

Educational Game Design For Carbon Emission Using Game Development Life Cycle Method

Dewi Tresnawati¹, Sri Rahayu², Randi Maulana³

^{1,2,3} Ilmu Komputer, Program Studi Teknik Informatika, Institut Teknologi Garut, Garut, Indonesia

¹ dewi.tresnawati@itg.ac.id, ² srirahayu@itg.ac.id, ³ 1906052@itg.ac.id

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Abstract— Carbon emissions are gases that arise from human actions, such as burning fossil fuels and industrial waste. Climate change is currently a problem that is increasingly attracting the attention of the wider community around the world, including Indonesia. The educational game about carbon emissions applies the Game Development Life Cycle (GDLC) approach which consists of six stages, including Initiation, Pre-Production, Production, Testing, Beta, and Launch. The educational game on carbon emissions is expected to help raise youth awareness about the importance of reducing carbon emissions and provide information about efforts to reduce carbon emissions for the younger generation and the general public.

Index Terms— carbon emissions; educational game; GDLC method.

I. INTRODUCTION

Climate change is currently an issue that is increasingly attracting the attention of the wider community worldwide, including Indonesia. The introduction of climate change and public concern over issues arising from climate change have resulted in new environmental regulations in recent decades [1]. Efforts to conserve energy and reduce carbon emissions, as a very important action in dealing with climate change and promoting sustainable economic development, have attracted great attention from countries around the world [2], [3], [4]. Since the adoption of the Kyoto Protocol in 2005, governments around the world have made great efforts to reduce carbon emissions by various methods. However, total greenhouse gas emissions worldwide have remained stable and have not decreased [5]. The significant increase in global temperature has led to climate change that impacts the environment and human life. Based on data from the Global Carbon Atlas, Indonesia ranks 9th with the highest amount of carbon emissions in Southeast Asia in the last two years. The total emissions produced reached 619 Metric Tons of CO₂ [6]. This shows how important it is to reduce carbon emissions in Indonesia to minimize the impact of climate change which is increasingly detrimental to humans and the environment. Carbon emissions themselves are gases

produced from human activities, such as the burning of fossil fuels and industrial waste. These carbon emissions are the main cause of climate change occurring around the world, such as increasing global temperatures, melting polar ice caps, and changing extreme weather patterns [7]. At the same time, human activities are predominantly related to energy production, industrial activities, and those related to forestry, land use, and land use change [8]. Climate change is becoming increasingly serious, and every country is paying more attention to carbon emissions. These activities have an impact on the environment in which humans are located. The environment is a place of activity and interaction of living things that are interdependent on one another. Environmental sustainability plays an important role in the sustainability of the environment and ecosystem of living things. Environmental damage is caused by irresponsible human behavior so environmental damage has entered a very alarming stage [9]. The gradual increase in human awareness of the importance of environmental protection has encouraged active efforts to produce low-carbon products with higher intensity [10]. The role of the youth generation is needed considering that youth is a milestone of change, in the 2009 Constitution explains Youth is an Indonesian citizen who enters an important period of growth and development aged 16 (sixteen) to 30 (thirty) years [11]. Youth is an important factor because of their high fighting spirit, creative solutions, and innovative manifestations also have the potential to make positive changes to the environment and reduce carbon emissions in the future [12]. They are the group that will inherit this earth from the previous generation and potentially become the decision-makers of the future. Therefore, raising young people's awareness about the importance of reducing carbon emissions can help create sustainable behavior change in the long run. In addition, the younger generation also has easier access to technology and information that can be used to reduce carbon emissions, educational games are considered as one of the interesting ways to reduce carbon emissions. Based on these problems, an educational game about carbon emissions will be built.

II. METHODS

The methodology applied in this research is the Game Development Life Cycle (GDLC), GDLC is a game development process that applies an iterative approach consisting of 6 development phases, starting from the initialization/concept creation, pre-production, production, testing, and release phases [13], which are contained in Figure 1 below.

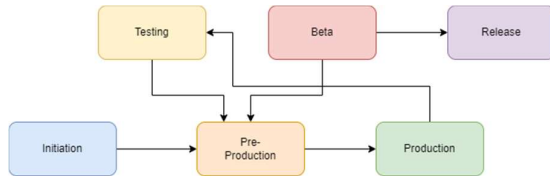


Fig. 1. GDLC Phase [13]

There are 6 phases used in the GDLC development method, namely:

1) *Initiation*, In the initial stage, problem identification, identification of needs in making games, identifying users, and identifying objects to have benefits in accordance with the purpose of making games.

2) *Pre-Production*, this stage is one of the main and important stages in the production cycle [14], planning will be carried out in the form of concepts and scenarios as well as features for the game to be created. Concepts are general ideas or ideas that underlie a project or product, including in terms of making games. Game concepts can include themes, gameplay mechanics, game characters and environments, and educational goals of the game.

3) *Production*, At this stage the author works on the core part of making the game. The work starts from collecting the required assets to coding and game development.

4) *Testing*, This stage is the stage where the game that has been made is tested to ensure its quality. At this stage, functional testing and bug fixes are carried out.

5) *Beta*, The Beta stage is the stage where the game is further tested by a small group of users. The goal is to find out the user's response to the game and make improvements if needed.

6) *Release*, The final stage of all game development processes is when the game is released to the public. This stage includes marketing the game, launching the game, and maintaining the game after its release.

Where the six stages are implemented into a series of activities presented in Figure 2.

Based on the picture of the framework, it is divided into three main parts in conducting this research.

a) *The first stage*, in this section, a series of activities are carried out such as Initial Identification and Analysis Initial identification in order to get results

in the form of problem formulation, and research gaps to GDLC research methodology.

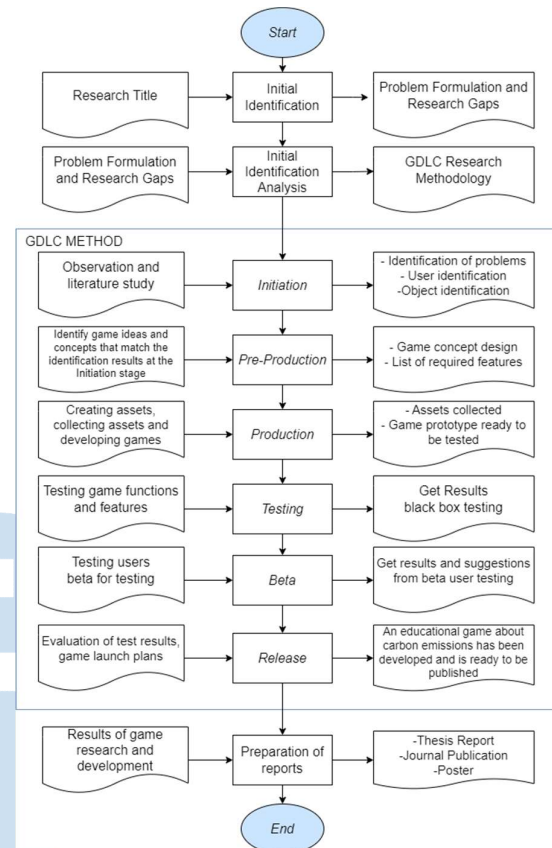


Fig. 2. Framework

b) *The second stage*, in this section, the software development process is carried out based on the stages in the GDLC methodology.

c) *The third stage*, in this last stage, is the preparation of reports and journals on the games that have been made.

III. RESULT AND DISCUSSION

A. Research results

The result of the research that has been done is the design and construction of a carbon emission educational game where the creation is by applying the GDLC method.

1) Initiation

Is an initial stage that involves creating a rough concept of the game, starting from determining the main characteristics of the game to be created [15].

a) Problem Identification

At this stage, problem identification is carried out, which is expected that youth can understand and internalize the importance of playing an active role in

reducing carbon emissions in everyday life, by presenting information about efforts to reduce carbon emissions, with educational results obtained by cleaning up garbage, saving energy, reducing disposable plastic waste, and planting trees.

b) User Identification

At this stage, user identification is carried out which is designed for the younger generation with an age range of 16 to 30 years. Gameplay that actively involves players, as well as content that is relevant to real life, all aim to provide a learning experience on the issue of carbon emissions.

c) Object Identification

At this stage, object identification is carried out where the objects include garbage, trees, electronics, and disposable plastic waste. These objects will be used in the context of the game to teach players about different aspects of carbon emissions with solutions.

2) Pre-Production

This stage is the process of planning, creating, and depicting sketches and other elements that form a unified whole in the game, involving the development of game prototypes along with the formation of the conception and basic design of the game [16]. This includes game concept and design, storyline, flowchart, map design, and storyboard.

a) Game Concept and Design

The concept and design of this carbon emission educational game invite players to understand the importance of reducing carbon emissions in everyday life. Players will play the role of city residents who strive to protect the environment and reduce the impact of carbon emissions through actions such as cleaning up trash, saving energy, planting trees, reducing disposable plastic waste, and adopting other environmentally friendly habits. The game features real-life situations that allow players to make decisions that impact carbon emissions.

b) Storyline

In RPG games, the storyline plays an important role because it is the main foundation of the game. It is told that Idnar is a young man who has lived in the big city for a long time, but he misses the village where he grew up and all the good memories there. He feels inspired by the environmental efforts he sees in the city and wants to contribute to protecting the environment and reducing carbon emissions in his own village.

c) Flowchart

This flowchart is organized based on the logic of thought that shows how the game will run, which is contained in Figure 3.

This game flow diagram explains that when the game starts, it displays the opening first then the player will enter the village intersection map where the map is the first time the player plays, after that, the player will explore the map until the player will meet with the NPC

and will talk to the NPC about the mission, then if the player takes the mission then the mission will begin with different challenges faced depending on the mission taken after the player completes the mission then the mission will be completed. If the player does not take the mission, the player can explore again to find another mission. If all missions are completed, the player will be transferred to the transition ending, where a closing remark will appear and thank you for completing the game.

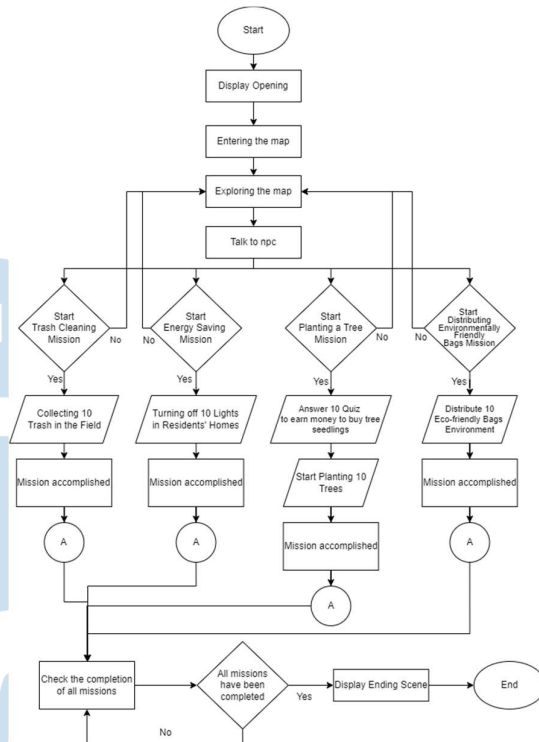


Fig. 3. Game flow diagram

d) Map Design

Is a description of the process of designing and creating the layout of the game environment in a game. The following is a description of the map that will be made in this research is contained in Figure 4:

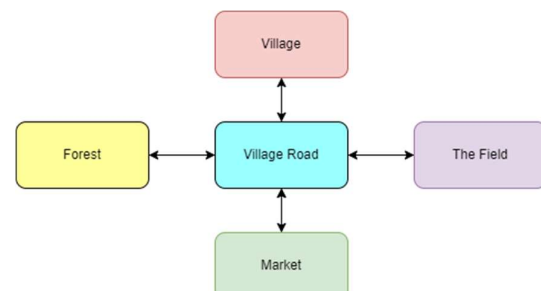


Fig. 4. Map design

In Figure 4 the map design describes how the process of designing and creating the layout of the game

environment, starting from the village road, field, village, forest, and market is described below:

Description of Mapping Design:

1) *Village Road:*

- The main road becomes the center of access to various areas in the village hall.
- Players will start the game on this main road.

2) *Field:*

- To the right of the main road is a large field.
- The garbage-clearing quest is located in this field. The player has to clean up the scattered garbage and complete the task of cleaning up the environment.

3) *Village:*

- Above the main road, there is a village with residents' activities.
- Players can talk to villagers, and get information about the story and life in the village.
- Some villagers may give side missions or tasks that are connected to the main story or to the daily activities of the villagers.

4) *Forest:*

- To the left of the main road, there is a shady forest that presents beautiful natural scenery.
- Tree planting missions and quizzes are found in this forest. Players must plant trees in designated areas to help protect the environment and answer the quiz.

5) *Market:*

- At the bottom of the main road, there is a market with various small shops. Players can shop at the market to purchase mission necessities, such as farming equipment and eco-bags.

e) *Storyboard*

The storyboard in this design aims to describe in detail the appearance and flow of the game to be created [17]. Users interact with the system through the interface. To ensure that users can easily use and interact with the system even if this is their first experience, the interface is designed to be user-friendly or easy. The following is an overview of the storyboard design of the carbon emission educational game contained in Table 1.

3) *Production*

The production stage in this game development includes several important steps that focus on producing collected assets and game prototypes that are ready to be tested. This stage involves the process of implementing the game concept that has been designed previously [18].

TABLE I. SUMMARY OF CARBON EMISSION EDUCATIONAL GAME STORYBOARD

No	Name	Description
1.	Beginning Storyboard	When the game is run, the user will be faced with the main menu display or the game's home page.
2.	Cutscene Storyboard	The appearance of the initial game narration text forms the flow of the main character in the game.
3.	Road Map Storyboard	Map design after the intro is complete, the main character will be placed on this map.
4.	Market Map Storyboard	Map design for the market street where the main character will go to a convenience store to buy an item.
5.	Village Conversation Storyboard	This view will emerge when the main character starts interacting with supporting characters where narration text appears.
6.	Field Map Storyboard	Map design for the field where the main character will start a mission.
7.	Market Shop Storyboard	Map design for a market shop where players when buying an item will appear first narration.
8.	Forest Storyboard	Map design for the forest where the main character will start a mission.
9.	Final Storyboard	The appearance of the end-of-game narration text that has completed the game.

a) *Event Creation Production*

Events in RPG Maker play a role in driving the story of the game. These events are created through the event editor which offers a variety of options, such as text display, show choices, switches, and variable control.

b) *Character Assets*

The main character to be played is named Idnar Analuam, called Idnar. The main character will later interact with supporting characters (Npc), namely Mr. Village Head, Mr. Coby, Mrs. Sarah, Mr. Heri, Mr. Budi, Mr. Tejo, and Mr. Bonbon.

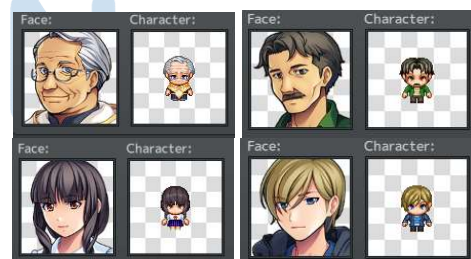


Fig. 5. Character assets

c) *Game Prototype*

A game prototype is an early version of a game created to test and illustrate key features and basic gameplay. Initial Display Screen: This is the implementation of the storyboard into the game where it displays according to the storyboard, namely the game title, and buttons such as New Game, Continue, Options, and Game End. As shown in Figure 5.

4) *Testing*

The production stage in this game development includes several important steps that focus on producing collected whether the game function runs

optimally [19]. The results of black box testing are contained as follows: In the dynamic world of the game app, every scenario seamlessly unfolds with resounding success, from the melodic main menu opening to embarking on triumphant journeys with the "New Game" button, effortlessly continuing ongoing adventures with the "Continue" button, exploring personalized settings through the "Options" button, and gracefully concluding sessions with the "Game End" button, all while immortalizing accomplishments with the "Save Game" button and seamlessly revisiting checkpoints using the "Load" button, as players navigate through intricate details, unlock new dimensions in the "Item" view, engage in conversations and quests, traverse diverse environments, and successfully complete missions, contributing to a virtuous impact on the virtual world's environment and economy, while quizzes add an intellectual twist, choices contribute to the evolving storyline, noble missions showcase commitment to a sustainable virtual environment, and the climax rewards players with an ending scene and narration, ultimately finding themselves back at the initial menu, basking in the glow of a triumphant adventure, and ready for future digital escapades.

The results of testing with a total test cases using black box testing showed that the game was successfully run according to the expectations that had been set. All test cases were successfully passed without any significant problems. With these satisfactory results, it can be concluded that the game is ready to enter the beta testing stage.



Fig. 6. Early game prototype

5) Beta

The stage where testing is carried out by a third party or external [20]. At this stage there are test results, testing is carried out by applying the System Usability Scale (SUS) method, testing is carried out using a 10-question technique that has been specially adapted for testing this game. The testing involved as many as 25 young individuals, which included youth from a class at SMAN 11 Garut. The results of the beta testing are contained in Table 2.

Q1 assesses the perceived difficulty level of mission tasks, gauging players' challenges in completing game objectives. Q2 evaluates the clarity of instructions and objectives for each mission, focusing on players' comprehension of provided guidance. Q3 measures

players' interest in replaying the game, determining its appeal for further engagement. Q4 examines the relevance of game features to carbon emission reduction, assessing alignment with the environmental theme. Q5 assesses players' understanding of the game's storyline, focusing on narrative comprehension. Q6 evaluates players' satisfaction with the game's visual aspects and design, considering graphics, interface, and overall presentation. Q7 measures the frequency of technical issues encountered during gameplay, assessing disruptions to game performance. Q8 evaluates the usefulness of game-provided information on carbon emission reduction, assessing its educational value. Q9 assesses the ease of interaction with the game's interface, focusing on user-friendliness. Q10 measures the likelihood of players recommending the game to friends, indicating overall satisfaction and endorsement potential.

The average score is obtained from the total SUS score divided by the total number of youth. With a total result of "79", according to the SUS assessment scale, it is included in the "B" category in the class scale with an adjective in the scope of "Good", this shows that the score is acceptable and also considered good and acceptable.

6) Release

At this stage, the game has been uploaded through the itch.io platform, a forum for indie game developers to share their work for free. With this step, the game can be accessed and played by users through the website.

B. Research results

The results of this study state that the creation of educational games using the quiz method and character interaction is alignment with previous research [21]. This study also applied the GDLC method in the development of educational games, which provides a systematic and structured approach to game design and development, improving the efficiency of the game creation process. In addition, this study used RPG Maker to facilitate the implementation of interactive educational games. This research aligns with previous research [22], which aims to increase the understanding and interest of the younger generation in a particular field of knowledge or expertise. In this study, young people were directed to better understand the important issue of carbon emissions and how they can contribute to reducing them.

The results and discussion of this study indicate that the research successfully designed and developed an educational game about carbon emissions through the application of the Game Development Life Cycle (GDLC) method. The main purpose of this game is to increase the understanding and awareness of the younger generation about the importance of reducing carbon emissions and their impact on the environment. The test results using the System Usability Scale (SUS) show that this educational game has a positive and

acceptable level of usability, with an average score of 79, indicating that this game is considered easy to use

by players and has succeeded in increasing understanding of carbon emissions.

TABLE II. BETA TESTING

No	Respondent	Question										Overall	Sus Score (Overall X 2.5)
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10		
1.	Respondent 1	4	5	4	3	4	3	3	4	3	3	36	90
2.	Respondent 2	3	4	3	4	3	4	3	4	3	2	33	78
3.	Respondent 3	2	3	4	4	4	4	4	5	4	2	40	95
4.	Respondent 4	5	4	2	2	2	2	2	3	2	2	26	73
5.	Respondent 5	3	3	4	3	3	3	3	3	3	2	32	90
6.	Respondent 6	4	4	3	4	4	4	3	4	3	3	36	75
7.	Respondent 7	2	3	5	4	4	3	3	1	3	3	33	65
8.	Respondent 8	5	4	4	4	4	4	4	2	4	3	44	90
9.	Respondent 9	4	5	3	3	3	2	2	3	2	2	29	98
10.	Respondent 10	3	4	5	3	4	3	3	3	4	4	41	75
11.	Respondent 11	4	3	2	4	3	3	3	3	3	2	30	98
12.	Respondent 12	3	4	4	3	2	2	2	2	2	2	26	70
13.	Respondent 13	5	3	3	4	3	4	4	4	3	3	37	93
14.	Respondent 14	3	5	5	4	5	4	3	3	4	3	43	75
15.	Respondent 15	2	4	4	2	3	3	3	3	3	3	30	78
16.	Respondent 16	4	5	4	4	4	4	2	4	4	4	41	65
17.	Respondent 17	3	4	2	3	3	3	3	3	2	2	28	65
18.	Respondent 18	3	3	5	5	4	4	3	4	3	3	39	78
19.	Respondent 19	4	4	4	4	3	2	2	3	2	2	30	73
20.	Respondent 20	3	3	3	3	3	3	3	3	4	3	37	63
21.	Respondent 21	2	4	1	2	3	3	3	3	3	2	31	90
22.	Respondent 22	4	3	4	2	2	2	2	3	2	2	28	78
23.	Respondent 23	4	4	3	3	4	3	3	1	3	3	37	95
24.	Respondent 24	3	3	3	3	3	3	3	3	3	2	32	73
25.	Respondent 25	4	3	2	3	2	2	2	3	2	2	29	90
	Overall	86	94	86	83	82	77	71	77	74	64	794	1985
Average													79

IV. CONCLUSION

The conclusion based on the research conducted is to develop an educational game about carbon emissions through the application of the Game Development Life Cycle (GDLC) method. The use of the GDLC method can also be a reference in the development of other educational games for various fields and educational purposes. With the aim of increasing awareness and understanding of the younger generation about the importance of reducing carbon emissions and their impact on the environment. It is expected that the

younger generation will be more interested and motivated to learn about environmental issues and take real action to reduce carbon emissions. Based on the SUS analysis, it can be concluded that this game demonstrates good usability, with relevant feature integration and positive user responses regarding interest, visual satisfaction, and understanding of the game's objectives, question 8 evaluates whether players find the information provided by the game about carbon emission reduction efforts informative and valuable. By receiving positive feedback on the usefulness of this information, the game can effectively fulfill its

objective of educating players about environmental issues and motivating them to take action to reduce carbon emissions. Suggestions that are expected for future researchers can be made such as adding a variety of content, and features and can be made in the form of a mobile version to make it more accessible.

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