Computer Science (CO-SCIENCE)
Volume 6 July 2 July 2026
Accreditation **Sinta 3** No. SK : 295/C/C3/KPT/2026

Adventure Game Development for Environmental Conservation Using Game Development Life Cycle

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Article Info: Received: 20-02-2026 | Revised : 26-07-2026 | Accepted : 29-07-2026

Abstract - The rapid development of information and communication technology has driven innovation in various fields, including digital entertainment through video games. This research develops an educational adventure game themed on environmental conservation titled Green Solaris, designed as an interactive medium to raise awareness about environmental issues among children and teenagers. The game adopts a 3D isometric format with a pixelated visual style, focusing on four main themes: Clean Water and Sanitation, Affordable and Clean Energy, Climate Action, and Life on Land. The development process employs the Game Development Life Cycle (GDLC) methodology combined with Agile-SCRUM approach, encompassing six main phases: initiation, pre-production, production, testing, beta, and release. The game features core mechanics including exploration, interaction with NPCs, waste collection and recycling systems, point-based upgrades, and environmental restoration missions across multiple islands. Testing results using Likert scale instruments show that 90% of respondents rated the game as "Very Satisfying" and 10% as "Quite Satisfying" with no negative assessments, indicating the game's potential as an effective educational medium. Green Solaris has been successfully published on the itch.io platform and is accessible to the public, demonstrating that video games can serve as an innovative and engaging alternative learning tool for instilling environmental awareness through creative, interactive, and educational digital experiences.

Keywords: educational game, environmental conservation, GDLC, 3D isometric, pixelated shade

INTRODUCTION

The increasingly rapid development of information and communication technology has driven the emergence of various innovations in various areas of human life. These innovations are not limited to the industrial and productivity sectors but have also penetrated the world of digital entertainment. One form of innovation that has seen significant growth is video *game*s, an interactive entertainment medium that has now become a part of global culture (Mustofa et al., 2021).

Games are created primarily to entertain people, and their importance has grown considerably over time (Tanoto et al, 2024). The current development of the gaming industry is characterized by advances in graphics technology, improvements in interaction quality, and a variety of features that create immersive gaming experiences. This rapid growth has also contributed to the increase in global revenue in the gaming industry, which shows a positive trend each year. Furthermore, video *game*s serve not only as a means of entertainment but also as an effective learning medium. This transformation has given rise to the concept of digital educational *game*s, namely digital *game*s designed to integrate entertainment and educational elements to achieve specific learning objectives (Prasetyo et al., 2021).

Based on this thinking, this study raises the theme of environmental conservation in the form of an isometric 3D adventure *game* created using a *game* engine called Unity (Farhan & Setiaji, 2023). Through a pixelated shader-style visual approach, this *game* is designed not only to provide a fun playing experience but also to instill awareness of the importance of maintaining the cleanliness and balance of the surrounding ecosystem. During the design process, this study also emphasized the visual aspect through the implementation of pixelated shaders (Fabroyir & Fahriza, 2025). This approach was chosen because it is able to present a simple yet artistic visual appearance, while being performance efficient. The visual style emphasizes simple, easily recognizable geometric shapes, while the pixelated effect provides a retro aesthetic that appeals to younger players. The

combination of the two is expected to create a unique visual identity that supports the delivery of environmental conservation messages without burdening the *game* system's performance (Agung et al., 2022). Pixel art as a visual medium in games has been shown to offer a distinctive aesthetic experience by leveraging the player's imagination, making it an effective tool for artistic expression and player engagement in digital games (Aleksic & Simeunovic, 2024).

Beyond its entertainment value, the use of games as an educational and behavioral change medium is theoretically grounded in a broad range of psychological mechanisms, including motivation, goal-setting, and immediate feedback, which collectively explain why gamified experiences can be more engaging and effective than conventional instructional methods (Krath, Schürmann, & von Korflesch, 2021). This theoretical basis is further supported by empirical evidence in the environmental domain, where a serious game combining geolocation and augmented reality elements was shown to significantly improve players' knowledge of and attitudes toward climate-change and sustainability issues after gameplay (Wang, Tekler, Cheah, Herremans, & Blessing, 2021). These findings reinforce the rationale for developing *Green Solaris* as an interactive medium capable of not only entertaining but also cultivating long-term environmental awareness among young players.

To support a structured and efficient development process, this study implemented the Game Development Life Cycle (GDLC) as the primary methodology. The GDLC method was chosen because it offers several advantages, including assisting in project planning and management, improving communication and collaboration between team members, and simplifying progress monitoring at each development phase (Hilmawan & Yuniati, 2024). Each stage of the GDLC, from initiation, pre-production, production, testing, beta, to release, provides a systematic framework that ensures every aspect of *game* development is directed and measurable. Furthermore, the development process was conducted using an Agile methodology with a SCRUM approach, which allows for rapid adaptation to changing needs and quality improvement through continuous iteration. The combination of GDLC and Agile SCRUM is expected to produce a flexible, collaborative, and efficient development process that achieves optimal results (Khalid et al., 2024). Empirical studies have confirmed that the application of Scrum in game development positively impacts productivity, quality, and user satisfaction throughout the development process (Afrizal et al., 2024).

Blender or Blender 3D is an open-source software widely used for creating interactive 3D content, supporting a complete production pipeline ranging from modeling, rigging, animation, and simulation to rendering, compositing, and video editing. This application can run on various operating systems such as Windows, Macintosh, and Linux, and offers several advantages including a flexible and customizable interface, strong simulation capabilities, and compatibility with various other 3D software (Sultan et al., 2022). In addition, Figma plays an important role in the UI/UX design process by providing prototyping features that facilitate visualization and development, particularly in the pre-production stage of game development, allowing design concepts to be structured more systematically before implementation in a game engine (Agustien, 2024).

Increasing awareness of sanitation and environmental cleanliness is an important step in maintaining public health and reducing the impact of global warming (Jamin et al., n.d.). By utilizing video *game* technology as an interactive educational medium, this study presents a *game* entitled Green Solaris, which is designed as an educational *game* with an environmental conservation theme. Through this *game*, players, especially children, are invited to understand the importance of maintaining cleanliness and ecosystem balance in a fun and contextual way. Green Solaris is expected to be an effective alternative learning tool in fostering concern for nature through creative, interactive, and educational digital experiences.

RESEARCH METHODS

The Game Development Life Cycle (GDLC) is a methodological framework for digital *game* development that emphasizes interactivity and iteration throughout the production process. This model consists of six main phases: initiation (concept/initiation), pre-production, production, testing, beta, and release. Generally, these phases can be grouped into three major stages: initiation, production, and launch, which are interrelated to form a systematic and structured *game* development flow (Saputra et al., 2022). A general illustration of the GDLC phases can be seen in Figure 1.

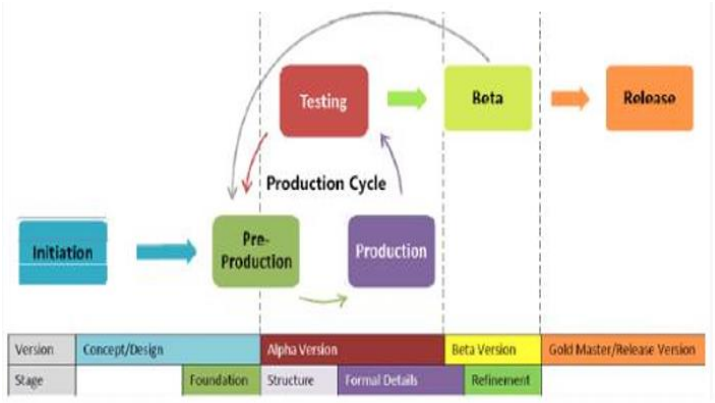


Figure 1. GDLC Phases and Processes
Source: (Saputra et al., 2022)

The Initiation/Concept phase is the conceptual phase that forms the basis for the direction of *game* development. It involves comprehensively designing the basic idea and *game*play concept to define the *game*'s core identity, resulting in a concept document containing a description of the *game*, its target audience, and the visual and mechanical direction to be used (Mustofa, Putra, & Kesuma, 2021). At the end of this phase, an initial design for both 2D and 3D *game*s is obtained, including determining the genre, *game*play style, and *game* name identity. This, in the context of educational *game*s, can include idea formulation, determining learning objectives, and planning the integration of additional educational features (Saputra et al., 2022).

The Pre-Production phase is a comprehensive planning and design process that bridges the concept to technical implementation, including refining ideas, preparing a Game Design Document (GDD), creating an initial prototype to validate the concept's feasibility, and determining core mechanics, *game*play systems, characters, backstory, user interface, and other technical requirements (Prasetyo, Syaputra, Cholil, & Sauda, 2021). In the Production phase, the entire conceptual design is realized through the creation of visual and audio assets, programming *game* mechanics, synergistic component integration, feature refinement, performance optimization, and bug fixes to achieve stable and engaging *game*play quality. The Testing phase is carried out through usability and functionality testing by an internal team to find bugs, assess the balance of difficulty levels, and measure player satisfaction. This is followed by the Beta phase involving external beta testers to obtain real-world feedback and detect issues missed during internal testing (Mustofa et al., 2021; Saputra et al., 2022). The Release phase as the final stage marks the launch of the *game* to the public, including distribution, final documentation, post-production evaluation (post-mortem analysis), and plans for further updates to ensure the *game* remains optimal across platforms and in accordance with user feedback (Mustofa et al., 2021).

Table 1. GDLC Stage Process

No	Stages	Input	Output
1	Initiation / Concept	Initiation / Concept	Initial concept and simple description of the *game* to be developed
2	Pre-Production	Video *game* detailed concept	Game Design Document (GDD) that has been prepared
3	Production	Creation of alpha video *game* and final GDD and *game* structure	Alpha version of the *game* ready for testing
4	Testing	Alpha version of the *game*	Internal testing results and Beta build of the *game*
5	Beta	Beta version of the *game* that has been tested internally	External testing results and feedback from beta testers
6	Release	Final version after testing and bug fixing phase	Games ready to be released on a specific platform (e.g. itch.io)

Source : Research Result (2026)

RESULTS AND DISCUSSION

1. Initiation Stage

In the initiation/concept stage, an initial concept was formulated that focused on designing an interactive entertainment product as well as an educational tool for environmental conservation, resulting in a concept

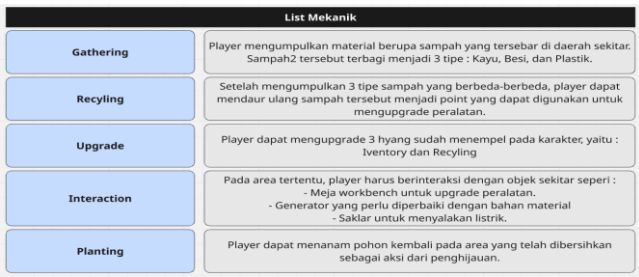
document containing a description of the *game*, target audience, visual and mechanical direction, and considerations for platforms and development methods. Through a brainstorming process, the Unity Engine was chosen for the PC platform considering its advantages in complete features, multi-platform support, visual rendering capabilities, ease of use in C#, and development flexibility. The *game* was designed as an isometric 3D *game* with a retro-modern pixelated visual style that carries four main themes: Clean Water and Sanitation, Affordable and Clean Energy, Climate Action, and Life on Land, chosen because of its potential in conveying educational messages about environmental sustainability and supporting a strong *game* narrative.

The development applies the Game Development Life Cycle (GDLC) method implemented using the Agile–SCRUM methodology to enable an iterative and collaborative process in continuous improvement. Implementation is facilitated using Miro as a project management tool for workflow, sprint backlog, and timeline through real-time visual collaboration based on kanban boards, Figma for UI/UX design with cloud collaborative features that enable parallel work, and Aseprite for pixel art asset creation with the ability to produce high-precision retro animations and sprites. The combination of these three tools creates an efficient, structured, and integrated development ecosystem between managerial, artistic, and technical aspects of programming to provide an engaging learning experience and foster ecological awareness.

Based on the results of the brainstorming process, it was determined that this *game* would carry the theme of environmental conservation with an adventure genre. Through this *game*, players are expected to learn about various forms of environmental pollution that occur in the *game* world and understand the initial actions that can be taken to improve these environmental conditions. During this initiation stage, a list of five main *game* mechanics was also compiled, designed to serve as the basis for developing the *game*play system. Details of each mechanic are shown in Figure 3 in a table generated using the Miro application

Source : Research Result (2026)

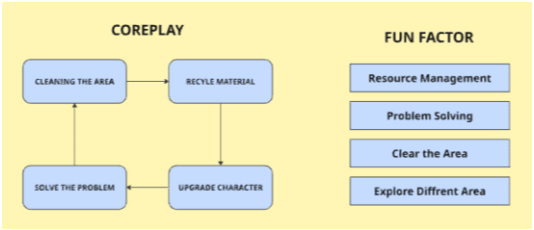
Figure 2. Video Game Concept Mind Map



Source : Research Result (2026)

Figure 3. Determining *game* mechanics in Miro application

Furthermore, this *game* has a core *game*play concept that describes the player's primary activities within the *game* world. Furthermore, the fun factor has been defined, which is the main distinguishing and unique element of this *game* compared to similarly themed *game*s.



Source : Research Result (2026)

Figure 4. Determining coreplay and fun factor in video *game*s

2. Pre-Production Stage

During the pre-production phase, the detailed *game* design is developed into a document called a Game Design Document (GDD). This document serves to provide a comprehensive description of the *game* being developed and establish clear development goals and directions.

At this stage, the *game* being developed was titled Green Solaris. The *game* is set in a post-environmental world, where air pollution, land degradation, and rising sea levels have forced humans to live on a cluster of small islands. Amidst these conditions, human civilization has achieved high technological advancements based on environmentally friendly innovations. Players will assume the role of the main character tasked with restoring the environment by cleaning up pollution, assisting local communities, and using green technology to address various ecosystem problems on each island.

This *game* features several genres, including casual, adventure, puzzle, and single-player, emphasizing exploration and environmental problem-solving within an educational and interactive context. The *game*'s main objectives include:

1. Solve various environmental pollution problems on land, sea, and air.
2. Collect and utilize environmentally friendly technologies to repair environmental damage.
3. Rebuild natural elements such as forests, rivers, and vegetation to maintain ecosystem sustainability.
4. Address environmental challenges such as storms, droughts, and forest fires caused by climate change.
5. Educate players about the importance of renewable energy, water sanitation, and climate action through fun *game*play mechanics.

In this phase, a search for similar *game* references was also carried out to be used as a reference in creating a low-fidelity prototype.

Table 2. Green Solaris *game* details

No	Aspect	Explanation
1	**Nama Game**	*Green Solaris*
2	**Deskripsi**	A game themed around environmental conservation set in a solarpunk future world, where players are tasked with restoring ecosystems damaged by pollution and climate change. Players use environmentally friendly technology to help communities and restore the balance of nature across various islands.
3	**Konsep**	Players explore a world consisting of multiple islands with different environmental conditions. Each island has unique missions such as cleaning polluted air, restoring water sources, and replanting forests. The game emphasizes exploration, cooperation with NPCs, and the use of green energy–based tools.
4	**Genre**	Casual, Adventure, Puzzle, Single Player
5	**Target Audience**	Children and teenagers (ages 10–20) who are interested in environmental issues, educational games, and interactive exploration.
6	**Objective / Tujuan Utama**	- Complete environmental restoration missions on each island. - Use green technology to reduce pollution. - Educate players about nature conservation and renewable energy. - Build environmental awareness through interactive and entertaining gameplay.

Source : Research Result (2026)

During the pre-production stage, various *game*play mechanics for Green Solaris were designed, such as exploration, interaction with NPCs, and an objective-based mission system within the GDD. The main mechanic was a recycling system, where players collect waste such as wood, plastic, and metal to be processed into upgrade points for their bags. Each island was given a different environmental challenge to reinforce the educational message, while the story and dialogue were designed to support the narrative flow and provide emotional motivation throughout the player's journey. Furthermore, a low-fidelity prototype was prepared as an initial user interface design and a reference for *game*play. The visual concept was designed with a unique low-poly art style and soothing music to provide a comfortable immersive experience while maintaining optimal *game* performance.

Source : Research Result (2026)

Figure 5. *low-fidelity* prototype of the *game*

In this pre-production stage, work planning is also carried out using a sprint system divided by task categories and color codes. The division consists of: Project Manager (red), Game Designer (orange), Art Designer (purple), and Programmer (blue). This categorization system aims to simplify the coordination process and clarify the division of responsibilities between team members in *game* development. In addition, at this stage, a sprint kanban table is also implemented as a project management tool. The use of kanban is intended to monitor the progress of each team member's tasks in a structured manner based on predetermined color categories. The kanban table is divided into three main columns, namely To Do, In Progress, and Done, which represent the completion status of each task in the development process. To support more efficient time management, a project calendar is also created that serves as a guide for work schedules and records the activities of each team member. Through this system, the entire pre-production process can be monitored properly, so that the completion of each stage of *game* development can run more regularly and measurably.

3. Production Stage

During the production phase, concepts, low-fidelity designs, and the Game Design Document (GDD) are implemented into scenes or models that can be used directly in the *game*. In Unity, a scene serves as the primary unit that contains and organizes all objects, components, and *game* logic for a specific section of the *game*. In this phase, the asset creation process is closely linked to the planned performance evaluation, requiring careful calculation of asset load and performance. Game balancing is also performed to ensure an appropriate level of difficulty. Quality criteria at this stage emphasize that the *game* must be fun and accessible, allowing for the development of additional, previously unplanned features. All refinement activities during this phase are aimed at increasing player engagement, challenge, and ease of understanding.

During the production phase, the main character of the Green Solaris *game*, Solya, was developed. This character was initially designed as a two-dimensional illustration before being implemented into a three-dimensional model using Blender software. In the storyline, Solya is depicted as an individual who comes from a small island where he grew up. His mother is an ecologist tasked with preserving the environment and natural resources from damage caused by the SOLIS Corporate activities. Since childhood, Solya has aspired to live in a world that is green again, as told by his mother. This belief drives him to embark on a journey to restore the environment and reduce pollution so that humans can once again live side by side with a sustainable ecosystem. There are 9 characters in this *game*, Solya as the main character, Solea as Solya's mother, Ilya a teenage elf woman who lives on Escuri Island, Silvi an older sister of Ilya who lives on Escuri Island, Grandpa as Solya's grandfather, Yudi as someone who lives on Aeris Island, Fixy as a fox with a human form who lives on Terran Island, Viktor a worker on Noxis Island and Fixer who is also a worker on Noxis Island.

During the location design phase, the *game* environment was developed, encompassing the main character's residential area and exploration islands with varying environmental concerns. Escuri Island serves as the protagonist's starting location and home, Gili Island as his grandfather's home, Aeris Island with its air pollution, Terran Island damaged by mining, and Noxis Island filled with polluting industries. NPCs were placed on each island to provide information, hints, and missions to keep exploration focused and educational. Puzzle elements were also introduced to add variety to the challenges, such as the inventory distribution of waste of varying weights in each area, air filtration devices that must be activated, and recycling stages to earn equipment upgrade points.

Source : Research Result (2026)

Figure 6. Production stages

The production phase focused on implementing core mechanics, including exploration, NPC interactions, a waste collection and recycling system, point utilization for upgrades, and features supporting ecosystem restoration. An achievement system was also implemented, featuring stuffed animal collections on each island to reinforce *game*play motivation. All concepts from pre-production were translated into Unity through the creation of interconnected scenes, assets, narratives, and visuals. Performance optimization was carried out through memory management, level of detail, and script efficiency, ensuring all *game* components functioned consistently and were ready for the next evaluation phase.

4. Testing Stage

During the testing phase, evaluations are conducted internally to ensure that all operational functions, system stability, and player engagement aspects are running as planned. Among the various evaluation techniques available for assessing games during the testing stage, heuristic evaluation is one method that is widely applied (Feng, 2023). The methods employed include usability testing, functionality testing, and black box testing, which validates functionality without examining the internal structure of the code. Playtesting runs in parallel to assess the overall *game*play experience, including ease of interaction, interface clarity, and balance of difficulty to ensure the *game* doesn't feel too easy or repetitive. All findings, such as bugs, missing assets, inconsistent object behavior, and navigational issues, are recorded in detail, along with steps to reproduce them, allowing for systematic improvements. This iterative, Agile-based approach ensures that when significant issues are discovered, development is transitioned back to production until the *game* reaches a stable, release-ready state. In addition to ensuring functional accuracy and accessibility for players, test results are also used to assess user satisfaction with *game*play and system responsiveness. A summary of the test results for the *game*'s core features is presented in Table 3.

Table 3. Test Results

No	Features Tested	Expected Results	Results
1	Go to the main page and start the game	Move to the opening scene and enter the game	✓ Succeed
2	Tutorial Pop Up	Displaying the tutorial page correctly	✓ Succeed
3	Interaction with NPC	Successfully interact to start the quest	✓ Succeed
4	NPC animation during interaction	NPC animations are active when the player interacts	✓ Succeed
5	Doing Quests	Players can complete quests and NPCs display dialogue according to progress	✓ Succeed
6	Retrieving and saving objects	Successfully picked up the trash and put it in the inventory	✓ Succeed
7	Item Collection	The dolls at each level are successfully collected and appear as decorative collectible items in the house	✓ Succeed
8	Turn trash into points and upgrade	The system carries out the process of recycling trash into points in recycling machine and inventory upgrade through a upgrade table	✓ Succeed
9	Turn on the engine and do some spam action	The engine starts, the animation runs, and stabilizes when the button is pressed repeatedly	✓ Succeed
10	Planting plants	Players can plant crops in designated locations	✓ Succeed

11	Open the map and move islands	The map can be opened, and players can move to other islands after the quest is completed	✓ Succeed
12	Button works fine	Buttons work fine All UI buttons (start, exit, menu tab, interaction) work as intended	✓ Succeed
13	Settings	The settings menu (volume, resolution) works according to the parameters	✓ Succeed

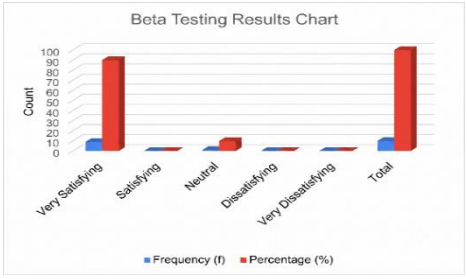
Source : Research Result (2026)

5. Beta Stage

During the beta phase, external evaluations are conducted to ensure that all operational functions, system stability, and targeted player engagement aspects are running as planned. Testing is conducted through usability and functionality testing methods by a group of people outside the development team, with the goal of identifying bugs, checking object behavior consistency, assessing difficulty balance, and measuring user experience when interacting with *game* features. Playtesting is implemented to obtain a more comprehensive assessment of functional quality and the overall *game*play experience, running in parallel with functionality testing so that the development team can validate the completeness of features and the system's response to various player actions. If issues such as bugs, missing assets, or missing UI elements are found, testers document the triggering conditions, reproducibility steps, and the impact on *game*play so that the improvement process can be restarted.

The testing method used is Black Box Testing, which is testing system functionality without looking at the internal structure of the code, with a focus on ensuring that every component in the *game* functions as expected. Game balance testing is also a crucial part of this phase, where the testing team runs several adjustment scenarios to ensure the difficulty level is neither too easy nor too difficult, thus maintaining the essence of the desired challenge. Feedback from fellow developers and players is used to assess whether the *game*play feels repetitive, boring, or provides an engaging and flowing experience. Accessibility aspects are also observed through tester behavior when playing the *game*, where difficulties in understanding instructions, reading the UI, or navigating the environment are indicators that the system is not yet user-friendly enough and requires further refinement.

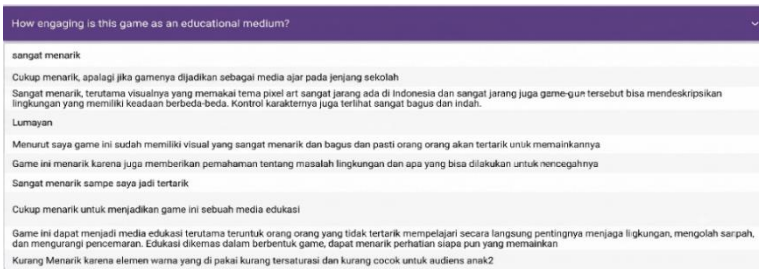
The results of beta testing using the Likert Scale instrument for each assessment as shown in the graph in Figure 7 show that the overall average assessment of the Green Solaris *game* as an educational medium is in the very satisfactory category, with 90% of respondents stating that they are very satisfied and 10% stating that they are quite satisfied.



Source : Research Result (2026)

Figure 7. Beta Testing Results

The majority of respondents expressed positive feedback on this interactive educational *game* with an environmental conservation theme, stating that the *game* can be an effective educational tool, especially for those less interested in directly learning the importance of environmental protection, waste management, and pollution reduction. Education packaged in *game* form is considered to be able to attract the attention of anyone who plays it, so the existence of the Green Solaris *game* can help as an educational tool for children and teenagers.



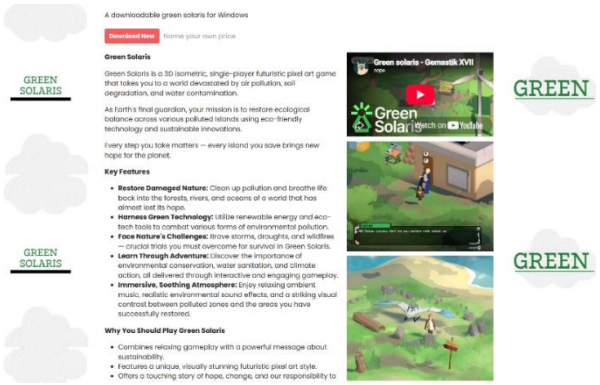
Source : Research Result (2026)

Figure 8. Respondents' responses to Green Solaris as a promising educational *game* media

6. Release Stage

At the release stage, Green Solaris development has entered its final phase, where the *game* is declared ready for distribution and access by the wider public. This release process is the culmination of all the development stages that have been passed, including preparing comprehensive project documentation, creating an optimized *game* build, and packaging all *game* assets to meet the distribution standards of the target platform. In the context of this research, Green Solaris is published through the itch.io platform, a digital distribution service chosen for its ease of supporting independent *game*s, flexibility in managing *game* pages, and providing a means of communication and direct feedback from players that can be used for further development. Before the *game* is officially published, a comprehensive final validation is conducted to ensure that all technical aspects of the *game* function properly. This validation includes system stability checks to avoid crashes or errors that could disrupt the playing experience, compatibility testing with various hardware specifications for the target user, and *game* performance evaluations to ensure stable frame rates and optimal loading times.

In addition to technical aspects, the release phase also includes the development of various supporting materials aimed at providing clear and engaging information to potential players. These include a *game* description explaining the concept, theme, and educational objectives of Green Solaris, preview images (screenshots) showcasing visuals and *game*play to entice players, and installation instructions that make it easy for players to download and run the *game* on their devices. This material was developed with both visual and textual communication in mind, allowing players to quickly understand the *game*'s context, key features, and the educational value conveyed through the *game*play experience. Furthermore, post-release support also opens up opportunities for further content development, such as the addition of new islands, additional missions, or more in-depth educational features, to ensure Green Solaris remains relevant, engaging, and able to continually evolve according to user needs and expectations. The *game* can be accessed through the following link: https://qopal99.itch.io/green-solaris.



Source : Research Result (2026)

Figure 9. *Game* Release

CONCLUSION

Based on the research that has been conducted, *Green Solaris* is an educational *game* themed around environmental conservation, developed in a structured and iterative manner using the GDLC and Agile–SCRUM approaches. The *game* features exploration mechanics, waste collection, point-based recycling for ability upgrades, NPC interactions, and thematic quests within a 3D isometric adventure format that emphasizes four main issues: clean water, clean energy, climate action, and life on land. The *game* has been proven ready for release through a series of internal and external tests. User evaluation results, measured using a Likert scale instrument across 17 indicators, showed that 90% of respondents rated the *game* as "Very Satisfying" and 10% as "Sufficiently Satisfying," with no negative ratings. This indicates its potential as a learning medium that enhances environmental awareness through a consistent pixelated visual style that is efficient and easily accessible via the itch.io platform. However, limitations identified during the closed beta phase—such as the limited tester profile, the absence of broader quantitative user experience measurements using standardized methods like SUS or GEQ, and the need to improve NPC stability, visual consistency, and UI accessibility—highlight important opportunities for future development. Expanding content, refining mechanics, and applying more measurable educational evaluation methods are essential steps to ensure that learning objectives and overall *game*play quality continue to improve in future versions.

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