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Game development "kill corona virus" for education about vaccination using finite state machine and collision detection

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Abstract
COVID-19 is a disease caused by the coronavirus and causes the main symptoms in the form of respiratory problems. One way to overcome the COVID-19 pandemic is through the vaccination process. However, in practice, the public is still not educated about the importance of vaccination in preventing coronavirus infection, so it is necessary to develop a game that provides education to the public to vaccinate. This study chose games as educational media because there are many game enthusiasts and the delivery of education through games is more memorable than on other platforms. This study uses the Game Development Life Cycle (GDLC) method in the game development stage. In addition, to create intelligent coronavirus enemy NPC characters in this study, Finite State Machine (FSM) and Collision Detection methods will be implemented to detect the accuracy of players' shots. The results were obtained in the form of a game "Kill Corona Virus" which is used as a medium of education for the public about the importance of vaccination. Based on the results of the tests carried out, it was found that the implementation of the Collision Detection method in the game in detecting collisions was appropriate and quite accurate and the Finite State Machine method succeeded in creating coronavirus enemy NPCs with appropriate states. In addition, based on the results of processing respondents' answers, it is known that the "Kill Corona Virus" game that was built can convey vaccination education messages well and make people interested in vaccinating.

1. Introduction

The development of information technology is currently increasing rapidly. Its utilization in the life of society at large has also experienced a very large increase. One of the developments in information technology that is very fast and is in great demand by the public is the process of developing game platforms [1]. Games are one of the entertainment facilities that are the choice of children and even adults to relieve boredom or just to fill spare time. Aside from being a means of entertainment, games also have other benefits, such as as an educational medium to add insight to the players [2]. Indirectly, educational games have significantly improved learning outcomes in traditional Science, Technology, Engineering, and Mathematics (STEM) and other subject areas [3]. Providing education through game platforms is certainly more effective and memorable than through other media such as brochures or websites. One of the education that needs to be conveyed to the public is related to the conditions faced by the world until 2022, namely the COVID-19 pandemic (Coronavirus Disease 2019). COVID-19 is a disease caused by the coronavirus that emerged at the end of 2020 and causes the main symptoms in the form of respiratory problems. This disease is highly contagious and quite dangerous with a Case Fatality Rate (CFR) of 2.7% [4]. Although the pandemic has begun to subside at this time, every country must not relax health protocols and continue to carry out efforts to prevent the spread of the Corona virus [5][6].

One way to overcome the COVID-19 pandemic condition is through the vaccination process to contain and curb the spread of the COVID-19 pandemic But the problem is that not everyone agrees to be vaccinated because one of the most important reasons is fear of the side effects of vaccination and safety reasons, especially for children [7][8][6]. This phenomenon can occur due to a lack of education to the public about the benefits of vaccination [9]. The educational process about vaccination that is widely used today is through writing articles or conducting socialization through videos. However, the problem is that the method of delivering education is too general and ineffective. In contrast to the game-based educational method, which is more effective and able to provide deeper motivation to the community to carry out the educational message conveyed. Game-based educational methods provide a learning experience while playing so that it is indirectly more memorable and easy to remember by the public [10]. There are several previous studies that discuss game design in delivering education, namely in 2018 an adventure game was built using Javanese characters by applying the Collision Detection method to detect collisions between objects in the game using Javanese script objects. This game was built to train children to recognize Javanese characters [11]. Further

research in 2018 discussed the development of educational games to introduce Prince Diponegoro's struggle. This research implements the Finite State Machine (FSM) method in giving behavior to player characters and creating enemies in the game [12]. The latest research in 2021 tries to develop a game to educate the public about vaccination where in this study a game called "Covid War" was built to educate users that the COVID-19 virus is dangerous and must be destroyed through the vaccination process [13].

In this study, to provide vaccination education to the public, a game called "Kill Corona Virus" was developed where this game is an arcade game with the concept of a First Person Shooter (FPS) game. In this game, players shoot vaccination needles at the enemy, namely the coronavirus to kill the virus. Each successfully shot coronavirus increases the score and as the level increases, the coronavirus becomes faster and harder to shoot. To create an intelligent corona virus enemy in the game, the Corona virus enemy is made using the Finite State Machine (FSM) and Collision Detection method to detect the accuracy of shots. The FSM method is a method of designing a control system that describes the behavior or working principle of the system by using three things, namely: state (state), event (event), and action (action) [14]. FSM is a simple state machine where different states are connected by some conditions. If certain conditions are met then we transition from one state to another state [15]. While the Collision Detection method is a detection method when two or more objects collide and cause a reaction. This method is very widely used in the world of animation and game-making [16]. This game can be used as a medium to educate the public that vaccines can kill the coronavirus so it is expected to attract public interest in vaccinating. In the contribution of this research, we analyze and combine the three previous studies described in the form of building an educational game with the theme of COVID-19 by combining the FSM and Collision Detection methods. The combination of the FSM and Collision methods can create smart Coronavirus villain NPC enemies so that they make the game more interesting and can provide education to the public about vaccination.

2. Research Method

In this study, the game development method used is Game Development Life Cycle (GDLC) defined by Heather Candler [17]. GDLC was chosen in this study because it has been widely used by previous researchers and has proven to be an appropriate game development method if implemented in game design. This method has simple steps and is by the conditions in this study as shown in Figure 1 [18][19][20].

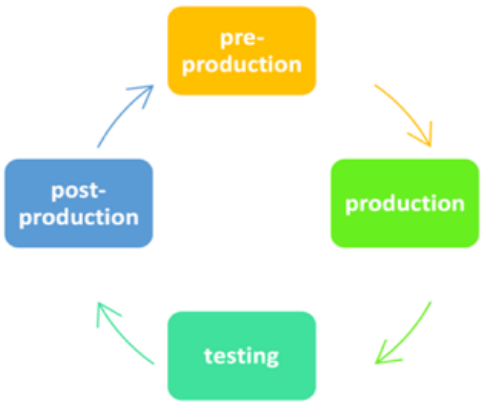


Figure 1. GDLC Steps

The steps of the game development method in this research consist of several production cycles starting from pre-production which defines game design and planning. Once the designs and plans have been defined and approved, it's time to move on to the production act which deals with the creation from both a technical and artistic perspective. Then, test the game and fix any bugs found. When a build is considered complete for a cycle, post-production is performed to provide up-to-date documentation and post-mortem activity.

3. Results and Discussion

3.1 Pre-Production

This stage defines the game design and the implementation plan of the "Kill Corona Virus" game project in this research. The game built in this research is a First Person Shooter (FPS) concept with the type of Arcade game genre where the game level is not limited and only focuses on collecting scores until the game ends. The target market of this game is parents, children aged 8-17, and adults from 18 to 40 years old. The Pre-Production stages are divided into 3, namely character design, display design, and finally the storyboard game design.

1. Character design

There are 3 characters in this game, namely the coronavirus character, the shooter's hand, and the vaccination syringe as shown in Figure 2.

(a) (b) (c)

Figure 2. Game Character Design

a) Coronavirus is an NPC villain (enemy) that infects human lungs so it must be exterminated by players. Each coronavirus enemy shot increases the player's score. This NPC was created quite intelligently by implementing the Finite State Machine (FSM) method, which is a model based on data structures to describe actions with a sequence of events [21][22]. The FSM method is used to describe the character's behavior so that the coronavirus character can move and avoid being shot by the player's needle. Figure 3 shows the behavior of the coronavirus NPC based on the implementation of the FSM method.

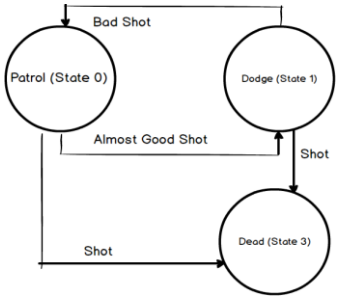


Figure 3. Behavioral Modeling on Coronavirus NPCs Using FSM

The application of the FSM plot on the enemy character of the coronavirus has initial behavior starting with patrols and if the player shoots and the coronavirus is almost shot, speed increases and coronavirus dodge, but if the shot doesn't feel good, Coronavirus continues to patrol. If the shot hits the coronavirus, the coronavirus will automatically die or disappear.

b) The shooter's hand is the hand to shoot the vaccine needle into the coronavirus so that the virus will die. Shots can occur if the player shoots and to detect a shot regarding the coronavirus the Collision Detection method is implemented. The type of Collision Detection used in this study is a Bounding Box, which is a box containing an object represented in a square or rectangular shape with X and Y coordinates, as well as width and height. [23][24]. Figure 4 shows the Flowchart of the implementation of the Collision Detection method.

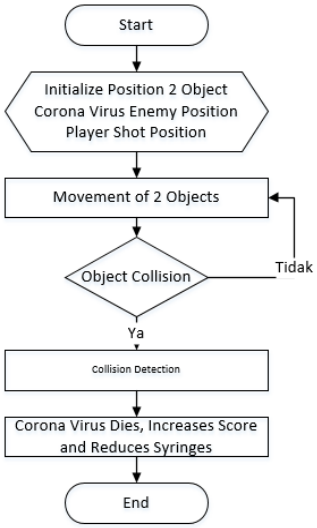


Figure 4. Collision Detection Method Implementation Flowchart

The Collision Detection method begins by detecting the player's firing position and the enemy's position (coronavirus). After the two objects move and collide with each other, the logical equation detects whether the two objects collide with each other or not. If the logical equation is 'true', then Collision Detection occurs and continues the programming flow to the next step like the coronavirus dies, increases the score, and reduces the syringe.
In this game, implementing a Bounding Box in the form of a Bound, Collision Detection requires an object to be created, and has a Bounding Box for each object so that it will find an intersection ratio for each object with certain coordinates [25]. To determine the regional Bounding Box on the object is determined by the following formula [23]:

$$\text{Regional R} = \{(x, y)\} | \min x \leq x \leq \max x$$

Defined:
regional R = Regional *Bounding Box Collision*
x,y = coordinate point y,x
minx,maxy = Coordinate minimum value x,y
maxx,maxy = Coordinate maximum value x,y
The above coordinates can be seen in Figure 5.

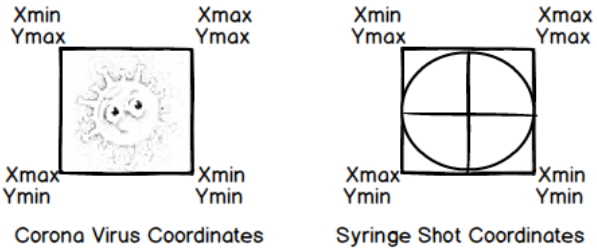


Figure 5. Min-Max Bounding Box

As seen in Figure 5, the Bounding Box is tested on Collision Detection regions that collide with each other or not, a test is carried out by comparing the maximum and minimum values in the x.y area, and the coordinates of the two regions will collide with each other if the following circumstances:
AxMin < BxMax dan AMax > Bxmin
AyMin < ByMax dan AyMax > BxMin
From the situation described previously, it will be explained where:
AxMin,AyMin = Coordinate minimum value x,y regional A
AxMax,AyMax= Coordinate maximum value x,y regional A
BxMin,ByMin = Coordinate minimum value x,y regional B
BxMax,MyMax = Coordinate maximum value x,y regional B
By looking at the formula above, it will be explained that the collision between two bound boxes on the x dimension will be seen in Figure 6.

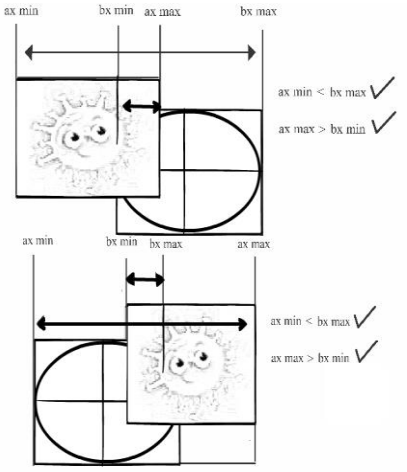
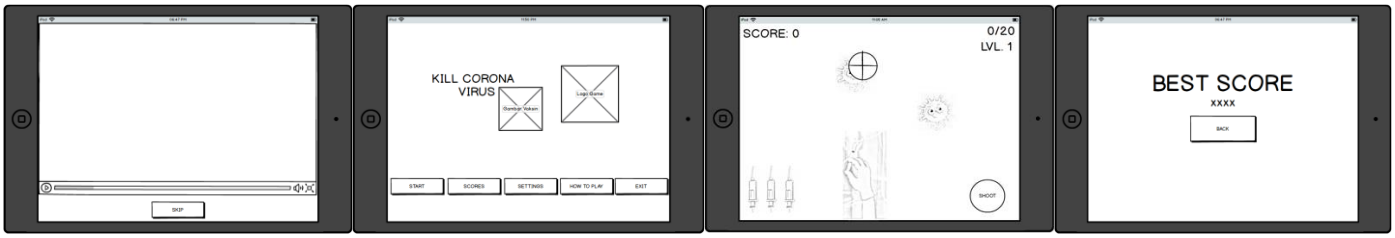


Figure 6. Bound Collision

c) Vaccine syringe bullets are bullets to shoot dead the coronavirus.

2. Display design
   The display design contains several prototypes of the "Kill Corona Virus" game display that will be built as shown in Figure 7.

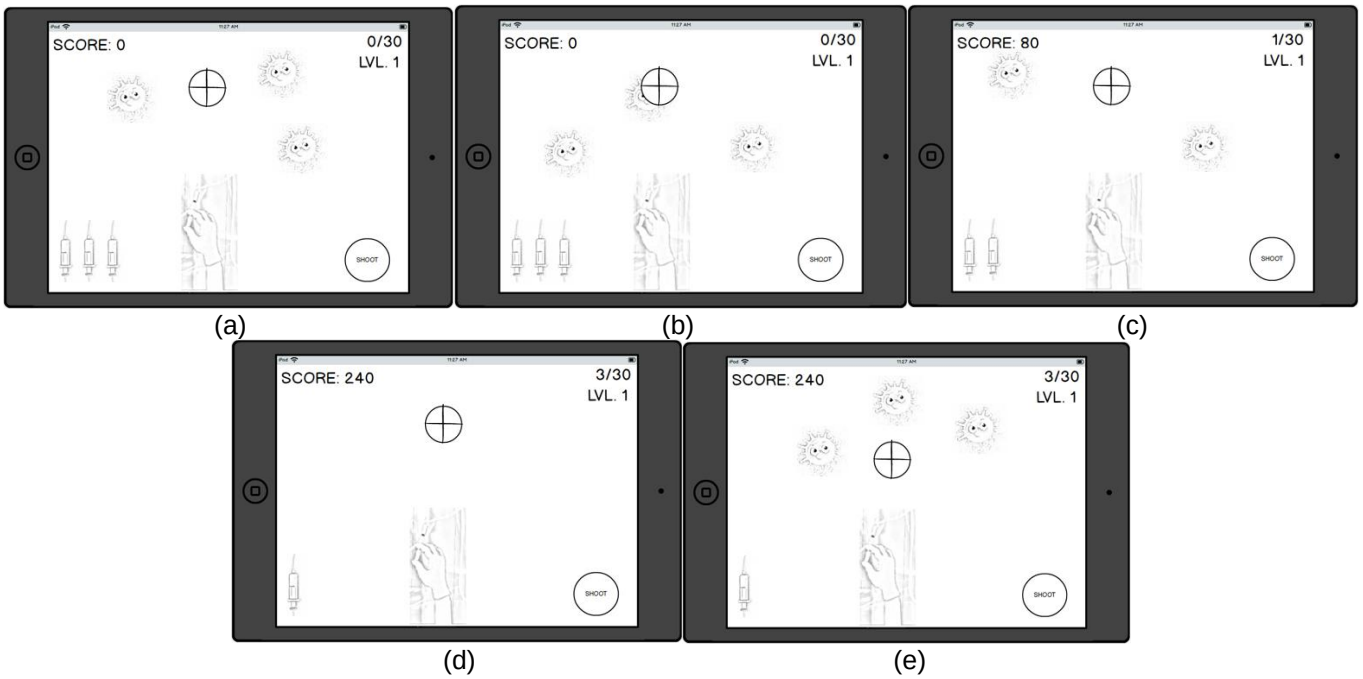


(a) (b) (c) (d)

Figure 7. Sequential from Left to Right is the Game Display Design "Kill Corona Virus"

a) Design of educational video display about the importance of vaccination.
b) The main menu display design contains navigation menus found in the game that was built.
c) The design of the display when the game starts.
d) Design display of the highest score achieved by the player.

3. Storyboard design
   Storyboards are designed to depict every scene in the game that is built [26]. The storyboard of each scene in the game "Kill Corona Virus" can be seen in Figure 8.



(a) (b) (c) (d) (e)

Figure 8. Sequential from Left to Right is the Scene Design of the Game "Kill Corona Virus"

a) Initial sketches show that 2 coronavirus enemies are flying when the game starts.
b) The next sketch shows a shot pointing right at the coronavirus.
c) When the shot hits the coronavirus, the virus will die, the syringe will decrease and then the score will increase.
d) The sketch shows if the coronavirus is shot again, the virus will fall and the score will increase again.
e) The sketch shows the new coronavirus will reappear up to 30 viruses and if the number of coronaviruses that have been shot dead is 24 viruses, then the game will continue at the next level where the movement of the coronavirus will increase faster so that it is more difficult to shoot.

3.2 Production

The production stage is in the form of game development stages related to the creation of technical and artistic aspects that implement the concepts, designs, methods, and plans that have been described in the previous stage, namely pre-production [20]. Figure 9 shows the results of the initial appearance of the game when it is run in the form of an educational video about the importance of vaccination and the display of the main menus available in the game that has been built.

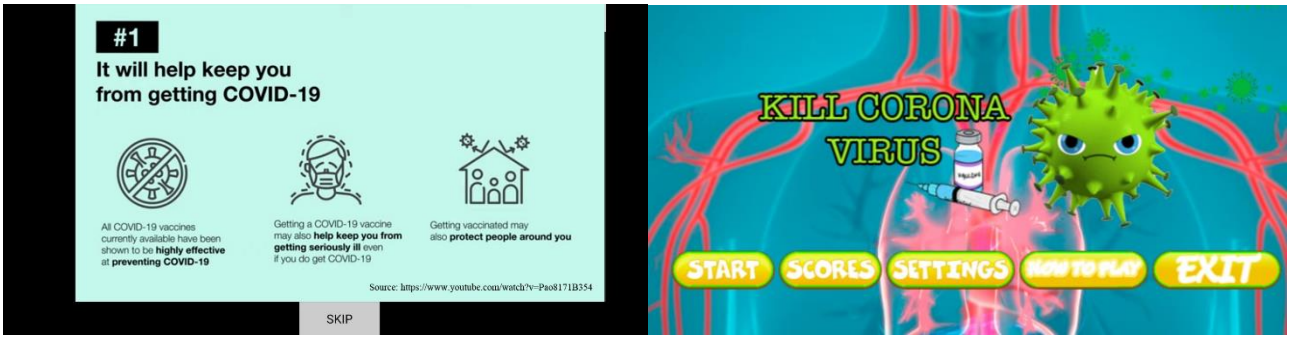


Figure 9. Sequentially from Left to Right are Examples of the Initial Appearance of the Game in the form of an Educational Video on the Importance of Vaccination and Implementation of the Main Menu

Each menu button is pressed, which will direct the player to a different view. Sequentially, Figure 10 shows the displays that will be displayed from each menu available in the game.

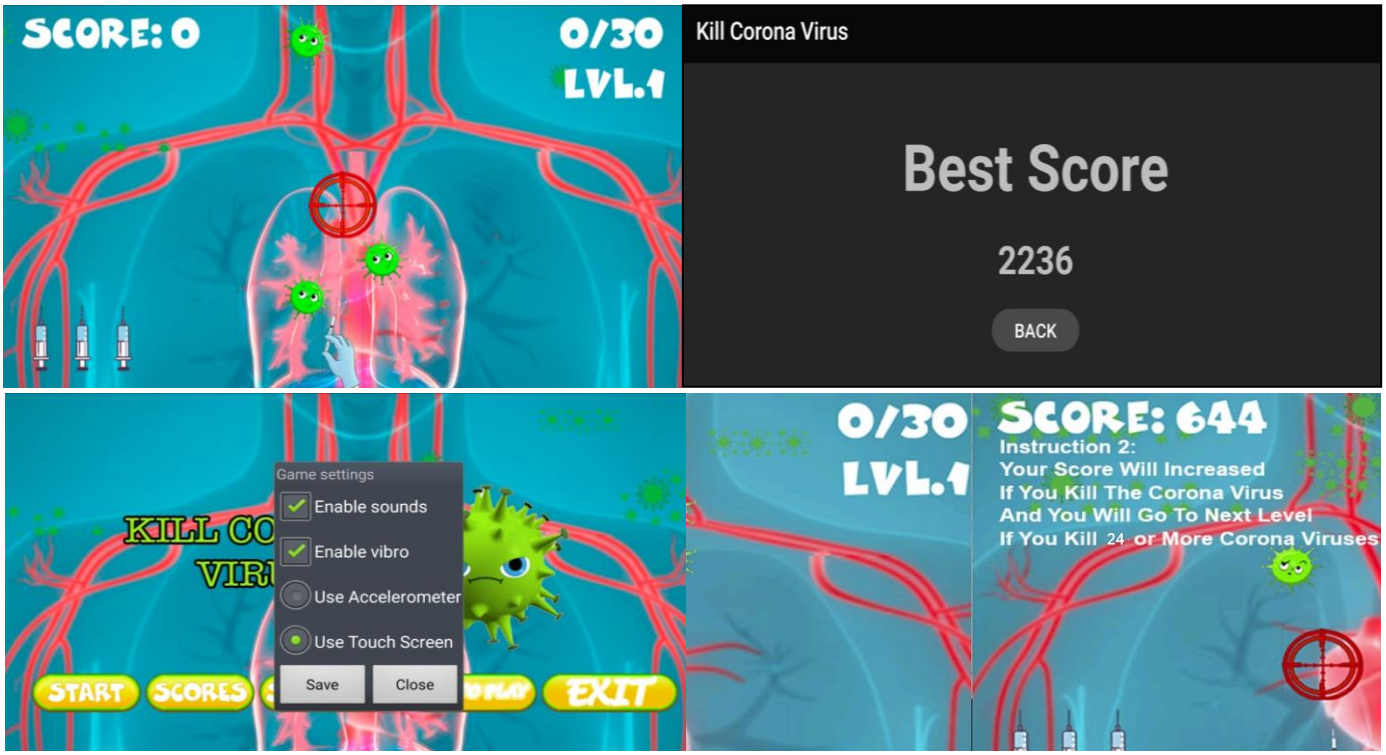


Figure 10. Sequentially from Left to Right shows How the Game Starts, the Highest Score, Game Settings, and How to Play the Game

In Figure 10 it can be seen that when the game is first started there will be 3 flying coronavirus enemies where behavior is formed from the implementation of the FSM method. Every shot by the player will be checked whether there is a collision or not by implementing the Collision Detection method. The game that is built is an arcade game so it only focuses on chasing the highest score so that the next menu shows the display of the best score recording in the game. The third menu is in the form of the game settings display, where in this view, players can close or turn on music and turn off vibration on the mobile platform. In addition, there are two choices of game modes, namely Accelerometer and Touch Screen modes. The accelerometer is a sensor used to measure the speed of an object [27]. The accelerometer

can measure dynamic as well as static acceleration, so in this study, the Accelerometer mode will be implemented in games where players have to shake their mobile platform left or right to change the direction of the shot. The second game mode is a touch screen which is played by touching the screen to shoot the coronavirus enemy. The different game modes, make the game more interesting to play so that educational messages can be conveyed properly. The display of the two-game modes is shown in Figure 11. Next, the last menu is a photo slider display that displays the rules and how to play the game.

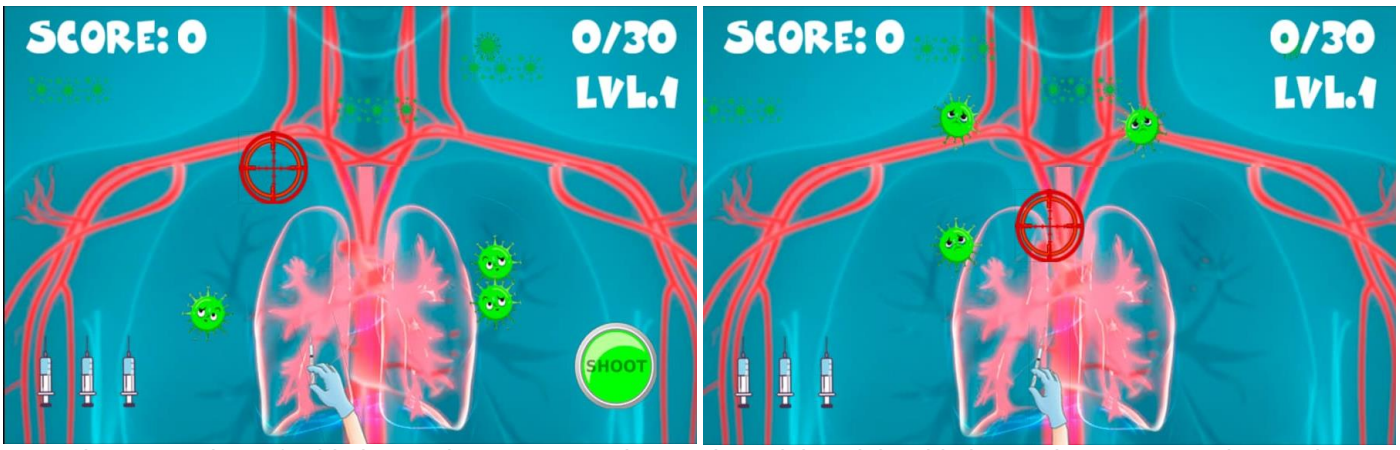


Figure 11. The Left Side is Accelerometer Gaming Mode and the Right Side is Touch Screen Gaming Mode

Figure 11 shows the differences between the two modes available in the game. The image on the left shows the Accelerometer game mode and the right shows the Touch Screen game mode. The Accelerometer game mode is much more difficult to play because to direct the right shot you have to do it by shaking the smartphone left and right. Unlike the Touch Screen game mode, which can shoot by touching the screen. Each level has a time, and if the player does not shoot, the CoroCoronavirusl automatically infects the human body, so players must immediately shoot properly to kill the Coronavirus. However, if the player shoots correctly and manages to kill 24 coronaviruses or more in one level, the game will continue to the next level. On the other hand, if the player cannot kill 24 viruses, the game will end. The display of the next level and the game over is shown in Figure 12.

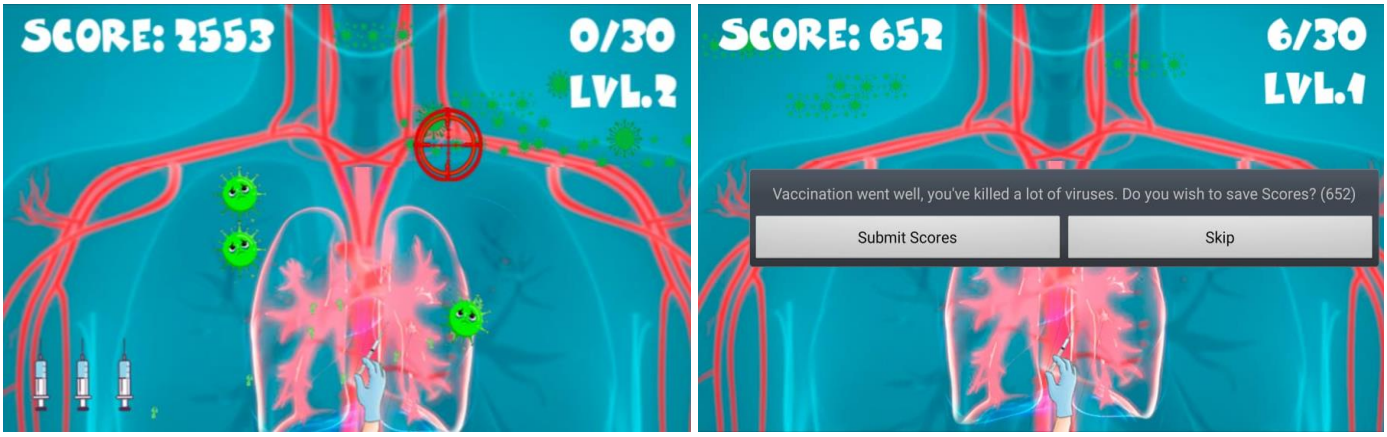
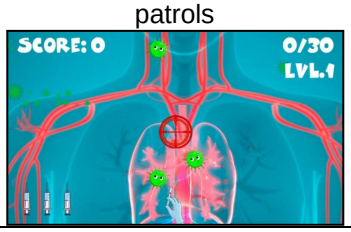
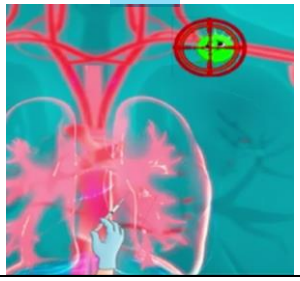
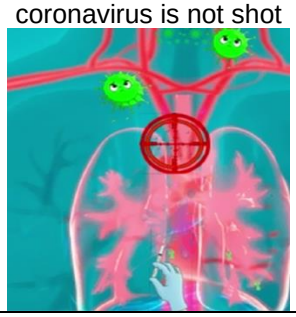
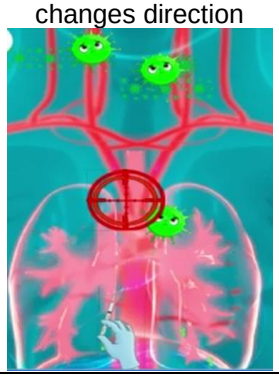


Figure 11. The Left Side is Game Continued to Next Level and The Right Side is When Game Ends

3.3 Testing

At this stage, testing is carried out which is divided into two scenarios, the first scenario is testing the correctness of the implementation of the Finite State Machine and Collision Detection methods in the game, and the second scenario tests the game's ability to provide education to its players to vaccinate [28]. The first test scenario will be carried out using the Black-box testing method shown in Table 1.

Table 1. Black-box Testing Results

Case/Tested	Test Scenario	Expected results	Test result
Testing the Finite State Machine method on the state patrol 	Press the start button	Coronavirus appears and patrols 	In accordance
Testing the Collision Detection method when shooting the coronavirus and testing the Finite State Machine method in the off state when the coronavirus is shot 	Shoot	Coronavirus Dead 	In accordance
Testing the Finite State Machine method on the dodge state when the coronavirus is not shot 	Shoot	Coronavirus avoids and changes direction 	In accordance

The results of the Black-box Testing test in Table 1, it shows that the application of the Collision Detection and Finite State Machine methods in the "Kill Corona Virus" game has been running according to the expected results of each test case.

The second test scenario was carried out by distributing questionnaires to 100 respondents from various ages ranging from children, teenagers to adults to test the games that had been built. The indicators used are collected and summarized from several papers [28][10][29] to get a summary of 3 important indicators, namely Playful Specifications, Technical Specifications, and Pedagogical Specifications. Based on the results of the questionnaire in Table 2, then the percentage of each answer will be searched using Equation 1.

$$y = \frac{\text{x}}{ideal\ score} \text{x}\ 100\% \quad (1)$$

Where y is a percentage value, x is the sum of the results of the multiplication value each answer with the number of respondents, and the ideal score is the highest likert value multiplication with the number of respondents.

Table 2. Results of the Recapitulation of Respondents' Answers

No	Statement	SA	A	JA	DA	SA	Total (X)	Percentage
	Playful Specifications							
1	The game has an interesting storyline and is in accordance with the educational message you want to convey	43	33	6	10	8	393	78.6
2	The game is very fun to play because it has interesting animations and effects	52	37	5	5	1	434	86.8
3	The concept of leveling available in the game makes me want to keep playing the game in order to record the highest score	53	25	6	10	6	409	81.8
4	The presence of Corona virus enemies in the game makes the game even more challenging to play	55	27	7	10	1	425	85
5	Game visuals make players interested in playing it	54	28	6	10	2	422	84.4
	Technical Specifications							
1	The game has attractive graphics	50	27	5	10	8	401	80.2
2	Game has appropriate background music and appropriate sound effects	60	25	6	8	1	435	87
3	Game has a good navigation menu	55	27	5	10	3	421	84.2
4	The game has interesting backgrounds and character designs	56	27	5	10	2	425	85
5	Coloring in the game is very comfortable for the eyes	61	29	6	3	1	446	89.2
	Pedagogical Specifications							
1	Visual game is able to convey educational messages about vaccination well	57	27	5	10	1	429	85.8
2	The game concept makes players understand that vaccination can kill the Coronavirus in the body so it doesn't infect the body	52	27	5	8	8	407	81.4
3	The game that was built understands the principles of education about the importance of vaccination in preventing the spread of the corona virus	53	27	5	10	5	413	82.6
4	Educational videos available according to the concept of the game	57	27	5	10	1	429	85.8
5	The presence of games makes it easy for parents to educate their children so they don't have to be afraid to	59	27	5	8	1	435	87
	Average							84.32

Information: SA = Strongly Agree, A = Agree, JA = Just Agree, DA = Don't Agree, SA = Strongly Disagree

Based on the percentage results shown in Table 2 the overall average score is 84.32%. Therefore, it can be concluded that the average respondent strongly agrees that the game is interesting to play and is able to educate the public about the importance of vaccination in preventing the Corona virus.

3.4 Post-Production

Post-production is carried out to present current documentation and post-mortem activities [20]. The main post-production goals are to create a closing device and to complete a postmortem. Post-production in this research is done by filing related assets and game documents for the development of the next game [19].

4. Conclusion

After the research is completed, it is necessary to put forward the conclusions from the research results obtained, namely based on the results of testing with Black Box Testing, it is shown that the application of the Collision Detection method in the game "Kill Corona Virus" in detecting collisions is precise and quite accurate and the Finite State Machine method has succeeded in creating enemy NPCs. Coronavirus with appropriate status. Based on the results of processing respondents' answers, it is known that the "Kill Corona Virus" game that was built is interesting to play and can convey vaccination education messages well and make people interested in vaccinating. However, the game in this study still has limitations where the game cannot be played online multiplayer and enemies made using the FSM

method are still limited so they tend to make players bored quickly. In addition, the research conducted has not focused on testing the complete specifications of game content so that it is not known how well the specifications of the game content built are. It is hoped that further research can develop a 3D-based educational game "Kill Corona Virus" that can be played online multiplayer and make more enemy characters of the corona virus using the FSM method so that the game becomes more interesting and educational messages about the importance of vaccination can be conveyed better.

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