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Design of rubbish as pickup object in the maze game using cellular automata

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ABSTRACT

An educational game is a good learning tool for children because they like to play while learning. Lots of children nowadays play games that are made for adults. This is quite concerning because the age of children should be the age of moral formation, one of which is regarding the aspect of environmental hygiene. In this game, it consists of many square-shaped grid cells in which there is rubbish as a pickup object and wall as a barrier for players while walking. This journal focuses on the design of pickup objects in the form of rubbish using the cellular automata method. The cellular automata method was chosen because this method can make the location of the rubbish always different in each iteration. In addition, this method can prevent rubbish as pickup objects from piling up wall objects in the same cell. This maze game has three levels, and the amount of rubbish the player must pick up increases at each level. The results to be achieved in this study are ensuring that the game can run smoothly and successfully taking objects in the form of rubbish according to what was designed. Then, the rubbish as pickup objects can be picked up properly at each level with an average value of 4.4 and also the placement of rubbish successfully changes every time its iteration restarts the room with an average value of 4.5 (maximum value 5.0) from respondents who have played this "Maze Cleaner" game.

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1. INTRODUCTION

Environmental cleanliness is a condition where the environment is free from dust, garbage and odors. Keeping the environment clean is an effort to realize and preserve a healthy and comfortable life. This can be started by maintaining cleanliness around the residence which can be done by cleaning the surrounding environment from garbage. The habit of keeping the environment clean is expected to emerge in children's daily behavior [1].

Games have the potential to promote physical activity and provide a fun alternative to traditional forms of exercise. However, parents and children should also be aware of the potential limitations of these games and consider them as part of a balanced approach to promoting physical activity. Parents saw these games as a way to promote physical activity and a way to provide a fun alternative to traditional forms of exercise. Children enjoyed playing active video games and saw them as a way to be physically active while also having fun [2].

In recent years, excessive use of video games has been a growing concern among parents and mental health professionals. Some children may develop an addiction to playing video games, which can negatively affect their health, social life, and academic performance. Children addicted to video games often spend many hours playing them, to the point where it interferes with their daily life. To prevent video game addiction in children, parents must monitor their children's game use and set limits on the amount of time they spend playing. It is also recommended that parents encourage their children to engage in other activities, such as sports or hobbies, to promote a healthy balance between screen time and physical activity [3]. Playing age-appropriate games is also an essential thing to avoid other harmful things. Because some games are for adults where the way to play is that the user has to kill his opponent in the game, of course, this is not very suitable for children to play. Playing educational games is one of the right solutions in this case because children can play and learn simultaneously in the game [4].

Games have the potential to create engaging and motivating learning environments, which can lead to improved learning outcomes. According to this theory, games can facilitate learning by providing a safe space for trial-and-error experimentation, allowing for active participation, and providing immediate feedback [5]. Educational games can support active learning by engaging learners in interactive experiences that encourage exploration and experimentation. Active learning has been shown to be an effective way to promote learning, as learners are more likely to remember information and skills that they have discovered and applied themselves [6].

Maze games have been theorized to have the potential to improve understanding of location, space, and pathfinding skills. This theory suggests that humans have an innate ability to learn and remember spatial information about their environment. Maze games can tap into this ability by providing players with opportunities to navigate through virtual environments, learn the layout of the environment, and develop spatial awareness [7]. In this game, it consists of many square-shaped grid cells in which there is rubbish as a pickup object and wall as a barrier for players while walking. This journal focuses on the design of pickup objects in the form of rubbish using the cellular automata method. The cellular automata method was chosen because this method can make the location of the rubbish always different in each iteration. In addition, this method can prevent rubbish as pickup objects from piling up wall objects in the same cell.

2. TEORITICAL BASIS

Game-based learning has become an increasingly popular approach to teaching and learning in recent years. By incorporating games into the learning process, educators can create a more engaging and interactive experience that can enhance student motivation and improve learning outcomes. One recent example of a successful game-based learning program is the "Minecraft: Education Edition," which has been widely used in classrooms to teach a variety of subjects, including science, history, and language arts. Studies have shown that this program can lead to improved student engagement and academic achievement [8].

Educational games can offer several benefits to learners. These games can provide an engaging and interactive learning experience that can help students retain information more effectively. They can also help students develop problem-solving, critical thinking, and decision-making skills. Educational games can be used to enhance traditional classroom instruction. By incorporating games into the classroom, teachers can create a more active and collaborative learning environment that can help students stay motivated and engaged in the learning process. However, caution that not all educational games are equally effective. To ensure the games are contributing to learning process, the games must be designed with clear learning objectives and should align with the content being taught. Moreover, educators must carefully select games that are appropriate for their students' age, interests, and skill levels [9].

Parents should be critical consumers of media and able to evaluate the content they consume. Parents can use media literacy principles to select games that align with their children's learning needs and interests. Children learn through observation, imitation, and modeling. Parents can model critical thinking and decision-making skills when selecting games for their children, encouraging their children to be selective in their own game choices. Children are motivated when they feel competent, autonomous, and connected to others. Parents can support their children's motivation to learn by selecting games that align with their children's interests and abilities, allowing them to feel competent and autonomous [10].

Maze game is a game that aims to achieve a certain goal by passing a branching maze path. There is a dividing wall as a barrier or a dead end in the game. Players must avoid these dead ends and find another way to reach their destination. Maze games have been popular for many years and continue to be a favorite among players of all ages. One recent example of a successful maze game is "Monument Valley," a puzzle game that requires players to navigate through a series of optical illusions and mazes to reach their goal. This game has been praised for its beautiful graphics and innovative gameplay, and has won numerous awards and accolades [11].

The player starts the game from the starting point, then the player must go through the labyrinth paths to find a path to reach the finish. Usually maze games have a certain time limit, so players must reach the finish before the time runs out [12].

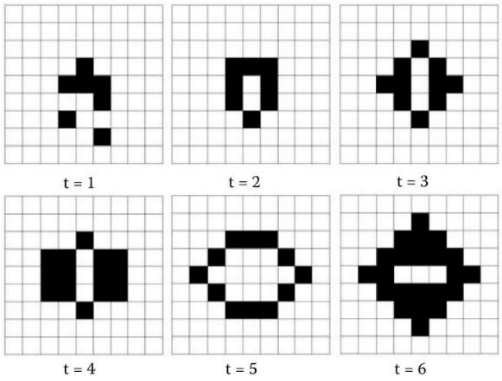

Figure 1. Simple Cellular Automata Simulation.

Figure 1 has a meaning which is cellular automata are discrete dynamical systems in which space is divided into spatially ordered cells and time processes at different stages. Each cell in this system has one condition, where this condition will always be updated according to local rules, the time is given, its own state, and the state of its neighbors at the previous time. A cellular automaton (CA) is a computational model consisting of a grid of cells, each of which can be in a finite number of states. The states of the cells are updated based on a set of rules that depend on the current state of the cell and its neighbors. The rules are applied simultaneously to all cells in the grid, creating a dynamic system that evolves over time [13].
Cellular Automata consist of 5 elements, namely:

1. Cell (Cell) is the basic spatial unit in cellular space. These cells are arranged in a spatial tessellation, which is a two-dimensional grid of cells, which is the most common form of cellular automata used in modelling urban growth and land conversion.
2. Condition (State) defines the attributes of a system. Each cell can only take one condition out of a set of conditions at any given time. In this study, conditions represent types of land use.
3. Neighborhood, which is a series of cells that interact with each other. In two-dimensional space, there are two basic types of environment, namely the Von Neumann environment (four cells, including North, South, East, and West) and the Moore neighbourhood (eight cells). In this study, a 3x3 filter will be used.
4. Transition Rules define how a cell changes in response to current conditions and neighbouring conditions.
5. Time (Time-step) is a variable that determines the time dimension used during the calculation process and calculations based on cellular automata processes. Time here can also be defined as the iteration period [14].

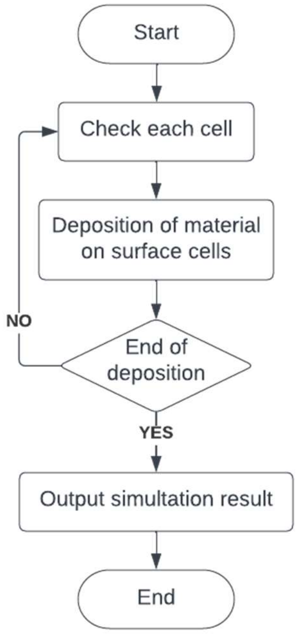

Figure 2. Cellular Automata State Chart.

Figure 2 is a flowchart of the cellular automata used. When the system is run, the first step is checking cells randomly on the automata cellular grid, then depositing the material and applying the rules. If the process of applying the rules has been completed, it will display output by placing a trash object. If it has not been completed, the cell-checking process will repeat. A typical cellular automata (CA) flowchart consists of several steps to generate the next state of the cell based on its initial state and the state of its neighbors. The first step is initialization, where the grid is initialized with an initial state, which can be either random or predetermined. After initialization, a neighborhood is defined for each cell to specify the adjacent cells that influence its state. Next, a set of rules is defined to determine the next state of each cell based on its current state and the state of its neighbors. These rules are crucial to generating a new state for each cell [15].

The next step is to update the rules for all cells in the grid simultaneously, creating a new state for each cell. This process is repeated for a given number of iterations or until the system reaches a stable state. The CA model can be used to simulate a wide range of systems, including physical, biological, and social systems. With its simple rules and flexibility, the CA model is a powerful tool for generating complex behavior from simple interactions. This makes it a suitable tool for game development, where it can be used to generate maze-like structures with predetermined rules, creating unique and challenging gameplay experiences [16].

3. SYSTEM DESIGN

To achieve the theme "Education Cares for the Environment" in this game, the researchers provide a focus mission for players so they can proceed to the next level. The focus mission in question is that the player must collect all the trash scattered on the maze path with the time vulnerability given by the developer. Each piece of rubbish collected will give points to the player. If the player does not collect all the rubbish in the allotted time, the player will lose one life, and the player will be returned to the starting point. The labyrinth map and the location of the rubbish as a pickup object will change randomly according to the workings of the cellular automata method used. The workings of the cellular automata method used to place pickup objects are quite different from obstacle walls, and they still use neighbourhood cell checking. However, for pickup objects, the algorithm ensures that the objects are spaced apart and do not overlap on adjacent cells.

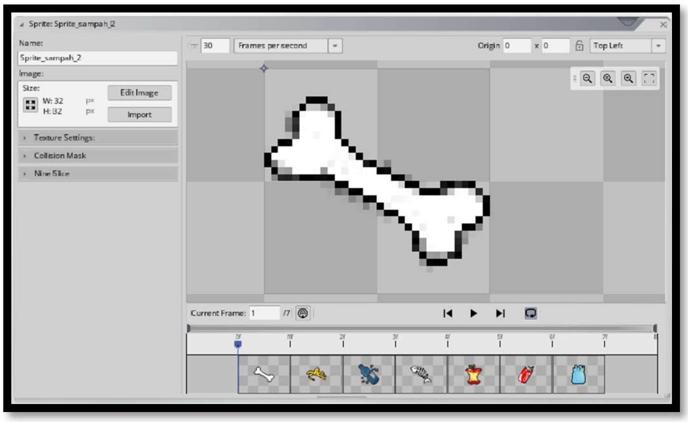

Figure 3. Pickup Object View

Figure 3 is a tab view for picking up rubbish as pickup objects used in the Maze Cleaner game. The rubbish object assets use sprites with a size of 32x32. This rubbish sprite has 7 frames, where each frame has a different rubbish image.

Rubbish designed for pickup objects serves to provide education to children who will later play this game because this pickup object is set to be able to increase the score and finish the level if the rubbish runs out. The features contained in this pickup object are rubbish that can be lost or picked up by the player when the player hits the rubbish.

The following is the source code for designing the pickup object as expected using the cellular automata algorithm.

```
image_speed=0;

random_pickup = irandom_range(0, image_number -1);

image_index = random_pickup;

type = "";
if (random_pickup >= 0 && random_pickup < 3){
type = "points";
}
else if (random_pickup > 2 && random_pickup < 6) {
    type="health";
}
else if (random_pickup >= 6 ) {
    type="points";
}
```

Figure 4. Source code pickup object in the game "Maze Cleaner".

Figure 4 is the source code for determining the effect if the player hits a pickup object in the form of rubbish. So, there are seven different types of rubbish. The collision pick up object with the player also has differences according to the source code above, namely:

1. If the player hits rubbish number 0, then the total score will increase
2. If the player hits rubbish number 1, the total score will increase
3. If the player hits rubbish number 2, the total score will increase
4. If the player hits rubbish number 3, the health bar will increase
5. If the player hits rubbish number 4, the health bar will increase
6. If the player hits rubbish number 5, the health bar will increase
7. If the player hits rubbish number 6, then the total score will increase

```
while ((sisa > 0)||(_npc > 0)){
        _x = irandom_range(1,41);
        _y = irandom_range(1,22);
        _x_ = irandom_range(1,41);
        _y_ = irandom_range(1,22);
    var nwall = 0;
```

Figure 5. Source code pickup object in the game "Maze Cleaner".

Figure 5 is the source code which shows that the pickup point of the rubbish object is randomly spread from the available 41x22 cells. Total grid in this game is 43x24 cells. This is based on the number of pixels used in this game, which is 1376x768 pixels, where 1 cell measures 32x32 pixels. However, on the top, bottom, right, left there are walls to limit the playing arena. Then the available cells are 41x22 cells.

```
if((my_map.map[_x][_y] == false) && (nwall < 3)){
    instance_create_layer(_x * _spacing, _y * _spacing, layer, object_pickup_CA);
    sisa = sisa - 1;
```

Figure 6. Source code pickup object in the game "Maze Cleaner".

Figure 6 shows that if the program chooses a certain point to place a pickup object in the form of rubbish and the number of walls around it is less than 4, then the rubbish display will appear. If the rubbish has a collision with the player, then the remaining trash will be reduced by 1.

4. RESULTS AND DISCUSSION

In this Maze Cleaner pickup objects are placed on the room level, where level 1 has 10 rubbish, level 2 has 15 rubbish, level 3 has 20 rubbish. Trash will immediately appear on the map when the game starts. Trash's position spreads randomly on the labyrinth map. When a player hits rubbish, the rubbish will be lost or picked up and the total score will increase.

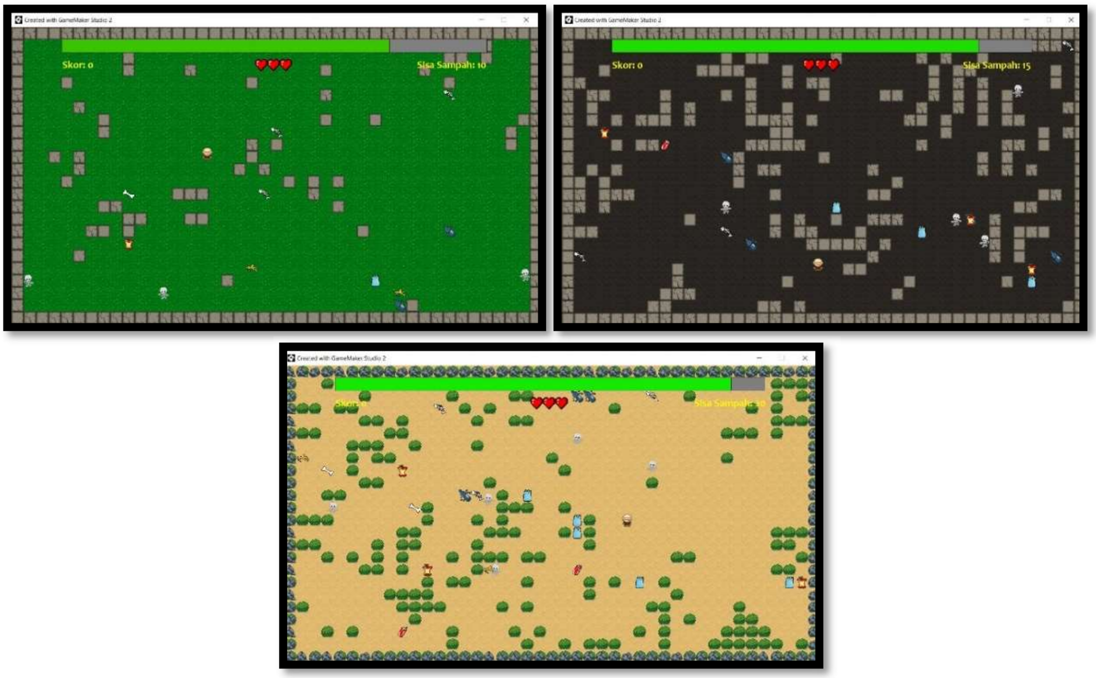

Figure 7. Room Level Interfaces: (a) Level 1 Interface Page, (b) Level 2 Interface Page, (c) Level 3 Interface Page

Alpha Testing

This test aims to ensure that the functions and features of the object pickup are running properly. Alpha testing is carried out using the white box method to ensure that the pickup of the developed object goes as desired. The conditions to be tested are as follows:

Table 1. Testing functional

No	Description	Inputs	Expected results	Output	Information
1	Start game	Click Start button on the main menu	Direct appearance to room level 1	Room level 1 appears corresponding expected	Appropriate
2	Collision with players	Player crashed pickup object	Score or health bar increase	Score or health bar increase	Appropriate
3	Collision with players	Player crashed pickup object	Help panel remainder rubbish reduce	Help panel remainder rubbish reduce	Appropriate
4	Collision with player if remainder rubbish = 1	Player crashed pickup object	Victory room appears along with-it total score obtained	Victory room appears along with it total score obtained	Appropriate
5	Randomly generate pickup objects	Player caught by NPCs The health bar runs out	Restart room and location pickup object on maze changed .	Rooms succeed restart, and position labyrinth walls changed .	Appropriate
6	Restart after game over	Click knob restart and repeat levels	Direct appearance to the previous level and change shape labyrinth .	Rooms succeed return to the previous level , and position pickup object maze changed .	Appropriate
7	Next level	Click knob next	Direct appearance to the next level and do generate random pickup objects	Succeed direct appearance to the next level and do generate random pickup objects	Appropriate

After Maze Cleaner game tested with alpha test, the results show that the development of pickup objects is in accordance with what has been designed by the developer. The development of pickup objects can be said to be successful because the pickup object that is developed includes seven factors based on the test results is accordance with the expected results. However, occasionally the pickup object cannot be picked up because it is closed by the wall around it. This is used as input so that in the future can add a detection program if there is rubbish that cannot be collected.

Beta Testing

Beta testing was conducted on 10 respondents regarding using cellular automata algorithms in the Maze Cleaner game. This test is carried out by giving a simple questionnaire to respondents after playing the Maze Cleaner game and then giving an assessment with a score of 1-5 for each question.

Table 2. Beta Test Questioner Score

No	Name of Respondent	Question					
		x1	x2	x3	x4	x5	Total
1	Wirna	5	5	5	5	5	25
2	Hafid	5	5	5	5	5	25
3	Ilham	3	4	3	4	3	17
4	Restu	5	5	4	4	4	22
5	Fajri	5	4	5	5	5	24
6	Angga	3	3	3	3	4	16
7	Teguh	3	5	5	4	5	22
8	Zidan	5	5	5	4	5	24
9	Fajar	5	5	4	5	4	23
10	Farhan	3	4	5	4	5	21

x1 to x10 = question items 1 to question 10
1 to 5 = point of answers (minimal 1, maximal 5)
total = total point answers per respondent

Table 3. The average value of the question score

No	Question	Average Score (1-5)
1	What are the variations of the types of trash displayed in the game “Maze Cleaner”?	4,2
2	Does the location of the trash as a pickup object change every time it iteration restarts room?	4,5
3	Can trash be picked up by the player for the game "Maze Cleaner" being played?	4,4
4	How is the amount of trash that must be picked up in the game "Maze Cleaner"?	4,3
5	How is the total score added when the trash is picked up by the player in the game "Maze Cleaner"?	4,5

Validity Test

The validity test aims to determine whether the questionnaire used in obtaining data from respondents is valid or not. This validity test uses a significance value of 5% with 10 respondents, then the rtable value used is 0.632. If the value of rcount> rtable = valid, and if the value of rcount < rtabel = invalid.

$$validity\ test \begin{cases} rcount\ > rtabel = valid \\ rcount < rtabel = \ invalid \end{cases} \quad (1)$$

$$rount = \frac{n\Sigma - (\Sigma x(\Sigma y))}{\sqrt{\{n\Sigma x^2 - (\Sigma x)^2\}\{n\Sigma y^2 - (\Sigma y)^2\}}} \quad (2)$$

Table 1. Validity Test

Item	rcount	rtable	Description
1	0,794	0,632	Valid
2	0,774	0,632	Valid
3	0,855	0,632	Valid
4	0,801	0,632	Valid
5	0,724	0,632	Valid

Table 4 above is a calculation using the Excel and SPSS applications. The results of the calculation of the validity test value of the questionnaire are declared valid because it meets the requirements, namely, rcount> rtable.

5. CONCLUSION

Based on the development of the Maze Cleaner game and the testing that has been done, it can be concluded that, all the functions of the pickup objects can run successfully according to the alpha, beta, and validity test.

The placement of rubbish as a pickup object using cellular automata method has been successfully changed every time the iteration restarts the room with an average value based on the respondents' answers is 4.5 (maximum value is 5.0). Pickup objects in the form of rubbish can be picked up properly at each level with an average value of 4.4 (maximum value 5.0) from respondents who have played this "Maze Cleaner" game, this proves that cellular automata method can prevent rubbish as pickup objects from piling up wall objects in the same cell.

The results of the development of the Maze Cleaner game are of course still lacking, here are some suggestions to make Maze Cleaner game even better, such as added a wider variety of player characters, added a feature to sort organic and inorganic rubbish, and added a trash can animation so players can dispose of trash in its place.

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