

INTRODUCTION

Project Context

Environmental sustainability and conservation are critical global issues in this modern time. There is a need to disseminate knowledge about worldwide environmental issues. Possessing this knowledge will make us capable of applying common practical solutions as well as formulating innovative solutions. This will enhance our capacity to address environmental challenges. Every individual plays a crucial role and is responsible for taking care of our environment. The state of our environment will reflect on our actions. Practicing good habits towards the environment and strengthening environmental awareness through continuous learning will lead to a more sustainable future.

According to Dimante *et al.* (2016), developing a sustainable awareness will help lessen environmental impacts in our community. For this reason, the school plays an important role in teaching students about environmental awareness. The students are taught discipline and actions towards the environment. Traditional teaching methods are valuable but have limited capacity to fully engage students. Learning through a game is one of the modern and immersive methods of teaching.

As per Papadimitriou *et al.* (2021), point-and-click narrative games prove to be effective tools for learning due to their capacity of applying educational content in games. These games are best for enabling students to engage with the digital world that allow them to freely explore the game, providing a comfortable environment for learning while developing problem solving and decision making skills. The immersive nature of these

games encourages active participation of the students, enabling them to apply critical thinking and in a digital environment.

In this study, the proponents used a point and click interaction game style. The game allows the players to explore the campus digitally. The players can explore a variety of locations using the in-game map. There are challenges awaiting in these locations. To level up, the player must perform eco-conscious decision making and critical thinking. By embracing eco-friendly practices, the player can enhance their gaming experience. The player can change locations any time they want.

Objectives of the study

The study aims to develop a mobile game that will allow students of Cavite State University to engage into a virtual eco-friendly campus. Specifically, it aims to:

1. Create a 2D mobile game that replicates Cavite State University campus' facilities and specific locations allowing players to explore and participate in environmental activities.
2. Develop environmental awareness through providing information about environmental issues and the importance of biodiversity.
3. Promote eco-conscious decision making by engaging in game-based environmental challenges and solving puzzles.

Purpose and Description

According to Capellán *et al.* (2019), lack of knowledge about environmental issues and unawareness of human activities that can damage nature can lead to irreversible problems in the environment, therefore it is essential to follow the

implemented measures for sustaining the environment to develop the community awareness about environmental concerns.

Capellán *et al.* (2019) discussed that student's interest to learn environmental topics depends on the approach of teaching they are provided with, considering that the traditional approach of teaching often causes students to lose attention on the topic. The solution that the researcher's devised for this problem is to adapt to a modernized way of learning, an interactive approach to share the information, which can be accomplished through the use of a game.

This study aims to develop an 2D environmental mobile game that will effectively disseminate the CvSU Environmental Management Policy to students, enabling them to gain understanding of the correct approach for each aspect within the set of policy. The study will significantly benefit the following:

As for the students, the game will help them to be knowledgeable about Cavite State University's Environmental Management Policies which are implemented to maintain and secure all of its natural resources and be able to take appropriate actions that could have a negative impact on the Campus Environment. The system will also serve as a training platform for students, helping them to develop their actions toward the environment in the real world.

As for the educators, the game will assist them to educate students the significance of the Environmental Management Policies by utilizing the game as a tool for presenting the concept, allowing students to take pleasure while acquiring knowledge.

As for the future researchers, the study will serve as related literature for their study and will provide them a valuable foundation in their study. The system can be developed further by addressing the gaps that are not included in the study.

Scope and limitations of the study

This study is dedicated to the development of an offline 2D environmental game tailored for students within the College of Engineering, Information and Technology (CEIT) department at Cavite State University Main Campus. The primary goal is to educate as well as to engage players on crucial environmental issues, focusing on collecting trash, waste segregation, water conservation, and power conservation. The game is accessible on Android devices and can be played offline. The decision to maintain offline accessibility is rooted in the game's single-player nature, eliminating the need for a collaborative online environment. The sole purpose of the study is to develop a 2D environmental game that not only captivates players but also instills a sense of environmental responsibility and consciousness through an engaging and informative gaming experience.

The **Character Module** directs the integration of two characters, a female and a male, embodying student avatars from Cavite State University Main Campus (CvSU). This module manages the nuanced implementation of these characters, dictating their movements, interactions, and unique attributes within the game's environment.

This module is responsible for four (4) basic features that allow players to interact with the environment which include pick, drop, customize and movement.

Pick feature allows players to pick up items, objects and waste that are scattered all over the map and put it in inventory for later use.

The study limits players to picking up items and objects directly related to the quests and tasks within the game. This restriction prevents unnecessary clutter in the inventory and maintains focus on the game's core objectives.

Drop feature is used to remove items from inventory and put it down in the ground.

The study limits players to drop items and objects to designated zones within the game environment. Players cannot drop arbitrarily, ensuring strategic decision-making when managing their inventory and contributing to a cleaner in-game environment.

Movement feature is used to control the character to move from one point to another, allowing the player to freely roam in the 2d environment.

The study limits players to moving within the designated ground and with a moderate speed limit. This prevents rapid traversal and encourages players to explore and engage with the surroundings more thoughtfully.

Customize feature allows players to modify their character's appearance and attributes within predetermined parameters.

The study limits customized features to hairstyles, clothes and accessories. This ensures the cohesive visual theme within the game while still providing players with a degree of personalization.

The **Map Module** coordinates the creation of in-game environments focusing on the surroundings of the university. This module intricately designs and structures the virtual landscape, ensuring a customized and immersive experience of players.

This study limits the in-game location to Cavite State University Main Campus. The game will not feature the location outside the said campus.

The **Inventory system module** is responsible for storing and managing items located within the game. This allows players to carry objects that will be crucial in the game progression.

This study limits the player inventory capacity. Inventory system is a 5-slot inventory that prevents the player from picking up more than 5 items. The inventory system is 1x5 grid located at the bottom of the screen.

The **NPC (Non-Playable Character) module** introduces interactive characters within the game, enhancing the overall gaming experience. This module is divided into two (2) sub-modules, namely NPC Assessment and NPC Information, each contributing distinct elements to the overall game.

NPC Assessment sub-module focuses on characters representing professors within the game, responsible for providing mini-assessment to the player.

NPC Information sub-module focuses on student characters within the game who provide valuable information to players, contributing to the overall narrative and assisting in the completing quest and achievement.

The **Quest system module** serves as the main objective of the game that needs to be accomplished, this allows the game to provide puzzles and challenges for the player to solve, this contributes in enhancing the player engagement and activities inside the game making the game more enjoyable. This module also offers rich narrative storylines that enhance the player's immersive experience, absorbing the player into the character's shoes as it gives a realistic portrayal of situations in the real world.

The study limits the number of required quests, emphasizing a specific quantity for completion. This will enhance the game by prompting overwhelming quest volume, and allowing players to fully engage with and enjoy each quest's challenges and narrative elements. The game features four types of quests: collecting trash, waste segregation, water conservation, and power conservation. Each of these quests includes four sub-quests that must be completed before the main quest is considered accomplished.

The **Achievement module** is responsible for tracking the player's progress during the game, determining if the player is able to meet the requirements to complete the task. Aside from the main quest that the player does to finish the game, there are

also fifteen achievements that the player can complete in order to attain the gaming experience that the game wants to offer. Each achievement has its own set of requirements, awarding the players badges upon its completion it showcases the acknowledgement of the game to the player's accomplishment of a specific task. Receiving a badge comes with cosmetics where players can use to customize their own player such as clothes, hairstyle and accessories. The study limits the attainment of achievement by ensuring that badges are awarded only when players meet predetermined requirements.

Definitions of terms

2D stands for "two-dimensional". In the field of graphics and multimedia, it refers to the performance or representation of objects in a flat proportion, such as an image or picture with width and height.

3D or "three-dimensional" refers to a type of visual representation or space that has three dimensions which are length, width, and depth.

3Rs - Reduce, Reuse, and Recycle represent a set of principles and practices aimed at promoting environmentally sustainable behavior.

Godot Engine is an open-source, cross platform game engine used for the development of 2D and 3D games.

Game-Based Learning refers to the use of games as educational tools to enhance learning experience.

GDScript is a high-level scripting language specifically designed for the Godot game engine and is used for programming game logic, defining behaviors, and creating interactive elements within Godot Engine projects.

Krita is a free and open-source raster graphics editor and digital painting application. It is designed for artists, illustrators, and animators and provides a wide range of tools for creating digital art, illustrations, and concept design.

Point-and-click refers to a method of interaction with a computer interface, typically used in games. The term is commonly associated with graphical user interfaces (GUIs) where users navigate and interact with elements by pointing at them and clicking.

REVIEW OF RELATED LITERATURE

This section presents an overview of the review of related literature and related studies used in the study. The references were collected from online journals and research papers available online.

Technical Background

In the development of the proposed system, the proponents will develop a mobile game that does not require an internet connection. This feature ensures that users can access the game anytime and anywhere without the need of online connectivity.

The following are the tools that will be utilized in the development of the system. The researchers will develop a 2D mobile game and implement its functionalities using Godot Engine as the primary game development tool. Godot Engine is known for its versatility, user-friendly interface, and lightweight architecture. This platform has a built-in coding feature that utilizes GDScript, a scripting language designed for game development within the Godot Engine ecosystem (Salmela, 2022). In creating the prototype of the game, the researcher utilizes Figma, a real time visual design tool that is capable of creating prototypes. This software is designed for collaboration, making it effective for a group insight (Sharma, 2021). Additionally, Clip Studio Paint and Krita will be employed for graphic design to create characters, enhancing the visual elements of the 2D mobile games developed using Godot Engine.

Related Literature

Game-Based Learning. In times, terms like Serious games and Game-based Learning have arisen in the field of educational games. According to Qian and Clark (2016), game-based learning is a method of education that uses games to teach people. The implementation of game-based learning can be an effective way to teach because it can be engaging, motivating and interactive.

According to Moritz (2016), educational games will develop students' willingness to learn as well as maximize their potential. This is the best approach to encourage people to learn especially nowadays when people are becoming increasingly engaged with digital media. Developing a game as an innovative educational tool within the context of environmental sustainability is a powerful way to teach people about this topic.

This will give them insights and understanding to formulate solutions and expand their knowledge about environmental awareness. Utilizing convenient locations will increase the students' adaptability with the game.

GBL, with the edutainment genre, has become the most effective in developing the problem solving and analytical thinking skills of the students. There are several game design elements that create impact on players' experience and this includes competition, collaboration, and exploration and discovery, aligning with the findings from Qian and Clark (2016). These elements are the top three factors which boost the players' motivation and engagement.

To ensure that the study will be an educational game for student learning, the game will implement an assessment as a type of challenge to progress in the game. This will encourage the player to pay attention to the elements of the game.

Mobile Learning. In contemporary education, using technology is one of the common approaches to implement learning. Mobile learning has emerged as a powerful educational paradigm which facilitates learning anytime and anywhere (Sönmez, 2018). According to Sung *et al.* (2016), mobile devices, as one of the most accessible devices, allow the student to enable more convenient learning.

The integration of mobile learning enables the learners to access educational content instantly. Learners can use their mobile devices to explore additional resources and communicate seamlessly with educators (Chee *et al.*, 2017). Mobile learning not only enhances the learning experience but also encourages students to engage proactively in a digital environment. In the realm of the mobile game, the principles of mobile learning play a pivotal role. By utilizing mobile device capabilities, the game ensures that players can smoothly explore and engage with environmental concepts, promoting an interactive learning experience.

Simulation Games for Environmental Education. Simulation games have become one of the most effective tools for teaching environmental concepts, providing a virtual experience learning environment that simulates real-world solutions to a practical problem. Madani *et al.* (2017), support this notion by emphasizing the importance of serious environmental management games in enhancing understanding and addressing environmental sustainability problems.

As noted by Katsaliaki and Mustafee (2014), games whose goal is sustainable development serve a dual purpose. These games aim to actively engage learners, ensuring not only comprehension but also entertainment during the learning process. This highlights the potential of games to make the learning experience enjoyable, where learners are not only educated but also entertained and motivated. Madani *et al.* further contribute to this perspective, noting that learning through games, which ignites passion and focus, will lead to better learning outcomes.

Adventure Games. In recent years, gaming and education has gained substantial attention as researchers investigate the potential of video games to raise awareness, particularly in areas such as environmental conservation. Educational content can be integrated into adventure games, utilizing and leveraging the knowledge of the students (Papadimitriou *et al.*, 2021). This synthesis explores two significant studies that provide insights into the impact of video games in promoting environmental awareness with the adventure game genre.

The first study, conducted by Larreina-Morales and Gunella in 2023, titled "Video games for environmental awareness: the accessibility gap," not only discusses the potential use of video games to promote environmental awareness, it also dives deeper on one of the factors that may hinder the effect of environmental games which is accessibility. The study examines three PC games released in the last five years, namely Plasticity, Alba: A Wildlife Adventure, and The Sims: Eco Lifestyle Expansion Pack.

Among these, Alba: A Wildlife Adventure stands out as a game that mirrors the researchers' objectives, emphasizing exploration and interaction with the environment. The game follows a story of a little girl named Alba who is visiting his grandparents that lives near the coast. The player can explore the island while interacting with things in the environment. The player can also interact with other characters and unravel the story about an upcoming construction in the island that can cause the destruction of its nature reserves. In order to stop this, the players can finish different environmental tasks scattered around the island. The game that has been evaluated in this study is related to the game that is being developed by the researchers as it shares the same elements and primary goal which is using games as a way to promote environmental awareness.

The second study by Nindyapratama and Ahmad in 2021, titled "The Potential of Adventure Game as a Media to Visualize Waste Disposal as Environmental Problems," identifies the potential use of adventure games to emphasize waste disposal. Focusing on visual elements within adventure games, the study examines three examples: The Silent Age, Machinarium, and The Inner World. Among these, Machinarium, a point-and-click adventure game developed by Amanita Design and XGen Studios, aligns closely with the researchers' project. The game revolves around the character which is a robot in a semi post-apocalyptic world full of junk and metal scraps. The character can interact with the environment through a point-and click mode of control in order to progress the story. The game displays no dialogue so the game solely focuses on visuals. The study explains that in order to locate hints or anything that may be interacted with to advance the game, a player playing an adventure game must pay close attention to the environment's elements. In other words, since the player might be impacted by the details in the game and its surroundings, it can be used to raise awareness depending on what you put on the background. One way to enhance environmental consciousness among players is by strategically incorporating trash into

the background to create the appearance of a problem. This study helps the researchers by providing knowledge on where the player focuses when playing adventure games which is the same genre as the game that is being developed.

These two studies will serve as foundation, providing insights into the strengths and challenges of using video games with adventure genres for environmental education.

Point-and-Click. The point-and-click game style allows the player to explore the digital environment (Vranešević, 2014). This game style involves interacting with the objects and elements within the game through point-and-click interaction. According to Cau *et al.* (2020), point-and-click adventure games are well-suited for creating virtual environments that mimic the feeling of exploring fictional or real places. Actual locations can be used as the reference virtual environment which can involve tourism promotion.

Point-and-click narrative games demonstrate increased effectiveness in promoting educational content (Papadimitriou *et al.*, 2021). By encouraging players to interact with diverse elements within the digital environment, these games create an immersive learning experience. Utilizing actual locations as reference points for the digital environment can further enhance educational potential. To maintain the players' active engagement, the plot of the game should develop progressively (Torrente *et al.*, 2013).

Inventory Systems. An inventory system is a storage of items which is used primarily for storing, using, and managing items. The inventory system displays the icon of the item in order to identify them. This allows the players to recognize rather than recall an item, which makes the game a good design. Cmentowski *et al.* (2019) stated that, in a limited screen space, presenting excessive information can hinder a good user experience. Prioritizing on displaying short and essential information will reduce

cognitive load on users, allowing them to process and utilize information more effectively. The inventory system is important in efficiently managing in-game items (Glasell & Josefin, 2023).

One of the most dominant inventory systems is the grid inventory system. According to Bateman and Zagal (2017), in their study entitled “Game Design Lineages: Minecraft’s Inventory”, the grid inventory system which is implemented in the game “Minecraft” allows players to quickly access their items. The inventory system is placed at the bottom part of the user interface that is simple to use and easy to understand. Minimizing extra frames will boost the efficiency of the game.

Game Engine (Godot Engine). In the field of game development, the Godot Engine stands out as a pivotal open source video game development tool, emphasizing its importance in the growing landscape of independent game development. It holds considerable potential, encompassing crucial aspects such as design, features, and workflows, as noted by Salmela (2022).

According to Flomen (2020) Godot Engine emerges as a favorable entry point for beginners in game development. The engine’s simplicity, highlighted by a straightforward GUI, makes it accessible for novice developers. The study recognizes Godot’s limitations in providing extensive information within the tool but acknowledges its role as a beneficial starting point for individuals new to game development.

Godot Engine is an open source development engine that provides a comprehensive set of tools and features for creating 2D and 3D games. It has support for several platforms, a flexible scene system, a specialized programming language (GDScript), and visual development environment. Godot is a popular choice for beginner as well as experienced game developers due to its user-friendly interface, effective

workflow, and collaborative production capabilities. The engine adheres to the open-source software principles of being free to use, modify, and distribute.

Environmental Psychology. According to Martin *et al.* (2020), establishing positive communication between nature and human emotion and affection to the environment helps in improving public health and sustaining the environment, the impact on nature can vary based on the influence of the psychological bond of an individual to the environment. In the same study, the findings show that individuals that engage more in shows about nature inclined towards adopting pro-environmental behaviors.

Gifford (2014) stated that one of the factors that study must include in the study of human behavior is the contribution of the environment to the human mind. Based on the findings, the unhealthy habits of living environment cause harmful effects to the well-being of an individual residing in it, influencing the way of thinking and hinders the ability to learn of an individual.

Information Dissemination. In the constantly evolving world of information dissemination, technology has triggered significant changes to the modern world. From traditional printed materials to the digital age, our approach to accessing knowledge and facts information has transformed. The rise of the internet and mobile phones has redefined how information is sought, trusted, and accessed. Rosmani *et al.* (2020) emphasizing the crucial role of technology in our modern information ecosystem.

Nolasco *et al.* (2019) highlight a low priority placed on public awareness of Solid Waste Management (SWM) in Naga City, Philippines. The city must improve information dissemination and heightened attention to garner community involvement to ensure effective waste management practices.

Solid Waste Management. Humanity continues to develop and produce cutting-edge products in order to fulfill its most fundamental needs of life. Unsurprisingly, the Philippines generates more solid waste as population increases. Even though living

standards are enhanced, the country's waste generation steadily increased from 61,000 million metric tons per day, of which 24 percent is plastic waste as reported by the Philstar Global (Cariaso, 2023).

According to Coracero *et al.* (2021), in the Philippines, solid waste management is a critical issue with problems including growing garbage, weak law enforcement, and inappropriate disposal of waste. Implementation of RA 9003, which emphasizes segregation and appropriate disposal, is the primary key. Participation and public awareness are essential for the Philippines to be trash-free. Effective governance and cooperation between all stakeholders are essential for success.

In addition to that, improper management of solid waste poses significant health risks. According to the World Health Organization (WHO), Contamination from poor disposal methods, such as water, soil, and air pollution, poses risks to both waste workers and surrounding communities. Vulnerable groups, including children, face increased health risks.

Furthermore, the environmental impacts of improper solid waste management extend beyond local concerns. Improper disposal contributes to environmental degradation, including soil degradation, deforestation, and biodiversity loss. It exacerbates climate change through the release of greenhouse gasses from decomposing waste in landfills.

Programs Involving Cleanliness. The Ecological Solid Waste Management Act No. 9003 of 2000 aims to protect and enhance the environmental and public health protection. The primary objectives include promoting resource conservation, recovery, and recycling, to transfer waste management to local governments, to stop illegal dumpsites, to invest in waste facilities, and to reduce and appropriately handle solid wastes. This act also assigns the Department of Environment and Natural Resources (DENR) as the primary government agency responsible for the implementation and

execution of the said act, with the support of other government organizations, local government units, non-government organizations and the private sector.

In response, the DENR implemented the Solid Waste Management Program that aims to improve environmental quality by addressing solid waste issues in the Philippines. Priorities include closing dumpsites and establishing Material Recovery Facilities (MRFs). The program aligns with RA 9003, the program supports local government units, promoting systematic waste management and sustainability, contributing significantly to economic development and job creation while reducing reliance on imports and increasing power generation.

Bernardo *et al.* (2019) highlights that implementing Republic Act 9003 or known as the “Ecological Solid Waste Management Act of 2000”, mandates a systematic and ecological approach to ensure public health and environmental protection. The study emphasizes the need for effective implementation to address issues in solid waste management as highlighted in Cabuyao, including inadequate facilities, weak enforcement, and low compliance. The article underscores that despite efforts, progress is hindered by challenges such as limited funds, uncooperative citizens, and low awareness.

Furthermore, Cubebe *et al.* (2022) Evaluating solid waste management (RA 9003) and awareness programs in Rizal, Kalinga is essential for gauging their effectiveness. Findings indicate high awareness and positive practices among households, reflecting the success of information campaigns and waste management initiatives in promoting environmentally responsible behavior.

CvSU Environment Policies. According to Boeve-de Pauw *et al.* (2017), several factors can impact schools' ability to effectively promote environmental responsibility among students and instill eco-conscious practices. This can be achieved by engaging in projects aimed at sustaining resources and protecting the environment. The study also

emphasizes that a well-developed school policy on environmental management has a positive impact on students' environmental principles, influencing them to comply with the policy.

In accordance with the University Pollution Control Office (UPCO), the office takes on the responsibility for the Campus' Environmental management aiming to protect the life form and ecosystem of Cavite State University including land, water and air quality. The UPCO implements the policies which are designed to achieve the objective they seek to fulfill. The environmental management policies are created and comply with the guidelines of Solid Waste Management act of 2003. According to Bagolong (2017), the policy's purpose is to assist people in properly managing their waste and developing a behavior to act considering the environment. Ukaogo *et al.* (2020), noted that failure to ensure the proper waste management process harms not only the environment but also a person's health. The lack of understanding of the pollutants and its causes also contributes to their harmful effect.

Related Studies

The game to promote the capability of reducing, reuse and recycling waste (Rodrigues & Bruno, 2020). This study aims to develop environmental awareness through a 3D game. The study assessed the usability and interactivity of the game "3Rs" developed with Unity 3D game engine. A game whose primary objective is to inform community members about the significance of the 3Rs - Reduce, Reuse, and Recycle featuring solid waste recycling, water and electricity conservation activities (Rodrigues & Bruno, 2020).

3Rs is a 3D game where players can interact with the object and explore available facilities within the game. Players can earn points by completing tasks. Tasks include picking up and segregating solid waste (recycling), shutting down computers that

are not in use (electricity saving), and turning off open faucets in bathrooms (water saving). The game presents a digital environment where eco-conscious decision making will be tested as well as developed. As the players progress with the game, this means that players are actively engaging with sustainability concepts in a virtual environment. Through this method, players can practice and refine environmental responsibility understanding.

The study entitled “The game to promote the capability of reducing, reuse and recycling waste”, (Rodrigues & Bruno, 2020), aligns with the developed study whose focus is to develop an interactive environment that promotes environmental awareness. Both of the studies implemented challenges addressing environmental problems through the digital world.

Designing Educational Game to Increase Environmental Awareness (Huda & Ramadhan, 2021). This study discusses the effects of plastic waste to the community and as a response, an educational game that promotes environmental awareness of the dangers of plastic waste has been developed.

“Plastic Stream” is a 2d game developed by the researchers. The gameplay of the game is to protect the city from flooding and protect the sea from plastic waste. Plastic wastes appear randomly in three different waves. The task of the players is to prevent the trash from reaching the net by placing garbage pickup boats (Huda & Ramadhan, 2021). The boats have different colors: red, blue, and yellow and have different functions: collect plastic bags, bottles, plastic straw respectively. The nets will be destroyed if the players have missed catching the plastic waste three times. To finish the game, the players must not let the net be damaged by the plastic waste.

Integrating these elements into the game not only addresses the issue of plastic waste but also provides an interactive platform for raising environmental awareness. According to the study’s findings, 71.11% of the primary school student respondents

acquired greater understanding about the environment. This outcome underscores the potential effectiveness of educational games as a tool for instilling knowledge and awareness among young learners.

This study aligned with the study being developed as both projects share the same elements. The inclusion of waste segregation as a featured aspect in both studies serves as inspiration for the development of the current study.

Sara's Quest: Simulation-Based Approach to a Nature Inspired Adventure Game Using Unity Game Engine (Chua et al, 2022). This study focuses on environmental problems that cause an increasing rate of global warming including deforestation and pollution. In order to raise awareness about these environmental problems, the researchers of this study decided to develop a simulation based mobile game that displays possible ways to help on said problems by performing activities and practices that can possibly reduce global warming.

Sara's Quest is a 2d educational simulation based game that follows the main character Sara. Sara will be the one who will give players information about global warming, different chemical reactions and activities that will be performed within the game. The game revolves around Sara performing different tasks and talking to NPCs which gives information about different kinds of processes and how it affects global warming. The game has different mechanics and game types, for example, all stages have an oxygen level meter which serves like a timer which gives players more challenges. The game presents an assessment screen where the player can answer questions about previously discussed topics within the game in order to continue the game. Lastly, after taking the assessment, the game provides a score based on the results of the player's answers in the assessment.

The study "Sara's Quest: Simulation-Based Approach to a Nature Inspired Adventure Game Using Unity Game Engine" (Chua et al, 2022) shows how games can

be used not only to provide players with useful information about important things like global warming, it can also show players the possible steps that the player can take in order to contribute into solving environmental problems. Results from this study implies that with the right implementation, the game is able to deliver its purpose to promote awareness to players. This study helps the researcher by showing possible ways to integrate learning and information dissemination into games.

Table 1. Table of comparison of the related studies to the study.

Game title:		3Rs	Plastic Stream	Sara's Quest	EcoCampus
Game-based learning		✓	✓	✓	✓
Adventure / Exploration		✓			✓
Environmental awareness		✓	✓	✓	✓
Point-and-click		✓	✓		✓
Graphics	2D		✓	✓	✓
	3D	✓			
Platform	Computer	✓			
	Mobile Phone		✓	✓	✓

Synthesis

The selected related literature showed the different methods on how games can be used as means of teaching. Game-based learning and Serious games are two of the used methods. Findings from the related literature shows that video games have a very large potential to be used in teaching and learning.

However, the credibility of video games as a learning tool are still not well accepted by many. It is because of the playful nature of video games which can cause loss of focus. This problem is what Serious games are meant to solve. Serious Games are designed for more than entertainment purposes, but to address specific educational or training objectives. These games expand to different areas, including healthcare, defense, and corporate training. By immersing learners in realistic scenarios, Serious Games offer a risk-free environment for skill development, enabling practical applications in fields ranging from medical simulations to corporate decision-making simulations.

The researchers chose environmental awareness as a topic for the game under development because of curiosity towards the steps taken by Cavite State University to promote their policies about pollution and waste management. The researchers also think that playing video games while learning something as important as environmental awareness can be a very good way to spread awareness to the future generations.

The related studies provided a variety of games that focus on disseminating environmental awareness and waste management. The games featured in the studies selected by the researchers possess common features as the game that is being developed such as game type, control type and main purpose. The related studies stated that most of the systems lack accessibility which can lower the effectiveness of these games to promote environmental awareness. The researchers can use the games presented as a reference for what to add in order to maximize the effectiveness of the games in promoting environmental awareness and waste management,

The current study chose the game as a way to disseminate information directly to students and to focus their attention on missions that teach the significance of the environment. The game was designed to run on mobile devices, aiming to offer a new way of learning about the campus' environmental policies. The establishment of environmental policies in any organization, especially in schools or universities

demonstrates their significance since the study highlights the effect of the environment on students' behavior, emphasizing that the condition of the environment influences students' way of thinking and how it hinders the ability of students to learn effectively.

METHODOLOGY

This section presents requirements documentation, design and methodology, and development testing. This chapter contains an overview of the methodology that will be used in every part of the study.

Requirement Documentation

The table below presents the comprehensive features and descriptions of the system's module.

Table 2. List of modules and its features and description

Module	Features	Description
Character Module	Choose character	Feature 1. The player can choose between a male and female character.
	Pick	Feature 2. This feature will allow the players to pick up items or objects.
	Drop	Feature 3. This feature will be used to remove items from current inventory and drop it to the ground.
	Move	Feature 4. The player can move the character by tapping the mobile screen. This allows them to freely explore the environment.
	Customize	Feature 5. Players can customize the character with

		the items acquired through achievements.
Map Module	Navigation	Feature 6. This feature will serve as a guide for available locations. The player can select their preferred locations.
Inventory System module	Manage inventory	Feature 7. This feature allows the players to manage their items.
	Select item	Feature 8. This enables players to select their preferred items whenever they want.
NPC module	NPC assessment (sub-module)	Feature 9. Players will be assessed through a quiz.
	NPC Information (sub-module)	Feature 10. This feature will provide players valuable information about the environment as well as a

		guide throughout the journey.
Quest System module	Check quest info	Feature 11. This feature displays the quests that need to be accomplished.
Achievement Module	Rewards and Badges	Feature 12. Completing predetermined requirements for every achievement will reward the players with a badge that can be used to customize the character.

Functional requirements.

Control system.

- Players can explore the virtual environment.
- Interact with objects by tapping on mobile screens.
- Pick up items by tapping.
- Drop items by dragging them out of the inventory system.

Feedback system.

- Provides text responses and information to players based on actions or progress.
- Congratulations messages upon task completion and passing the assessment.
- Serves as a guide by providing tips or suggesting alternative actions in case of mistakes.

NPC Interaction.

- Players can interact with non-playable characters (NPCs) by going near them.
- NPCs serve as educational guides, providing quests, environmental tips, and information.
- NPCs will test your learning through assessment.
- Information displayed in a dialog box.
- Three types of NPCs: Student NPC, Guard NPC and Professor NPC, all fulfill a similar role as educational guides.

Inventory.

- Players can manage and store items in an inventory system.
- Inventory system is a 1x5 grid at the bottom of the screen.
- Limited to 5 slots, preventing additional pickups when full.
- Indication given when the inventory is full, discarding items will create a space

Navigation.

- Players can navigate the game environment through a map.
- The map displays key locations within the virtual campus.
- Upon selecting a location, the camera enters a static state for a focused view.
- Players are restricted from walking beyond specified boundaries in the game environment.

Tasks and Challenges.

- Various activities for players to accomplish in the game.
- Players can navigate available quests.
- Corresponding achievements awarded upon task completion.

- Rewards can be acquired when achievement requirements are met.
- Specific tasks include:
 - Picking up Virtual Trash and Waste Disposal.
 - Waste Segregation (biodegradable, non-biodegradable, recyclable).
 - Water conservation (turning off open faucets).
 - Power conservation (turning off electronic devices).
- Virtual trash bins are labeled with text and different colors: green for biodegradable, blue for non-biodegradable, and red for recyclable.

Non-functional requirements.

User Interaction.

- Controls are responsive, providing a seamless experience.
- Navigation is smooth and lag-free.
- Efficient interaction with objects and NPCs.
- The character faces the direction instantly when the players tap on the screen.

Visual Appeal.

- Graphics and visuals are designed to be aesthetically pleasing.

Resource Utilization.

- Optimized use of system resources to prevent excessive battery drain.

Consistency.

- Consistent performance across different versions of devices.

Availability.

- The game can be played without an internet connection.

Design and Methodology

Scrum Sprint Cycle

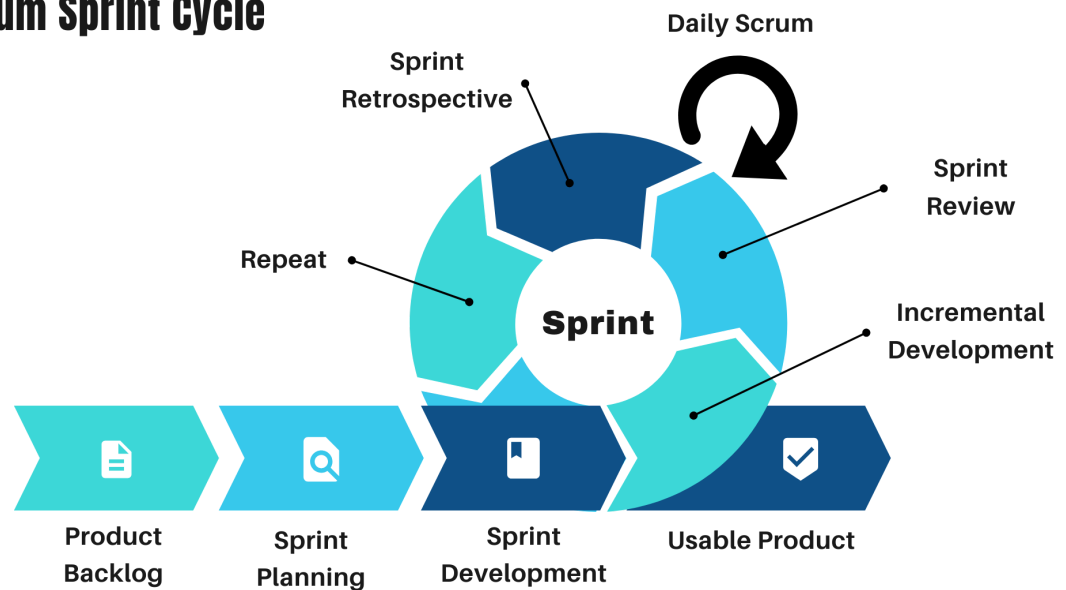


Figure 1. Scrum Sprint Cycle model

The study developed the system using the Scrum model as its development methodology. Scrum model is one of the most popular types of Agile methodology that splits the members and provides roles in order to split the task into smaller manageable tasks. According to Abrahamsson (2017), Scrum model was first presented in Japan in an article by Takeuchi and Nonaka. The article described Scrum as an adaptive and quick methodology for product development. The word Scrum originated from rugby where scrum means “getting an out-of-play ball back into the game”.

Scrum model divides members and provides roles namely The Scrum Master, Product Owner and Developers. The Scrum Master's role is to help the Developers into using the Scrum model to develop the project. The product owner knows the vision of the project and focuses on the things in the system that need to be improved. The developers can be anyone in the team who gets things done in order to build the project.

A study from Kistriadi et al.(2019) suggests the use of Agile methods especially scrum in game development as it is one of the most effective methods for software development. Compared to the traditional waterfall methodology, Scrum does not make developers wait for other components of the system to be completed.as the tasks needed to be accomplished will be distributed by the project manager in order to allow the development team to be more efficient. The study also states that Scrum methodology makes the project alot more readable and allows developers to make sensible decisions in developing the game.

Conceptual Framework.. This study uses an Input - Process - Output - Impact model for its conceptual framework as shown below.

The input section contains knowledge, software and hardware requirements for developing the system. After knowing the requirements, the researchers then proceeded to the process of developing the system. The steps taken by the researchers can be seen in the process section of the figure. After development is complete, the researchers will conduct an evaluation and gather feedback to identify specific areas for improvement or correction within the system. The impact section of the figure shows the effect of the final output.

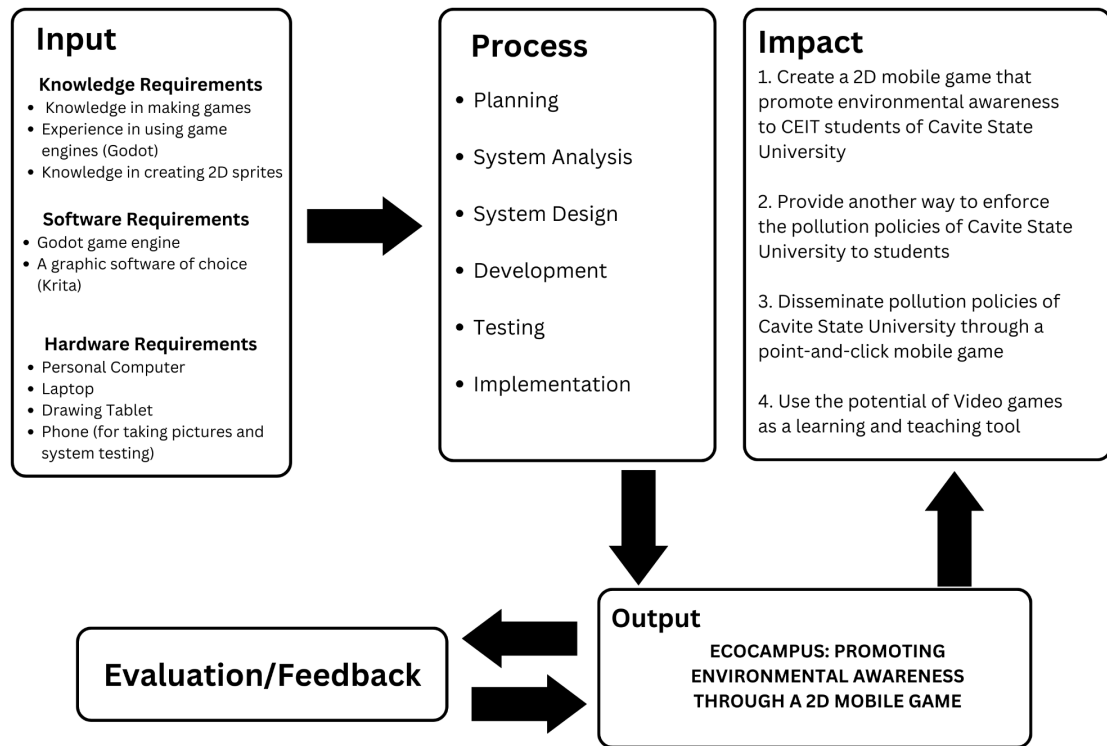


Figure 2. Conceptual framework of the study

System Architecture. The system architecture for EcoCampus: Promoting Environmental Awareness Through A 2D Mobile Game, an environmental education game, incorporates various modules that seamlessly integrate to deliver an engaging and educational experience. At its core lies the Character module, providing the option to choose between a boy or girl character and integrating the Pick and Drop system. This movement mechanic empowers players to navigate the characters through the virtual environment, facilitating the pickup and responsible disposal of items critical for addressing environmental challenges.

Upon character selection, the journey progresses until the Map module engages, allowing players to choose their preferred location and setting the stage for the upcoming environmental challenges. Within the Game, players encounter a variety of

challenges in the Environment module, such as waste picking, segregation, power conservation, and water conservation. The Inventory module complements these challenges, offering a space for players to manage the items collected during their eco-friendly endeavors.

To instill a sense of purpose and direction, the Quest module outlines specific tasks and objectives for players to fulfill, guiding them through a knowledgeable environmental journey. This interconnected system not only educates players on environmental issues but also encourages them to actively participate in sustainable practices, fostering awareness and a sense of responsibility for the university.

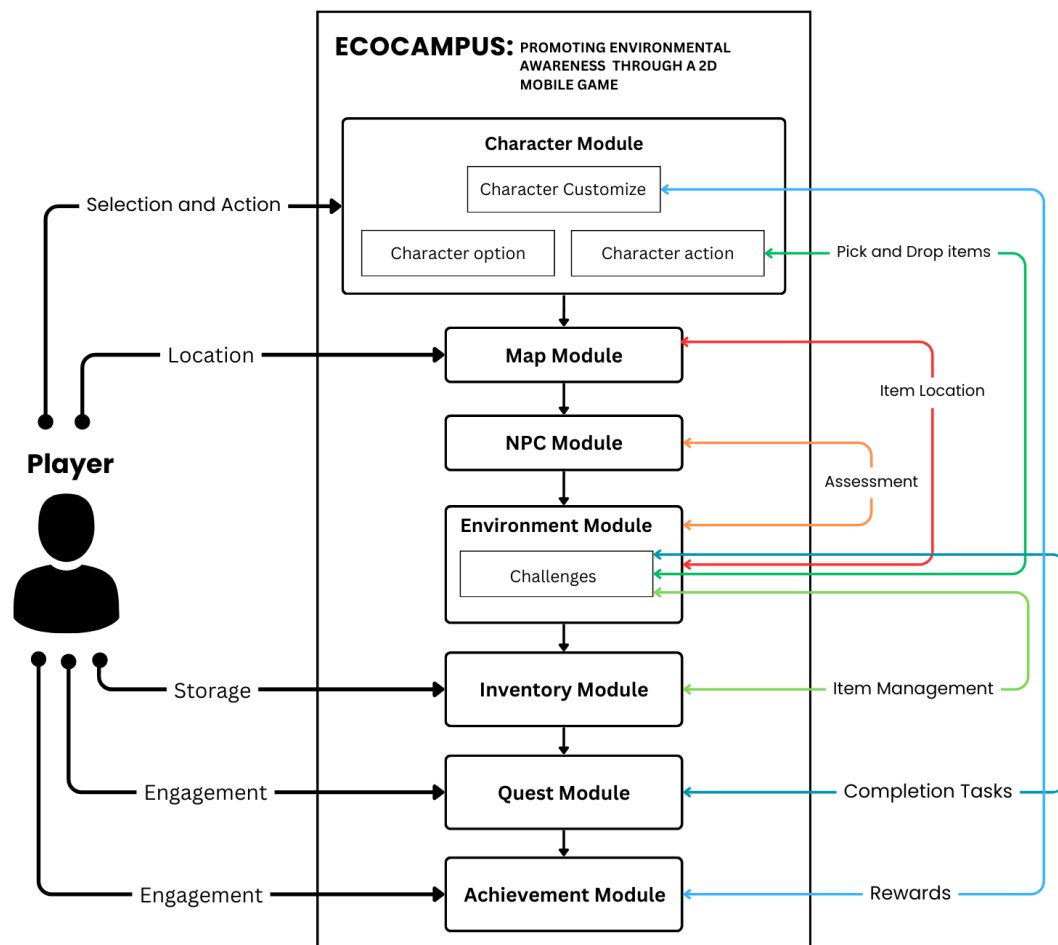


Figure 3. System Architecture of the study

Development and Testing

This study follows the Agile Scrum model for the development of the system. The researcher decided on what system to develop and the approach that will be used in its development. After that the researchers then build the system using the plan created beforehand. After creating a product that is somehow functional, the researchers tested the product and reviewed it for future improvements and overall changes. This one cycle is called a sprint. Multiple sprints are created in order to make the system meet the expectations of the product owner. Meetings are conducted by the Scrum master at the middle of the sprints making sure that the results from the review of the last sprint will be taken in consideration in creating the plan for the second sprint. A sprint can usually take 3 to 5 weeks depending on the plan.

Data Analysis Plan. The researchers utilized the International Organization for standardization (ISO) 25010 throughout the development of the system. The researchers will make use of the selected system quality model to ensure that the game being developed is aligned with the international standards. The ISO 25010 has eight quality characteristics used in evaluating the system, which are functional sustainability, performance efficiency, compatibility, usability, reliability, security, maintainability and portability. Through the application of this quality model the researchers can focus on developing the system to make it fit in the characteristics, further enhancing the game's quality. The figure below illustrates the characteristics of the quality standards that will be used.

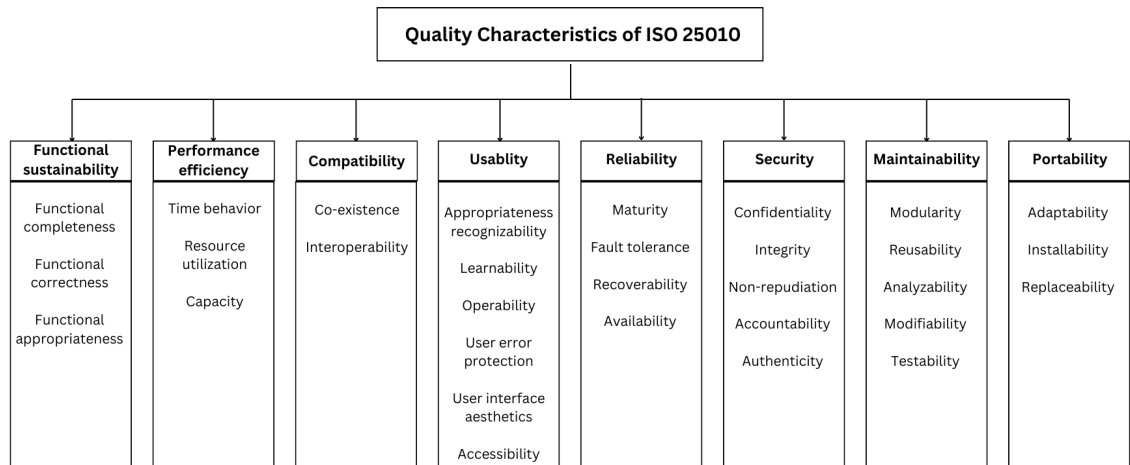


Figure 4: System Quality Characteristics (ISO/IEC 25010)

To evaluate the assessment of the game, the researchers will use the mean and standard deviation. The formulas are shown below.

Mean formula:

$$\bar{x} = \frac{\sum x}{N}$$

Where,

\bar{x} = mean;

$\sum x$ = sum of all values; and

N = overall amount of participants

Standard Deviation formula:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

Where,

s = standard deviation for a sample;

x = each individual value in the collection of data;

\bar{x} = mean of all values in data set;

\sum = the summation of; and

n = total number of participants

References:

- Abrahamsson, P., Salo, O., Ronkainen, J., & Warsta, J. (2017). Agile Software Development Methods: Review and Analysis. Retrieved from <https://arxiv.org/ftp/arxiv/papers/1709/1709.08439.pdf>
- Bagolong, S. P. (2017). Community Participation on the Implementation of Ecological Solid Waste Management Act of 2000 (R.A. 9003) in Davao City. *Journal of Solid Waste Technology and Management*. <https://doi.org/10.5276/JSWTM.2017.305>
- Bateman, C., & Zagal, J. (2018). Game Design Lineages: Minecraft's Inventory. *Transactions of the Digital Games Research Association*, 3. <https://doi.org/10.26503/todigra.v3i3.77>
- Bernardo, A. M. I., Blauta, A. N. S., Castillo, A. A. V., Dizon, C. J. A., & Limsiaco, R. M. B. (2019). A Policy Analysis on Republic Act 9003: "The Ecological Solid Waste Management Act of 2000" as Implemented on the Households of Cabuyao City. Retrieved from https://www.researchgate.net/profile/Carl-Aguila-Dizon/publication/349277640_A_Policy_Analysis_on_Republic_Act_9003_The_Ecological_Solid_Waste_Management_Act_of_2000_as_Implemented_on_the_Households_of_Cabuyao_City/links/6027643ea6fdcc37a821a8d3/A-Policy-Analysis-on-Republic-Act-9003-The-Ecological-Solid-Waste-Management-Act-of-2000-as-Implemented-on-the-Households-of-Cabuyao-City.pdf
- Boeve-de Pauw, J., & Van Petegem, P. (2018). Eco-school evaluation beyond labels: the impact of environmental policy, didactics and nature at school on student outcomes. *Environmental Education Research*, 24(9), 1250-1267. <https://www.tandfonline.com/doi/abs/10.1080/13504622.2017.1307327>
- Capellán-Pérez, I., Álvarez-Antelo, D., & Miguel, L. J. (2019). Global sustainability crossroads: A participatory simulation game to educate in the energy and

sustainability challenges of the 21st century. *Sustainability*, 11(13), 3672.
<https://doi.org/10.3390/su11133672>

Cariaso, B. (2023, August 5). Philippines produces 61,000 million metric tons of waste daily. *Philstar.com*.
<https://www.philstar.com/headlines/2023/08/06/2286595/philippines-produces-61000-million-metric-tons-waste-daily>

Cau, F. M., Mereu, A., & Spano, L. D. (2020). Intelligent Assistance for End-Users in creating Point and Click Games Storylines. In 2020 IEEE International Conference on Humanized Computing and Communication with Artificial Intelligence (HCCAI) (pp. 67-73). IEEE.
<https://doi.org/10.1109/HCCAI49649.2020.00018>

Cavite State University. (n.d.). University Pollution Control Office. Retrieved from
<https://cvsu.edu.ph/university-pollution-control-office/>

Chee, K. N., Yahaya, N., Ibrahim, N. H., & Hasan, M. N. (2017). Review of Mobile Learning Trends 2010-2015: A Meta-Analysis. *Journal of Educational Technology & Society*, 20(2), 113–126. <http://www.jstor.org/stable/90002168>

Chua, D., Florendo, I., Sales, A., & Vidar, A. (2022). Sara's quest: simulation-based approach to a nature inspired adventure game using unity game engine.
<http://library.cvsu.edu.ph/cgi-bin/koha/opac-detail.pl?biblionumber=62755>

Cmentowski, S., Krekhov, A., & Kruger, J. (2021). "I Packed My Bag and in It I Put...": A Taxonomy of Inventory Systems for Virtual Reality Games. In 2021 IEEE Conference on Games (CoG) (pp. 1-8). IEEE. DOI: 10.1109/CoG52621.2021.9619153

Coracero, E. E., Gallego, R. J., Frago, K. J. M., & Gonzales, R. J. R. (2021). A Long-Standing problem: A review on the solid waste management in the

- Philippines. *Indonesian Journal of Social and Environmental Issues*, 2(3), 213–220. <https://doi.org/10.47540/ijsei.v2i3.144>
- Cubebe – Cawayan, C., Lingbawan, S., Putic, R., A. Ubeña, M., & Bayed, E. (2022). War on Waste: Implementation of solid waste Management (RA 9003) in the Municipality of Rizal. *International Journal of English Literature and Social Sciences (IJELS)*, 6(6). Retrieved from <https://journal-repository.theshillonga.com/index.php/ijels/article/view/4558>
- de Freitas, S. (2018). Are Games Effective Learning Tools? A Review of Educational Games. *Journal of Educational Technology & Society*, 21(2), 74–84. <http://www.jstor.org/stable/26388380>
- DENR Priority Programs. (n.d.-b). Solid Waste Management Program <https://ncr.denr.gov.ph/index.php/priority-programs?start=5>
- Dimante, D., Tambovceva, T., & Atstaja, D. (2016). Raising environmental awareness through education. *International Journal of Continuing Engineering Education and Life-Long Learning*, 26(3), 201-213. <https://www.inderscienceonline.com/doi/abs/10.1504/IJCEELL.2016.078446>
- FAO.org: (n.d.). Ecological Solid Waste Management Act No. 9003 of 2000 <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC045260/>
- Eder, M. S. (2016). ITrash: Proper Waste Segregation Mobile game. *Indian Journal of Science and Technology*, 9(42). <https://doi.org/10.17485/ijst/2016/v9i42/100212>
- Flomén, R. (2020). Game developer experience : A cognitive task analysis with different game engines. *DIVA*. <https://urn.kb.se/resolve?urn=urn:nbn:se:bth-19615>
- Gifford, R. (2014). Environmental Psychology Matters. *Annual Review of Psychology*, 65, 541-579. <https://doi.org/10.1146/annurev-psych-010213-115048>

Glasell, J., & Jönsson, T. (2023). Active Inventory Systems in Games: And What Defines Them. Retrieved from

<https://uu.diva-portal.org/smash/get/diva2:1809544/FULLTEXT01.pdf>

Godot Engine. (n.d.). Free and open source 2D and 3D game engine. <https://godotengine.org/>

Huda, S. N., & Ramadhan, M. F. (2021). Designing educational game to increase environmental awareness.

<https://online-journals.org/index.php/i-jet/article/view/22661/9699>

International Organization for Standardization. (n.d.). ISO25000. ISO/IEC 25010. <https://iso25000.com/index.php/en/iso-25000-standards/iso-25010>

Katsaliaki, K., & Mustafee, N. (2015). Edutainment for sustainable development: A survey of games in the field. *Simulation & Gaming*, 46(6), 647-672. <https://doi.org/10.1177/1046878114552166>

Larreina-Morales, M. E., & Gunella, C. (2023). Video games for environmental awareness: The accessibility gap. *Universal Access in the Information Society*. Advance online publication. <https://doi.org/10.1007/s10209-023-01026-6>

Madani, K., Pierce, T., & Mirchi, A. (2017). Serious games on environmental management. *Sustainable Cities and Society*, 29, 1–11. <https://doi.org/10.1016/j.scs.2016.11.007>

Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *Journal of Environmental Psychology*, 68, 101389. <https://doi.org/10.1016/j.jenvp.2020.101389>

Mayer, R. E. (2019). Computer games in education. *Annual Review of Psychology*, 70(1), 531–549. <https://doi.org/10.1146/annurev-psych-010418-102744>

- Moritz, A. (2016). The effect of serious gaming on elementary student learning. Graduate Research Papers, 723. <https://scholarworks.uni.edu/grp/723>
- Nindyapratama, L. T., & Ahmad, H. A. (2021). The potential of Adventure Game as a media to visualize waste disposal as environmental problems. *Advances in Social Science, Education and Humanities Research*. <https://doi.org/10.2991/assehr.k.211228.020>
- Nolasco, M. A., Begua, Y. P., & Padua, M. L. O. (2019). Solid Waste Management in Naga City: Its Culture of Information Dissemination <http://www.apjmr.com/wp-content/uploads/2019/09/APJMR-2019.7.04.02.pdf>
- Papadimitriou, S., Kamitsios, M., Chrysafiadi, K., & Virvou, M. (2021). Learn-and-play Personalised Reasoning from Point-and-click to Virtual Reality Mobile Educational Games. *Interactive Design and Technology*, 321–332. <https://doi.org/10.3233/idt-200204>
- Qian, M., & Clark, K. R. (2016). Game-based learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, 63(50-58.). Retrieved from <https://doi.org/10.1016/j.chb.2016.05.023>
- Rodrigues, E., & Bruno, L. (2020). The game to promote the capability of reducing, reuse and recycling waste. *E3S Web Conf.*, 171, 01012. <https://doi.org/10.1051/e3sconf/202017101012>
- Rosmani, A. F., Mutalib, A. A., & Sarif, S. M. (2020). The evolution of information dissemination, communication media and technology in Malaysia. *Journal of Physics*, 1529(2), 022044. <https://doi.org/10.1088/1742-6596/1529/2/022044>
- Salmela, T. (2022). Game development using the open-source Godot Game Engine. Retrieved from

https://www.theseus.fi/bitstream/handle/10024/746943/Salmela_Tero.pdf?sequence=3&isAllowed=y

Scrum Alliance. (n.d.). What is Scrum? Retrieved from <https://www.scrumalliance.org/about-scrum#!section1>

Sharma, V., & Tiwari, A. K. (2021). A Study on User Interface and User Experience Designs and its Tools. Retrieved from https://www.wjrr.org/download_data/WJRR1206016.pdf

Sönmez, A., Göçmez, L., Uygun, D., & Ataizi, M. (2018). A review of Current Studies of Mobile Learning. *Journal of Educational Technology and Online Learning*, 1, 12-27. <https://doi.org/10.31681/jetol.378241>

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, 94, 252-275. <https://doi.org/10.1016/j.compedu.2015.11.008>.

Torrente, J., Marchiori, E., Moreno Ger, P., Fernández-Manjón, B., Vallejo-Pinto, J., & Ortega-Moral, M. (2013). Evaluation of Three Accessible Interfaces for Educational Point-and-Click Computer Games. *Journal of Research and Practice in Information Technology*, 45, 517-536. https://www.researchgate.net/publication/284183151_Evaluation_of_Three_Accessible_Interfaces_for_Educational_Point-and-Click_Computer_Games

Ukaogo, P. O., Ewuzie, U., & Onwuka, C. V. (2020). Environmental pollution: Causes, effects, and the remedies. In Chowdhary, P., Raj, A., Verma, D., & Akhter, Y. (Eds.), *Microorganisms for Sustainable Environment and Health* (pp. 419-429). Elsevier. ISBN 9780128190012. <https://doi.org/10.1016/B978-0-12-819001-2.00021-8>.

Vranešević, G. (2014). The secret of the point and click adventures: Psychoanalytic point of pointing in a bygone genre. 51, 22-42. Retrieved from https://www.researchgate.net/publication/292667527_The_secret_of_the_point_and_click_adventures_Psychoanalytic_point_of_pointing_in_a_bygone_genre/citation/download

World Health Organization. (n.d.). Guidance on solid waste and health. World Health Organization. <https://www.who.int/tools/compendium-on-health-and-environment/solid-waste#:~:text=Improper%20disposal%20can%20lead%20to,waste%20burning%20and%20neighbouring%20communities>.