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# Engaging Learning with Game on Food and Nutrition for Pre-School Children

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## ABSTRACT

With the growing rates of children obesity and concerns on the related health consequences, the awareness in transforming children's eating habits to a healthier direction to reduce their threat of developing diet-related disease during adulthood has been growing in recent years. Recent evidence suggests that a game-based approaches have a potential in health and wellbeing sector. This research is conducted based on two main aspects: development of game application on food and nutrition for pre-school children and evaluation involving users on the usability of the developed game. This game application has been developed based on the ADDIE model which consist of five phases, Analysis, Design, Develop, Implementation and Evaluation. The usability evaluation on the game application involved children in early ages. The genre of the games is based on platform and it is a single-player game that contains three modules: food pyramid, healthy maze, and my plate. For the usability, the game application received positive feedbacks from the users where they gain some knowledge and enjoy playing the game. This finding provides a valuable knowledge to the design and development of the game application in food and nutrition sector.

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## 1. Introduction

Children are essential to the nation's present and the future. Just like adults, children also need energy from balanced food and nutrients. Eating habits are essential for the development of their future consumption pattern. Children's dietary habits affect equally their physical and mental growth. Especially, overweight children tend to be more vulnerable to remain overweight and at the end of the day becoming obese during adulthood, which in turn can develop degenerative illnesses at a younger age [1]. With the growing rates of children obesity and concerns on the related health consequences, the awareness in transforming children's eating habits to a healthier direction to

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reduce their threat of developing diet-related disease during adulthood has been growing in recent years.

Up to now, there are different game-based interventions have been developed relating to health[2]. Indeed, all children enjoyed and loved playing games during their early childhood. Learning at an early age will help the children to learn and absorb the foundational knowledge better and help in children's brain development. Therefore, implementing games in education can help to increase children's motivation and engagement in learning. Learning through digital games is not a new idea. It has started to develop relatively early in the computer science history[3]. With the growing market of digital game, the appearance of "gamification" in education is on the leading[4]. When playing educational game, children are required to make smart decisions in which they need to think strategically. This will help to improve children's problem solving and thinking skills. In addition, it is discussed that educational games can effectively be exploited for educational purposes where it has the capability to engage students and deliver virtual worlds for learning through the element in the game such as engaging storyline, social interaction/player interaction, concentration, and involvement.

Recent evidence suggests that a game-based approaches have a potential in health and wellbeing sector. Data from[5] who reviewed 19 game-based approaches relating to health and wellbeing suggest that more than half of the studies have reported positive outcome. A study by[6] also indicated that a game has a potential in encouraging the nutritional knowledge. Previous research has established that digital games can improve children's learning. In[7], they have postulated a meta-analysis that indicated that digital games significantly increase learning when compare with conventional way (non-game) condition. Research on the digital game has been mostly investigated children's learning outcome, however far too little attention has been paid to the development of the game that might help to clarify these reported learning gains. Therefore, this study set out to explain the development of a food and nutrition game for pre-school children and investigate the usability of the developed game by the users.

In this project, a game is developed for educational purposes, more specifically in the Science field, food and nutrition for children aged 5 to 6 years. This game can motivate children to learn about food and nutrition. According to a research, forming food preferences in the early age is important as it will affect the children's eating habit for life[8]. This game can give an insight on the food categories as well as healthy and unhealthy foods to the children.

## **2. Research Background**

In this technological development, studying under traditional system of education such as the process of teaching by using whiteboard and textbook are not very engaging and exciting. One of the problems is that the traditional learning method is less effective. The process of teaching and learning in traditional method relies mainly on the textbooks[9]. Teacher write on the whiteboard and explain the contents in the textbook to the children. Children must also read the textbook by themselves in order to understand better. However, children might find it hard to focus and bored by reading and listening to the explanation given by the teacher. Boredom can kill a learner's interest [10] and motivations are required for them to carry on. Children will not be able to absorb the knowledge given by the teacher when they lost the interest and motivation to learn. Games that are designed for educating children can stimulate their ability of self-learning as well as their motivation [11].

Besides that, the lack of food and nutrition education. Nutrition education can affect the way children view food choices and eating habits[12]. It is important to provide education on food and nutrition to children at an early age. Nutrition education is vital in bringing awareness in adopting a healthy lifestyle. Childhood obesity has been a serious public health problem in the United States and other country in the world. One in three children in the United States is trouble with overweight or obesity[13]. While in Malaysia, one in five of 7 to 12 years children were found overweight[14]. Nutrition education in early childhood is very important. Children's future eating habits can be shaped in a healthy manner by providing them with education on nutrition during their preschool period[15]. Nutritional games are effective in influencing the cognitive development of the children. This is because it attracts and hold attention, easily understood, and have good visual impact[16]. Hence, there is a need to develop an educational game which provide learning approach other than the traditional learning method to promote a good eating habits for children.

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### 3. Methodology

The methodology employed in this study was divided into two parts: 1. The game development of food and nutrition and 2. the usability of the game.

#### 3.1 Game Development

The chosen software development life cycle (SDLC) model is ADDIE model. The justification for this model due to the flexibility in changing requirements, ability to return to earlier phase, simple to use, and the higher chance of success. Each phase related to the project will be discuss in this section. ADDIE model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation as shown in Figure 1.

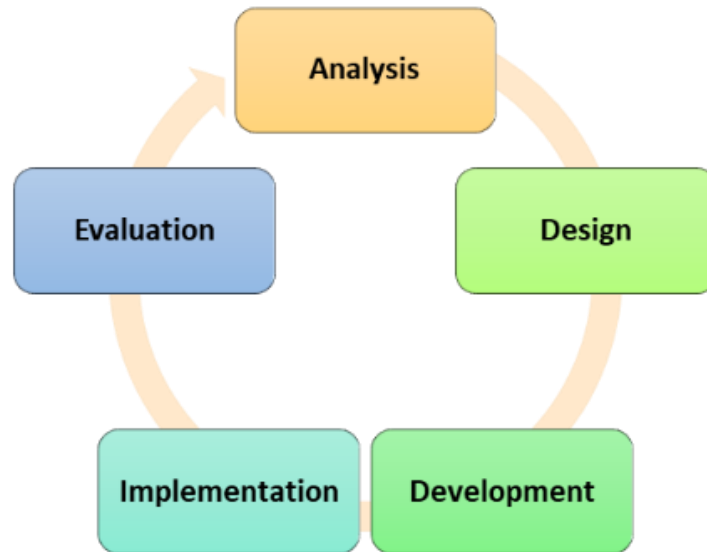


Figure 1. ADDIE Model

##### 3.1.1 Analysis

Analysis phase is the foundation for all other phases. The analysis phase will start with identifying learning problems that children currently faced. After that, the objectives can be identified. Objectives are important in project development as it will make sure that the goal of this project can be achieve. The target users of this project are pre-school children aged 5 to 6 years. However, teachers and parents can also use this game application to guide the child(ren) in learning process. This project will develop a 2D and platform-based game that covers the topic Food and Nutrition which can be used to educate children in healthy eating. Multimedia elements will also be inserted into the game which will help the children in learning because children learn best through graphics and audio. Multimedia elements are inserted to make the games more interactive and fun. A survey is conducted on seven individuals to collect the user requirements for the project. The responses of the survey are summarized and tabulated in Table 1.

Table 1. Responses from survey for user requirements

No	Question	Responses
1	Traditional teaching techniques is one way in educating pre-school children. Do you think games can also help in teaching pre-school children?	<p>A pie chart with a single blue slice representing 100.0% 'Yes' and a white slice representing 0.0% 'No'. A legend below shows a blue square for 'Yes' and a pink square for 'No'.</p>
2	Have you played or heard of any Food and Nutrition related games for pre-school children before?	<p>A pie chart with a blue slice representing 71.4% 'Yes' and a pink slice representing 28.6% 'No'. A legend below shows a blue square for 'Yes' and a pink square for 'No'.</p>
3	Do you think Food and Nutrition games can benefit the pre-school children? Why?	<ul style="list-style-type: none"> <li>• Can educate them on healthy eating</li> <li>• Yes. They can learn more knowledge on food and nutrition which seldom teach in lesson</li> <li>• Yes, they can know about what type of food is healthy</li> <li>• Yes, because it is easier way to catch the children's interest and attention.</li> </ul>
4	If the game application developed for pre-school children consists of graphics and multimedia elements (images and music), do you think it will help them in learning?	<p>A pie chart with a single blue slice representing 100.0% 'Yes' and a white slice representing 0.0% 'No'. A legend below shows a blue square for 'Yes' and a pink square for 'No'.</p>
5	Based on your answer above, please state the reason.	<ul style="list-style-type: none"> <li>• Children learn best through graphics and music</li> <li>• Visual and vestibular input are effective feedback given to the children.</li> <li>• Children likes colorful thing to stimulate their interest and memory.</li> <li>• These cues help them to understand and remember it better</li> <li>• Multimedia can attract children interest.</li> </ul>
6	What do you expect from the game application that will be developed for pre-school children?	<ul style="list-style-type: none"> <li>• Suitable for user's age, colorful and fun</li> <li>• More academic help for the children.</li> <li>• Correct knowledge and suitable genre</li> <li>• Easy game but bring benefits or knowledge to children</li> </ul>

### 3.1.2 Design

Design phase is where all the information from the previous phase is used. Design phase will design and create the content of the game. The designs of the game content are based on the

user requirements collected which are suitable for user's age, colorful, and fun. The game should also be included with multimedia elements such as images and audio. The genre of the game is based on platform and it is a single-player game. There will be 3 modules covered in this game consisted of Food Pyramid module, Healthy Maze module, and MyPlate module. Figure 2 illustrates the flowchart for this game. A detail of each of this module were presented in Figure 3, 4 and 5 respectively.

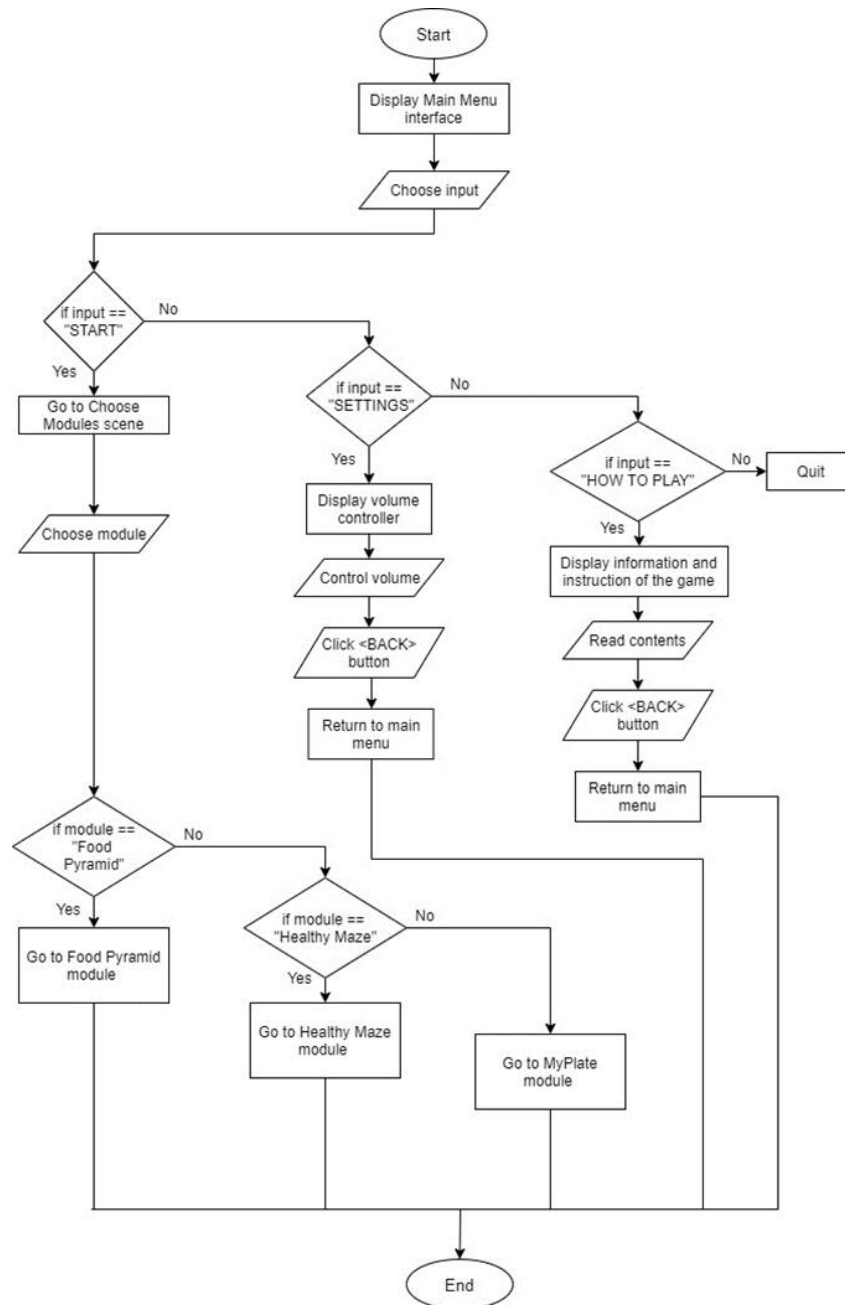


Figure 2. Flowchart of Food and Nutrition game application

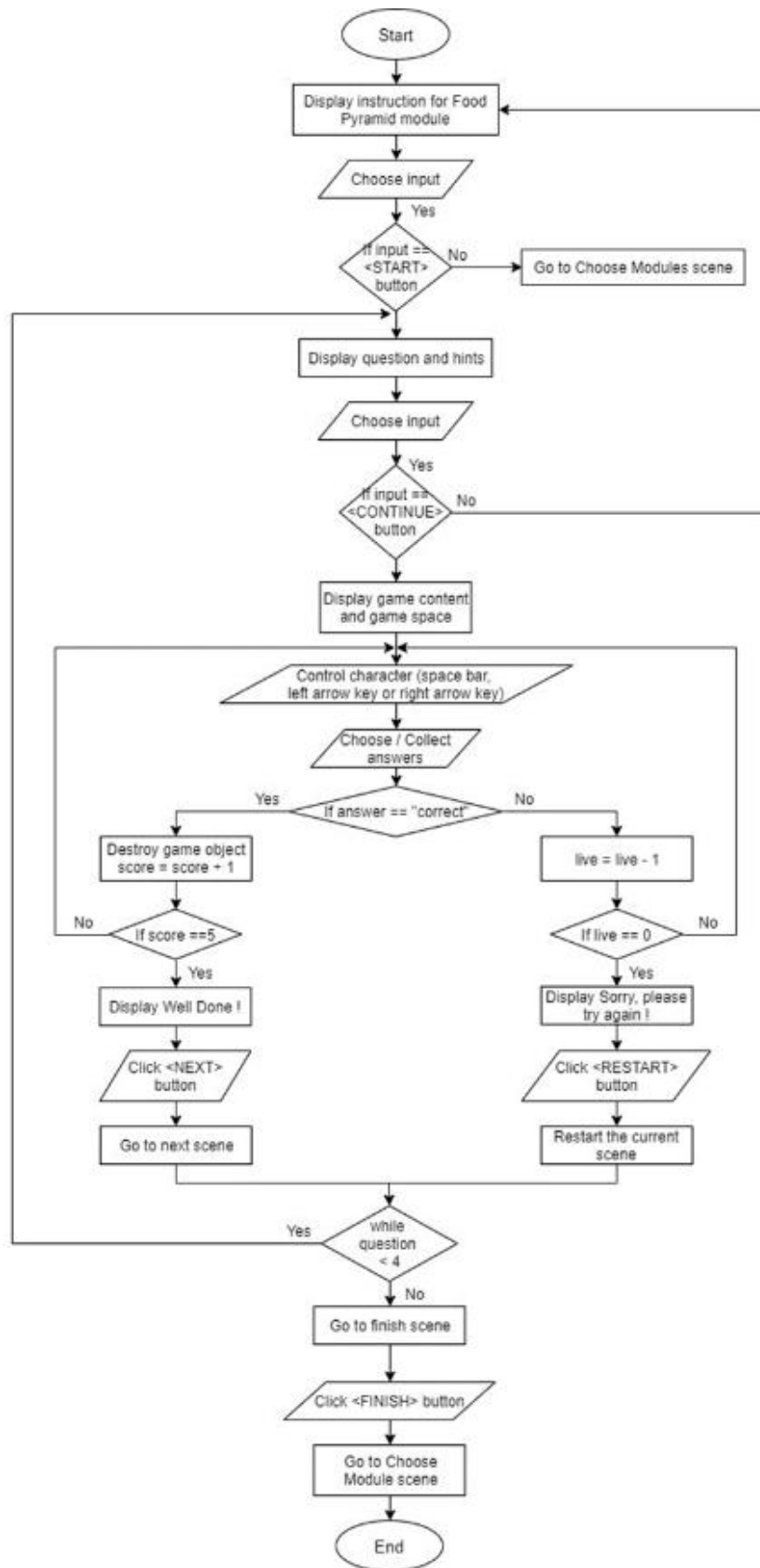


Figure 3. Flowchart of Food Pyramid module

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In the Food Pyramid Module, there will be eight game objects (correct answer and wrong answer) appear in this game space. Platforms will also be provided to help the character in collecting the game objects. The mission of Food Pyramid Question 1 is to choose and collect foods that belong to carbohydrate. User need to control the character using keyboard controls in order to complete the mission. The keyboard controls that are required for this question and its function are as follow:

- i. Spacebar – To jump
- ii. Left arrow key – To move left
- iii. Right arrow key – To move right

In this question, user will be provided with three lives and can keep playing until the required score is achieved (no time limitation). Each time user collects the wrong answer, the lives will be reduced by one. When there are no more lives left, a panel indicating that user need to try the question again along with a “RESTART” button will pop up. Besides that, there will be a live score update to show the score obtain by user at that moment of time as well as how much more score user need to get to achieve the required score. Each correct answer collected will increase the score by one. The score that user need to get in this question is five. User need to complete this question first before continuing to the next question. After user finish the question, a panel indicating that user has successfully complete the question along with a “NEXT” button will pop up. Clicking the “NEXT” button will navigate user to the next question. Question 2 to Question 4 will have a similar hints interface, game space, and gameplay as Question 1.

For Healthy Maze module (refer to Figure 4), the game space will be design based on the maze structure concept with the help of platforms. User will be provided with a mini map at the bottom right corner to aid user in orienting themselves within the game world. There will be eight game objects (five wrong answers and three wrong answers) appear in this game space. The mission of Healthy Maze Question 1 is to identify and collect the healthy foods. User need to control the character using keyboard controls in order to complete the mission. The keyboard controls that are required for this question and its function are as follow:

- i. Left arrow key – To move left
- ii. Right arrow key – To move right
- iii. Up arrow key – To move forward
- iv. Down arrow key – To move backward

In this question, there is a time recorder which will record the time used by the user to complete Question 1. Besides that, user will be provided with three lives. Each time user collects the wrong answer (unhealthy foods), the lives will be reduced by one. When there are no more lives left, a panel indicating that user need to try the question again along with a “RESTART” button will pop up. The function of this restart button is the same as the one in the pause menu. Besides that, there will be a live score update to show the score obtain by user at that moment of time as well as how much more score user need to get to achieve the required score. Each correct answer (healthy foods) collected will increase the score by one. The score that user need to get in this question is five. User need to complete this question first before continuing to the next question. Question 2 (Maze 2) and Question 3 (Maze 3) will have a similar hints interface, game space, and gameplay as Question 1. The structure of maze is different for all three questions (mazes). There will be nine game objects (five correct answers and four wrong answers) appear in the game space of Question 2. While, there will be ten game objects (five correct answers and five wrong answers) appear in the game space of Question 3.

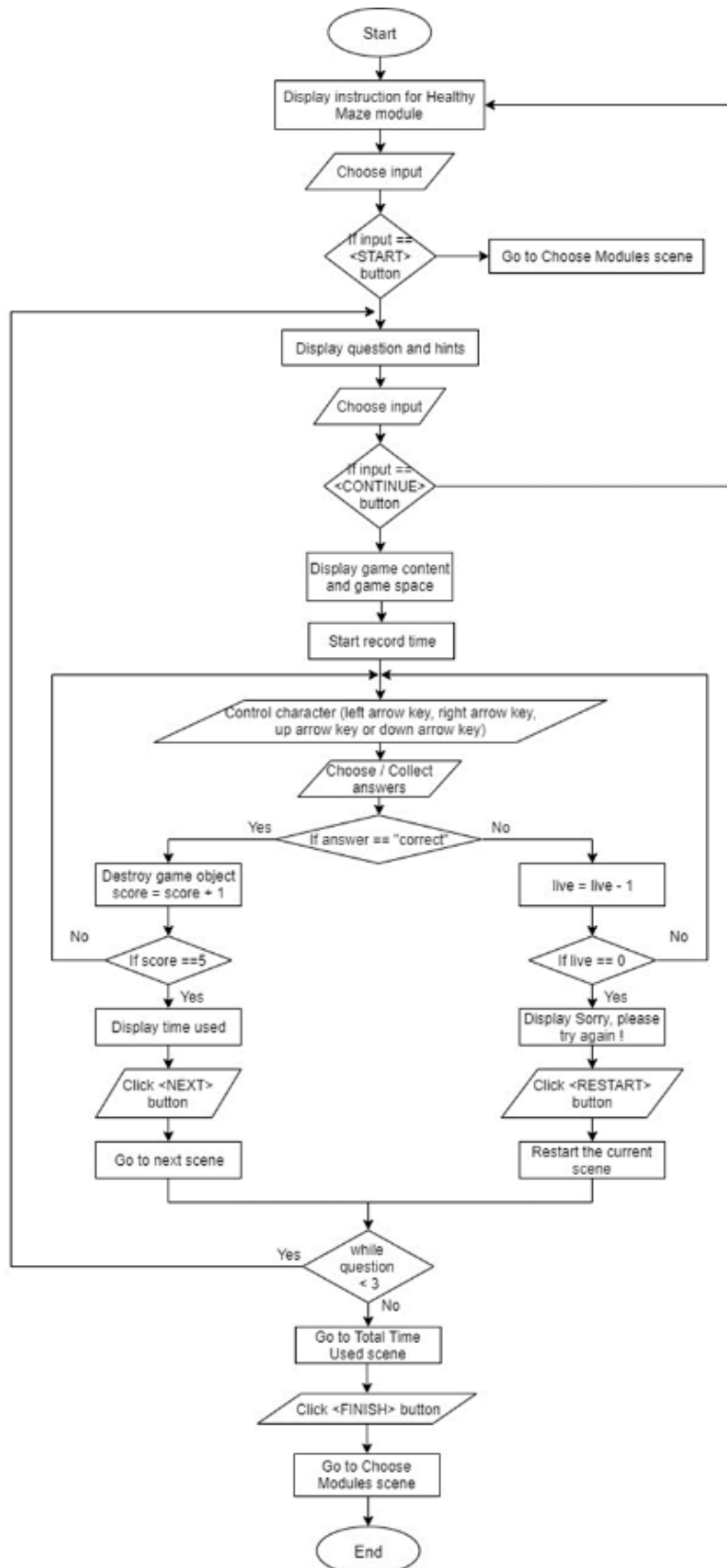


Figure 4. Flowchart of Healthy Maze module



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For MyPlate module (Refer to Figure 5), there will be nine game objects (five correct answers and four wrong answers) appear in this game space. The mission of MyPlate Question 1 is to identify and collect the foods that are part of the fruit food group. User need to control the character using keyboard controls in order to complete the mission. The keyboard controls that are required for this question and its function are as follow:

- i. Left arrow key – To move left
- ii. Right arrow key – To move right
- iii. Up arrow key – To move forward
- iv. Down arrow key – To move backward

In this question, user will be provided with three lives and a time limitation of 30 seconds. Each time user collects the wrong answer, the lives will be reduced by one. When there are no more lives left, a panel indicating that user need to try the question again together with a “RESTART” button will pop up. The function of this restart button is the same as the one in the pause menu. If the time is up, a panel displaying the score obtained within the time limit together with a “NEXT” button will pop up. User is not allowed to restart the question and can only click the “NEXT” button to continue to the next question. Besides that, there will be a live score update to show the score obtain by user at that moment of time as well as how much more score user need to get to achieve the required score. Each correct answer collected will increase the score by one. The score that user need to get in this question is five. User need to complete this question first before continuing to the next question unless the time is up. After user finish this question, a panel displaying the score obtained together with a “NEXT” button will pop up. Clicking the “NEXT” button will navigate user to the next question. Multimedia elements such as text, image, background image, background music, and sound effect are included in this scene. Question 2 to Question 5 will have a similar hints interface, game space, and gameplay as Question 1.

### **3.1.3 Development**

Development phase starts when the design phase finishes. All the development process such as create game content and gameplay as well as programming the game application are done in this phase. Adobe Photoshop CS6 is used to edit images that will be use as game contents in the game application. Unity 3D is used to create the game content and gameplay of the game application. Scripting, debugging, and building the game application are also done in Unity 3D. Draw.io is used to create the flowchart and use case diagram. In this game, there are three modules; food pyramid, healthy maze, and my plate. Children can choose which module they want to play.

### **3.1.4 Implementation**

Implementation phase is where the developed game application is present to the user or client. The game application will be implemented in the test environment to test the functionality of all features in the game application. The game application will also be implemented in teaching environment.

### **3.1.5 Evaluation**

Evaluation is tests designed for users after they use the game application to measures the usability of the game application. Any change or improvement on the game application is based on the feedbacks from users. User Acceptance Test (UAT) is used to test the features' functionality in the game application. In this phase, the revision of the game application will also be carrying out.

## **3.2 Usability of the game**

After the development of Food and Nutrition game is completed, testing process is carried out to evaluate the functionality and usability of the game application. The developed game is based on platform and it is a single-player game. The content validity of the game has been validated by the expert panel in the food and nutrition. Testing and evaluation of the game play were done on 10 childrens after they played the game. The users of this study consist of children in early ages (5 to 6 years old) where typically have a low medium proficiency in reading. They might not be competent to read masterly and usually misunderstood the intended answer. Therefore, in evaluation with children using survey, smiley faces are utilized as scales for measurement.

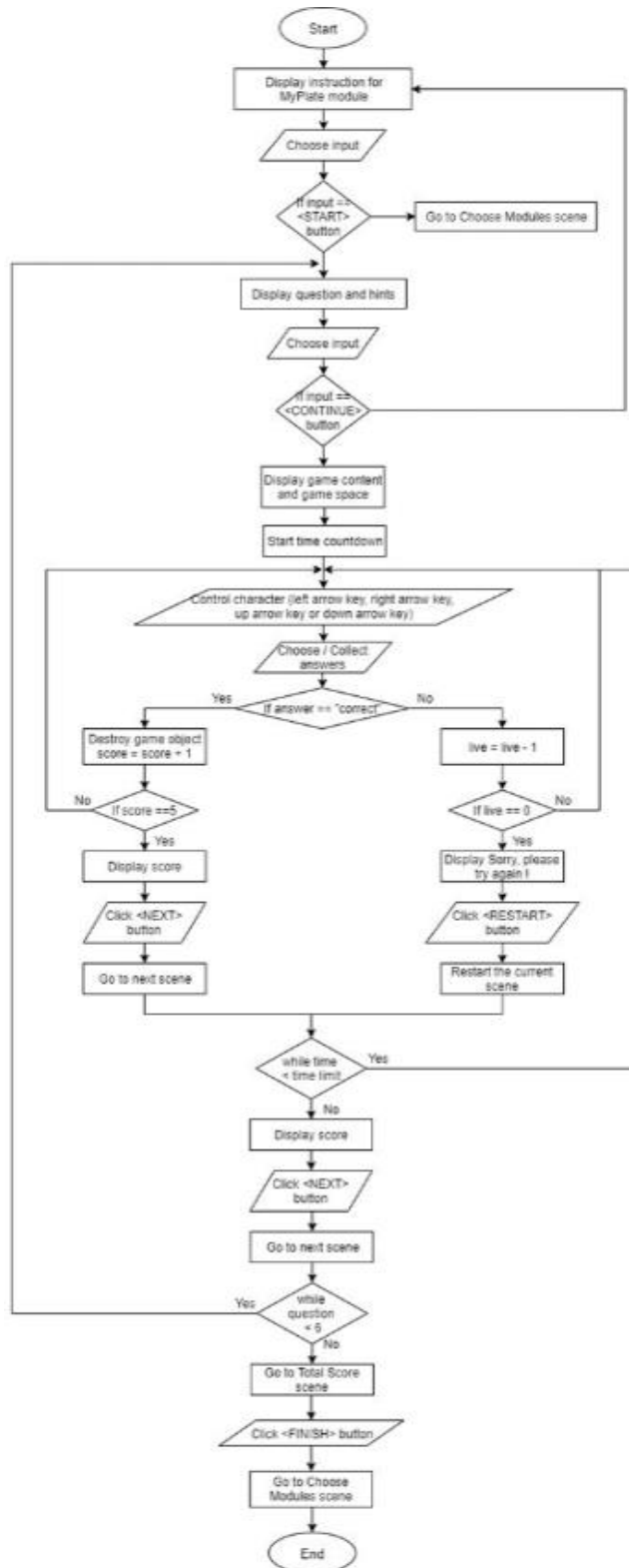


Figure 5. Flowchart of MyPlate module

#### 4. Results and Discussion

Findings of this paper are divided into two parts, which are the game development of food and nutrition and the usability of the game by users.

##### 4.1 Development of the Game

Food and Nutrition game application is a game for pre-school children. This game application is developed to help stimulate children's interest as well as motivate them in learning Science, more specifically in food and nutrition from an early age. There are three modules in the game application which are Food Pyramid, Healthy Maze, and MyPlate. Food and Nutrition game application operates on personal computer (PC) with Windows operating system. The PC that user used to run the game application need to be at least running Windows 7 or macOS 10 operating system. It does not require any Internet connection to play/run the game application.

The main menu will appear after user run the Food and Nutrition game application. Figure 6 shows the main menu interface in Food and Nutrition Game. The main menu consists of several buttons. The "SETTINGS" button will open the settings menu where user can control the volume of background music. The "HOW TO PLAY" button will open the how to play menu that contains instructions and information that user need to know. The "START" button will navigate user to the Choose Modules scene where user can choose which module to play as in Figure 7, which shows the example of game space and game content in the three modules.



Figure 6. Main Menu

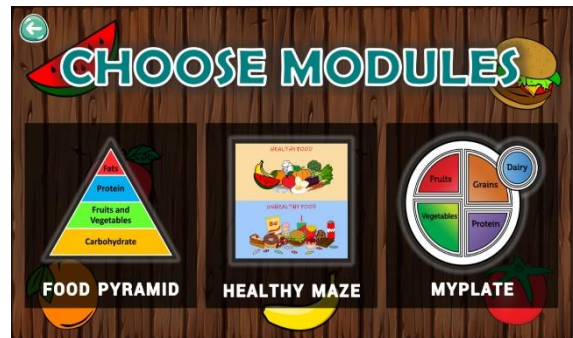


Figure 7. Choose Modules menu

Clicking "FOOD PYRAMID" button will navigate user to Food Pyramid Instruction scene. In this module, there will be a sprite character named Monica as shown in Figure 8.



Figure 8. Game space and game content of Carbohydrate (Question 1) scene

Rigidbody 2D component is added to the character to allow the interaction with physics such as the gravity. The game objects used in this scene such as the platforms/obstacles and the answers are 2D sprites. Collider are added into these game objects to create collisions between the character and the game objects. User need to control the character and collect the game objects (answers) based on the question given. For this scene, user need to control the character and collect the foods game objects that are belong to carbohydrate. Besides that, there will be a live score update to show the score obtained at that moment of time as well as how much score are needed to achieve the required score. Each correct game object collected will increase the score by one. The total required score for this question is five. After user finish the question, a panel as shown in Figure 9 will pop up.



Figure 9. Win panel

User need to click on the “NEXT” button in the panel to go to the second question (Protein scene). Protein (Question 2) scene, Fruits & Vegetables (Question 3) scene, and Fats (Question 4) scene will have the similar hints interface, game space, and gameplay as Carbohydrate scene. Figure 10 shows the game space and game content of Question 1 (Maze 1) scene in Healthy Maze module.



Figure 10. Game space and game content of Maze 1 (Question 1) scene

The game space is designed based of the maze structure concept and there will be provided with a mini map to aid user in orienting themselves within the game world. In Maze 1 scene, there will be a sprite character named Amy. Rigidbody 2D component is added to the character to allow the interaction with physics such as gravity. The game objects used in this scene such as the platforms/obstacles and the answers are 2D sprites. Collider are added into these game objects to create collisions between the character and the game objects. User need to control the character and collect the game objects (answers) based on the question given. For this scene, user need to control the character and collect the healthy foods. In this scene, there will have a time recorder to record the time used to answer the question. There will also have three lives provided where each wrong game object (unhealthy food) collected will reduce the lives by one. After user complete all the three questions (mazes) in Healthy Maze module, user will be navigated to the Healthy Maze

total time used scene. This scene Maze module contains a panel showing the total time used to complete all three questions as shown in Figure 11. Maze 2 (Question 2) scene, and Maze 3 (Question 3) scene will have the similar hints interface, game content, and gameplay as Maze 1 scene.



Figure 11. Healthy Maze total time used scene

Figure 12 shows the game space and game content in Question 1 (Fruits) scene in MyPlate module.



Figure 12. Game space and game content of Question 1 scene in MyPlate module

In Question 1 scene, there will be a sprite character named Mike. Rigidbody 2D component is added to the character to allow the interaction with physics such as gravity. The character has animation and can be control using the keyboard input; left arrow key, right arrow key, up arrow key, and down arrow key. The game objects used in this scene such as the platforms/obstacles and the answers are 2D sprites. Collider are added into these game objects to create collisions between the character and the game objects. The background of the scene also uses 2D sprite. In this question/scene, user need to control the character and collect the game objects (answers) based on the question given. For this scene, user need to control the character and collect the foods that belong to the fruit food group. Besides that, there will be a live score update to show the score obtained at that moment of time as well as how much more score are needed to achieve the required score. Each correct game object collected will increase the score by one. In this scene, there will have time limitation of 30 seconds to answer the question. Besides that, there will be a live score update to show the score obtained at that moment of time as well as how much more score(s) are needed to achieve the required score. Each correct game object collected will increase the score by one. The total required score for this question is five. There will also have three lives provided. Each wrong game object collected will reduce the lives by one. Examples are shown in Figure 13.

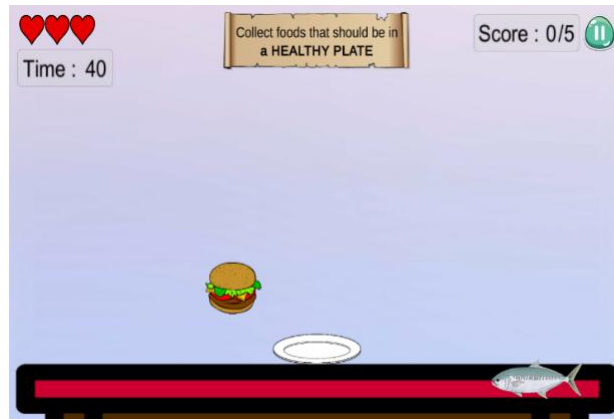


Figure 13. Game space and game content of Question 6 scene in MyPlate module

#### 4.2 Usability of the game

After the development process is completed, testing process is carried out to investigate the functionality and usability as well as the effectiveness of the game application. Figure 14 shows the results of user feedbacks for Likert scale questions after playing the game.

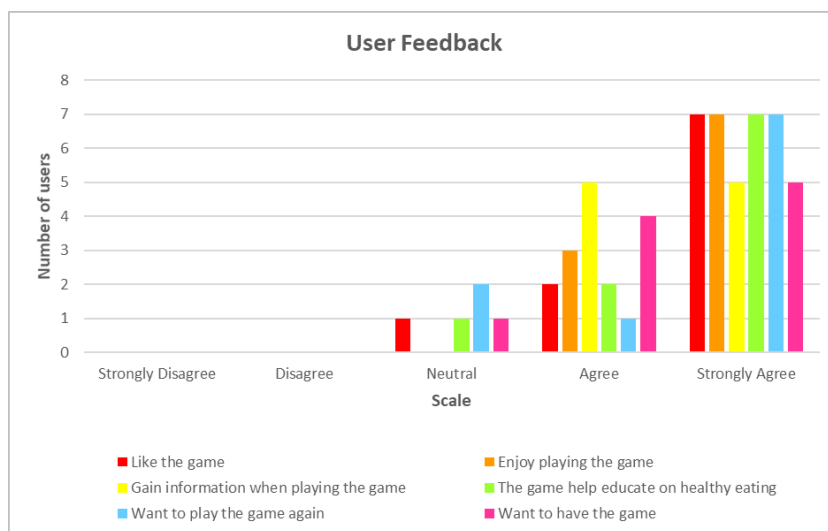


Figure 14. Results of user feedbacks for Likert scale questions

Based on the graph, 70% of users rated strongly agree that they like the game. Whereas, the other 20% and 10% of users rated agree and neutral respectively. When the users were asked if they enjoy playing the game, 70% of them strongly agree and 30% of them agree. Among the 10 users, half of them strongly agree and the other half agree that they can gain information when playing the game. Besides that, 70% of users rated strongly agree that the game can help educate on healthy eating while the remaining 30% of users rated agree (20%) and neutral (10%). It is also found that 70% of users rated strongly agree that they would want to play the game again. The remaining 10% and 20% of users rated agree and neutral respectively. Half of the users strongly agree that they would want to have the game if there is an opportunity. The other half of the users rated agree (40%) and neutral (10%). From the analysis, most of the users rated strongly agree and agree. Therefore, it can be concluded that the game application received positive feedbacks from the users.



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## 5. Conclusion

The aim of this study was to develop a food and nutrition game for pre-school children and investigate the usability of the developed game by the users. This study has developed the game which is based on platform and it is a single-player game that contains three modules; food pyramid, healthy maze, and my plate. Each module contains 5 different questions with different level of the game. The advantages of Food and Nutrition game application is that the game encourages the children to learn while playing games. Besides that, this game can also motivate children to learn about food and nutrition which can affect the way children view food choices and eating habits. Since the game application contains graphic and multimedia elements as well as colors, it can attract children's interest and attention. In general, therefore, it seems that the game application fulfilled the users' needs and requirements where most of the feedbacks were positive. The generalisability of these results is subject to certain limitations. For instance, the small sample size did not allow for the generalization of the findings and there are only three modules with limited contents included in this game application. In spite of its limitations, the study certainly adds to our understanding of the development of the game in education specifically on food and nutrition topic which can be use by student as self-learning tool or teaching aids by teacher. Considerably more work will need to be done to determine the learning gains by employing this game with more modules and contents in the game application.

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