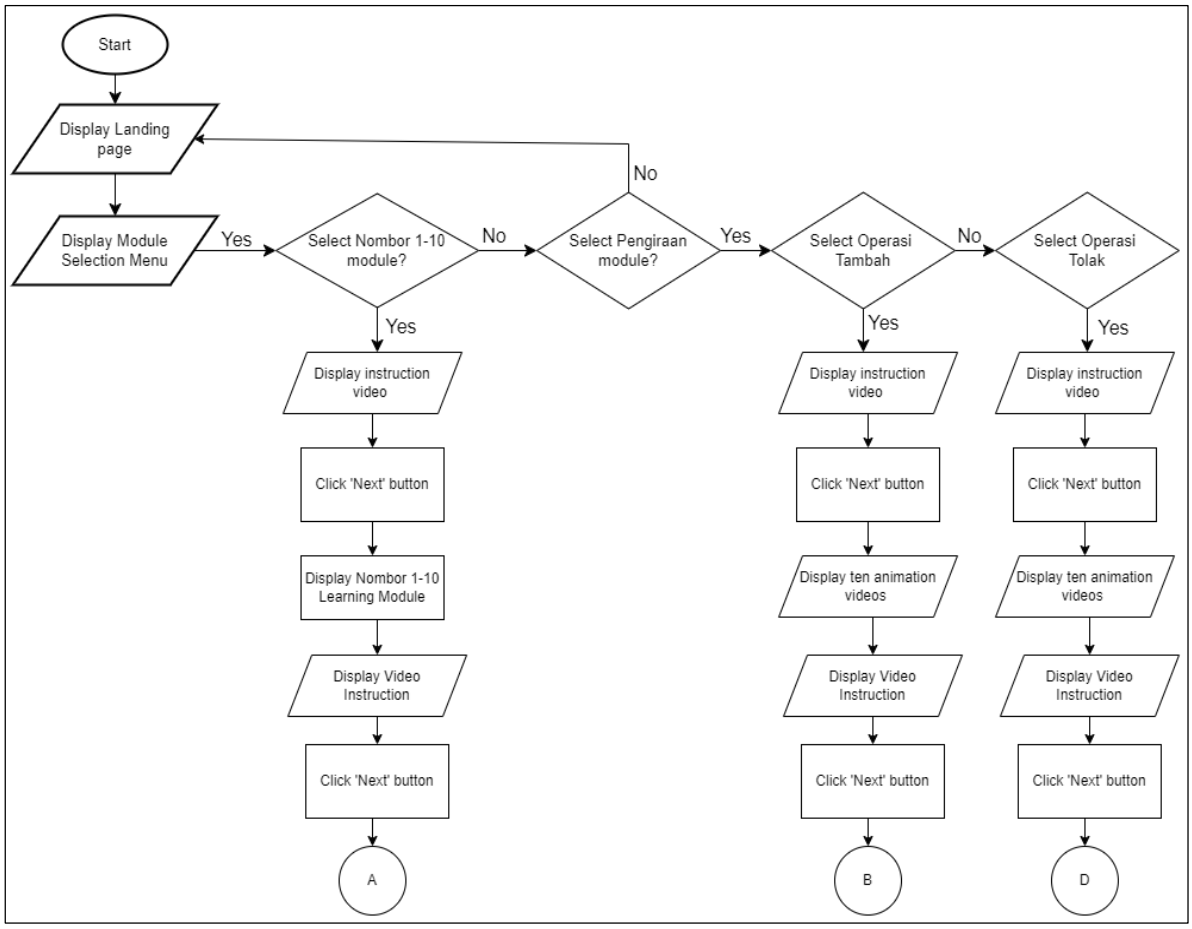


Figure 4: System flowchart

3.3 Design the Process

Design of the process is the third phase of the MMCD approach. Design objects and write the single function prototype scripting are two subphases in this stage. The prototype for the Learning and Activity modules will be completed at the end of this process. In this project, authoring tools such as Canva, Capcut and ibisPaint X are used to create images, 2D animation and also storyboard. Meanwhile, Unity and Visual Studio are used to compile the assets with scripting. Table 6 shows the button design, while Table 7 shows the interface design.

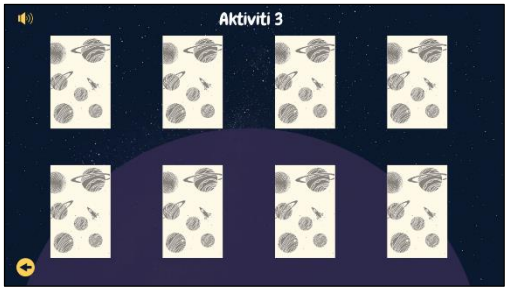
Table 6: Button Design

Button	Description	Button	Description
	Basic Number Module button		Addition button
	Basic Calculation Module button		Subtraction button
	Start button		Back button
	Quit button		Previous button
	Setting button		Next button
	Volume button		Retry button
	Confirmation button for quit		Confirmation button for quit

Button	Description	Button	Description
Kembali	Back button for quiz panel	Main Semula	Retry button for quiz panel

Table 7: Interface Design

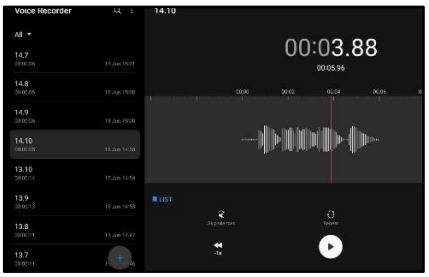
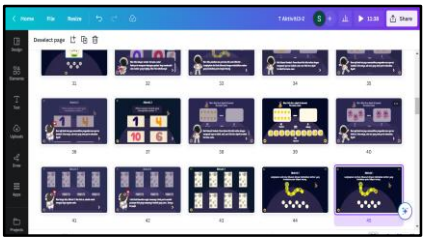
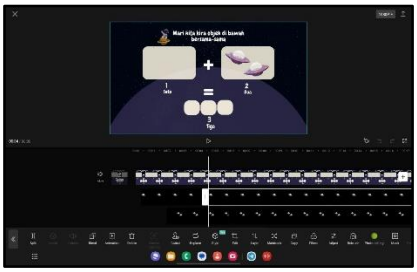
Interface	Description
	This is the startup interface of the proposed application. It contains Mula button, setting button and also exit button.
	This is the main menu interface after user clicked on the Mula button on the previous interface. In this interface, there are sound button where the user can mute or unmute the background music. Then there are also Nombor 1-10 button and Pengiraan button. Both buttons will lead user to the learning module.
	This is the interface for learning module of Number 1-10. The user needs to drag the puzzle pieces to the correct place to form a complete number. It also has back button.
	This is the interface for Aktiviti 1 where user need to choose the correct answer and placed it on the caterpillar body.

Interface	Description
	This is the Pengiraan interface for the learning module. There are four buttons in this interface which are Operasi Tambah button, Operasi Tolak button, back button and sound button.
	This is the interface for learning module of Operasi Tambah. There will be an animation video which shows the addition calculation. It contains graphics and also audio. There are also next and back buttons.
	This is the interface for *Aktiviti 2* which contain quiz. User just need to click on the answer to get some score. There are also back button and sound button.
	This is the interface for learning module of Operasi Tolak. There will be an animation video which shows the addition calculation. It contains graphics and also audio. There are also next and back buttons
	This is the interface for Aktiviti 3 which contain flip card game. There are also back and sound button.

3.4 Develop Main Function

The main functions of the proposed applications are developed. In the learning module, the main function is to deliver the learning content in the form of animation technology. In addition, prototypes of the modules will be integrated with the C# script to link with the main menu. This will enable the navigation between the selected menu and each module of the application. The core process for this application is created at this phase. This section ensures that all processes referred to by the user requirements work effectively. If the application process fails, the application must be fixed and continue to suit the user's demands. The development of the main function of the application is tabulated in Table 8.

Table 8: The development of the main function of the application

Assets	Development	Variable Value
Audio		The audio files in the *Matematik Pintar* application are recorded using the Voice Memos. In addition, this audio is recorded in FSKTM, UTHM's audio recording room to avoid the noises.
Graphics		Canva platform is used to design the storyboard. The background or artboard of the elements such as buttons, images and application icons are set to transparent.
CapCut		CapCut platform is used to insert the subtitle to the 2D animation video and put the recorded voiceover to the video.

Furthermore, C# scripts are developed to enable the application's core function. Each interactivity in the Matematik Pintar application uses Visual Studio Code software to type C# programming code for Unity. Among the programming codes used are to build drag and drop games, memory games and also quiz games. Figure 5 and Figure 6 shows the snippet code for Drag and Drop game for activity module.

```
public void DragOne()
    {
        One.transform.position =
Input.mousePosition;
    }
```

Figure 5: Snippet Code for Drag Method

The `DragOne(), DragTwo(), DragThree(), DragFour(), DragFive(),` and `DragSix()` methods handle dragging the puzzle pieces. These methods update the position of the corresponding puzzle piece based on the position of the mouse cursor.

```
public void DropOne()
    {
        float Distance =
Vector3.Distance(One.transform.position,
oneBlack.transform.position);
        if (Distance < 50)
        {
            One.transform.position =
oneBlack.transform.position;
        }
        else
        {
            One.transform.position = OneInitialPos;

        }
    }
```

Figure 6: Snippet Code for Drop Method

`The DropOne(), DropTwo(), DropThree(), DropFour(), DropFive(),` and `DropSix()` methods handle dropping the puzzle pieces. These methods calculate the distance between the dropped puzzle piece and its corresponding black placeholder position. If the distance is less than 50 units, the puzzle piece snaps to the placeholder position. Otherwise, it is reset to its initial position. Overall, this script provides the functionality for dragging and dropping puzzle pieces, checking their correct placement, and showing a completion panel when all the pieces are correctly placed.

In Unity, the given code represents a quiz manager. It consists of numerous components that are required for the quiz games. Figure 7 and 8 shows the snippet code from the Quiz Manager class.

```
    void SetAnswer()
    {
        for (int i = 0; i < options.Length; i++)
        {
            options[i].GetComponent<AnswerScript>().isCorrect = false;

options[i].transform.GetChild(0).GetComponent<Image>().sprite =
QnA[CurrentQuestion].Answers[i];

            if (QnA[CurrentQuestion].CorrectAnswer == i + 1)
            {
                options[i].GetComponent<AnswerScript>().isCorrect =
true;// Perform the desired action when the answer is correct
            }
        }
```

Figure 7: Snippet Code for SetAnswer Method

The `SetAnswer()` method plays an essential part in setting the answer options for the current question. It updates the UI by changing the answer text and sprite based on the data from the current question. It also marks the related option as correct to identify which option is the right answer.

```
    void generateQuestion()
    {
        if (QnA.Count > 0)
        {
            CurrentQuestion = Random.Range(0, QnA.Count);

            QuestionTxt.text =
QnA[CurrentQuestion].Question;
            SetAnswer();
        }
        else
        {
            Debug.Log("Out of Questions");
            GameOver();
        }
```

Figure 8: Snippet Code for the Generate Question Method

Finally, during gameplay, the `generateQuestion()` methods generates a new question. It chooses a question at random from the list, updates the UI with the question-and-answer options, and handles the situation when there are no more questions left, triggering the game over state.

Next, other programming codes that have been used in this application are to create a Memory Game. The Unity GameControl script acts as the core controller for a memory game. It is in charge of orchestrating many components of the game's logic and functionality. Figure 9 shows the Snippet Code from GameControl class.

```
public bool CheckMatch()
    {
        bool success = false;
        if (visibleFaces[0] ==
visibleFaces[1])
        {
            visibleFaces[0] = -1;
            visibleFaces[1] = -2;
            success = true;

    }
        return success;
    }
```

Figure 9: Snippet Code for the Check Match Method

The `CheckMatch()` function determines if the first and second elements of the `visibleFaces` array are the same. If they are, the matching cards are marked as invisible by giving particular marker values (-1 and -2). It returns true if the match is successful.

Table 10: Interface of the developed application

Module	Interface	Module	Interface
Landing Page Interface		Main Menu Interface	
Instruction Video Interface		Learning Module Interface	
Activity 1 Interface		Pengiraan Interface	
Learning Interface		Activity 2 Interface	
Learning Module Interface		Activity 3 Interface	

3.5 Testing

Testing is crucial in the development process because it allows the developer to determine if an application will work effectively and be approved by the target users. The primary goal of the testing stage is to analyze the application efficiency toward the intended users and ensure that the application's objective is achieved. There are two stages in testing which are Alpha and Beta testing. Alpha testing is conducted throughout the development process by the developer to determine the functionality and effectiveness of the application whereas beta testing beta testing was carried out in the form of user acceptance test by distributing the learning mobile application alongside with questionnaire to the slow learner children which age 5 to 6 years old with help from teachers or guardians through online method. The questionnaire is presented in Google Form to collect feedback from target users on their satisfaction with the developed learning mobile application. The questionnaire is presented in Google Form to collect feedback from target users on their satisfaction with the developed learning mobile application. After collecting data in the form of target users' feedback, it is analyzed and utilized to make future improvements.

4. Results and Discussion

The last testing process carried out is beta testing where the developed application is tested on users. This testing was done on slow learner children which age 5 to 6 years old and the online questionnaire link was distributed through the WhatsApp application. The evaluation of user acceptance was assessed using Google Form and divided into three sections namely user information, user acceptance test and application functionality. The respondents answer the questionnaire with the help of teachers and their guidance. Furthermore, a 5-point Likert scale has been applied to the questionnaire with options such as 'strongly disagree', 'disagree', 'neutral', 'agree', and 'strongly agree'. A total of 31 responses were collected and the results were analyzed.

The results of this questionnaire found that 64.5% of respondents were female while 35.5% were male as shown in Figure 5. As for the age, most users are 6 years old which is 58.1% while 41.9% are 6 years old. Figure 16 shows the results of the user's age.

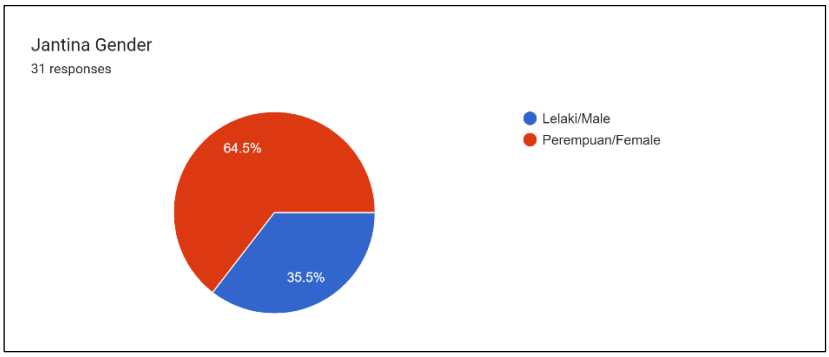


Figure 10: Gender of the Respondent

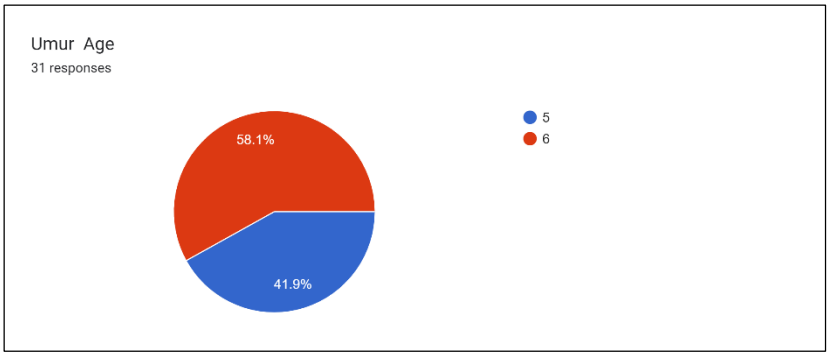


Figure 11: Age of the Respondent

The second section, which is the level of user acceptance, is studied to identify the extent to which users accept the design and elements used in the application. Based on the Figure 7, 45.2% of respondents agreed that the design of the application is very interesting while 41.9% totally agreed.

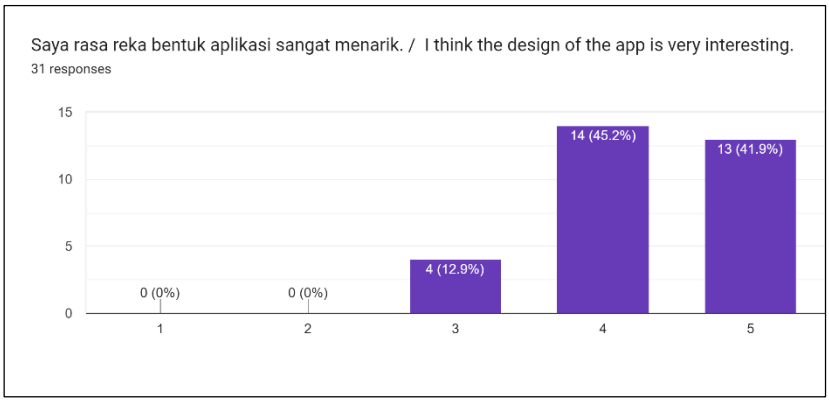


Figure 12: Respondent's Feedback On Design

For Figure 8, 58.1% of respondents totally agreed that they would like to use the application frequently while 22.6% of respondents agreed with the statement.

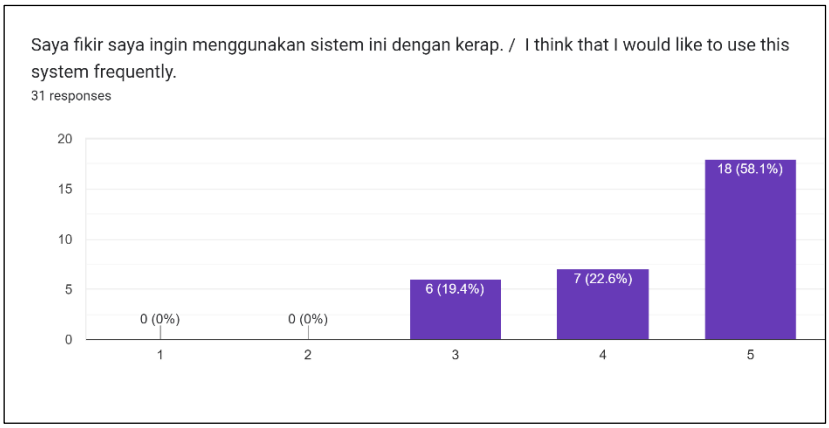


Figure 13: Respondent's Feedback on Application Use

Figure 9 shows that 45.2% of respondents are both totally agreed that the application is easy to use. There are 9.7% of respondents who are neutral with the given statement.

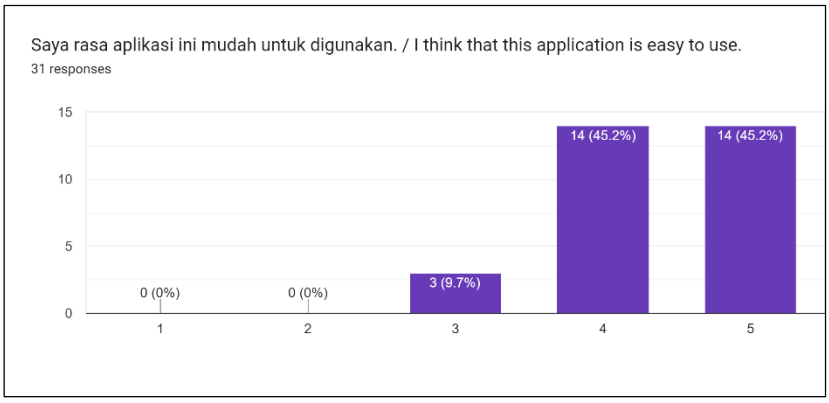


Figure 14: Respondent's Feedback on Ease of Use of Application

Based on Figure 10, an average of 58.1% of respondents totally disagreed, 19.4% agreed and 12.5% is neutral that the application is inconsistent. However, it also received 6.5% totally agreed and 3.2% agreed. This is because there are some buttons are not in the same shape or size. Therefore, it will look not consistent to certain device's size screen.

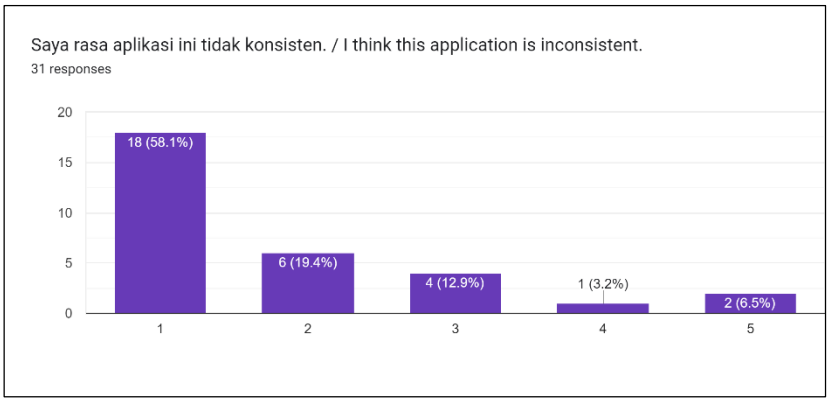


Figure 15: Feedback on Consistency

Based on the Figure 11, 9.7% of respondents are agreed and 6.5% totally agreed. Since the target user are slow learner children, there will be some confusion or instructions that they are not understands and need helps from other person.

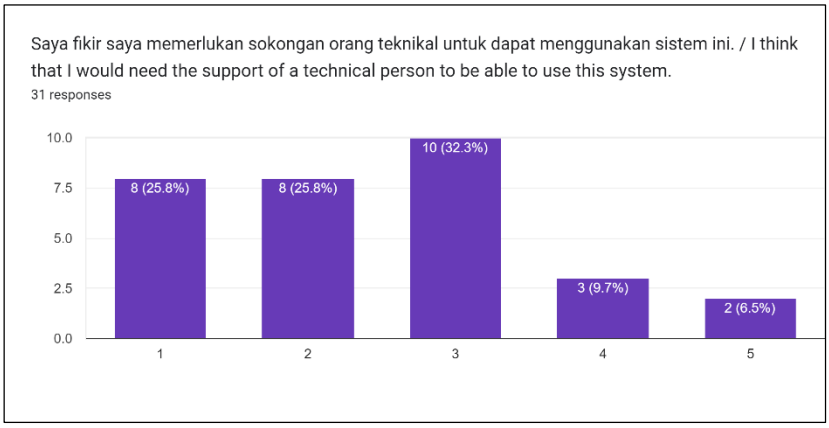


Figure 16: Respondent's Feedback on the Need of Technical Support

The last section is the functionality of the application where the purpose is to identify the functionality of the developed application. Based on the Figure 12, 66.7% of respondents totally agree that the application help them in understanding the concept of addition and subtraction operations. Meanwhile, 23.3% of users agree.

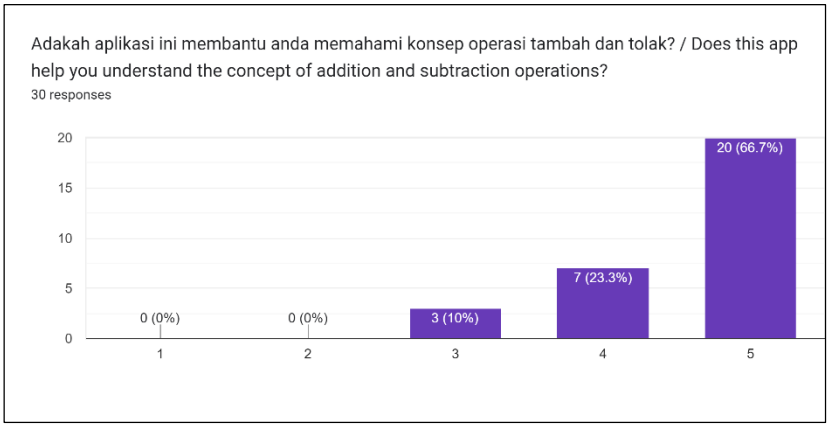


Figure 17: Respondent's Feedback on the Concept of Addition and Subtraction Operations

Figure 13 shows that 53.3% of respondents totally agreed that they are interested in learning Mathematic while 30% of users are agreed and 16.7% are neutral with the statement. The total percentage of agreed

and strongly agreed are more than half, therefore, Matematik Pintar can be one of the alternatives for them to learn more about Mathematics.

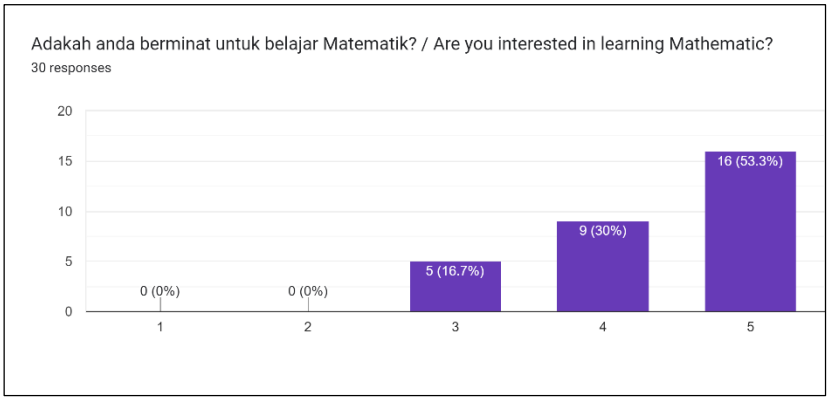


Figure 18: Respondent's Feedback on Interest in Mathematic

Figure 14 shows that 60% of respondents totally agreed that after using the application, they can remember the sequence of numbers one until ten and 30% are agreed while 10% are neutral. In summary, the Matematik Pintar application has completed user acceptance testing with positive feedback and results from the target user.

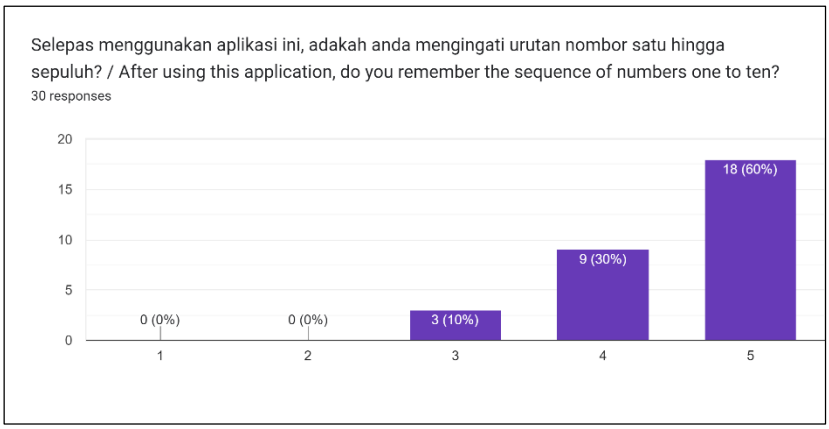


Figure 19: Respondent's Feedback on Learning Module

5. Conclusion

Based on the results analyzed from the testing phase, Matematik Pintar application is suitable for the target user to learn Mathematic. The three objectives of this project were fully accomplished by first designing the content of "Matematik Pintar" an interactive mobile application for slow learning using tactile learning style. Secondly. Successfully develop an interactive mobile application using gamification approach on Android platform. Lastly, performing the functional and user acceptance testing after the development phase are completed. The project followed to a well-planned Multimedia Mobile Content Development (MMCD) approach and integrated valuable feedback from users through testing.

Acknowledgment

I would like to thank the Faculty of Computer Science and Information Technology, University Tun Hussein Onn Malaysia for their support.

Appendix A

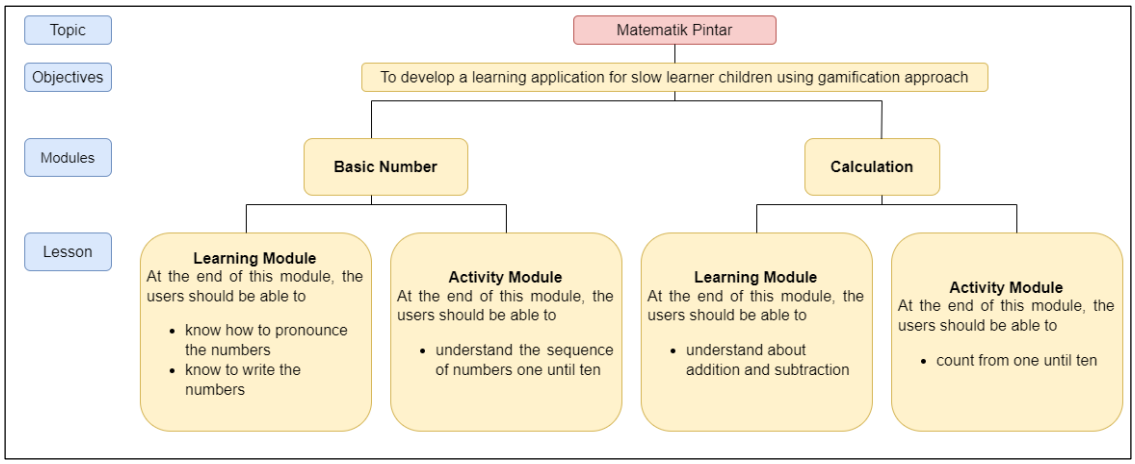


Figure 13: Content Structure

Appendix B

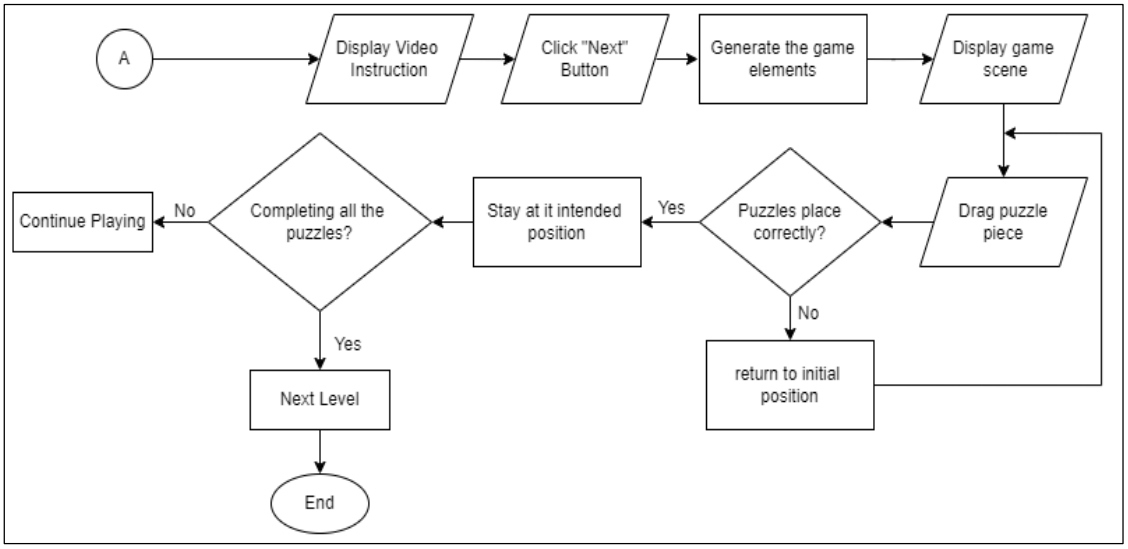


Figure 4(b): System Flowchart for Drag and Drop Games

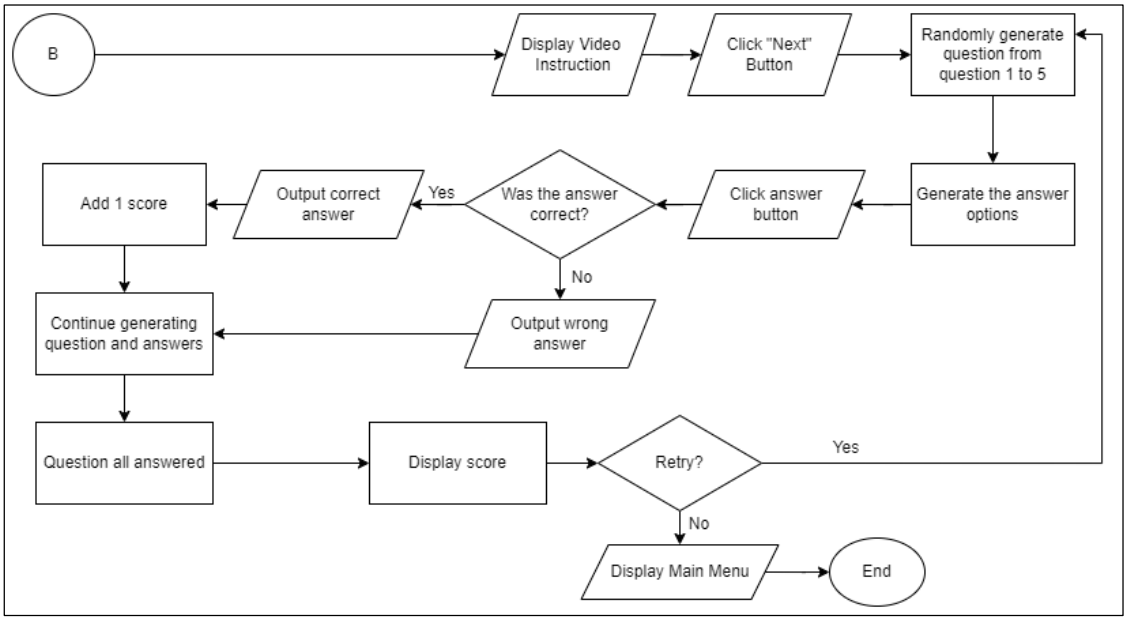


Figure 4(c): System Flowchart for Quiz Game

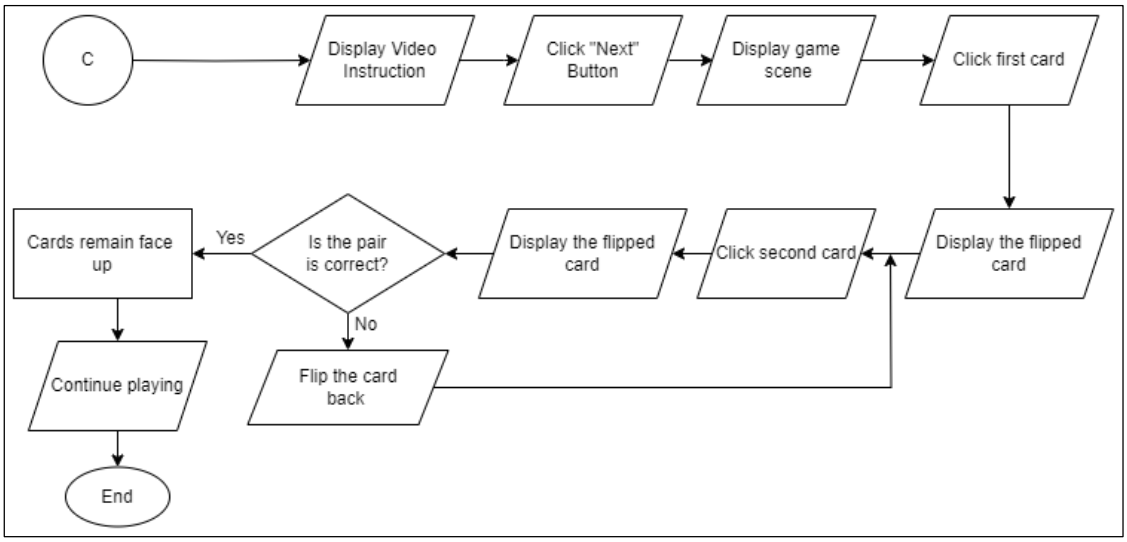


Figure 4(d): System Flowchart for Flip Card Game

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