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Mood Chem: Development of an Android-Based STPM Chemistry Learning Application using Gamification Approach

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Abstract: Organic chemistry is an important topic in the STPM Chemistry curriculum. Many students struggle with it as it requires extensive memorization of numerous reactions. Moreover, the topics used in the existing applications were not based on the Malaysian Examination Council (MEC) STPM Chemistry syllabus. Thus, Mood Chem has been developed as a learning tool for STPM science students to learn Organic Chemistry through a gamification approach. It is an Android application with syllabus-based content. The objectives of this project are to design a mobile learning application about Organic Chemistry for STPM students based on the Malaysian Examination Council (MEC) STPM Chemistry syllabus, to develop a mobile learning application about Organic Chemistry on the Android-based mobile platform with a gamification approach and to test the functionality and user acceptance of the mobile learning application about Organic Chemistry to STPM students. This project is developed using the Agile model. It was tested on 30 STPM science stream students. In the user acceptance testing, more than 80% of the respondents strongly agreed or agreed with the statement in all constructs. Mood Chem is an application that eases the students to understand Organic Chemistry as learning module and game are provided. To conclude, Mood Chem is well received by the intended audience.

Keywords: Organic Chemistry, STPM, Gamification Approach

1. Introduction

Malaysian Higher School Certificate (STPM) is one of the channels for post-secondary science students to pursue a bachelor's degree program. According to the MEC STPM Chemistry syllabus, Organic Chemistry is one of the main topics in the syllabus. It is a complicated subject as it is about organic compounds' structure, properties, and reactions, which discourages the students from learning this subject. The common problems that the students face when studying this subject are identifying a given organic compound's functional group and constructing the molecular and structural formulae of

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the organic compound [1]. Nowadays, mobile learning (M-learning) applications are becoming popular as the way they deliver information decreases traditional education's limitations [2]. M-learning is categorized as a teaching and learning gamification category [3]. Therefore, this project is to develop an Android-based mobile application about Chemistry with a gamification approach for STPM students as an additional learning tool to learn Organic Chemistry.

Organic chemistry is a subject that students find tough and challenging. It requires extensive memorizing of a huge number of reactions, names, the reagents and conditions needed for each reaction which are the popular exam topics. Due to the numerous strategies to answer synthesis questions, it is common when many students to fail to answer the questions during the exam. Moreover, finding a Chemistry learning application explicitly designed for STPM students is difficult. One of the existing applications on Google Play Store, entitled Organic Chemistry Flashcards [4], the contents of the applications are mostly different from the MEC syllabus. Thus, finding a Chemistry learning application that is based on the STPM syllabus is rare. Furthermore, finding a learning application about Chemistry with a gamification approach in the Google Play Store is hard. Based on the problem statement, several objectives can be identified, which are to design a mobile learning application about Organic Chemistry for STPM students based on the Malaysian Examination Council (MEC) STPM Chemistry syllabus, to develop a mobile learning application about Organic Chemistry on the Android-based mobile platform with a gamification approach and to test the functionality and user acceptance of the mobile learning application about Organic Chemistry to STPM students.

Mood Chem is an Android-based Chemistry learning application with a gamification approach, which is easier for STPM students to understand and memorize chemical reactions. It is written entirely in English and will consist of four modules which are the Chemical Reactions Module, Functional Group Module, Chemical Tests Module, and Game Module. The contents are based on the latest STPM Chemistry syllabus and focus on Organic Chemistry.

The rest of the paper is organized as follows: Section 2 will discuss the literature review of the related work and existing applications. Then, Section 3 will discuss the methodology used to conduct this project and the activities in each phase. Next, Section 4 will show the user acceptance testing results and Mood Chem's advantages and limitations. Lastly, Section 5 will conclude the progress that has been made, and the suggestions for future work on the application will be listed.

2. Related Work

In this section, the domain background of this project, Organic Chemistry, will be discussed in Section 2.1. The gamification approach that applies to the project is also discussed in Section 2.2. A study of existing applications and the proposed application is included in Section 2.3.

2.1 Organic Chemistry

Organic Chemistry is one of the important topics of Chemistry for students who enroll in the science stream for STPM. This topic will be taught in the third semester of the STPM program. Many breakthroughs in physics and biology have been made possible by applying chemical principles. However, Malaysian Educational Statistics [5] revealed the number of students enrolled in the STPM science stream for the year 2021 is 3981, while the number of students enrolled in STPM humanities streams is 42950. It is due to "Chemophobia", where students fear chemicals and Chemistry as a course [6]. Moreover, it is a subject that necessitates extensive memorization of chemical reactions, and students frequently fail to make the connection between atoms and molecules [7]. Thus, utilizing the learning applications by gamification will promote learning and motivate students to continue learning, as m-learning is common in this century [8].

STPM is a one-and-a-half-year long program that includes a total of three semesters. It is one of the channels for students to pursue a bachelor's degree in an open university in Malaysia. A new modular

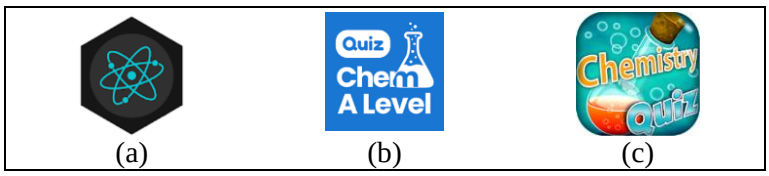
system of STPM has been replaced with the existing terminal system since 2012. There will be three terms in the STPM curriculum, and examinations will be held at the end of each term. Students from the science stream are required to sit for paper 1, paper 2, paper 3 and paper 4 (coursework) for the subject of STPM Chemistry.

2.2 Gamification Approach

Over the last decade, applying the gamification approach in education has gained interest and attention from many people. According to Kapp [9], gamification uses game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems. Klock [10] mentioned that applying the gamification approach in education encourages the students and promotes a better user experience. It is a technique that can be adopted to improve the user experience. Achievement, rewards, storyline, and time are the features that can be embedded in gamification for education. Thus, Generation Z, who are better equipped with technology, will not feel bored or frustrated while learning. According to Noradzan [11], it increases the motivation and engagement of the students. The use of technologies in teaching and learning will emerge as the traditional teaching method is less effective than the modern method.

2.3 Study of Existing Applications

The existing applications, such as Organic Chemistry Basics [12], A-level Chemistry Quiz [13], and Chemistry Quiz Games - Fun Trivia Science Quiz App [14], will be reviewed and compared with the proposed application. A comparison between these will be tabulated in Table 1. Figure 1 shows the icons of the three applications.



(a) (b) (c)

Figure 1: (a) Organic Chemistry Basics (b) A-level Chemistry Quiz (c) Chemistry Quiz Games - Fun Trivia Science Quiz App

Table 1: Comparison Between Reviewed Applications and Proposed Application

Features	Organic Chemistry Basics	A level Chemistry Quiz	Chemistry Quiz Games - Fun Trivia Science Quiz App	Mood Chem
Strengths	• Steps were given to draw and name the chemical reactions. • Graphical explanations were provided for 2 modules.	• The correct answers will be given after completing the 10 questions. • Free to use. • A time limit is provided for every module.	• 2 game modes were provided. • 4 modes of displaying questions. • Different chances for answering the questions.	• Free to use. • Consists of 3 learning modules and a game module. • Consistent user interface design.

Table 1: (cont)

Features	Organic Chemistry Basics	A level Chemistry Quiz	Chemistry Quiz Games - Fun Trivia Science Quiz App	Mood Chem
Limitations	• 2 themes were provided, only the light theme can display properly. • Annoying advertisements. • An internet connection is required.	• Annoying advertisements. • An internet connection is required. • The world rank feature has not been fully developed.	• Annoying advertisements. • The loading bar is not in the center. • The leaderboard cannot display correctly.	• Only support the Android platform. • Only covers chemical reactions, functional groups and chemical tests.

3. Methodology

The methodology chosen to develop Mood Chem is the Agile model, as it is easier to fix or change the requirements of the product. It is developed in rapid cycles where tasks are broken into different phases. There are 5 phases in the Agile model which are the brainstorming phase, design phase, development phase, implementation and testing phase, and feedback phase [15]. Figure 2 shows the flow of the phases in the Agile model. The activities of each phase will be described in Section 3.1 to Section 3.5.

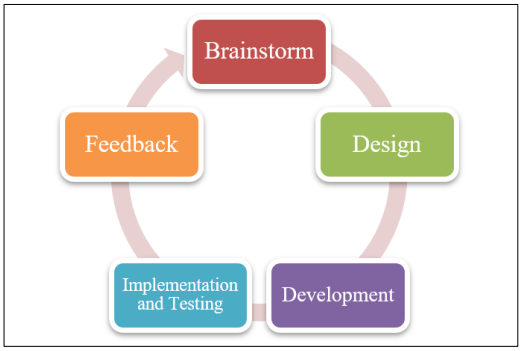


Figure 2: Agile model

3.1 Brainstorm Phase

The phase was where the idea of the project needed to be identified and approved by the supervisor. The intention to execute this project was determined by explaining the purpose, problem statements, objectives, scope, significance, and expected result. STPM science students were the intended audience for this application. Then, research 3 similar mobile applications available on the Google Play Store platform to identify their strengths and weaknesses. The review of these applications helped to enhance the proposed application. Plus, a Gantt Chart on tracking the project plans is produced in this phase. A suitable method as a guide to carry out this project is also studied and chosen in this phase.

3.2 Design Phase

In the design phase, the project scope and the mobile application feature were described through diagrams and tables. The requirements for Mood Chem were studied to develop the user experience (UX) and user interface (UI) designs. A storyboard of Mood Chem was created and the system analysis was conducted, including the functional and non-functional requirements, content structure, system flowchart, application modules diagram, and the object design.

3.2.1 System Requirement

In this section, the system requirement will be discussed in terms of Mood Chem's functional and non-functional requirements. A functional requirement describes what the system should do and the service that a system offers for the users. There are two types of functional requirements which are autonomous system activity and user interaction. Table 2 will show Mood Chem's autonomous system activity and user interaction.

Table 2: Functional Requirement

Functional Requirement	Description
Autonomous System Activity	• After the users open the application, the buttons shall be displayed automatically. • Level 2 in the Game Module shall be unlocked when the users pass the minimum score in Level 1. • While running each level in the Game Module, the system shall automatically countdown the time for three minutes for the users to complete the level. • The application shall display the correct icon or wrong icon to the users in the Game Module. • The application shall display the score obtained before continuing to the next level.
User Interaction	• Users should be able to click on the two buttons on the Main Menu and navigate them to the proper interface. • The application shall allow the users to choose the four modules in the Module Selection interface with the button provided. • The application shall allow the users to switch modules with the button provided. • The application shall allow the users to open and close the menu in the Chemical Tests Module. • The application shall allow the users to move the 2D character in the Game Module by clicking on the right buttons. • The application shall allow the users to answer the question in the Game Module.

The non-functional requirement will specify the criteria or elements that will judge the operation of a system. The requirement will include performance, implementation, usability, legal, and cultural. Table 3 will show the non-functional requirement of Mood Chem.

Table 3: Non-Functional Requirement

Non-Functional Requirement	Description
Performance	• The application is offline-based. • The application has a 3-second maximum response time for any interaction.
Implementation	• The application shall be able to operate on any Android mobile phone with the Android version of 4.1 and above.
Usability	• Users are able to access this application anywhere and anytime without connecting to the network. • Users shall find this application user-friendly, with clear buttons navigation and an enjoyable user experience.
Legal	• Users have no right to modify or change the application's content but can only view the content.
Cultural	• The language used for this application is English.

3.2.2 System Design

In this section, the system design will be discussed in diagrams to understand better the content structure, system flowchart and application modules diagram. Figure 3 shows the content structure of the application Mood Chem. It was separated into three categories which included a goal, module and topic. This application aimed to help the STPM science students memorise the chemical reactions using the gamification approach.

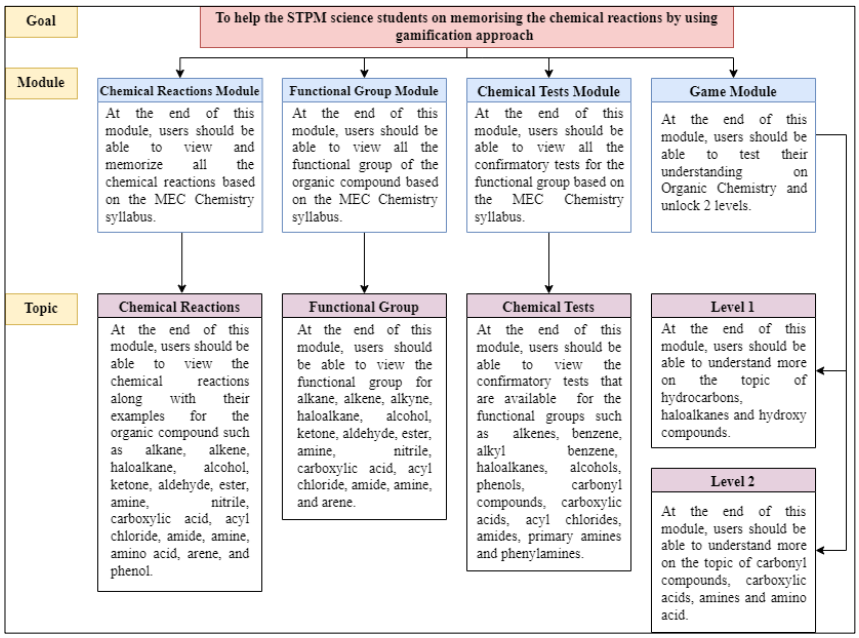


Figure 3: Content structure

The flowchart was designed to explain the overall flow of Mood Chem, which included the main process and the subprocess. There will be four modules in this application, namely the Chemical Reactions Module, Functional Group Module, Chemical Tests Module and Game Module. The system

flowchart has shown how the users can open different modules by pressing the respective buttons attached in Appendix A. Figure 4 shows the application modules diagram of the application Mood Chem. Two buttons were provided in the main menu and the experiment button consists of four modules such as the Chemical Reactions, Functional Group, Chemical Tests and Game modules.

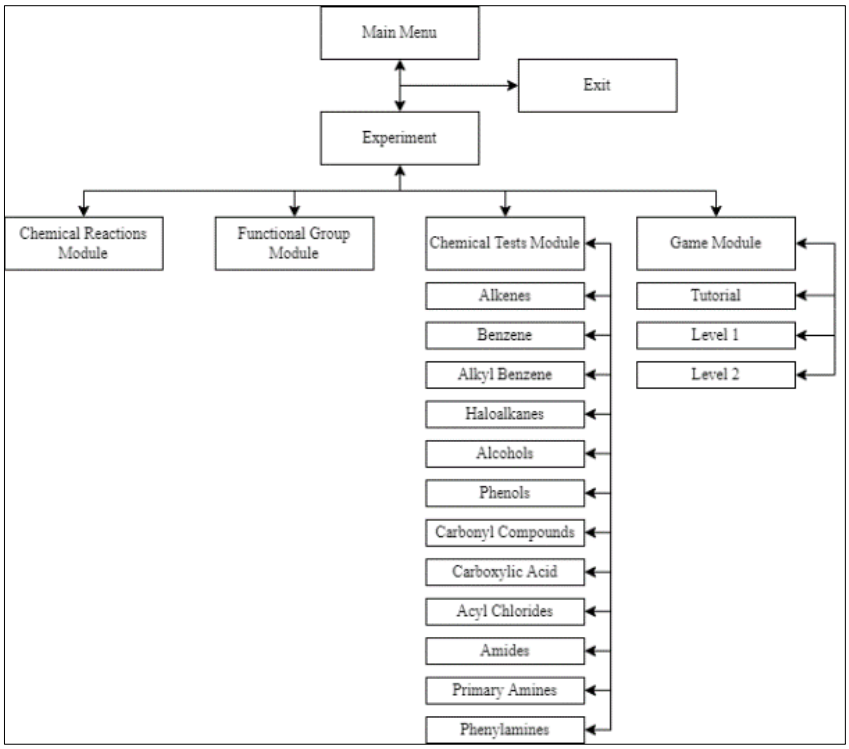


Figure 4: Application modules diagram

3.2.3 Object Design

This section will discuss the object design, such as the button design of Mood Chem. The button design is tabulated in Table 4. Adobe Photoshop CC 2019 and Adobe Illustrator CC 2019 were the design tools.

Table 4: Buttons design

Button	Function Description	Button	Function Description
EXPERIMENT	The experiment button navigates the users to the Module Selection interface.	×	The close button closes the description in the Chemical Reactions Module.
TUTORIAL	The tutorial button navigates the users to the Game Tutorial interface.	Hydration Combustion	The reaction buttons will open the description of the reactions in the Chemical Reactions Module.
EXIT	The exit button will open the Exit Warning interface.	ALKENES	The button will display the chemical test in the Chemical Tests Module.

Table 4: (Cont).

Button	Function Description	Button	Function Description

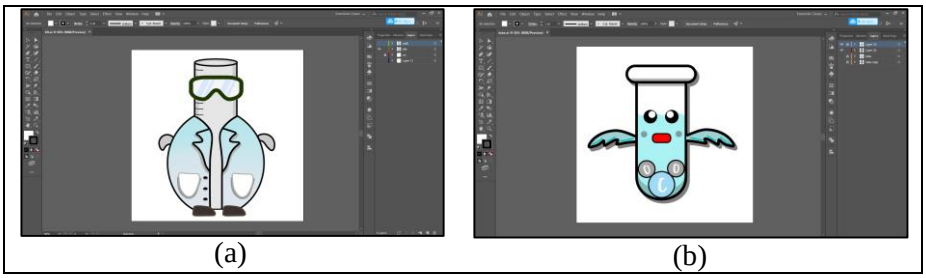
	The back button navigates the users to the previous interface.		The level unlock button appears on the Game Module.
	The Chemical Reactions button navigates the users to the Chemical Reactions Module.		The right button moves the chemist in the Game Module.
	The Functional Group button navigates the users to the Functional Group Module.		The play button will let the users continue the game.
	The Chemical Tests button navigates the users to the Chemical Tests Module.		The exit button will exit the game.
	The Game button navigates the users to the Game Module.		The restart button will restart the game level.

3.3 Development Phase

In the development phase, the proposed application was developed based on the requirements set during the design phase. The assets such as graphics, video and animation were developed while the buttons and user interfaces were integrated into Unity. All the game elements in the Game Module's quiz game were built using C# programming language in Visual Studio, such as the exit function, timer function, etc. The four modules, namely the Chemical Reactions Module, Functional Group Module, Chemical Tests Module and Game Module, were developed in Unity.

3.3.1 Assets Development

The software used to develop the graphics of Mood Chem are Adobe Photoshop and Adobe Illustrator. It was important to apply graphic assets in the Game Module to attract the target users' attention. Figures 5(a) and 5(b) show the development of the graphics assets.



(a) (b)

Figure 5: (a) Main character in Game Module (b) question trigger object in the Game Module

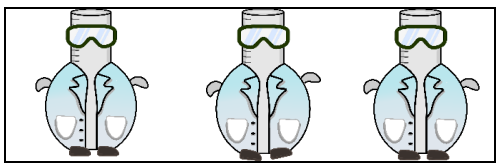


Figure 6: Walking animation

Figure 6 shows the walking animation of the main character. This animation will be displayed when the users move the player to the right by clicking on the player controller button.

3.3.2 Integration in Unity with Scripting

In this section, the method to integrate the assets of Mood Chem into Unity will be discussed along with the script. The features that were available in Mood Chem, such as show and hide the game object, load scene function, quiz game, player controls, timer function and unlock feature, will be explained in this section.

3.3.2.1 Show and Hide Game Object

The function of showing and hiding a game object was extensively used in Mood Chem in order to run this application successfully. The reason for using this function is to prevent some interface from popping out at the beginning of a scene. These interfaces can be opened only when the users click a particular button.

```
IEnumerator LoadCorrect()
{
    yield return new WaitForSeconds(0.5f);
    correctToShow.SetActive(true);
    yield return new WaitForSeconds(0.5f);
    correctToShow.SetActive(false);
    script.Q1lvl1.SetActive(false);
    script.Q2lvl1.SetActive(false);
    script.Q3lvl1.SetActive(false);
    script.Q4lvl1.SetActive(false);
    script.Q5lvl1.SetActive(false);
    script.Q6lvl1.SetActive(false);
    script.Q7lvl1.SetActive(false);
    script.Q8lvl1.SetActive(false);
    script.Q9lvl1.SetActive(false);
    script.Q10lvl1.SetActive(false);
}
```

Figure 7: Questions are set to inactive after the correct icon is popped up

Figure 7 shows the coding to hide a game object. The questions panel is hidden or inactive after the correct icon is displayed to the users when they choose the correct option for each question. SetActive(false) is used to make the game object invisible to the users in order for them to answer another question at each level.

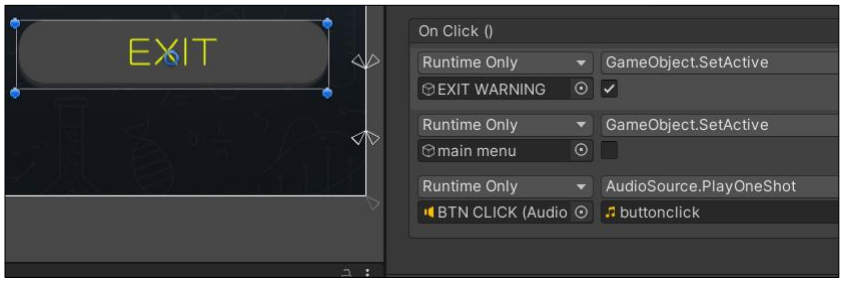


Figure 8: Questions are set to inactive after the correct icon is popped up

Figure 8 shows the game object function applied to the Exit Warning interface. When the users click the exit button, as shown in the On Click () in Figure 8, the Exit Warning interface will be invoked and displayed to the users. Then, the current scene, which is the Main Menu interface, will be hidden.

3.3.2.2 Load Scene Function

The function of loading to another scene is also important in developing Mood Chem. Figure 9 shows the load scene function called LoadLevel(int levelIndex). The levelIndex is the number of scenes as

shown in Figure 10. The only requirement to make the LoadLevel() can function is to import UnityEngine.SceneManagement in the script.

```
using UnityEngine;
using UnityEngine.SceneManagement;

Unity Script | 0 references
public class loadlevel : MonoBehaviour
{
    // Start is called before the first frame update
    0 references
    public void LoadLevel(int levelIndex)
    {
        SceneManager.LoadScene(levelIndex);
    }
```

Figure 9: Load scene function

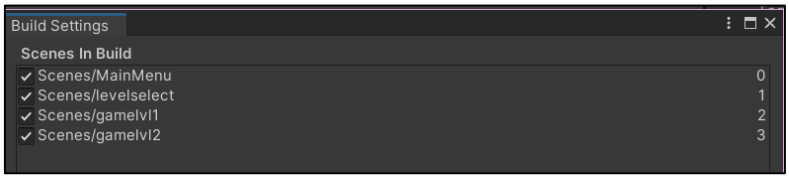
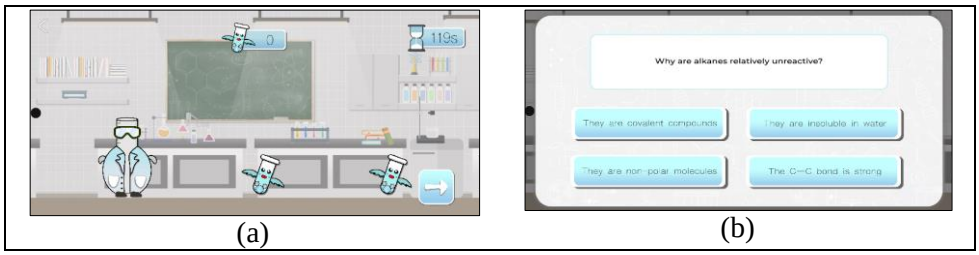


Figure 10: Scene in build in Mood Chem

3.3.2.3 Quiz Game

In this section, the quiz game that is used in the Game module of Mood Chem will be discussed. There are two levels in Game Module, which are Level 1 and Level 2. The users are required to choose one out of the four options provided for each question.



(a) (b)

Figure 11: (a) Example of quiz game (b) Question in the quiz game

The users need to move the player in the game by using the player controller to bump into the tube to open the question, as shown in Figure 11(a). Figure 11(b) shows the panel that will pop up when the users move the player by using the player controller to bump into the tube. Four options were provided, but the users can choose only one option to answer this question. The option buttons were assigned with a task.

```
void TaskOnClick39()
{
    a10.enabled = false;
    b10.enabled = false;
    c10.enabled = false;
    d10.enabled = false;
    StartCoroutine(LoadCorrect());
    total += 10;
    mark.text = "" + total;
    StartCoroutine(LoadScore());
}

1 reference
void TaskOnClick40()
{
    a10.enabled = false;
    b10.enabled = false;
    c10.enabled = false;
    d10.enabled = false;
    StartCoroutine(LoadWrong());
    mark.text = "" + total;
    StartCoroutine(LoadScore());
}
```

Figure 12: Code snippet of Quiz game

Based on Figure 12, every TaskOnClick() function consists of different activities that will need to be done when the respective button is clicked. For instance, when TaskOnClick39() is invoked, buttons a10, b10, c10, and d10 will be set to disable, meaning the users cannot click them. Then, it will run the LoadCorrect() function to set the correct icon to active by using SetActive(true). After displaying the icon, 10 marks will be added to the total score collected.

3.3.2.4 Player Control

The player control script was applied to the main character, the chemist, in the Game module. To complete the game, the users need to move the chemist to answer the question that pops up once the chemist hits the tube.

```
Unity Message | 0 references
void Update()
{
    if (transform.position.x > rightRange)
    {
        transform.position = new Vector2(rightRange, transform.position.y);
    }
    horizontalInput = CrossPlatformInputManager.GetAxis("Horizontal");
    rb.velocity = new Vector2(horizontalInput * moveSpeed, rb.velocity.y);


    if (horizontalInput == 0)
    {
        anim.SetBool("isRunning2", false);
    }
    else
    {
        anim.SetBool("isRunning2", true);
    }
}
```

Figure 13: Player control script

Figure 13 shows the player control script attached to the chemist in Unity. The script was used to enable the users to move the chemist in one direction, which is to the right. An asset called CrossPlatformInputManager is imported and applied to the script in order to move the chemist.

3.3.2.5 Timer Function

A timer was applied to the two-level in the Game Module as a countdown function. It is used as a time limit for the users to complete each level. The timer was considered a tool for the users to challenge themselves to answer all the questions provided in each level in a limited time. Hence, the users can feel like they are having a real examination while playing the game, as they also need to answer all the questions in a given time.

```
if (start && secondsLeft > 0)
{
    secondsLeft -= Time.deltaTime;
    countdown.text = secondsLeft.ToString("0") + "s";
}
else if (countdown.text == "0s" && start)
{
    Debug.Log("habis time");
    if (mark.text == "50" || mark.text == "60" || mark.text == "70" || mark.text == "80" || mark.text == "90" || mark.text == "100")
    {
        Debug.Log("can play lvl2");
        finalscore.text = "" + mark.text;

        script.Q1lvl1.SetActive(false);
        script.Q2lvl1.SetActive(false);
        script.Q3lvl1.SetActive(false);
        script.Q4lvl1.SetActive(false);
        script.Q5lvl1.SetActive(false);
        script.Q6lvl1.SetActive(false);
        script.Q7lvl1.SetActive(false);
        script.Q8lvl1.SetActive(false);
        script.Q9lvl1.SetActive(false);
        script.Q10lvl1.SetActive(false);

        congrats2.SetActive(true);
```

Figure 14: Timer function

Figure 14 shows the timer function attached to the timer text in Unity. The time will start counting due to the secondsLeft -= Time.deltaTime as shown in Figure 13. The secondsLeft is set to 120 at the beginning and will decrease by 1 as the game starts.

3.3.2.6 Unlock Feature

The unlock feature is applied in the Game module. There are two levels provided for the users where the topic of the questions is different. In Level 1, the questions will cover the topic of hydrocarbons, haloalkanes and hydroxy compounds. Meanwhile, the topics covered in Level 2 are carbonyl compounds, carboxylic acids, amines and amino acids.

Figure 15: Unlock feature in Game module

Based on Figure 15, there are two levels provided in the Game module. Only Level 1 can be played by the first-time users, while Level 2 is locked. In order to unlock Level 2, the users need to reach a minimum of 50 marks in Level 1.

```
IEnumerator LoadScore()
{
    yield return new WaitForSeconds(1f);
    if (mark.text == "50" || mark.text == "60" || mark.text == "70" || mark.text == "80"
        || mark.text == "90" || mark.text == "100")

    {
        Debug.Log("can play lvl2");
        finalscore.text = "" + mark.text;
        congrats2.SetActive(true);
        int currentLevel = SceneManager.GetActiveScene().buildIndex - 1;
        if (currentLevel >= PlayerPrefs.GetInt("unlocklevel"))
        {
            if (currentLevel <= 2)
            {
                PlayerPrefs.SetInt("unlocklevel", currentLevel + 1);
            }
        }
        Debug.Log("Level " + PlayerPrefs.GetInt("unlocklevel") + " Unlocked");
    }

    else if (mark.text == "0" || mark.text == "20" || mark.text == "30" || mark.text == "40")
    {
        Debug.Log("cannot play lvl2");
        finalscore.text = "" + mark.text;
        congrats.SetActive(true);
    }
}
```

Figure 16: Unlock script

Figure 16 shows the script of the unlock feature. When the total score collected in Level 1 is 50, and above, Level 2 will be unlocked. The record of the users will be stored in the PlayerPrefs by using the integer that is assigned to unlocklevel. If the users scored 50 marks and above, the unlocklevel would be set to 2, meaning Level 2 is unlocked.

3.4 Implementation and Testing Phase

In the implementation and testing phase, Mood Chem was built entirely according to the requirements set in the design phase. The assets were integrated into Unity successfully by using scripting and the graphics assets and the interfaces could interchange smoothly. Then, application functionality and user acceptance testing were conducted among the developer and the target users. The 4 modules in Mood Chem developed during the development phase were tested one by one based on the system requirements set on Unity. Installing the Mood Chem APK file into an actual mobile phone could ensure that the application's actual result meets the expected results. Debugging was compulsory to prevent more errors when bugs were found during the testing phase. User acceptance testing was conducted on the 30 STPM science students by sending the APK file to them.

3.5 Feedback Phase

In the feedback phase, the feedback from the target users is considered an application improvement. A Google Form was created to collect feedback from the target users and was analyzed to identify whether the project objectives could be achieved or not.

4. Results and Discussion

This section discussed the result of the application functionality testing and user acceptance testing for Mood Chem. Application functionality testing was carried out during the implementation phase until the application was built successfully. The elements being tested were the buttons in Mood Chem in terms of the functionality of the buttons. If errors appear during testing, amendment and improvement will be made to ensure the buttons can function as planned. Table 6 shows the application functionality testing results regarding the functionality of the buttons in Mood Chem.

Table 6: Application functionality testing results

Buttons	Expected Result	Actual Result	Corrective Action
Experiment button	Display Module Selection interface	Works well as expected	Not needed
Exit button	Display Exit Warning interface	Works well as expected	Not needed
Back button	Back to previous interface	Works well as expected	Not needed
Chemical Reactions button	Display mind map	Works well as expected	Not needed
Reactions button	Display information	Works well as expected	Not needed
Functional Group button	Display scrollable functional group interface	Works well as expected	Not needed
Game button	Display game lore	Works well as expected	Not needed
Skip button	Skip the game lore	Works well as expected	Not needed
Chemical Tests button	Display slide menu	Works well as expected	Not needed

Table 6: (cont)

Buttons	Expected Result	Actual Result	Corrective Action
Tutorial button	Display tutorial interface	Works well as expected	Not needed
Menu button	Open and close the menu	Cannot open the slide menu	Make sure the menu can open or close once the button is clicked
Level 1 button	Display Level 1 interface	Works well as expected	Not needed
Right button	Move the chemist to the right	The camera does not follow the chemist's position	Make sure the camera follows the chemist's position
Play button	Continue the game	Works well as expected	Not needed
Exit game button	Exit the game	Works well as expected	Not needed
Replay button	Restart the game	Works well as expected	Not needed

The user acceptance testing that was carried out among the target users will be discussed in detail. A total of 30 STPM science stream students were involved in the testing of Mood Chem. A questionnaire was prepared by using Google Form for the target users to collect their feedback on Mood Chem as the collected data can be analyzed and summarised into charts automatically. Then, the questionnaire was sent to the students to answer. An instruction was written in the Google Form where they must install Mood Chem through the link attached before filling out the questionnaire. The questionnaire can be viewed in Appendix D. The questions in the Google Form were measured using the Likert scale ranging from 1 to 5, from strongly disagree to strongly agree. The analysis of the user acceptance testing is shown below.

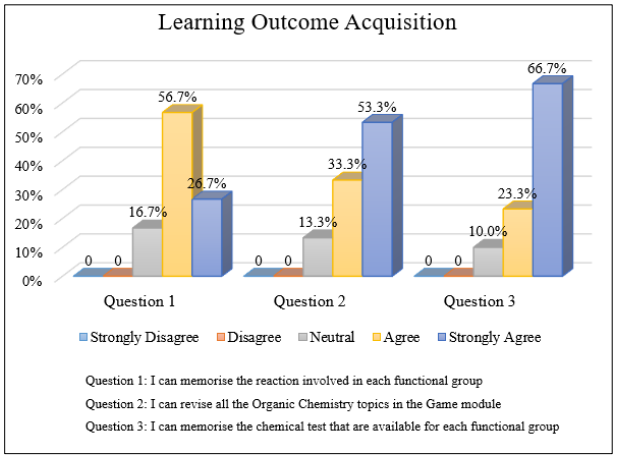


Figure 17: Analysis of Learning Outcome Acquisition

Figure 17 shows the analysis of the Learning Outcome Acquisition on Mood Chem. A total of three questions were included in this section. In response to Question 1, the majority of the respondents where 56.7%, agreed that they could memorize the reactions involved in each functional group. 26.7% of the respondents strongly agreed, and 16.7% felt neutral with Question 1. Besides, 53.3% of the respondents

strongly agreed with Question 2 as a total of 10 questions were provided in Level 1 and 10 questions for Level 2 where the topics were mentioned in Figure 3. Meanwhile, 33.3% agreed they could revise all the Organic Chemistry topics in the Game module, and 13.3% felt neutral with this statement. Lastly, 66.7% of the respondents strongly agreed that they could memorize the chemical test available for each functional group by using Mood Chem, while 23.3% agreed with this statement. Only 10% of the respondents felt neutral with Question 3.

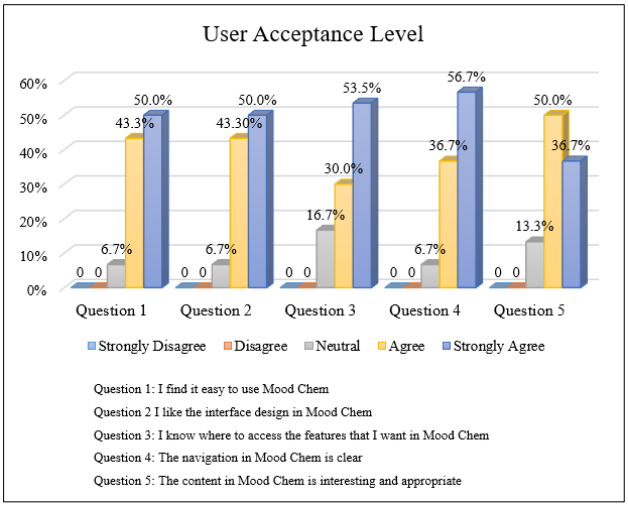


Figure 18: Analysis of User Acceptance Level

Figure 18 shows the analysis of the User Acceptance Level of Mood Chem. A total of five questions were included in this section. In response to Question 1, half of the respondents strongly agreed that they find it easy to use Mood Chem. 43.3% agreed with Question 1 while only 6.7% felt neutral with this question. The same goes for Question 2 where half of the respondents strongly agreed that they like the interface design in Mood Chem, while 43.3% of them agreed with this statement. Meanwhile, 6.7% of them felt neutral with Question 2. In response to Question 3, more than half of the respondents, which was 53.5% of them, strongly agreed that they knew where to access the features they wanted in Mood Chem. Only 30% agreed and 16.7% felt neutral with Question 3. Besides, Question 4 had the most respondents where 56.7% reacted strongly agreed that the navigation in Mood Chem is clear. There were 36.7% of the respondents agreed and 6.7% felt neutral with Question 4. Lastly, half of the respondents agreed with Question 5 that the content in Mood Chem was interesting and appropriate. Meanwhile, 36.7% of the respondents strongly agreed, and 13.3% felt neutral with Question 5.

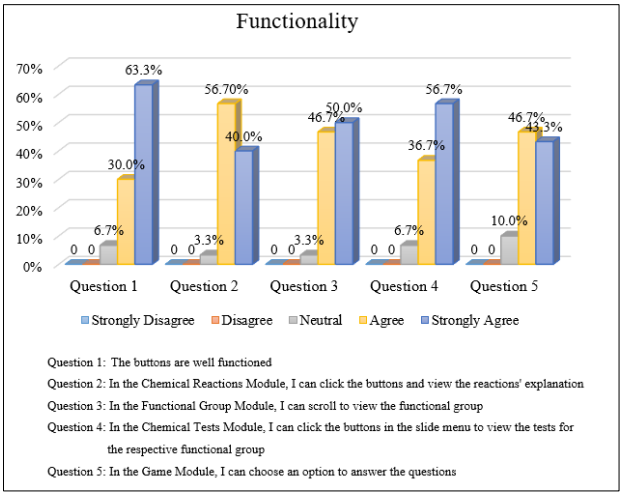


Figure 19: Analysis of Functionality

Figure 19 shows the analysis of the Functionality of Mood Chem. A total of five questions were included in this section. In response to Question 1, more than half of the respondents where 63.3% of them, strongly agreed that the buttons were well functioning. 30% of the respondents agreed and 6.7% of them felt neutral with Question 1. Next, 56.7% of the respondents agreed with Question 2, where they could click the buttons and view the reaction's explanation in the Chemical Reactions module. 40% of the respondents strongly agreed and only 3.3% felt neutral with Question 2. Besides, half of the respondents strongly agreed with Question 3 where they can scroll to view the functional group in the Functional Group module. Meanwhile, 46.7% of the respondents agreed and only 3.3% felt neutral with this question. In response to Question 4, 56.7% of the respondents strongly agreed that they could click the buttons in the slide menu to view the tests for the respective functional group in the Chemical Tests module. Only 36.7% agreed and 6.7% of them felt neutral with Question 4. Lastly, 46.7% of the respondents agreed with Question 5 where they can choose an option to answer the questions in the Game module. There were 43.3% of the respondents agreed and 10% felt neutral about this question.

In a nutshell, Mood Chem received positive responses from most of the respondents through this user acceptance testing where all the constructs received more than 80% of the respondents strongly agreed or agreed with the statements. Moreover, the results have proven that Mood Chem had fulfilled the users' requirements. Thus, Mood Chem can be used as an additional tool to learn Organic Chemistry for the STPM science stream students. Besides, it can be concluded that Mood Chem has advantages such as Mood Chem provides the information on Organic Chemistry based on the MEC STPM Chemistry syllabus, allowing users to view all the topics in the syllabus in one application. Plus, Mood Chem provides an Organic Chemistry reactions mind map where the reactions' names and descriptions are based on the MEC STPM Chemistry syllabus, allowing users to view all the reactions easily. Mood Chem provides a Game module for the users, a 2-level quiz game that includes all the topics in the STPM Organic Chemistry syllabus with a gamification approach allowing users to revise the topics in Organic Chemistry while playing the game. Mood Chem also provides a user-friendly interface for the users with clear and simple navigation to prevent them from feeling lost while using the application. Meanwhile, Mood Chem was developed in English, allowing users to understand the application's content easily.

After analyzing the feedback of the user acceptance testing that was collected from the target users, it is discovered that there is no application that is always perfect. The same goes for Mood Chem, which also has its limitations. The limitations of Mood Chem include the Game module in Mood Chem only has 2 levels, the question order provided in the Game module is fixed, the number of questions that can be included for each chapter in the Game module is limited and the animations used in the learning modules in Mood Chem are not enough.

5. Conclusion

In conclusion, the Mood Chem application was developed successfully in the expected timeline as an Android-based application for the STPM science students by following the phases in the Agile model. It is a learning application that is focused on STPM Organic Chemistry, where the material used in the contents of the application is based on the MEC syllabus. The four modules provided namely the Chemical Reactions Module, Functional Group Module, Chemical Tests Module and Game Module, were successfully built. Based on the user acceptance testing results, more than 50% of the respondents strongly agreed and agreed with the statements in all of the constructs. By analyzing the collected feedback, the three objectives of this project have been achieved. Moreover, the advantages and limitations of Mood Chem were evaluated.

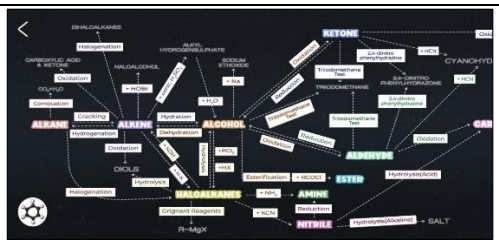
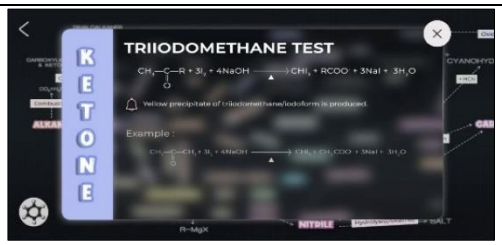
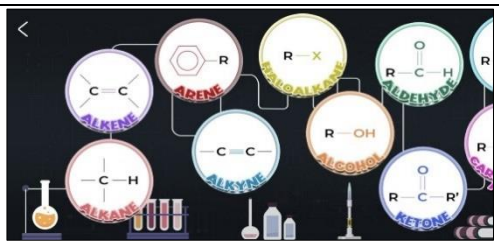
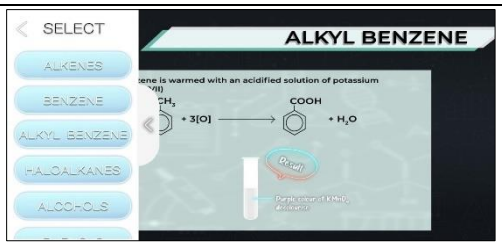
In order to enhance and overcome the current limitations of Mood Chem, some improvements can be made for an updated version of Mood Chem in the future. One suggestion for improving the Mood Chem application is to increase the game levels in the Game module to make the game more challenging. Next, randomization can be done on the order of the questions in the Game module

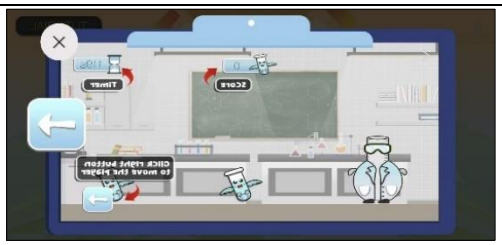
whenever the users play the game. Plus, the number of questions for each chapter in the Game module can be increased and include more animations in the learning module to make the learning process more interesting.

Acknowledgment

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

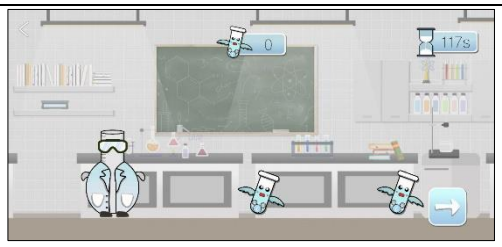
Appendix A

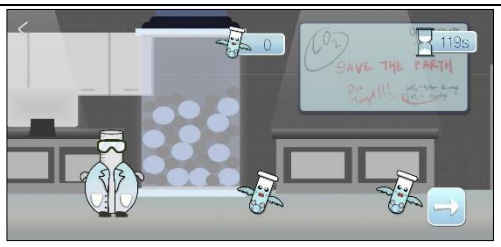
Main Menu interface	Exit Warning interface
	
Module Selection interface	**Chemical Reactions Module interface**
	
Reaction Description interface	**Functional Group Module interface**
	
Chemical Tests Module interface	**Game Lore in Game Module**
	
Level Selection interface	**Game Tutorial interface**



Game Module Level 1 interface

Game Module Level 2 interface





Game Pause Warning interface

Game Result interface in Level 2

Game Result interface when not achieve the passing score in Level 1

Game Result interface when achieve the passing score in Level 1

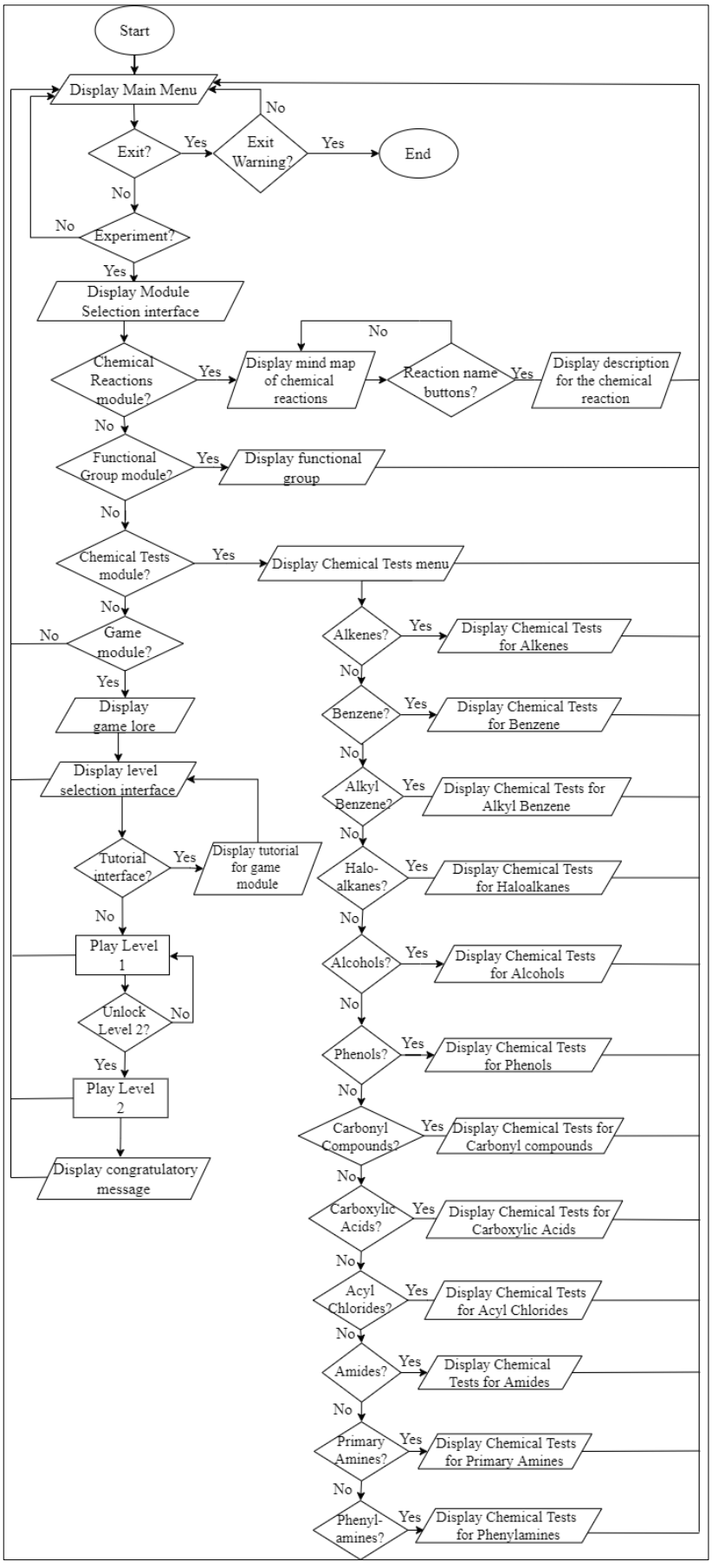


Figure 20: System flowchart

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