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Development of Environmental Cleanliness Education Game for Grade 5 Students at SD Inpres Kalu

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Abstract

Technological advances have brought major changes in various aspects of life, including the world of education. One form of use of technology in education is the development of interactive learning media such as educational games. This research aims to develop an Android-based educational game that raises the theme of environmental cleanliness and is intended for 5th grade students of SD Inpres Kalu, East Sumba. The background of this research is based on the low understanding of students on the importance of maintaining environmental cleanliness, which is caused by conventional learning methods that are less interesting and less interactive. The educational game developed will contain materials such as types of waste, how to sort and dispose of waste, and dirty environmental impacts. The research method used is research and development (R&D) with a waterfall model that includes the stages of needs analysis, design, implementation, verification, and maintenance. Supporting data were obtained through interviews, observations, and literature studies. The results of the trial showed an increase in students' understanding of environmental hygiene materials, which was evidenced by an increase in the average score from 78.0 in the pre-test to 87.2 in the post-test, with a difference of 9.2 points or an increase of 11.79%. Testing using the Black Box Testing method showed that all in-game features performed as intended, while the System Usability Scale (SUS) test results obtained an average score of 83.5, which is in the excellent category.

Keywords: *Educational Games, Waterfall Method , C#, Unity 3D*

1. Introduction

Technology is one of the means that continues to develop rapidly in modern life today. The rapid development of technology provides various conveniences, including in the world of education. One of the positive impacts of technological developments in the field of education is the emergence of various innovative learning media that can increase the effectiveness of teaching and learning activities. Technology not only enriches learning methods, but is also able to foster students' interest in learning, increase creativity, and strengthen understanding of subject matter. In the context of basic education, especially in grade 5 of elementary school, it is important to instill values related to environmental cleanliness. Environmental cleanliness education from an early age aims to form the character of students who care about the surrounding environment. However, in practice, learning about environmental cleanliness is still carried out conventionally, such as lectures and discussions. This method is often less effective because students quickly get bored and find it difficult to understand the material thoroughly.

2. Library Studies

2.1. Types of Waste

2.1.1. Organic Waste

Organic waste is waste derived from the remains of living things, such as humans, animals, and plants, that undergo decay or weathering and can decompose with the help of bacteria naturally. This process takes place quickly, so organic waste is classified as environmentally friendly. However, the accumulation of organic waste in landfills (landfills) can cause unpleasant odors due to anaerobic decomposition (Rosita & Mintarsih, 2021).

2.1.2. Inorganic Waste

Inorganic waste is a type of waste that is difficult to decompose and generally contains materials such as metals, plastics, cans, and other solid objects. This waste cannot be destroyed just by relying on microorganisms because the carbon element has a long and complex

structure (Hasibuan, 2016). The impact of inorganic waste is very dangerous, because if left unchecked, it can cause flooding disasters (Jannah & Itratip, 2017).

2.2. Educational Games

Education is a process that occurs when a person begins to discover his or her identity. This process takes place through observation and learning which ultimately results in the actions and behaviors of the individual. Educational games, on the other hand, are games that are specifically designed as a learning medium. This medium integrates various elements such as sound, text, images, video, and animation. Material in educational games typically focuses on a specific topic with the goal of helping users broaden their understanding of concepts, gain deeper insights into the material, such as historical or cultural events, while also learning effectively. Through educational games, users can easily understand the material while playing, so that the learning process becomes more fun and interactive (Purnomo 2020).

2.3. Waterfall Method

According to Nugroho (2010), one of the waterfall models used by researchers is the so-called linear sequential model or software lifecycle sequentially or sequentially, starting from planning, analysis, design, implementation, testing, and maintenance.

3. Research Methodology

The research flow in making an android-based environmental hygiene education game can be seen in the image below:

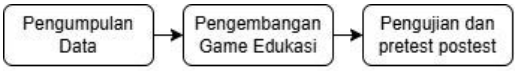

Fig 1: Research Flow

3.1. Data Collection

aim to gather information to support and address the problem. Data collection was carried out by interviews, observations, and documentation.

3.2. Educational Game Development

The method used in the development of this software is the Waterfall method. Waterfall is a software development model that is carried out gradually and systematically, moving from one stage to the next like a waterfall. The following is an explanation of the stages in the Waterfall method used, namely:

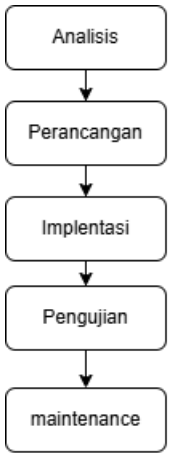

Fig 2: Waterfall Method

1. **Analysis**
   The initial stage of this flow aims to identify the needs of the user. The target of the development of this educational game is 25 5th grade students of SD Inpres Kalu with an age range of 10 to 11 years.
2. **Planning**
   In the next stage, the design of the educational game display is carried out
3. **Implementation**
   At this stage, the application began to be built technically by the developers using Unity 3D Software with the C# programming language.
4. **Testing**
   At this stage, internal testing is carried out to assess the functionality of the game or game, the result of this test is in the form of bug reporting. Testing this software uses black box testing. Black box testing is carried out to test the functionality in the application whether it can run and function as expected.

5. Maintenance

After the application is used, maintenance is needed to fix bugs that appear, adjust the content according to the development of the curriculum, add new features to keep the application interesting to use, and maintenance is carried out periodically with an evaluation of the results of using the application at school.

3.3. Pre-test *and* Post-test *testing*

The pre-test and post-test tests will be carried out on 5th grade students of SD Inpres Kalu which totals 25 students, where users will be given Pre-test and post-test questions.

4. Results and Discussion

4.1. Implementation

The results of the research are a result obtained by the researcher from research conducted in accordance with the steps and stages of research that have been made so that it can produce outputs or outputs in the form of *educational games* and test results from the educational games. The development of Environmental Hygiene Education Games for Grade 5 Students at SD Inpres Kalu is designed to provide solutions to the problems faced to increase students' understanding of the importance of cleanliness.

1.Main Menu View

In this view, there is an application title placed at the top as the main identity. The background of the application uses illustrations of mountain scenery, trees, and the activities of several people who are picking up garbage, so that it provides an educational and interesting feel for users. In the middle there are four main menu buttons, namely Learn, Play, About, and Exit.

Fig. 3: Main Menu View

2.Learning Display

After the user presses the Learn button on the main page, it will display the Learn to Know Waste menu page. On this display, there is a title Knowing Waste located at the top as a marker that this page serves to provide learning materials about the types of waste. The page is divided into two main sections, namely the left column containing descriptions and examples of garbage, and the right column which is intended for the presentation of supporting images.

Fig. 4: Learning View

3.Play Menu Display

Once the user presses the Play button on the main page, it will display the play menu page. In this view, there are two main columns on the left labeled Organic and Non-Organic as places to group waste. On the right side, you will see various images of the garbage that the user has to move. The game mechanics are carried out by drag and drop, where the user drags the garbage image from the right column to the left column according to the correct category. At the top of the screen, there is time information that serves to provide a challenge in completing the game. Players are given a 30-second time limit to group all the junk pictures and each correct answer picture will get a score of 10, but if it is wrong it will get a score of 0.

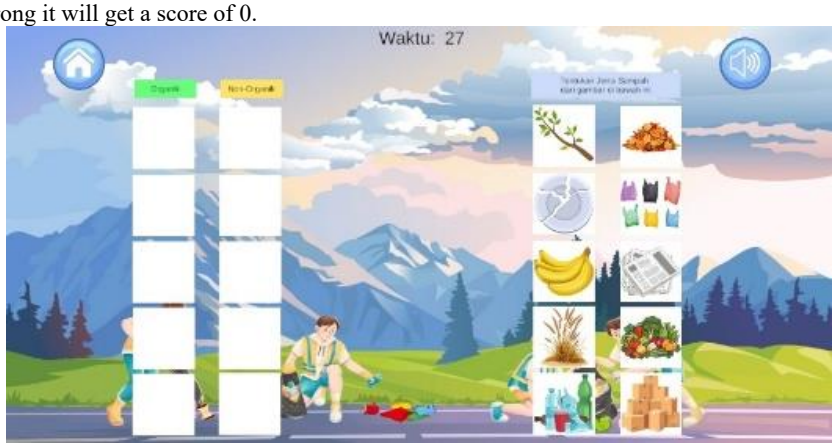

Fig. 5: Play Menu View

4.Final Score View

On this page, the final score obtained by the user is displayed in the middle of the screen with a large and clear font size, making it easier for users to see the results of their achievement in the form of answer scores and correct and there is a red cross on the image placed in the wrong place as an indicator of student error in grouping the type of garbage, so that it can be direct feedback to correct mistakes when the game is repeated. At the bottom, there's a Reload button that you use to restart the game from the beginning.

Figure 6: Final Score View

5.About Views

After the user presses the About button on the main page, it will display the About menu page containing game information. In this view, information about the identity of the app developer is displayed in a light blue box. This information includes name, NIM, application

development purpose, and origin of study program and university. In addition, it also displays a photo of the developer on the right side of the information box.

Figure 7: About View

6.Exit Menu Display

On this page, it will show the Exit menu that appears when the user presses the exit button on the main page of the Organic and Non-Organic Waste Processing application. This display displays a confirmation dialog box with the question "Are You Sure You Want to Sign Out?" prominently displayed in the center of the screen. Below the question text, there are two options for interactive buttons, namely the blue Yes button that serves to close the application, and the pink No button that will return the user to the previous page.

Figure 8: Exit Menu View

4.2. Testing

4.2.1 *Black Box*

Testing of Environmental Hygiene Education Games for Grade 5 Students at SD Inpres Kalu using the black box testing method. The results of the black box testing can be seen in Table 1

Table 1: *Black Boxes*

Functions tested	How to Test	Expected results	Test Results
Main Menu	The user selects the menu button	Each button goes to the page accordingly	[✓] Successful [ ] Didn't work
Study Menu	The user selects the material	Complete Material	[✓] Successful [ ] Didn't work
Play Menu	User *drag and drop* trash into the column	Correct garbage is scored, *timer* runs	[✓] Successful [ ] Didn't work
Final Score View	Game features scores	Score recap and *home* and *reload* options (to replay to the original game)	[✓] Successful [ ] Didn't work

About Menu	Display personal data information from game creators	Information displayed	[✓] Successful [ ] Didn't work
Exit Menu	Displays exit menu	User exits the game	[✓] Successful [ ] Didn't work

In Table 1, you can see the results of the Environmental Hygiene Education Game test using the black box method that shows successful results or successfully executed according to the expected function. Based on the results of these tests, it can be said that the game built has run well according to its respective functions.

4.2.2 SUS (*System Usability Scale*) Testing

In the Environmental Cleanliness Education Game test using the System Usability Scale (SUS) method, testing was carried out on 10 respondents consisting of 5 teachers and 5 students. The score results obtained from the respondents in the application test using the System Usability Scale (SUS) can be seen in Table 2.

Table 2: SUS Testing

Reply	SUS Statement										Entire	Score SUS
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10		
1	4	4	3	2	4	3	3	4	2	4	33	82.5
2	1	4	4	4	2	4	3	3	4	4	33	82.5
3	3	3	4	3	4	3	4	4	4	2	34	85
4	4	3	2	4	3	4	4	4	3	4	35	87.5
5	3	2	4	3	4	4	3	2	4	3	32	80
6	2	4	2	4	4	4	4	4	4	4	36	90
7	4	3	3	4	3	3	4	3	3	3	33	82.5
8	1	4	1	3	2	4	3	4	4	4	30	75
9	4	3	3	2	4	3	4	3	3	2	31	77.5
10	4	3	4	4	4	4	3	4	4	3	37	92.5
Entire												**835**

The total SUS score of the respondents in this study is 835 as shown in Table 2 obtained from 10 respondents. For the next calculation, the SUS score of each respondent was searched for the average score.

$$\bar{x} = \frac{835}{10} = 83{,}5$$

4.2.3 *Pre-test* and *Post-test*

The test in this study used pre-test and post-test, the test was carried out on Grade 5 students at SD Inpres Kalu consisting of 25 students. Pre-test and post-test are given to students with the scores obtained in Table 3

Table 3: *Pre-test* and *Post-test*

No	Student Name	Value	
		Pre-test	*Post-tests*
1	Kayla	100	100
2	Radin	100	80
3	Sovia	90	100
4	Gembira	60	80
5	Rambu	80	90
6	Kinan Language	90	100
7	It is	100	100
8	Juan	90	100
9	Abdullah	80	100
10	Alexander	100	100
11	Iqbal	90	100
12	Arnesta	60	80
13	Gabriel	90	80
14	Bungsu	30	50
15	Iestantiano	80	100

16	Düsseldorf	100	100
17	Kevin	100	100
18	Kostantina	80	90
19	Maria	30	50
20	Wulandari	30	30
21	Denisius	50	80
22	Niki	100	100
23	Ricad	80	90
24	John	90	100
25	Ucil	50	80
	Entire	**1950**	**2180**

Table 4.3 shows the results of the pre-test and post-test conducted, the number of pre-test scores in this study is 1950 and the number of post-test scores in this study is 2180. For the next calculation, the number of scores from each test is searched for the average score. The formula for calculating the average score of the pre-test and the formula for calculating the average score of the post-test can be seen below:

Calculation of the average score of the *pre-test:*

$$\bar{x}_{Pre} = \frac{1950}{25}$$

$$\bar{x}_{Pre} = 78{,}0$$

Calculation of the average score of the *post-test*:

$$\bar{x}_{Post} = \frac{2180}{25}$$

$$\bar{x}_{Post} = 87{,}2$$

From the results of the calculation, the average score of students was obtained as 78.0 and *the post-test* score was 87.2. Then from the results of the average score obtained, the percentage increase in students' scores is then calculated using the formula for calculating the percentage number which can be seen below:

$$Angka\ Persentase = \frac{87{,}2-78{,}0}{78{,}0} \text{ x } 100\%$$

$$Angka\ Persentase = 11{,}79\%$$

Based on the results of *pre-test* and *post-test* tests for students, the scores obtained by students can increase by around 11.79% after learning and playing using *educational games*. Based on the results of these tests, it can be said that the educational *game* application built can be used to help students learn and remember environmental cleanliness.

5. Conclusion

Based on the results of analysis and testing from the Development of Environmental Hygiene Education Games for Grade 5 Students at SD Inpres Kalu, it shows that the existing features have functioned as expected to overcome problems arising from manual processes such as errors in the delivery of materials and lack of interactivity in learning. The results of the trial showed an increase in students' understanding of environmental cleanliness materials as evidenced by the results of the pre-test and post-test. The average pre-test score obtained was 78.0, while the average post-test score increased to 87.2, with a difference of 9.2 points or an increase of 11.79%. This shows that the use of educational games can increase students' understanding and involvement in the learning process. Testing using the Black Box Testing method ensures that all in-game features run as well as they should, while testing with the System Usability Scale (SUS) results in an average score of 83.5, which indicates that the app has an excellent usability level and is worth using. Thus, this new student registration information system can increase the understanding of 5th grade students of SD Inpres Kalu regarding the importance of maintaining environmental cleanliness.

Confession

The author would like to thank Wira Wacana Christian University Sumba and the Informatics Engineering Study Program for the support and facilities provided during this research process. Thank you also to the supervisors and colleagues who have helped in collecting and processing data, so that this research can be completed properly.

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