

Development of Mobile Game Application: Escape Room No Pest!

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Abstract

Pest control is a critical component of agricultural education, equipping students with essential knowledge to manage and prevent pest-related issues in farming. However, educational tools designed for students who is studying agriculture are still limited. This project proposes the development of a 3D mobile game tailored to the agricultural curriculum, focusing on key topics such as pest control management, relevant legislation, and standard procedures. The game incorporates challenges related to agricultural activities, enabling students to apply their knowledge in managing pests, understanding legal frameworks, and implementing appropriate procedures. The Game Development Life Cycle (GDLC) methodology is utilized to ensure a structured and efficient development process, creating an educational experience that aligns with students' learning needs. Testing and evaluation was conducted using System Usability Scale (SUS) measurement with the average of 68.63. This application aims to enhance students' understanding of pest control while fostering critical thinking and practical problem-solving skills in agriculture.

1. Introduction

Pest control refers to the management of creatures classified as pests, which adversely affect human activities, particularly in agriculture. It aims to mitigate or eliminate the damage these organisms inflict on crops, animals, and human health [1]. The Agriculture Form 5 syllabus includes pest control methods such as biological, physical, chemical, organic, and integrated pest management (IPM), alongside legislative frameworks and pesticide implications [2].

However, traditional learning methods, reliant on static materials like textbooks, struggle to convey these concepts effectively, often leaving students unable to apply them practically [3]. Current pest control education resources for Form 5 Agriculture students are not interactive enough and do not offer clear visual comparisons of different approaches and relevant legislation. Based on observation with Agriculture's students from Sekolah Menengah Kebangsaan Senggarang, it shows that conventional methods that mostly rely on textbooks and supplemental materials make it difficult to distinguish between different pest management techniques and comprehend how they are used in real-world situations. This lack of engagement hinders comprehension and retention, particularly for complex topics like pest management [4].

Though, the objectives of this project are to design a user-friendly Escape Room: No Pest! game application that is visually appealing and intuitive, to develop interactive point-and-click features to facilitate engaging activities focused on pest control management, and to evaluate the usability of the application through structured feedback and testing. Escape Room: No Pest! seeks to close gaps in conventional agricultural education. Players can travel into four stages of learning in this single-player mobile application, which was created for Android

platforms. The modules are Environmental legislation, management of plant pest control, methods of plant pest control and effects of pest control on plants and environment. Following the Game Development Life Cycle (GDLC) technique, the game uses Unity, Blender, and Canva Pro to provide the students with an interesting, syllabus-aligned experience. Positive feedback on usability and alignment with educational aims, increased engagement through immersive learning, and better understanding and retention of pest management techniques are just a few of the anticipated consequences of this innovative project. In both academic and real-world settings, Escape Room No Pest! expected to help students grasp pest control principles more deeply by providing a dynamic substitute for conventional tools.

The rest of the paper is arranged as follows: Section 2 covers the domain of study, the gameplay used, and the result of the comparative analysis. Section 3 describes the Game Development Life Cycle (GDLC) methodology that has been chosen to be used in this project, as well as the output of the analysis and design phases of this project. Furthermore, Section 4 discusses the result and discussion, while Section 5 states the conclusion of the current progress.

2. Related Work

This section discusses the background of the study, gameplay used, and the result of the comparative analysis.

2.1 Pest Control in Agriculture for Secondary School Student

Pest control is a subtopic in the Agriculture syllabus for secondary schools, specifically for Form 5 students. It introduces students to sustainable agricultural practices, focusing on techniques that promote ecosystem stability and crop health [5]. Pest control management involves monitoring, minimizing, and eliminating pests that harm the environment, animals, and agriculture. It aims to protect food supplies, preserve soil and water quality, and manage pest populations without compromising environmental health or food safety [6]. Traditional teaching methods, such as textbooks and lectures, provide fundamental knowledge but lack the interactivity required for deep engagement. According to experts, this traditional teaching method often hinders students from fully grasping complex pest control techniques and applying theoretical concepts in practical scenarios. Gamification, which includes elements like levels, rewards, and virtual scenarios, can make learning more engaging and effective by bridging the gap between theory and practice [7]. By integrating these elements, Escape Room: No Pest! aims to create an immersive learning environment that enhances students' understanding and application of pest management techniques.

2.2 3D Mobile Game

3D mobile games are digital games designed for mobile platforms such as smartphones and tablets where it uses 3 dimensional graphics and environment to create an immersive and interactive experience[8]. It also allows players to navigate and interact within a virtual 3D space where it is more real compared to traditional 2D mobile games. Aside from that, 3D mobile games span a variety of genre like role-playing game (RPG), action-adventure, casual, shooter and puzzle-solving games where each genre have unique gameplay mechanics. However, among these, exploration and puzzle-solving games are particularly impactful in educational settings, as they encourage logical thinking, curiosity, and the application of knowledge.

Using puzzle-solving and exploration features, Escape Room: No Pest! offers players a fun platform on which to work through scenarios, complete chores, and solidify their knowledge of pest management concepts. Players move through levels with content that is intended to resemble real-world scenarios. They must finish tasks according to various pest control management and solve riddles. These thoughtfully designed exercises are meant to motivate players to put their knowledge to use, strengthening their comprehension in a useful and engaging manner. The game offers a pleasant and engaging platform that keeps players engaged while reinforcing their understanding of crucial pest management strategies by fusing exploration with obstacles. This gamified method guarantees that learning becomes effective and pleasurable.

2.3 Comparative Analysis

Comparative analyses were conducted on three related applications to the proposed system. The three applications are Bug Heroes 2 [9], Pest Diagnostic: Simulator [10], and Insect Invaders: Space Shooter [11].

The comparison is based on ten features observed from the previous mentioned applications. The features that are being discussed is the content of the game, purpose of the game, type of the gameplay, number of modules, multimedia elements, number of levels, strength, scoreboard availability, limitation and character. Table 1 shown the details of the comparison on three related applications with the proposed system.

Table 1 *Comparative Analysis*

Applications / Features	Bug Heroes 2 [9]	Pest Diagnostic: Simulator [10]	Insect Invaders: Space Shooter [11]	Escape Room No Pest!
Content of the game	Action-packed strategy involving bug characters with unique abilities.	Simulation of pest identification and control strategies.	Space shooter featuring insect enemies and power-ups.	Exploration and puzzle-solving escape room game
Purpose of the game	Entertainment through strategy and teamwork	Education about pest infection	Entertainment through competitive edge	Education about pest control management
Type of gameplay	Strategy and action	Simulation	Arcade Shooter	Exploration and Puzzle-solving game
Number of modules	Two modules: • Single Player • Multiplayer	Three modules: • Scenario • Investigation • Diagnostic	One module: • Battle mode	Four modules: • Environmental legislation • Management of plant pest control • Methods of plant pest control • Effects of pest control on plants and environment
Multimedia elements	• 3D graphics • sound effects • animations	• 3D graphics • Informative animations • Tutorials	• 2D graphics • Sound effects • Colorful user interface	• 3D graphics • Background music • Interactive user interface
Number of levels	None.	7 level	60 level	4 level
Strength	Engaging gameplay with strategic elements and variety of characters.	Realistic simulations enhance learning and practical applications.	Simple mechanics that are easy to learn and engaging graphics.	Interactive learning experience and aligns with educational curriculum.
Scoreboard availability	Yes	Yes	Yes	No
Limitation	May lack depth in educational content, repetitive.	May be less engaging for younger audiences.	Limited educational value and focuses primarily on entertainment.	Requires critical thinking and may be challenging for some users.
Character	Bug characters with unique abilities	No specific characters, user-driven scenarios	Insect enemies and spacecrafts	No specific characters; user acts as the protagonist navigating through the escape room scenarios.

3. Methodology

The Game Development Life Cycle (GDLC) approach as shown in Figure 1, which was selected for its adaptability in allowing iterative changes without interfering with the overall process, served as the development framework for the mobile game application Escape Room: No Pest!. The six stages of the GDLC approach are initiation, pre-production, production, testing, beta and release [12]. The objectives, constraints, and intended audience were determined at the initiation phase, and a game concept with a preliminary proposal was created. During the pre-production stage, a Gantt chart was used to schedule and allocate resources, and comprehensive storyboards, design documents, and prototypes were created. During the creation phase, Blender and Canva were used to

create game assets, such as 3D models and user interface elements. C# programming was then used to integrate the assets into Unity for interactive features. Alpha and beta testing phases were used to find bugs, improve gaming mechanics, and get input from Sekolah Menengah Kebangsaan Senggarang's Form 5 agriculture students. The game was finished and optimized for Android devices during the release phase, guaranteeing that it will work on tablets and smartphones. The incorporation of instructional content into gaming mechanics was highlighted by minor adjustments to the GDLG technique, which matched the project's learning goals.

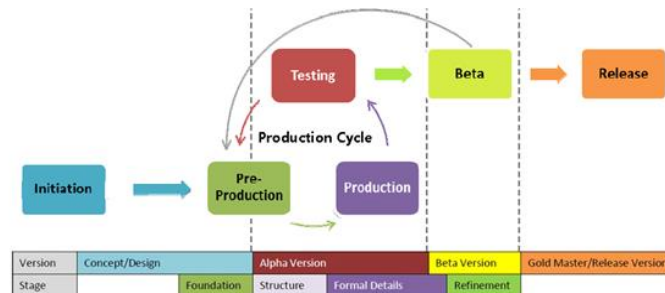


Fig. 1 Game Development Life Cycle methodology[13]

3.1 Initiation Phase

The goal of the Initiation Phase was to determine the specifications needed to create the Escape Room: No Pest! game application. In this stage, a few existing educational games were reviewed along with interview session with the Subject Matter Expert (SME), Mrs. Siti Fatimah binti Ishak who is a teacher that teaches the Agriculture subject at Sekolah Menengah Kebangsaan Senggarang. The interview session took place in person at the school, resulting in a thorough discussion that yielded insightful information as shown in Appendix A. As seen in Table 2, application idea creation checklist was created using these inputs. Furthermore, Table 3 displays the user analysis based on the SME's comments during the interview. Next, Table 4 and Table 5 displays the functional and nonfunctional requirements of the proposed application. The application development workflow which is Table 6, system flowchart and navigation structure are shown in Appendix B to Appendix H.

Table 2 Checklist for Application Idea Creation

Item		Description
Type of Application		A game mobile application.
Target Users		Form 5 students studying Agriculture subject
Target Device		Android-based tablets.
Graphical Interface (GUI)	User	A user-friendly main menu, four interactive game modules with point-and-click mechanics in a 3D interactive room setting.
Images		Backgrounds of interactive 3D rooms, navigation icons, visual elements such as pest control tools (e.g., light traps), and graphics of crops and pests.
Audio		Background music related to pest control activities.
Application Synopsis		Escape Room: No Pest! is a mobile game application designed for Form 5 students taking Agriculture as a subject. Using a game-based learning approach in a 3D escape room environment, the application offers a learning module and a game module featuring multimedia elements such as graphics and audio. Users will learn through interactive and challenging activities, including solving puzzles, matching tasks, and collecting codes to complete each level.

Table 3 *User Analysis*

Subject Matter Experts	Role in the Product	Design Implications	Required Actions
Mrs Siti Fatimah binti Ishak	Content consultant for agriculture-related topics and educator	Multimedia content	• Animation and interactive puzzles to engage students with the game. • Implement scenarios where students must choose the correct method for specific plants and situations.
		Easy Navigation	• Use universal icons on buttons, such as home, settings, and back ensuring easy access for users. • Provide hints to assist students when stuck in a level. • Simple navigation with clear instruction.
		Reliable Content	• Provide accurate and syllabus-aligned information • The content is designed based on Form 5 pest control syllabus. • Focus on delivering information through visual aids like 3D graphics instead of text-heavy content.
		User-friendly interface	• Use readable and clear text. • Use fonts that are suitable for secondary students.

Table 4 *Functional Requirements*

Module	Functional Requirements	Autonomous System Activities
Main Menu	Players can start or exit the game via the main menu.	The system automatically loads the game scene when "Start" is selected and closes the application when "Exit" is chosen.
Environmental Legislation in Pest Control	Players navigate the environment using point-and-click mechanics, collect items, and answer questions about legislation.	The system automatically loads new areas, registers collected items, validates answers with immediate feedback, and allows navigation to the exit area upon task completion.
Management of Plant Pest Control	Players navigate the environment, answer questions related to plant pest management, and interact with buttons	The system detects item collection and placement, updates the environment state, and responds to button clicks to progress tasks.
Effects of Pest Control on Plants and the Environment	Players navigate the environment, answer questions on pest control effects, and interact with buttons.	The system automatically loads new areas, provides immediate feedback for answers, and enables navigation to the exit area once tasks are completed.
Methods of Plant Pest Control	Players can collect and place items while navigating and answering questions about pest control methods.	The system detects item collection and placement, updates the environment state, and responds to button clicks to progress tasks.

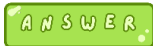
Table 5 *Non-Functional Requirements*

Non-Functional Requirements	Description
Usability	The game shall feature a hint and tutorial section to guide users on how to solve and play the game, operate offline, and be user-friendly and easy to use for players.
Compatibility	The game shall be compatible with Android devices running version 8.0 or later.
Localization	The system shall be developed in English to align with the target audience.
Validity	Users should not be able to modify any information displayed in this application.

3.2 Pre-Production Phase

The second phase of the GDLC, Pre-Production, focuses on planning and organizing the essential elements required for the development of the game. During this phase, key decisions are made regarding the game's storyline, mechanics, and visual style. The objective of this stage is to establish a clear roadmap for the game production process, ensuring that all necessary resources such as the design of related icons, images and buttons can be identified. The results of this phase form the foundation for the next stages of production, ensuring that the game aligns with both user expectations and technical feasibility. Table 6 outlines buttons design for this application.

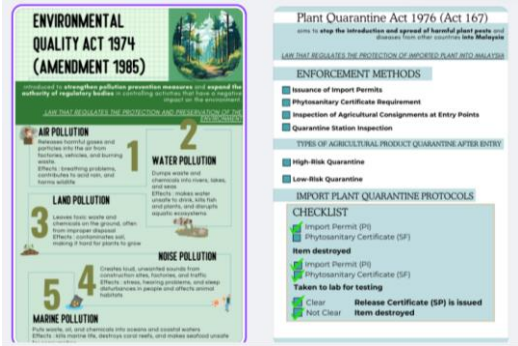
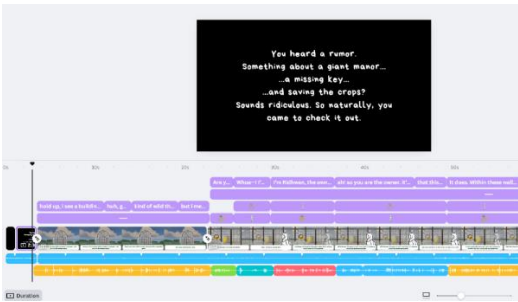
Table 6 *Button Design*

Button	Description	Button	Description
	This is Home Button		This is Start Button
	This is Next button		This is Settings Button
	This is Back Button		This is Quit Button
	This is Hint Button		This is Yes Button
	This is Settings Button		This is Task Button
	This is Close button		This is Retry Button
	This is Audio On and Off button		This is Reload Button
	This is Skip Button		This is Answer Button

3.3 Production Phase

The production phase of the GDLC is where the actual development of the game takes place, focusing on the implementation of the design concepts and features outlined during the preproduction phase. This phase involves the creation of game assets, such as 3D models, textures, animations, as well as programming the game mechanics, interactions, and functionality. Table 7 shows the assets development which are 3d models, graphics, audio and video while Table 10 shows the application interface in Appendix I.

Table 7 Assets Development

Asset	Development	Description
Graphics		All of the 2D graphical elements made use of in the game's interface, such as buttons and background elements, were made using Canva Pro. Scalability were key considerations in the design of each content, guaranteeing optimal performance at various mobile resolutions. To preserve visual coherence across the user experience, a consistent design approach was used, combining vector-based images, thematic color schemes, and uniform interface space.
Videos / Audio		Canva Pro was used to build the video assets, utilizing its timeline-based editor to layer text, graphics components and transitions. The built-in recorder on a mobile phone was used to capture narration, which were afterwards imported into Adobe Audition for post-processing. To guarantee clear and consistency across devices, editing activities included noise reduction and loudness normalization.
3D models		The game's 3D graphics, which included interior room elements, crops, and farming equipment, were made with Blender. Compatibility with mobile devices was taken into account when designing the models. In order to promote interactive gaming and provide a realistic scene for the point-and-click escape room experience, simple texturing which mainly uses image texture was employed.

3.4 Testing Phase

The alpha testing phase of the GDLC focuses on internal testing of the game by the development team to identify and resolve any bugs, glitches, or functionality issues. Table 8 shows the final result of Alpha testing.

Table 8 Alpha Testing

Test	Expected Result	Actual Result	Correction
Home Button	Navigates user to the main menu.	Works as expected.	Not required.
Next Button	Proceeds to the next task or scene.	Works as expected.	Not required.
Back Button	Returns to the previous task or scene.	Works as expected.	Not required.

Table 8 *Alpha Testing (cont.)*

Test	Expected Result	Actual Result	Correction
Hint Button	Displays answer pop-up or clue.	Works as expected.	Not required.
Settings Button	Opens settings menu allowing changes	Works as expected.	Not required.
Audio On / Off Button	Turns on/off background music.	Sounds did not play across the scenes	Make every scene have audio button.
Close Button	Closes current pop-up modal or panel.	Works as expected.	Not required.
Start Button	Begins the game	Works as expected.	Not required.
Task Button	Opens the list of tasks	Works as expected.	Not required.
Yes Button	Confirms user intent	Works as expected.	Not required.
Quit Button	Exit the application.	Works as expected.	Not required.
Answer Button	Provides the correct answer to a question or challenge.	Works as expected.	Not required.
Skip Button	Skip current video	Works as expected.	Not required.
Retry Button	Restarts the current activity	Works as expected.	Not required.
Video Playback	Plays videos for opening, closing and crop selection video.	Works as expected but in starting it clashed with the background music.	Make or adjust the audio script to pause during the video.
Camera Movement	Moves camera to focus on objects	Smooth but too much camera movement can lag the game application	Reduce the camera movement and just display using another zoomed in camera.
Level 1	PC games to play mini games resulting in obtaining key 1	Works as expected but players can get the key without playing all the games available.	Add condition that the key collider is only active if all the games played.
Level 2	PC game display and able to play mini games	Works as expected.	Adjust the user interface of the PC games
Level 3	Display and play games that cover the method control (module 3)	Some of the games work but the animation caused lags.	Change the display of cultural control into video instead of animation.
Level 4	PC games to play mini games resulting in obtaining key 2	Works but the camera movement in showing the key 2 lag.	Change the type of camera movement.

3.5 Beta Phase

Beta testing was conducted to collect direct feedback from external users who were not involved in the development process, in order to evaluate the usability and overall user experience of the game application. In this phase, the game application *Escape Room No Pest!* were tested by 20 respondents which is Form 5 student who takes Agriculture subject. These respondents represent the intended audience of the game and will evaluate the

game's usability according to 10 questions of Scale Usability Score (SUS) to measure the game effectiveness, efficiency and user satisfaction. The collected result are analyzed and discussed in Section 4 .

3.6 Release Phase

The Release Phase marks the final stage where *Escape Room No Pest!* has been fully developed and finalized based on feedback from Subject Matter Experts (SMEs) and target users. The game was built using the Unity Game Engine and exported as an Android application file (APK). This format was chosen to allow for easy installation and offline use on mobile devices, particularly for students who may not have consistent internet access. By distributing the game in APK format, players can download and install the application directly on their device without the need for an online platform, making it more accessible for educational use in classroom or home environments.

4. Result and Discussion

In this phase, response and feedback were taken using the SUS. Figure 2 shows the final analysis of SUS while Figure 3 shows the question list of SUS. Figure 4 shows the overall and more detailed score of each question and respondents. The list of SUS question can be referred in Appendix J.

Based on Figure 2, twenty participants answered all ten System Usability Scale questions. Firstly, Question 1 asked whether the game was enjoyable and fun to play; thirteen respondents (65 %) selected "Agree," four (20 %) selected "Strongly Agree," and three (15 %) were "Neutral," indicating that 85 % of users reacted positively to the game's entertainment value. Question 2 examined whether the system felt unnecessarily complex; seven respondents each (35 %) chose "Strongly Disagree" and "Disagree," while six (30 %) were neutral, showing that more than half rejected the idea of complexity. Question 3 assessed overall ease of use; twelve respondents (60 %) agreed and five (25 %) strongly agreed, leaving only three (15 %) neutral, which confirms that 75% of users found the interface straightforward. Question 4 asked if technical support would be required; responses split evenly, with ten participants (50 %) agreeing and ten (50 %) remaining neutral, suggesting that half of the sample anticipated some need for assistance. Question 5 evaluated the degree to which the system's functions felt well integrated; twelve respondents (60 %) agreed and the remaining eight (40 %) were neutral, showing there were no negative responses, but some users were unsure if the system's functions worked well together.

Question 6 addressed inconsistency within the system; nine participants (45 %) disagreed, eight (40 %) were neutral, two (10 %) agreed, and one (5 %) strongly agreed, revealing mixed but generally sceptical views on consistency. Question 7 explored learnability for new users; twelve respondents (60 %) agreed, five (25 %) were neutral, one (5 %) disagreed, and two (10 %) strongly agreed, indicating that most participants believed others could learn the game quickly. Question 8 asked whether the system was cumbersome; nine respondents (45 %) disagreed, seven (35 %) were neutral, one (5 %) strongly disagreed, one (5 %) agreed, and two (10 %) strongly agreed, showing that users had mixed opinions about how easy the system was to use. Question 9 assessed user confidence; ten participants (50 %) agreed, five (25 %) strongly agreed, three (15 %) were neutral, and two (10 %) disagreed, showing generally high self-confidence. Finally, Question 10 investigated whether extensive learning was required prior to use; eight respondents (40 %) strongly disagreed and six (30 %) disagreed, whereas four (20 %) were neutral, one (5 %) agreed, and one (5 %) strongly agreed, indicating that 70 % felt they could begin playing without significant preparation.

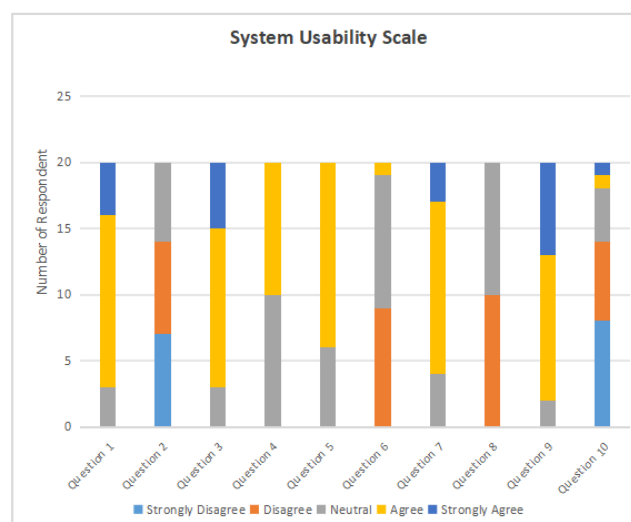


Fig. 2 Final Analysis of SUS

Based on Figure 3, the application obtained an average score of 68.63 out of 100 based on the SUS score calculation shown in the table. The average standards for satisfactory usability, as determined by established SUS criteria, is 68. Therefore, this outcome implies that the Escape Room No Pest! application is within the acceptable usability range as shown in Figure 4. The score shows that users found the application to be useful and clear, even though it might not achieve an outstanding usability rating. This average could be raised and total user satisfaction raised with small user experience enhancements, particularly in areas where lower even-numbered question scores are relevant.

Respondents	Item Score										Odd Score	Even Score	Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10			
R01	4	2	4	4	4	3	4	3	4	2	15	11	65
R02	4	3	5	4	3	2	4	3	4	3	15	10	62.5
R03	4	2	5	4	4	3	4	3	4	1	16	12	70
R04	5	3	4	4	4	3	5	2	5	1	18	12	75
R05	3	3	4	3	4	3	4	3	3	4	13	9	55
R06	4	1	4	3	4	3	4	3	4	1	15	14	72.5
R07	4	1	4	3	4	2	3	2	4	1	14	16	75
R08	4	1	4	3	4	2	3	2	5	1	15	16	77.5
R09	4	2	4	4	4	2	4	2	4	2	15	13	70
R10	4	3	5	4	3	3	3	3	4	3	14	9	57.5
R11	5	1	5	4	4	3	4	2	5	2	18	13	77.5
R12	5	2	4	3	4	3	4	2	5	1	17	14	77.5
R13	4	1	4	4	4	2	4	3	4	1	15	14	72.5
R14	4	2	3	3	3	2	3	2	4	2	12	14	65
R15	4	2	3	3	3	2	4	3	5	2	14	13	67.5
R16	5	1	4	3	4	3	4	2	5	2	17	14	77.5
R17	3	3	4	3	3	4	5	2	3	3	13	10	57.5
R18	3	1	4	3	4	2	5	3	4	3	15	13	70
R19	4	2	3	4	4	3	4	3	4	1	14	12	65
R20	4	3	5	4	3	2	4	2	5	5	16	9	62.5
	Average Score											68.63	

Fig. 3 Detailed SUS final result

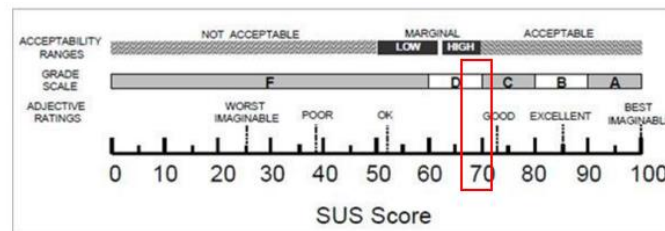


Fig. 4 SUS's result percentage

5. Conclusion

This phase concludes the Escape Room No Pest! gaming application's development and lists potential enhancements. Through interactive gaming, the project aimed to teach Form 5 students about pest management. Point-and-click tasks, instructive mini-games, and a user-friendly interface are some of the main features. Besides, it successfully fulfilled its three main objectives: designing a user-friendly and visually appealing interface, developing interactive point-and-click features to support learning activities, and evaluating usability and user acceptance through structured testing. After testing which students provided positive feedback on the application's design, functionality, and learning value during usability testing using the System Usability Scale (SUS) the game received good reviews, demonstrating its potential as a teaching tool.

The Escape Room No Pest! app has a few drawbacks despite its popularity. The camera transition is one significant problem that interfered with the gaming flow, since several scene changes were sluggish or delayed. Furthermore, when players choose the wrong answers, the program does not provide enough feedback, which makes it challenging for users to recognize and grow from their errors. The lack of a progress tracking system is another drawback, making it impossible for instructors and players to keep tabs on each other's progress and success in the game. Finally, issues with interface scaling were noted on some devices, where buttons and text seemed to be excessively small or misaligned, compromising overall usability and user experience.

However, a number of improvements are suggested for the Escape Room: No Pest! app's future development. Both teachers and players would be able to efficiently track performance and learning objectives with the addition of a score and progress tracking system. To increase engagement and strengthen understanding, time-based challenges could be implemented to mimic decision-making under pressure. Clearer feedback, including explanations or helpful recommendations, for wrong responses would promote learning from mistakes and a

deeper comprehension of the material. More mini-games, like matching, quizzes, or sorting exercises, would also add diversity to the gameplay and accommodate various learning preferences, making the experience engaging and instructive.

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Conflict of Interest

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

Author Contribution

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

*The authors confirm contribution to the paper as follows: **study conception and design:** Siti NurFaridah, Suriawati; **data collection:** Siti NurFaridah; **analysis and interpretation of results:** Siti NurFaridah, Suriawati; **draft manuscript preparation:** Siti NurFaridah, Suriawati. All authors reviewed the results and approved the final version of the manuscript.*

References

- [1] Dent, D., & Binks, R. H. (2020). *Insect pest management*. UK: CABI. <https://doi.org/10.1079/9781789241051.0000>
- [2] Jabar, S., & Alli, H. (2017). *Pertanian*. Multi Educational Book Enterprise.
- [3] Ulery, A., et al. (2020). Impact of multimedia learning tools in agricultural science classes. *Natural Sciences Education*, 49(1). <https://doi.org/10.1002/nse2.20011>
- [4] Dara, S. K. (2019). The new integrated pest management paradigm for the modern age. *Journal of Integrated Pest Management*, 10(1). <https://doi.org/10.1093/jipm/pmz010>
- [5] Jabar, S., & Alli, H. (2017). *Pertanian*. Petaling Jaya, Selangor: Multi Educational Book Enterprise.
- [6] Koul, O., Dhaliwal, G., Khkhar, S., & Singh, R. (2014). *Biopesticides in sustainable agriculture: Progress and potential*. Scientific Publisher.
- [7] Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, 30, 100326. <https://doi.org/10.1016/j.edurev.2020.100326>
- [8] Wattanasoontorn, V., Theppaitoon, M., & Bernik, A. (2019). A classification of visual style for 3D mobile games. In *Proceedings of the 23rd International Computer Science and Engineering Conference (ICSEC)* (pp. 1–6). <https://doi.org/10.1109/ICSEC47112.2019.8974779>.
- [9] Foursaken Media. (2014). *Bug Heroes 2* [Mobile game]. Android. <https://play.google.com/store/apps/details?id=com.foursakenmedia.bugheroes2free&hl=en>.
- [10] CABI. (2020). *Pest Diagnostic Simulator* [Mobile game]. Android. <https://play.google.com/store/search?q=pest+diagnostic+simulator&c=apps&hl=en>
- [11] Spirit Bomb - Arcade Shooting Game. (2023). *Insect Invaders: Space Shooter* [Mobile game]. Android. <https://play.google.com/store/apps/details?id=space.shooters.insect.invaders&hl=en>
- [12] Ramadan, R., & Widyani, Y. (2013). Game development life cycle guidelines. In *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)* (pp. 95–100). IEEE. <https://doi.org/10.1109/ICACSIS.2013.6761558>

Appendix A: Interview transcribes with SME

Siti NurFaridah: Assalamualaikum Cikgu. Thank you for your time in attending this interview session. Can you tell me a bit about yourself and your teaching role?

Mrs. Siti Fatimah: Waalaikumsalam. My name is Siti Fatimah binti Ishak. I teach Form 4 and Form 5 Agriculture at SMK Senggarang.

Siti NurFaridah: What is your opinion on the performance of students in understanding and applying pest control methods?

Mrs. Siti Fatimah: In my opinion, students struggle to compare and contrast different pest control methods. They often provide incorrect examples for each control method, confusing one with another. They also find it difficult to determine suitable pest control methods for

specific crops and lack the skills to create DIY pest control products, such as making a light trap for physical control methods.

Siti NurFaridah: What teaching methods do you currently use to help students understand pest control techniques?

Mrs. Siti Fatimah: I use explanations, examples, and videos to teach pest control methods. But I mostly use explanations since students can understand more by giving examples.

Siti NurFaridah: How effective are current teaching methods in engaging students?

Mrs. Siti Fatimah: It depends on the students. Some understand the concepts very well, while others require additional guidance to grasp the material.

Siti NurFaridah: Have you used any teaching aids or applications related to pest control?

Mrs. Siti Fatimah: I have used YouTube videos and books as teaching aids, but I have not used any applications.

Siti NurFaridah: Do you think the game-based learning application "Escape Room: No Pest!" can help students understand pest control methods better?

Mrs. Siti Fatimah: Yes, learning through games provides students with a better experience in applying the knowledge they have learned.

Siti NurFaridah: What features do you think are important for the application to include?

Mrs. Siti Fatimah: The application should include rewards for completing each level and scenarios that reflect real-world situations.

Siti NurFaridah: How important is it for the application to be user-friendly and easy to use?

Mrs. Siti Fatimah: It is very important. The application should have simple navigation, clear instructions, and an interactive interface to make sure that students can use it without difficulty. Complex controls or unclear guidance can make student more confuse so it reduce its effectiveness.

Siti NurFaridah: What suggestions do you have to make the application more user-friendly?

Mrs. Siti Fatimah: The application should have a clean layout, use icons or visuals to guide users, and provide step-by-step tutorials for first-time users. It would also help to include hints or tooltips to assist students when they are stuck in a level. Before I forget, make sure that all the content follow the curriculum standard. Referring the pertanian book, the subject are the best choice.

Siti NurFaridah: Would you be interested in using "Escape Room: No Pest!" as a teaching tool?

Mrs. Siti Fatimah: Yes, I am interested in using the application as a supplementary teaching tool.

Appendix B: Summary of The Output of the Game Development Life Cycle phases

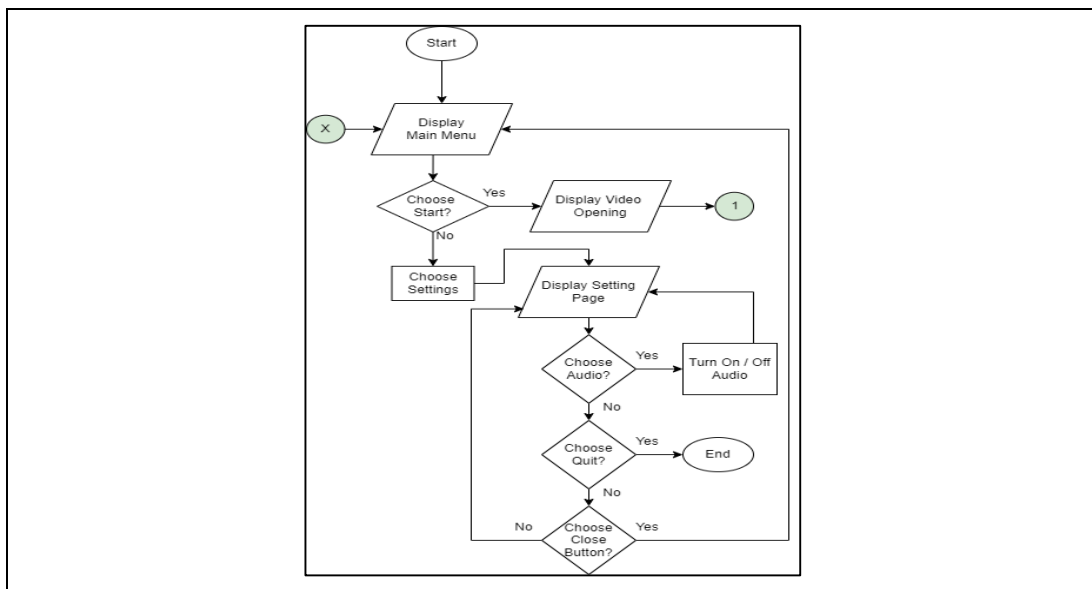
Table 9 Game Application Development Workflow

Phase	Activity	Output
Initiation	- Brainstorm ideas - Defining goals, project scope, target user - Conduct user research - Define functional requirements - Identify hardware compatibility	- Game concept - The project's title, objective, target platform, target user - User analysis and requirement checklist - Obtain functional and Non-Functional requirement - Hardware and software requirements
Pre-Production Phase	- Develop storyboards - Design documents - prototypes - allocate resources and create schedules.	- High-fidelity storyboard - Prototype - Project design (Button design)
Production	- Create 3D model, User Interface and scripts - Integrate assets into the game.	3D model in Blender - Functional game prototype in Unity software

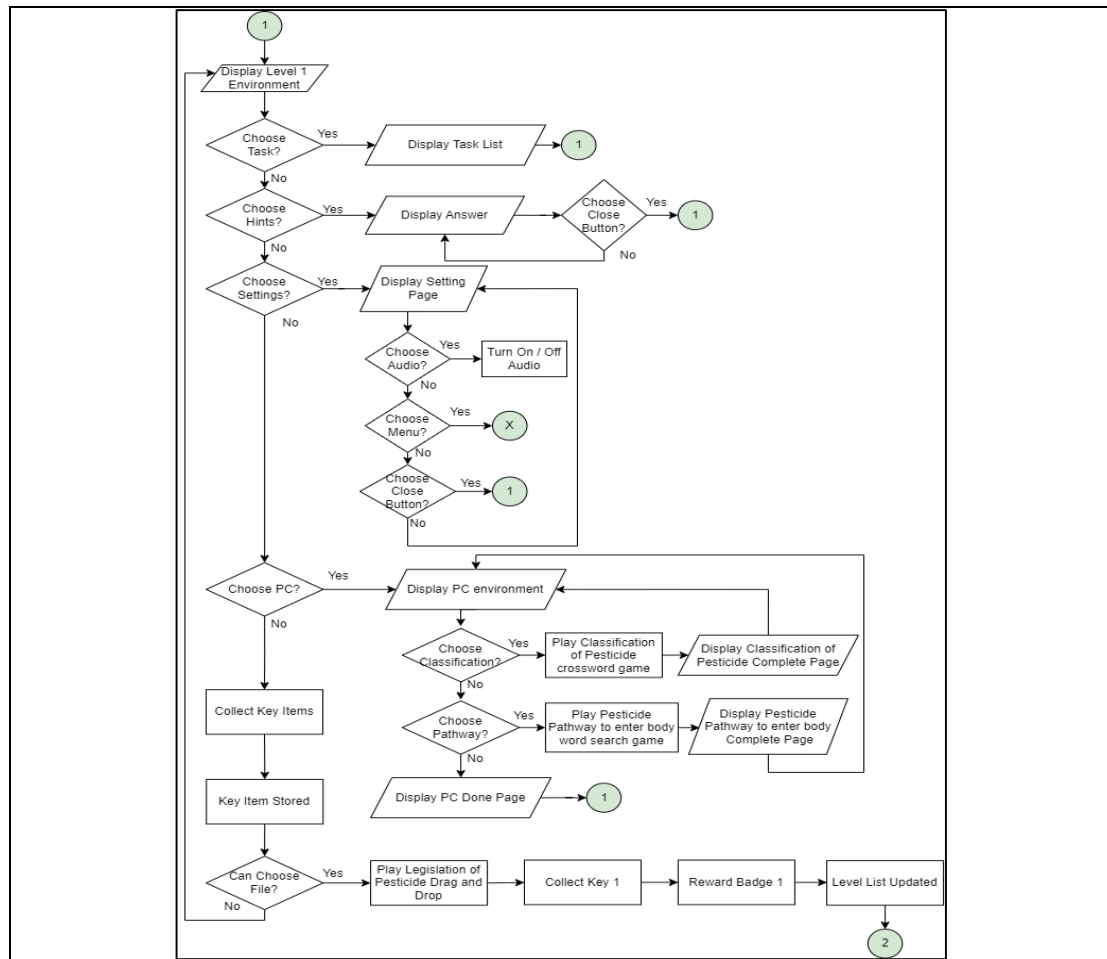
Table 9 Game Application Development Workflow (cont.)

Phase	Activity	Output
Testing Phase	• Conduct functional testing to ensure all features work as intended. • Perform user acceptance testing. • Run performance tests to ensure smooth gameplay across devices.	• List of identified functional bugs and issues. • Optimized game performance • Stable and polished version of the game.
Beta Phase	• Launch a beta version for external testing • Perform user acceptance testing to verify usability • Refine features.	• Improved game prototype • User feedback report • Features refined based on user feedback.
Release Phase	• Finalize the game and publish the game	• Fully functional game application and publishing the game

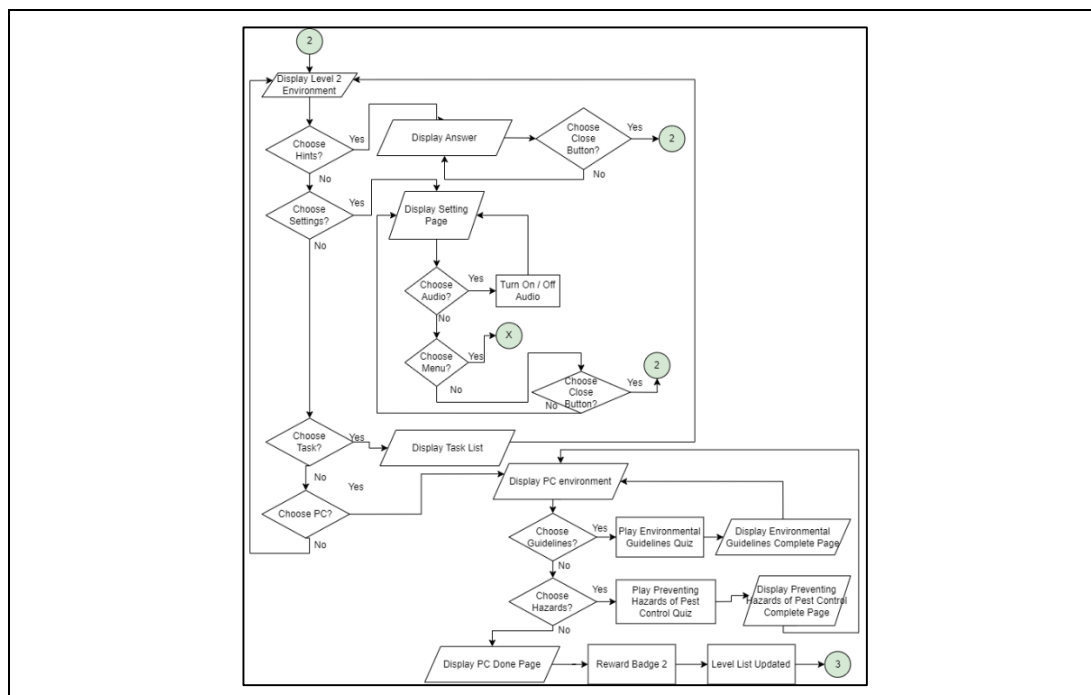
Appendix C: System Flowchart



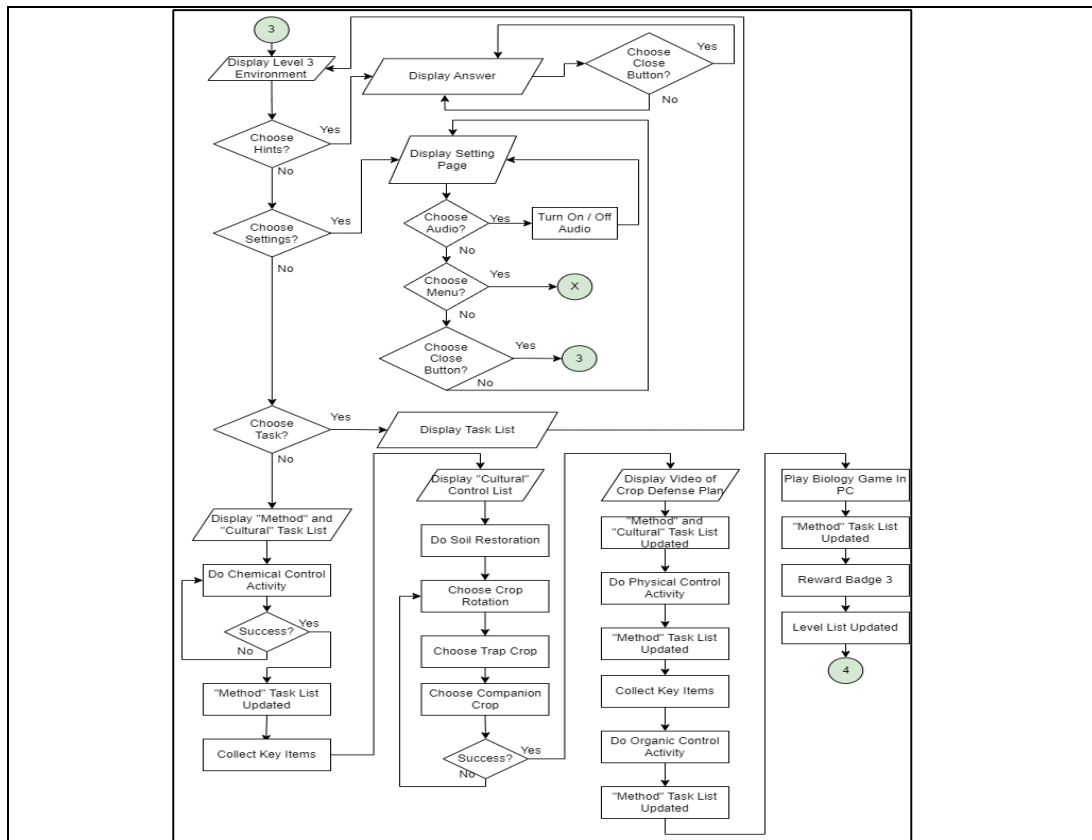
Appendix D: Flowchart of Level 1



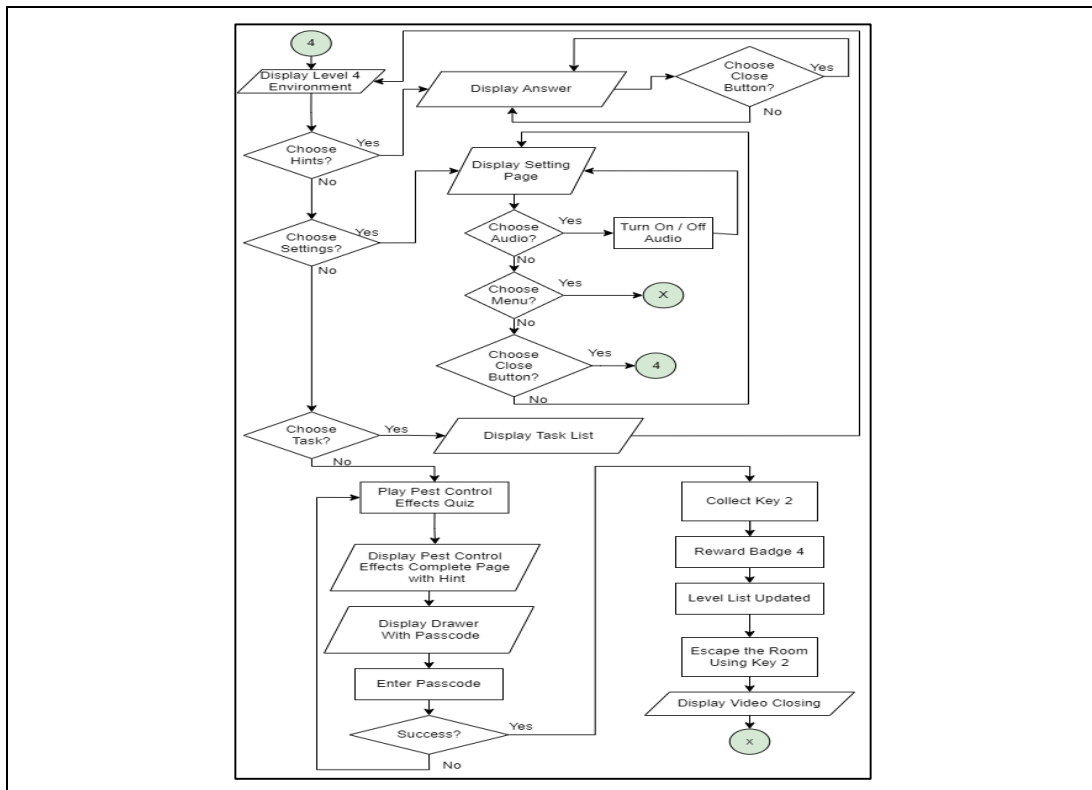
Appendix E: Flowchart of Level 2



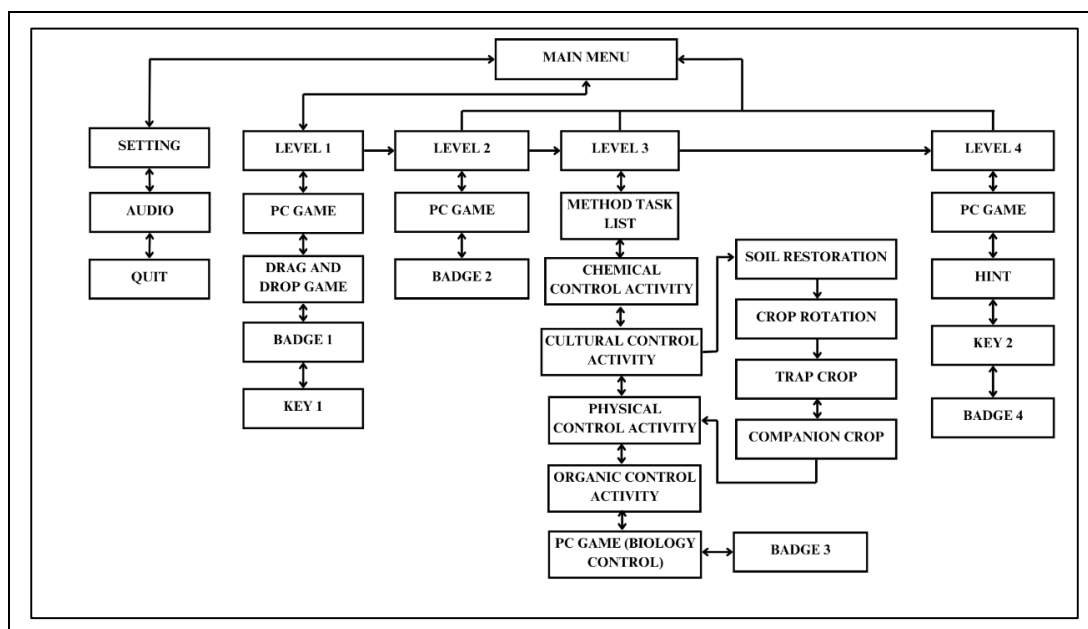
Appendix F: Flowchart of Level 3



Appendix G: Flowchart of Level 4



Appendix H: Navigation Structure



Appendix I: Application Interface

Table 10 Application Interface

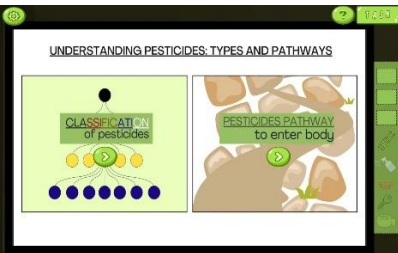
Items	Description
	• Main Menu of the game • Button 'START' to start the game • Button 'SETTINGS' navigates to Setting page which have audio and quit button.
	• Level 1 environment • Three activities can be done ; playing computer game, view the poster and labeling file
	• Computer game view • Two types of question, classification of pesticides and pesticides pathway to enter body

Table 10 *Application Interface (cont.)*

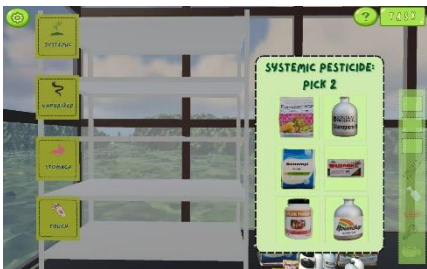
Items	Description
	• Hints for file game. Player need to collect this to play file game. •
	• Labeling file game. • Will get key 1 to exit the level 1 after complete the level along with badge 1. •
	• Level 2 environment. • Two computer game, environmental guideline and preventing hazards. • Will get badge 2.
	• Level 2 game activity
	• Level 3 task. • Task can be obtain on the task button on upper right of the game • Each task will be conducted in sequence • Will get badge 3 after finishing all the task.
	• Level 3 activity, chemical control method

Table 10 Application Interface (cont.)

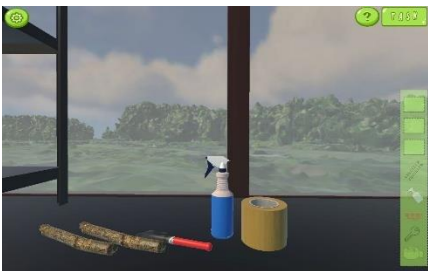
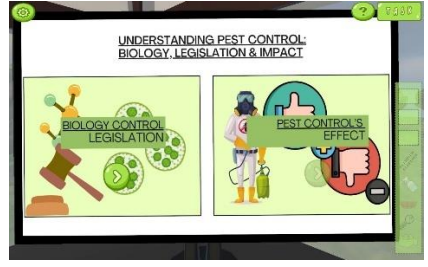
Items	Description
	• Player need to collect items that will be used for next activity
	• Cultural control method list
	• Activity 2, 3 and 4 of cultural control method list. •
	• After completing the cultural control method list, player will continue to complete the physical control method activity
	• After completing the physical control method activity, player will continue to complete the organic control method activity
	• After completing the organic control method activity, player will continue to complete the biology control method activity • Player will get badge 3

Table 10 *Application Interface (cont.)*

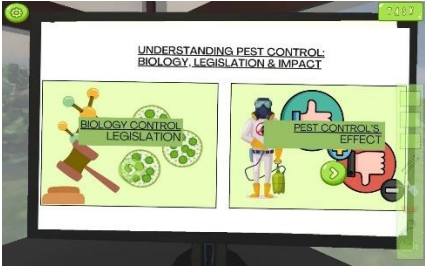
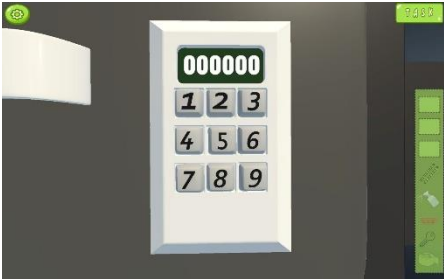
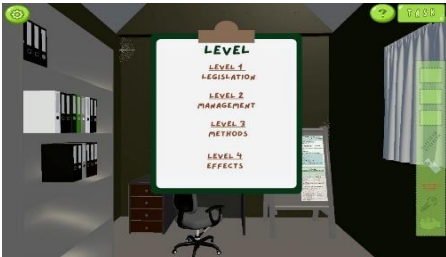
Items	Description
	- After completing the biology control method activity, player will continue to complete the pest control effect activity - Player will get passcode
	Table drawer that locks and player need to enter the passcode.
	- Locks that player need to open using the passcode received before. - If player did not get the passcode, player can retry the pest control effect game again.
	- After the drawer unlock and get key 2 to unlock the door and escape. - Player will get badge 4
	Escape page which is the ending.
	Level list. Will show the badge after complete any level.

Table 10 *Application Interface (cont.)*

Items	Description
	• Example of hint page. Player can click answer button to get answer.
	• Setting page. • Player can turn off and on the audio • Player can quit.

Appendix J: SUS Question List

Q1	I think that I would like to use this system frequently.
Q2	I found the system unnecessarily complex.
Q3	I thought the system was easy to use.
Q4	I think that I would need the support of a technical person to be able to use this system.
Q5	I found the various functions in this system were well integrated.
Q6	I thought there was too much inconsistency in this system.
Q7	I would imagine that most people would learn to use this system very quickly.
Q8	I found the system very cumbersome to use.
Q9	I felt very confident using the system.
Q10	I needed to learn a lot of things before I could get going with this system.