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Implementation of the Rapid Game Prototyping Method in the Educational Game E-Rush Using Unity 2D Engine

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Abstract

Technological development has progressed rapidly, including in the field of education. One result is educational games, which are practical and engaging tools for delivering content, such as environmental awareness training. Games today offer more than entertainment; they can foster interactive learning. This study developed an Android-based educational game, E-Rush, to increase youth awareness about waste sorting. The game employs a drag-and-drop interface, allowing players to classify waste into three categories: organic, inorganic, and hazardous (B3). It features gamification elements, such as scoring, time challenges, and enemy robots, to boost engagement. The development method used was Rapid Game Prototyping, which enabled quick iterations in design and testing. Requirement analysis identified user and system needs, followed by the design of storyboards, 2D models, and UML diagrams (Use Case and Activity). Blackbox Testing evaluated functionality from the user's perspective. The results show that E-Rush was successfully implemented with functional features such as scoring, levels, NPC enemies, and time limits. All components met the defined requirements. In conclusion, E-Rush can be an effective alternative learning medium for promoting early waste segregation habits and supporting environmental education programs.

Keywords: *black-box testing, educational game, gamification, waste sorting, rapid game prototyping.*

1. Introduction

The development of technology has advanced rapidly, accompanied by human needs to simplify various daily activities. As one of the key innovations, computer technology has been widely applied in numerous fields such as education, health, office work, telecommunications, business, and others. One of the fastest-growing areas is the entertainment industry, particularly in the field of gaming [1].

Game is a form of entertainment with a structured design, playable by various age groups, ranging from children, adolescents, to adults. Beyond its role as a source of entertainment to relieve boredom, games can also serve as effective educational tools. In this context, educational games hold significant potential in making the learning process more engaging and less monotonous [1].

Alongside technological advancements, the learning process has also undergone significant innovations, both in terms of methods, models, and learning media, aimed at enhancing the effectiveness and quality of education. One such innovation is the development of technology-based interactive games as a learning medium, designed to increase awareness and understanding of the importance of proper waste management. Interactive games can encompass various genres, such as action, adventure, puzzle, and simulation, allowing players to learn while engaging in play. The main advantage of this interactive medium lies in the use of multimedia elements such as text, graphics, images, audio, video, and animation, which make the learning experience more engaging, enjoyable, and effective, particularly for younger generations [2].

In the context of education on waste sorting, interactive games can serve to instill environmental awareness and cultivate the habit of waste segregation from an early age. E-Rush is designed with a drag-and-drop interface that allows players to sort waste into the correct categories, namely organic, inorganic, and hazardous materials (B3). Players are presented with various challenges within the game, including completing levels with specific score targets and overcoming obstacles that hinder the sorting process, such as garbage collectors or enemy characters that interfere.

The development method used in the creation of the E-Rush application is Rapid Game Prototyping, which enables iterative application development based on user feedback [3]. The testing conducted using blackbox testing techniques focuses on the functional aspects of the application, aiming to ensure that the game operates as intended and provides an optimal learning experience [4].

Based on the background, the author intends to develop an Android-based educational game with interactive and imaginative 2D visuals to enhance young people's awareness of the importance of waste sorting. Through gamification, E-Rush is designed as a learning

medium that is both enjoyable and effective, capable of reinforcing the habit of waste segregation from an early age. The game is expected to foster environmentally friendly behavior, reduce reliance on conventional teaching methods, and utilize digital technology as a dynamic educational medium. Furthermore, this game aims to support community-based waste management programs and broaden public understanding of environmental issues.

2. Theoritical Framework

2.1. Definition of Game

The term game originates from the English language and means a form of play or competition. A game is a structured activity, typically carried out for entertainment purposes. Therefore, games have become an essential part of enjoying life, while also serving as an educational medium for users. Games are often considered organized activities whose primary purpose is to provide enjoyment, but they can also function as effective learning tools. The background and concept of games are highly engaging and motivating, making them popular among people all over the world [5].
As stated by [6], a large portion of people tend to enjoy activities that involve problem-solving or facing challenges. A game always presents problems and challenges to its players, as without such elements, the game would likely feel uninteresting and lack engagement. In addition, games establish clear objectives or goals for users, giving them a sense of direction and purpose while playing. If a game lacks well-defined goals, players may quickly become bored or disinterested.

2.2 Game Genres

Gameplay in a game is classified based on genres, which are now highly diverse. Genres serve to define the creative space for game designers, allowing them to focus on more specific ideas and target audiences. Moreover, a single game may combine multiple genres, a classification commonly referred to as a hybrid genre. Some examples of game genres include Action Games, Strategy Games, Role-Playing Games (RPGs), Sports Games, Racing/Driving Games, Simulation/Building Games, Flight and Other Simulations, Adventure Games, Edutainment, Children's Games, and Casual Games [7].

2.3 Gamification

According to [8] , gamification is a learning method that integrates elements of games or video games with the aim of motivating students throughout the learning process. This approach also aims to increase students' enjoyment and engagement in educational activities. Furthermore, gamification can serve as an effective medium to attract students' interest and inspire them to remain enthusiastic in pursuing knowledge. On the other hand, according to [9], gamification is an integrated product, mindset, process, experience, design, and system that utilizes game elements to address problems outside the context of gaming.

2.4 Game Engine

Based on [10] , a game engine is a collection of simulation code modules that do not directly control the game logic or environmental data (such as level data). A game engine typically includes modules for handling input and output, such as 3D rendering, 2D graphics, audio, and general physics or game world dynamics. There is various game engines designed to run on video game consoles as well as desktop operating systems such as Microsoft Windows, Linux, and macOS. The core functionalities commonly provided by a game engine include a renderer for 2D or 3D graphics, audio processing, scripting, animation, artificial intelligence, networking, streaming, memory management, threading, localization support, and scene management.
Game engines generally provide an abstraction platform that enables a game to run across various platforms, including both consoles and personal computers, with minimal adaptation. In addition, game engines assist in decision-making processes ranging from frame management to the selection of artwork displayed within a scene.

2.5 Unity Engine

In the view of [11] , Unity is an integrated tool used for developing games, architectural designs, and simulations. Unity can be utilized for both PC-based and online games. For online gaming applications, a plugin called Unity Web Player is required, like how Flash Player functions in web browsers. It should be noted that Unity is not designed for the processes of design or modeling, as it is not intended to serve as a design or modeling tool.

3. Methodology

In the development of this game, the methodology employed is Rapid Games Prototyping. This method is a modification of the rapid software development approach based on Extreme Programming principles [6]. The game design process is carried out using a model that details each activity comprehensively, employing the Unified Modeling Language (UML) [12]. To illustrate the workflow of the Rapid Game Prototyping process, refer to **Fig.** 1.

Fig. 1: Workflow of Rapid Games Prototyping

Fig. 1 consists of three main stages: Requirement Analysis, Design, and Testing. This model emphasizes rapid iteration in game development. Requirement Analysis identifies user and system needs, the Design phase includes storyboard creation, modeling, and UML diagrams, while Testing aims to evaluate and correct interface errors and other technical aspects before proceeding to the next iteration.

Requirement analysis is conducted to identify user needs, data requirements, and user stories. In the subsequent design phase, a storyboard is developed, 2D asset models are designed through to the materialization stage, and UML diagrams such as Use Case and Activity Diagrams are created. This is followed by prototype development. Once the game prototype is completed, testing is carried out using the Black Box software testing method. This is then followed by an evaluation phase to assess the game's quality and functionality.

4. Results and Discussion

4.1 Requirement Analysis

In this phase, requirements are identified and analyzed to ensure that the developed system aligns with its intended objectives. E-Rush is an educational game designed to increase players' awareness of the importance of waste sorting. The game offers an interactive experience through a drag-and-drop mechanism, in which players sort waste into appropriate categories. By applying gamification principles, it is expected that players will better understand and apply waste segregation habits in their daily lives.

Educational games for younger audiences are designed to integrate learning elements with interactive and engaging gameplay mechanics, making the learning process more appealing and effective. As noted by [13], Educational games are games specifically designed to incorporate learning materials and aim to enhance players' abilities, thereby creating a new and engaging learning experience. This approach generates positive emotions such as joy and happiness, allowing the educational content to be more effectively received and understood by students.

In the E-Rush game, waste is categorized into three groups based on its properties: organic waste, inorganic waste, and B3 waste (Bahan Berbahaya dan Beracun), which refers to hazardous and toxic materials [14]. Organic waste refers to discarded materials that, although no longer used by their owners, can still be reused if managed properly. This type of waste is biodegradable and can naturally decompose through biological processes. Examples of organic waste include food scraps such as leftover meat, vegetable peels, leaves, and other garden waste [15]. Examples of organic waste used in E-Rush include banana peels, apple scraps, and paper. Inorganic waste refers to discarded materials that are no longer in use and are difficult to decompose naturally. If left to accumulate in the environment, this type of waste can cause pollution. Some examples of inorganic waste are plastic bottles, plastic bags, leftover detergent packaging or food wrappers, Styrofoam, and beverage cans [16]. Examples of inorganic waste used in E-Rush include beverage cans, plastic bottles, and plastic bags. Hazardous and toxic waste (B3) refers to waste generated from various activities or operations that contain harmful and toxic substances. Even in small quantities or concentrations, household B3 waste remains a risk to both the environment and human health. An example of B3 waste is mercury, a toxic metal commonly found in batteries [17]. Examples of B3 waste used in E-Rush include used motor oil, batteries, and fluorescent light bulbs. This classification helps in understanding the importance of proper waste management to reduce its negative impact on the environment.

The E-Rush game incorporates various gamification elements to keep players engaged and motivated to continue playing while enhancing their understanding of waste sorting. One of the key elements is the scoring system, in which players earn points for correctly classifying waste items. If players reach the minimum score required, they can proceed to the next level. In addition, the game provides achievements that players can unlock upon completing specific levels.

In the E-Rush game, the challenge system in each level is designed by adapting various approaches from previous studies on difficulty levels in educational games. The scoring concept proposed by [18] is implemented in this game, where players must achieve a specific score target to progress to the next level. For instance, in Level 1, players are required to reach 1,000 points, while in Levels 2 and 3, the required scores increase to 2,000 and 3,200 points, respectively. Furthermore, the time system applied in [19] is also implemented in the E-Rush game, where players are given a time limit to complete each level. In Levels 1 and 2, players have 3 minutes to finish the game, while in Level 3, the gameplay duration increases to 4 minutes, adding an extra challenge to the gameplay experience.

Additionally, inspiration from [20] is incorporated into the gameplay mechanism by introducing a progressive difficulty system in waste sorting. In each level, the number of waste items increases, and the time interval between appearances decreases: 1.5 seconds per item in Level 1, 1 second per item in Level 2, and 0.5 seconds per item in Level 3. Another challenge is adapted from the study by [21], which includes an enemy element that disrupts gameplay. In E-Rush, this takes the form of an evil robot that appears in Level 3 and attacks the filled trash bins, reducing the player's score by 10 points if it successfully strikes. A constraint system is also implemented by limiting the capacity of the trash bins in Levels 2 and 3, where each bin can hold only five waste items. To address this limitation, a garbage collector summoning feature is added, allowing players to empty the bins when they become full.

4.2 Design Phase

After conducting the requirement analysis for game development, the next step is the system design phase, which explains the foundation of the game to be built [22]. n this stage, the author employs a storyboard, Use Case diagram, and Activity diagram to illustrate the system design and gameplay flow.

4.2.1 Storyboard

Storyboarding is a visualization of the application's concept that helps provide an overview of the final product (Kunto et al. 2021). The result of the storyboard creation process can be seen in **Fig.** 2.

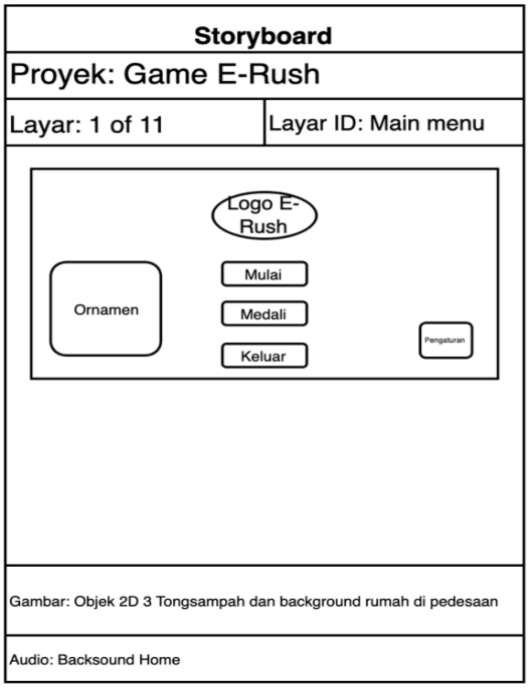

Fig. 2: Storyboard

Fig. 2 presents the storyboard of the main interface of the E-Rush game, a mobile-based educational game focused on waste sorting. On the main screen, players can select the Start option to begin the game, Medals to view achievements they have earned, and exit to close the application. The background design depicts a rural environment, with colorful trash bin icons representing the types of waste that need to be sorted. The cheerful and interactive visual elements are intended to enhance the player's learning experience in understanding the importance of proper waste management.

4.2.2 2D Modelling

A 2D graphic model is a combination of geometric elements (also known as vector graphics), digital images (raster graphics), mathematical functions, and related components. These components can be modified and manipulated through two-dimensional geometric transformations, such as translation, rotation, and scaling [23].
The visuals in the E-Rush game, including trash bins, various types of waste (organic, inorganic, and B3), the village environment, and game interface elements, are created as 2D vector art. Each model is designed in detail using Adobe Illustrator, starting from initial sketches and basic shape creation, through to coloring and shading stages, aimed at producing a more vivid and engaging appearance. This process ensures that every in-game element appears clear, aesthetically pleasing, and aligned with the educational concept embraced by E-Rush.

4.2.3 UML diagram

After the 2D modeling phase, the next step is the UML Diagram stage. In this stage, both Use Case and Activity diagrams are developed. The Use Case Diagram is used to illustrate the interactions between the player and the game system, including the roles and core functionalities available within the game. Meanwhile, the Activity Diagram represents the overall flow of activities within the game, starting from the initial gameplay process, player decision-making, to the end of the game.

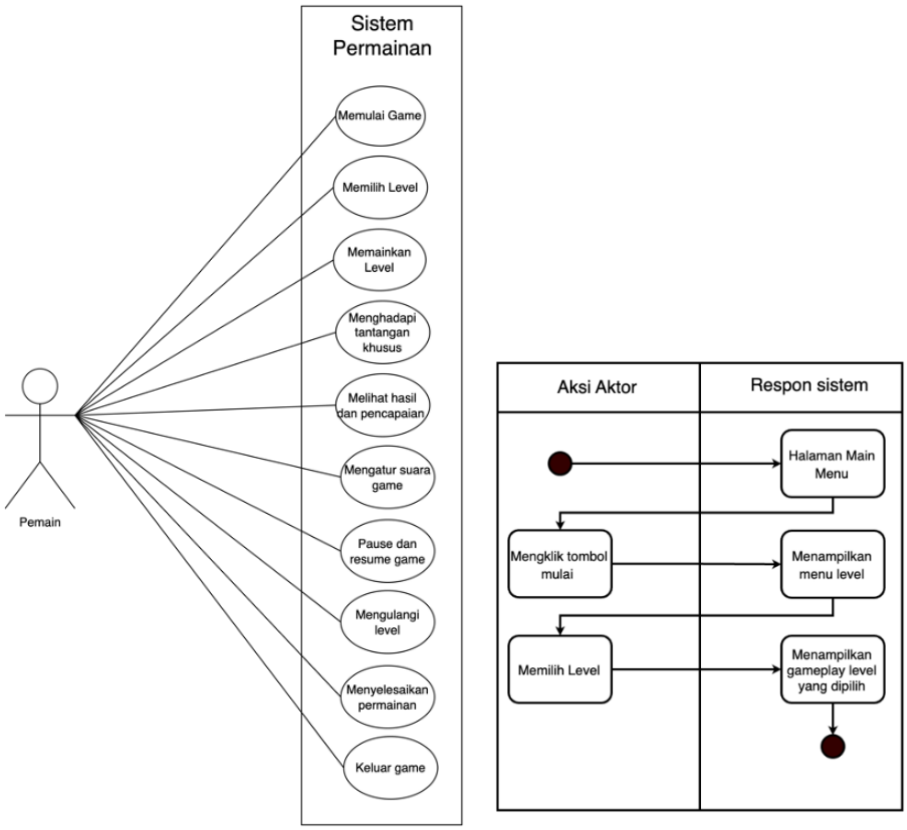

Fig. 3 : Use Case Diagram and Activity Diagram

4.3 Testing Phase

In this stage, system testing is conducted to ensure that all features of the E-Rush educational game function according to the predefined design specifications. The testing method employed is Blackbox Testing, which primarily focuses on verifying whether each feature operates correctly from the user's perspective, without examining the underlying source code. The purpose of this testing is to evaluate the game's functionality and to identify any errors or inconsistencies in the gameplay mechanics.

One of the key features tested was the waste classification system, which categorizes waste into three main bins: Organic, Inorganic, and B3 (Bahan Berbahaya dan Beracun – Hazardous and Toxic Materials). Each type of waste must be placed into the correct bin to earn a positive score, while incorrect sorting results in point deductions or audio warnings. This test aims to ensure that the system accurately recognizes and classifies waste items, as well as provides appropriate feedback when players make mistakes. For example, in Level 1 shown in **Fig.** 4, the following scenario is presented:

Fig. 4 : Level 1

The test results are presented in Table 3 below:

Table 1: Test Results of Level 1

No	Test Scenario	Expected Output	Test Result
1	Clicking the Pause button	Displays the pause screen, stops the game, and triggers animation effects on the button along with a sound effect when pressed	Valid
2	Clicking the Information Button	Displays the information page, pauses the game, and triggers animation effects on the button along with a sound effect when pressed	Valid
3	Countdown Timer	The timer counts down correctly until it reaches zero	Valid
4	Score Reduction	The score decreases when waste is placed into the incorrect bin, accompanied by an error sound effect	Valid
5	Score Increase	The score increases when waste is placed into the correct bin, accompanied by a correct-answer sound effect	Valid
6	Farmer Appearance and Waste	The farmer character appears, walks across the screen, and generates a	Valid

	Generation	piece of waste every 2 seconds. While walking, the farmer displays a walking animation and plays a corresponding footsteps sound effect	
7	Female Character Appearance and Waste Generation	The female character appears, walks across the screen, and generates a piece of waste every 2 seconds. While walking, the character displays a walking animation and plays a corresponding footsteps sound effect	Valid
8	Game Completion	When the score reaches 200, the game ends and a success sound effect is played to indicate that the level has been completed successfully	Valid

5. Conclusion

Based on the development of the E-Rush educational game using the Rapid Game Prototyping method, the author concludes that the E-Rush game application was successfully created by following each stage of the methodology: requirement analysis, design, and testing. The game is developed as a mobile-based application, allowing users, particularly the younger generation, who are the target audience for waste sorting education, to access it more flexibly. During the development process, the Rapid Game Prototyping method proved effective in accelerating design iterations and feature implementation. This approach enabled developers to rapidly test concepts, make continuous improvements, and ensure that the final product met the expected educational standards. The E-Rush game was tested using Blackbox Testing, which focuses on evaluating functionality without examining the source code directly. This testing ensured that gameplay mechanisms, including drag-and-drop interactions, scoring systems, character interactions, and audio-visual feedback, operated in accordance with the predefined specifications. Furthermore, E-Rush incorporates gamification principles, enabling players to learn about waste sorting through engaging gameplay mechanics such as drag-and-drop sorting, score achievements, and challenges posed by NPCs and enemies within the game. As such, E-Rush can serve as an interactive and innovative alternative for environmental education.

References

[1] Habdi and R. Supardi, "Pembuatan Game Balap Kelinci Dengan Unity Berbasis Android," *J. Ilm. Rekayasa dan Manaj. Sist. Inf.*, vol. 7, no. 1, p. 19, 2021, doi: 10.24014/rmsi.v7i1.10531.

[2] H. F. Santi and I. A. Astuti, "Pembuatan Prototype Aplikasi Game Edukasi Sistem Tata Surya Untuk Siswa Sekolah Dasar," *J. Inf. Syst. Manag.*, vol. 1, no. 2, pp. 6–10, 2020, doi: 10.24076/joism.2020v1i2.25.

[3] et. al Rezky, "Penerapan Metode Prototyping Dalam Mengembangkan Aplikasi Multimedia Pembelajaran Matematika Dengan Menggunakan Karakter 2 Dimensi (Studi Kasus Pada TK Hangtuah II)," *Ris. dan E-Jurnal Manaj. Inform. Komput.*, vol. 1, no. 1, pp. 26–29, 2016.

[4] R. D. Saputro, P. Kasih, and S. Rochana, "Pengujian Black Box dan Kuesioner Pada Game Gems Advanture," *Semin. Nas. Inov. Teknol.*, pp. 47–52, 2022.

[5] S. Aula, H. Ahmadian, and B. Abdul Majid, "Analisa Dan Perancangan Game Edukasi Student Adventure 2D Pada Smk Negeri 1 Al-Mubarkeya," *Cybersp. J. Pendidik. Teknol. Inf.*, vol. 4, no. 1, p. 21, 2020, doi: 10.22373/cj.v4i1.7132.

[6] M. Tjahyadi, A. Sinsuw, V. Tulenan, and S. Sentinuwo, "Prototipe Game Musik Bambu Menggunakan Engine Unity 3D," *J. Tek. Inform.*, vol. 4, no. 2, pp. 1–6, 2015, doi: 10.35793/jti.4.2.2014.6990.

[7] C. Swain and S. S. H. Man, *A Playcentric Approach to Creating Innovative Games*. 2008.

[8] H. Jusuf, "Penggunaan Gamifikasi dalam Proses Pembelajaran," *J. TICOM*, vol. 5, no. 1, pp. 1–6, 2020, [Online]. Available: https://media.neliti.com/media/publications/92772-ID-penggunaan-gamifikasi-dalam-proses-pembe.pdf.

[9] Fitri Marisa, Tubagus Mohammad Akhiriza, Anastasia Lidya Maukar, Arie Restu Wardhani, Syahroni Wahyu Iriananda, and Mardiana Andarwati, "Terakreditasi SINTA Peringkat 4 Gamifikasi (Gamification) Konsep dan Penerapan," *J. Inf. Technol. Comput. Sci.*, vol. 7, no. 1, pp. 219–228, 2022.

[10] Michael Lewis and Jeffrey Jacobson, "Game engines in scientific research," *Commun. ACM*, vol. 45, no. 1, p. 27, 2002.

[11] weliam jonatan mekel, S. R. . Sompie, and B. A. Sugiarso, "Jm_Informatika,+Jurnal+Wilyyy," *J. Tek. Inform.*, vol. 14, no. 4, pp. 455–464, 2019.

[12] A. Perdananto and A. Alam, "Prosiding Seminar Nasional Informatika GAME DESIGN ENDLESS RUNNING ON ANDROID PLATFORM USING RAPID GAME PROTOTYPING METHOD," vol. 2, pp. 458–465, 2017.

[13] W. Wibawanto, *Game Edukasi RPG (Role Playing Game)*, no. July. 2020.

[14] E. Sutanty and D. Kusuma Astuti, "DECODE: Jurnal Pendidikan Teknologi Informasi PENERAPAN MODEL ARSITEKTUR VGG16 UNTUK KLASIFIKASI JENIS SAMPAH," vol. 3, no. 2, pp. 407–419, 2023.

[15] A. C. Malina, Suhasman, A. Muchtar, and Sulfahri, "Kajian Lingkungan Tempat Pemulihan di Kota Makasar," *J. Inov. dan Pelayanan Publik Makasar*, vol. 1, no. 1, pp. 14–27, 2017, [Online]. Available: https://media.neliti.com/media/publications/290779-kajian-lingkungan-tempat-pemilahan-sampa-44972540.pdf.

[16] M. A. Dkk, "Edukasi Mengenai Pentingnya Pemilahan Serta Pengolahan Sampah Untuk Mengurangi Dampak Negatif Terhadap Lingkungan," *Darmabakti J. Inov. Pengabdi. dalam Penerbangan*, vol. 4, no. 1, pp. 11–17, 2023, [Online]. Available: https://e-journal.poltekbangplg.ac.id/index.php/darmabakti/article/view/108.

[17] T. I. Putra, N. Setyowati, and E. Apriyanto, "Identifikasi Jenis Dan Pengelolaan Limbah Bahan Berbahaya Dan Beracun Rumah Tangga: Studi Kasus Kelurahan Pasar Tais Kecamatan Seluma Kabupaten Seluma," *Nat. J. Penelit. Pengelolaan Sumber Daya Alam dan Lingkung.*, vol. 8, no. 2, pp. 49–61, 2019, doi: 10.31186/naturalis.8.2.9209.

[18] Y. Akbar and A. A. Albahy, "Jurnal JTIK (Jurnal Teknologi Informasi dan Komunikasi) Implementasi Game 2D Edukasi Pengetahuan Islam untuk Remaja Menggunakan Unity," vol. 9, no. March, pp. 120–129, 2025.

[19] A. L. Rizki, R. Salidowati, and Riwinoto, "Observasi Tingkat Stres dan Perfomansi Permainan Player Studi Kasus: Game Edukasi ChipMonk Season 1," *Semin. Nas. Apl. Teknol. Inf.*, pp. 29–37, 2017.

[20] Moch. Kholil, Rafika Akhsani, and Kristinanti Charisma, "Pengembangan Game Edukasi Pilah Sampah berbasis Android 2 Dimensi," *JAMI J. Ahli Muda Indones.*, vol. 1, no. 1, pp. 13–24, 2020, doi: 10.46510/jami.v1i1.9.

[21] H. Herdiman, J. Pragantha, and D. A. Haris, "Pembuatan Game Platformers 'Robot Hero' Multi-Platform," *J. Ilmu Komput. dan Sist. Inf.*, vol. 7, no. 2, pp. 191–195, 2019, [Online]. Available: https://journal.untar.ac.id/index.php/jiksi/article/view/7375.

[22] J. R. Lewis, "The System Usability Scale: Past, Present, and Future," *Int. J. Hum. Comput. Interact.*, vol. 34, no. 7, pp. 577–590, 2018, doi: 10.1080/10447318.2018.1455307.

[23] E. Eriya and Y. D. R.Putri, "2D & 3D Modelling Monumen Bersejarah Yogyakarta sebagai Media Edukasi Interaktif berbasis Virtual Reality," *Multinetics*, vol. 4, no. 1, p. 1, 2018, doi: 10.32722/vol4.no1.2018.pp1-7.