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DEVELOPMENT OF GLOBAL WARMING THEMED VIDEO GAMES: IMPLEMENTATION OF GAME DEVELOPMENT LIFE CYCLE (GDLC) FRAMEWORK

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ABSTRACT

Video games have become a part of people's typical livelihood. Video games can be used for various purposes, not only for entertainment, one of which is conveying messages with deep meaning. In this article, we will discuss the design and development of a video game in the form of a serious game, with the theme of global warming. This research aims to raise awareness of the environment to overcome environmental problems. The serious game was developed using the Game Development Life Cycle (GDLC) framework. We produced a video game that has the mechanics, dynamics, and aesthetics based on the game development document (GDD). The result of this study is a simulation video game that main objective is to grow trees successfully. By developing this video game, we attempting to spread the message of global warming and the cause that is deforestation to the younger generation. The following describes the process of development of the serious game.

INTRODUCTION

Video games had become one of the most inseparable things in the community (T Wibowo & Vicky, 2021). Video games can be used to pass the time, train cognitive abilities to learn, or train memory (Kefalis et al., 2020). Video games can stimulate the development of social skills and cognitive abilities, however playing too many video games can lead to negative social personalities, addiction, and health problems (Nrumala & Mashuri, 2021; Wang et al., 2019). In 2017, the mobile-based video game industry received the second-largest revenue after PC/Console based games. It can be concluded that smartphone and PC users have increased also the use of smartphones and PC to play video games has become a lifestyle (Dirgantara et al., 2019). The game world is currently experiencing an increasingly sophisticated and religious development, as there are many PC users, the need for entertainment throughout multimedia is increasing, especially in PC games. Video games are now one of the entertainment media that is the choice of almost everyone, video games are used as hobbies, and games are now used as electronic sports (e-sports) (Krisdiawan et al., 2020).

The high dependence of the younger generation on new technology can be seen from the results of a 2012 study which showed as many as 40% of children under 2 years old had used tablets and cellphones a lot, in addition, 75% of children over 8 years old had used this technology a lot. In a day, for more than 2 hours they use their mobile devices more just to play games, watch videos, and many others, on the other hand now some games are less educational. This will reduce the time to study and make children lazy to study (Chusyairi et al., 2020). This condition can also cause negative impacts such as a lack of socialization between parents and their children, which can also cause a lack of parental control (Damian Gałuszka, 2018).

In the last 10 years, the government and private organizations that care about their companies' sustainability have prioritized environmental issues as their agenda and policies. Some environmental problems, among others, pollution, deforestation, and global warming, have an impact on the earth. The environmental problem has become a global problem, which requires global action and solutions as well. This has resulted in every individual, private company, and every important figure being encouraged to care about environmental issues (Hartami, 2018). One of the solutions to environmental issues and problems is to educate children about environmental issues. Many studies have emerged using video games as an educational medium (Dale & Shawn, 2017; Dirgantara et al., 2019; Foxman, 2019; Holbert & Wilensky, 2019; T Wibowo & Limanda, 2020). This research stems from how to overcome environmental problems in everyday life by increasing awareness of the people in the environment (Hartami, 2018).In the last 10 years,

several media have used several promotional media to change social behavior regarding climate change, and one of the issues is global warming. However, media related to video games, despite their growing popularity, are still not being utilized for this environmental concern. More specifically is Serious Game, a new type of digital game that is devoted to specific purposes other than as a medium of entertainment, such as educational media, leading social impact in certain subjects, enhancing user talent, and many more. Although some serious games enfold climate change topics (advertising and educational games alone describe for 57% of serious games), some of them are textual and uninteresting (Boudreault et al., 2018).

Based on the facts and explanations above, video games have become a media that has become a new trend in society, but not many people use this media for educational purposes on environmental problems that exist in everyday life. Therefore, the purpose of this research is to develop a video game in the form of a serious game that aims to raise awareness of the environmental issue to overcome environmental problems, namely global warming by applying the Game Development Life Cycle (GDLC) framework. GDLC is a video game development model that applies an approach that follows 6 development phases, starting with initiation, preproduction, production, testing, beta, and release (Krisdiawan et al., 2020). This design is summarized in a thesis entitled "DEVELOPMENT OF GLOBAL WARMING THEMED VIDEO GAMES: IMPLEMENTATION OF GAME DEVELOPMENT LIFE CYCLE (GDLC) FRAMEWORK ". This was made with the hope of developing a video game with the theme of global warming as a medium to increase environmental awareness.

PROPOSED INNOVATION

Based on the facts that have been discussed above regarding environmental problems that cause climate change, one of the problems is global warming. Based on this problem, we conducted research to make a video game in the form of a serious game that aims to teach about environmental problems, namely global warming.

The purpose of this research entitled " Development of Global Warming Video Games: Implementation of GDLC Framework" Aims to develop a video game in the form of a serious game that aims to teach about environmental problems, namely global warming using the GDLC framework.

LITERATURE REVIEW

This research that entitled "Development of Global Warming Themed Video Games: Implementation of Game Development Life Cycle (GDLC) Framework ", based on several research that has been conducted previously, namely as follows:

The research that has been carried out by Krisdiawan et al., (2020) is the research that is the main basis for developing the topic of this thesis. The research conducted is applied research that aims to create an android puzzle mobile game using the Unity development tool. The development method used is the GDLC method which had 6 development phases, namely initiation, pre-production, production, testing, beta, and game release. Research begins with the creation of the game story that will be made, then begins to define the gameplay and game mechanics. After that, it will enter the asset creation stage and programming using Unity and the C# programming language, until finally beta testing is carried out to detect bugs and the feasibility of the game to be released to the public. The results of the research conducted by Krisdiawan et al., (2020) is a maze puzzle-based adventure game that is applied to mobile android, the purpose of this game is to train players in problem-solving and entertainment facilities.

The next research is the research conducted by Chusyairi et al., (2020) which is applied research. The research was conducted to provide education to gandrung users in Banyuwagi Regency using educational games (Gandrung Stories). This study discusses the design of interesting and interactive educational games using the RPG Maker tool, which is one of the tools to create games that lead to the RPG genre. Research conducted by Chusyairi et al., (2020) uses the Game Development Life Cycle (GDLC) method which has 6 stages, namely initiation, pre-production, production, testing, external beta testing, and game release. Following the stages of the method, Chusyairi et al., (2020) plan the concept of the gandrung story game to be made, then arrange a production planning schedule for the gandrung stories game. Then Chusyairi et al., (2020) would design a prototype game and perform internal and external testing of the prototype that has been made, then the game will be released. The results and conclusions of the research conducted by Chusyairi et al., (2020) are that the GDLC method

can make it easier for games and games to have gandrung stories to have features that can provide education to users, especially young people in the process of making gandrung dances in Banyuwagi Regency.

The next research is research that has been conducted by Dirgantara et al., (2019), which is a type of applied research. The research was conducted with the aim of training memory skills, understanding, and using games using an Android-based video game quiz (Mathventure). Dirgantara et al., (2019) uses GDLC as their research development method, which starts from the initiation process, pre-production, production, testing, beta external testing until later it will enter the game release stage. The research begins with the basic concept of the game to be made, then designs the characters, backgrounds, and objects of the game that would be used and determines the software to develop the game. Next, we will design a game prototype and carry out internal and external tests to look for bugs and functional deficiencies in the game, until the game can finally find them. The results of the research by Dirgantara et al., (2019) are that Mathventure video games have standard features that can improve cognitive abilities, namely remembering, understanding, and developing.

Furthermore, in other supporting research conducted by Boudreault et al., (2018) which is a type of applied combined research. The research aims to enable users to inform users of the impact of global warming by using a video game type serious game with the theme of global warming (penguin Panic!) which is interesting Boudreault et al., (2018) conducts research using the dynamic failure adjustment (DDA) system method, using the Unity engine development tool using the C# programming language. Boudreault et al., (2018) started the research by designing and developing the Penguin Panic! using the Unity development tool, then entering the difficulty adjustment using the dynamic difficulty adjustment algorithm, Boudreault et al., (2018) tested 30 users to find out observing the response from users to the DDA implementation. The purpose of this research is to optimize the effectiveness of serious games as learning media about climate change, one of which is global warming.

The last supporting research is research conducted by Hartami, (2018) which is a type of applied research. The research aims to increase awareness of the environment around users (children) by using a persuasive mobile game (EcoScout). Hartami, (2018) uses design science research (DSR) which consists of determining the purpose of persuasion, needs analysis, design, game development, playtest. The research begins by discussing and determining more specifically the concept of environmental care so that it can be implemented because the concept is broad. Next, perform the necessary analysis in gameplay and game design, then the character, background, and game object designs would be carried out. Finally, playtesting will be carried out which aims to find out if there are deficiencies and bugs in the game and responses from users on the topic of environmental awareness. The results of the research conducted by Hartami, (2018), namely, the success of the research, namely the research gave positive results in increasing environmental awareness using educational games.

Year	Name of writer	Conclusion
2020	Krisdiawan, Rio Andriyat Ramdoni, Ramdoni Permana, Aji	In this research, the GDLC framework, development tool, and programming language are used for video game development
2020	Chusyairi, Ahmad Setia, Jevitha Wibowo, Luchia Winata, Alam Kurnia	In this research, the GDLC framework is used for video game development
2019	Dirgantara, Harya Bima Prabowo, Yulius Denny Jermia, Matthew Marcellino	In this study, the GDLC framework and 2D base game types for video game development
2018	Boudreault, Maxime Bouchard, Kévin Bouchard, Bruno Gaboury, Sébastien	In this study, it is used as a project goal to be achieved at the end of the research
2018	Hartami, Aprilia	In this study, it is used as a case study that will be used as the main research on the research results

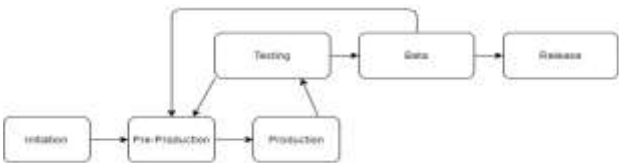

Table 1 Literature Review Conclusion

From these studies, we conducted this research, namely developing video games using the GDLC method as carried out by Oleh (Chusyairi et al., 2020), (Dirgantara et al., 2019), and (Krisdiawan et al., 2020). We would use more interesting serious game development case study such as that conducted by (Boudreault et al., 2018), also use the type of RPG game for video game development made as in the research conducted by (Chusyairi et al., 2020), and games made in the form of 2D base games as in the research conducted (Dirgantara et al., 2019). We would also use the main idea of the research conducted (Hartami, 2018), which is to inform the impact of climate change, one of which is global warming throughout video games. We also would use the Unity engine as a development tool and the C# programming language as done by (Krisdiawan et al., 2020) and (Boudreault et al., 2018).

RESEARCH METHODOLOGY

This research is a type of applied research that aims to design and develop a video game in the form of a serious game with the theme of global warming. The research flow that is used is the GDLC framework, which can be seen in **Fig. 1**.

Scene	Logic
Main Menu	New, Load, Hint Menu
In Game	Pause Game
	Increasing Plant Slot
	Shop
	Plant Inseklopedia
	Pest
	Time
	Currency Flow
	using fertilizers and pesticides
	Health Player
	Random Seed plant and tree
	Plant and tree Grow rate
	Economy buy getting gold and silver

Figure 1 GDLC diagram

Source (Chusyairi et al., 2020)

The development team consists of 3 people consisting of programmer, game designer, and supervisor. phase discussion results role-playing games and life simulation games. Also, the art that will be used is 2D pixel art for the entire game environment. Pixel art is composed of individual square-shaped pixels that are combined into a single object in a video game (Huynh & Nguyen, 2021). This game overview will be put in the Game Design Document (GDD) document that can be seen in **Table 2.**

Categorization	name	sprite
Tools and equipment	Pesticide	
	fertilizer	
	shovel	
	plant seeds	
	tree seeds	
	watering pot	
Currency	Gold	
	Silver	
Character		
Plant	sunflower	
	coffee	
	corn	
	peppers	
	green been	
	tomato	
Tree	oak	
	banana	
	fir	
	bodhi	
	coconut	

Table 2 Game Overview in GDD document

In the pre-production stage, what is done is planning and designing game design in the form of in-game art consisting of 2D art characters, game backgrounds, and objects in the game, namely 2D pixel art. The art will be designed using the Adobe Photoshop CC 2020 application and the media that will be used is the Wacom Intuos CTL 4100 small drawing pen tablet. In addition, some game objects would be searched using the unity asset. planning and designing prototyping in the form of

Scene	Logic
Main Menu	New, Load, Hint Menu
In Game	Pause Game
	Increasing Plant Slot
	Shop
	Plant Inseklopedia
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	Time
	Currency Flow
	using fertilizers and pesticides
	Health Player
	Random Seed plant and tree
	Plant and tree Grow rate
	Economy buy getting gold and silver

determining game mechanics by using an analog base game. The following **Table 3** shows the sprite that is used in video game development.

Table 3 Sprite Categorization

The prototype design uses the APK format with player settings specifically for the PC platform and a 16-bit display buffer. The prototype design uses the Unity engine development tool version 2019.4.12f1 (64-bit). We made the logic games using the C# programming language with Visual Studio IDE software with the 2019 16.7.3 version, on an Asus laptop with the X556UB series. For

The prototype build that has been made will be carried out internally by the developer team, where the developer team performs usability tests and functional tests. A usability test is to check whether

the game meets the desired criteria and conditions. the functionality test is to check if the

Figure 2 Main Menu overview

function of every button and feature in the game is working properly. If there are problems with the two tests above, they will be repeated from the pre-production stage. For more detail, **Fig. 2** and **Fig. 3** are the result of the in-game review of the video game "*Forestor*".

more detail, the following **Table 4** shows the logic of each scene in the video game.

Figure 3 Gameplay overview

In the external testing stage, the prototype build that has been made will be tested by 5 testers. The purpose of this stage is to detect complaints from testers that cause by errors from the video game or some inconveniences when playing the video game. Beta is out of the production cycle, but the results of the test could cause development to cycle through it again. the user will play the game from the home screen until it reaches each game goal will also check every feature of the game such as the pause button, audio, and inventory, the purpose of this stage is to detect errors through complaints from the tester. Beta is out of the production cycle, but the results of this test could cause the team to cycle through again.

After going through the production cycle and passing beta testing, the video game made is ready to be released to the public through the play store. At this stage, the game is finished and ready to be played in its entirety. This video game is in the form

of a serious game that can be played on a PC on the Windows operating system called "*Forestor*". This video game can be played with full HD resolution and with minimum specifications, namely 4GB RAM, Windows 7 or more, has a storage media of 30MB to 1GB.

DISCUSSION

At this current time, video games had become part of human daily life. Video games can be used to spend time having fun a of which is global warming. A lot of research has been done to increase public awareness of world environmental problems, such as research conducted by Boudreault which aims to provide information to players about global warming with the help of a video game that they developed called "Pinguin attack", or research conducted by Hartami to increase environmental awareness using persuasive mobile games (*EcoScout*). besides that, there are also many types of video games in the form of serious games to improve skills or add experience, namely: *Plague Inc.*, *IBM City One*, *Microsoft Flight Simulator*, *and peaceMaker*. This indicates that video games are not only intended as a medium of entertainment but can also be a medium for delivering complex information that has diverse goals to the players.

Video games are not only a medium for having fun and spending time but also a sporting event, namely E-sports, for example, one of the e-sport events "The International" which was held for the first time in 2011 by the game Dota 2 with a total prize of 1, 6 million US dollars, which made it the biggest prize e-sports tournament of its time. This concludes that video games have become something that is taken seriously in the eyes of the world as a medium of competition and has the potential to become a job opportunity for everyone. Not only that, but video games can also be a learning medium or a place to socialize depending on the genre of the game, such as video games that are included in the educational game and serious games category that aims to teach players through simulations or questions. there is also a type of MMO game that collects every player in a virtual world that allows each player in it to interact with others such as Minecraft or GTA Online We attempting to unroll the message of global warming and the cause that is deforestation to the younger generation.

During this pandemic, which makes it difficult for us to do outside activities, the increasing of using cell phones and one of them is playing video games. This indicates that in the 21st century, the intensity of the community in playing video games is increasing. This is due to many factors, from being a coping mechanism for the pandemic problem, as a substitute for socialization, due to increased free time, or even wanting to learn new things. Therefore, people began to develop a sense of normalization in playing games because video games began to be widely used for different purposes, both for playing games or just filling their spare time.

Therefore, we design and develop a video game in the form of a serious game with the theme of global warming (*Forestor*). We hope that with the advance of digital technology in the 21st century, video games can also develop as a learning medium to the young generation and our research can be also one of the steppingstones to other research that uses GDLC or video games as a learning medium.

LIMITATIONS

In the research that has been conducted there are several limitations and obstacles that we experienced. The following are the limitations and obstacles encountered during the development period in the research that we carried out:

1. Due to the COVID-19 pandemic, we have difficulty interacting with each other to develop the research
2. The difficulty of getting an asset that can be used for development purposes in Unity asset
3. The limited scope of game development due to lack of human resources and budget

FUTURE WORK

From the results of research conducted in designing and developing video games in the form of serious games with the theme of global warming, we can conclude that:

1. The need for online interactive media that can overcome problems in communication during the covid-19 pandemic
2. The need for funding in the research to facilitate the initiation process during game development
3. The need for a project manager for the sake of facilitating the planning, execution, monitoring, and control of game development.

CONCLUSIONS

We draw several conclusions from the process of developing video games in the form of serious games with the theme of global warming:

1. From the results of the research we have done, the GDLC framework development method can be used to develop video games
2. Unity Engine can be used as a medium for developing video games such as research that had been done previously by Krisdiawan.
3. the result of this research is a video game in the form of a serious game with the theme of global warming which can be played on PC on the Windows operating system called "*Forestor*"

REFERENCES

Boudreault, M., Bouchard, K., Bouchard, B., & Gaboury, S. (2018). Maximizing Player Engagement in a Global Warming Sensitization Video Game Through Reinforcement Learning. *Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good*, 196–201. https://doi.org/10.1145/3284869.3284920

Chusyairi, A., Setia, J., Wibowo, L., & Winata, A. K. (2020). Game Gandrung Strories untuk Edukasi Kebudayaan Menggunakan Metode GDLC. *JASIKA (Jurnal Aplikasi Sistem Informasi Dan Informatika)*, *1*(1), 67–75.

Dale, G., & Shawn, G. C. (2017). The Changing Face of Video Games and Video Gamers: Future Directions in the Scientific Study of Video Game Play and Cognitive Performance. *Journal of Cognitive Enhancement*, *1*(3), 15. https://doi.org/10.1007/s41465-017-0015-6

Damian Gałuszka, M. A. (2018). Video Games in the Family Context: How Do Digital Media Influence the Relationship Between Children and Their Parents? In *Global Leisure and the Struggle for a Better World* (8th ed.). The Jagiellonian University Institute of Sociology. https://doi.org/10.1007/978-3-319-70975-8_8

Dirgantara, H. B., Prabowo, Y. D., & Jermia, M. M. (2019). Development of android-based quiz video game: Mathventure. *2019 International Joint Conference on Information, Media and Engineering (IJCIME)*, 450–454. https://doi.org/10.1109/IJCIME49369.2019.00097

Foxman, M. (2019). United We Stand: Platforms, Tools, and Innovation With the Unity Game Engine. *Social Media and Society*, *5*(4). https://doi.org/10.1177/2056305119880177

Hartami, A. (2018). *Designing a Persuasive Game to Raise Environmental Awareness Among Children : A Design Science Research*. University of Oulu.

Holbert, N., & Wilensky, U. (2019). Designing Educational Video Games to Be Objects-to-Think-With. *Journal of the Learning Sciences*, *28*(1), 32–72. https://doi.org/10.1080/10508406.2018.1487302

Huynh, M., & Nguyen, T. (2021). *Fundamentals of 2D Game Art* [KAMK - University of Applied Sciences]. https://www.theseus.fi/handle/10024/504796

Kefalis, C., Kontostavlou, E. Z., & Drigas, A. (2020). The Effects of Video Games in Memory and Attention. *International Journal of Engineering Pedagogy*, *10*(1), 51–61. https://doi.org/10.3991/ijep.v10i1.11290

Krisdiawan, R. A., Ramdoni, R., & Permana, A. (2020). Rancang Bangun Game Treasure of Labyrinth Dengan Algoritma Backtracking Berbasis Android. *Nuansa Informatika*, *14*(1), 46–55. https://doi.org/10.25134/nuansa.v14i1.2442

Nrumala, S., & Mashuri, A. (2021). Pentingnya Mediasi Orang Tua (Parental Mediation) untuk Menangani Penggunaan Gawai (Gadget) pada Anak Sekolah Dasar. In *Researchgate.Net* (1st ed.). DEAZHA.

Wang, J. L., Sheng, J. R., & Wang, H. Z. (2019). The association between mobile game addiction and depression, social anxiety, and loneliness. *Frontiers in Public Health*, *7*(SEP), 5–10. https://doi.org/10.3389/fpubh.2019.00247

Wibowo, T, & Vicky. (2021). Survey Research of the Reasons of People Playing Games Using the Qualitative Methods. *CoMBInES-Conference on Management, Business, Innovation, Education and Social Sciences*, *1*(1), 776–783.

Wibowo, Tony, & Limanda, K. (2020). Penggunaan Naratif Dalam Video Game Sebagai Media Edukasi Isu Dunia : Studi Kasus Detroit Become Human Use of Narrative in Video Games as Educational Media World Issue : Case Study Detroit Become Human. *Jurnal Ilmiah Komputer Grafis*, *13*(2), 1–6.