EcoBlue - Recycle The River Trash

https://youtu.be/Ovgpmrj7AlM

An Educational Game

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ABSTRACT

A serious game to ensure more people know about recycling rubbish inside river bodies. The game is proposed to be localised to a specific region targeting nearby residents. The player selectively picks up the water waste items and places them in the appropriate recycle bins. Surrounding provides visual feedback to the player's actions. The game ends when much rubbish gets piled up, or the environment is recovered to an acceptably good condition. The game's gameplay makes sure that the player interacts with others to stop them from damaging the environment. At the same time, the player can interact with different areas such as farmland and factory to guide respective stakeholders in protecting the environment. This paper highlights the current issue of river pollution and the existence of organisations and serious games supporting the cause of cleaning wastewater. In the end, the proposed development process of the game is discussed, followed by the strategy that will be used to evaluate its success.

KEYWORDS

Serious Game, Environment, Recycling, River Pollution

1 Introduction

Video Games capture a wide variety of audiences, with more than 2.5 billion gamers worldwide. That's a third of the world's population. Seventy-two per cent of the gamers are age 18 or older, with an average gamer being 34 years old [1]. These demographics show us that games are not only for teens though teens and vicenarians love them. Thus, when appropriately used, video games could prove a potent tool in educating and bringing world reforms.

1.1 What are Serious Games?

The term 'Serious Games' has developed because people wanted to distinguish between games for fun and entertainment to games with serious outcomes, such as giving a social message or learning. A serious game from a learning perspective is a game that allows people to learn. Many think serious games originated in 2000 with the Serious Game initiative. If we go back to the 1970s, a man named Clarke C. Abt released a book called Serious Games. It even goes back way further. Games can give us non-linear experiences. We don't always have to go in order. We can think about the strategies differently. We can think about elements differently [2]. All these things are benefits of playing serious games.

1.2 How Serious is River Pollution Around the World?

Indonesia's Citarum River, which is relied upon by almost 19 million people, has been choked with chemicals and rubbish due to decades of pollution. About 3000 industries residing near the river introduce wastewater into the stream. Residents have nowhere to dispose of trash, so they either burn it or throw it into the river. In 2013 Asian Development Bank discovered that faecal coliform bacteria levels had shot through the roof, crossing 5,000 times the mandatory limits. Lead levels have become more than 1,000 times the US Environmental Protection Agency drinking water standard. Levels of other heavy metals such as Al, Fe and Mn are above the international average. People are suffering from dermatitis, contact rashes, intestinal problems, delays in child development, renal failure, chronic bronchitis, and a significant incidence of tumours. Contaminants are also ingested via the food, mainly rice, irrigated with water from factories and villages or the Citarum and its tributaries, affecting residents and nearby animal life [3].

Figure 1: The Citarum river near the village of Bojongsoang in Bandung, West Java, Indonesia

The mismanagement of plastic disposal has caused the chaotic spread of plastics in the environment and eventually led to the fragmentation of this substance into smaller particles, turning it into microplastics (MPs) that pollute the environment. Microplastics have been found in river water, sediments, ponds, and milkfish (Chanos chanos) downstream of the Citarum River. Based on the shapes, the microplastics found in the samples could be categorised into five types: a fragment, fibre, film, monofilament, and foam. The fragment was the most dominant shape of microplastics in both water and sediment samples. The most dominant polymers in the microplastics were polyethylene (PE) and polypropylene (PP) [4].

Antibiotic and metal resistance in sediments from the Ganges and Yamuna Rivers in India and streams in the River Tyne catchment were quantified by a collaborative effort of Newcastle University and the Indian Institute of Technology, Delhi. Their results showed that metal pollution also affected resident bacteria, with Firmicutes and Bacteroidetes being the most abundant species at sites with high metal pollution. These bacteria are common in metal-contaminated environments and are known to carry metal resistance genes (MRGs) and antibiotic resistance genes (ARGs) in groups in "gene cassettes", which causes antibiotic resistance.

The study showed that specific metal combinations that promote the most potent bacterial responses combined Cobalt with Nickel or Cobalt with Zinc and Cadmium [5].

1.3 River Cleaning Initiatives

#TeamSeas is a global campaign being led by famous YouTubers Mark (Rober), Jimmy (MrBeast) and Campaign Director Matt Fitzgerald (@fitz350) to raise $30M to remove 30M pounds of plastic and trash from the ocean, rivers and beaches. They have collaborated with "The Ocean Cleanup" and have developed technologies for river pollution called Interceptors, which have removed over 2 million pounds. It is solar-powered and can collect trash autonomously [6].

Canal & River Trust is a UK-based charity that looks after and brings 2,000 miles of waterways to life because they believe that life is better by water. Working with volunteers and communities across England and Wales, they help transform canals and rivers into spaces where local people want to spend time and feel better. They have started an initiative called #PlasticChallenge. They believe, "If every time someone visited our canals and rivers they picked up and disposed of just one piece of plastic, there could be no plastic left within a year." They provide a helpful guide for The Plastic Challenge, including safety tips such as: Do not reach into the water to collect any plastics or litter. Always stay away from the water's edge; Always use gloves, or a litter picker, to pick up plastics and litter and cover any cuts and grazes before you start [7].

Thus, the intricacies of the existing river problem and some of their implemented solutions are considered for gamification and exciting gameplay elements to make a safe, totally immersive and educative game.

2 Related Work

In this section, I will analyse the projects focused on serious games related to the environment, mainly river bodies.

2.1 SimBasin

This serious game focuses on communicating the complex relationships between different factors affecting river basins and enabling a dialogue between policymakers and scientists in the Magdalena-Cauca basin, Colombia. The game focuses on the elderly stakeholders responsible for policies and innovations [8]. But when it comes to on-ground implementation, the age group that needs to be targeted is much younger. Seventy-nine per cent of young people claim to be concerned about current environmental issues [9].

Aspects considered in this game are Flooding, Agriculture, Hydropower, River health, Forest remaining and Wetland remaining. The wide variety of focus forces oversimplification of core calculation logic of different aspects. For example, for river health, which has an important impact on ecosystems, two factors were combined: flow regime alteration and river network fragmentation. River alteration is considered a stochastic parameter. Flow regime alteration is expressed through mean "ecochange" over ten representative river reaches. Ecochange is the normalised area between the baseline flow-duration curve and the altered flow-duration curve in the reach. Quantifying ecological alteration of rivers is complex as evaluation of various flow components needs to be considered due to their differing impacts on riverine ecosystems. Therefore, total ecochange is not necessarily a good indicator of ecological alteration, as has been confirmed by studies [8, 10].

2.2 Eco Champion

It is an educational computer game aiming to stimulate and foster environmental awareness among elementary school students (age group 6-10). The game revolves around an Eco Champion, a local hero who starts in a central control room containing missions involving solving problems through direct action and cooperation with different actors (NPCs). The game consists of many mini-games bound together by a framing story. It also mediates between contradictory perspectives and interests [11]. River-related mini-games include:

1. River Manager: The player must clean a polluted river by a recently commissioned industrial textile dyeing plant which releases toxic wastewater discharges unthreatened into the river. The player also has to mediate between the interests of textile workers and fishers [11].
2. Saviour of the Seas: The players must remove the drifting nylon nets degrading the marine ecosystem. Once the fishers

lose, nylon nets take about 400 years to disintegrate entirely. Entangled fish die senseless and attract predatory fish, which get caught in the nets. The player must convince fishers not to throw old nets into the sea and that it's better to use cotton nets [11].

Giving the players alternative options to cope with environmental issues helps them better understand the causal relationships between their behaviour and corresponding effects on the environment. A central assumption during development was that ecological challenges should be perceived as local incidents within global contexts. To be able to localise the game for children from different geographical regions with different cultural backgrounds, an attempt was made to bring forth design-relevant input from children living in multiple countries: Germany, Argentine and Morocco. After that, the first game prototype was sketched, featuring different skins to accommodate cultural differences among target players [11].

2.3 SeAdventure

A platform game aimed at 8 to 10 years old children in which they play using an avatar that swims through a bunch of waste lost in the sea. The game is designed to be used in the classroom as a supporting tool for environmental education. This serious game is set in the Mediterranean Sea, and the chosen characters are the species estimated to be at risk of extinction: red tuna, great white shark, turtle (Caretta caretta) and the hippocampus. Language, graphics, and interaction were accurately defined to meet users' needs and characteristics. The player's mission is to help the character swim and reach the final point by avoiding junk and eating fish. Their pilot study quantitatively revealed that students and teachers appreciated the approach, and the preliminary data gave good results also in the students' perception of usefulness and satisfaction [12].

2.4 Contact From the Future

It is a 2D game developed to be played in the context of an aquarium or exhibition on marine ecosystem conservation or plastic pollution and to involve 8 to 11 years old visitors, raising their interest in environmental topics. The game is played on tablets while communicating with a remote avatar displayed in the aquarium spaces using projectors or screens. The character interacting with the player is an 11-year-old boy named Alex, who comes from a dystopian future and tries to communicate with the past. In his time, the Earth is completely polluted, and the oceans are full of plastic waste, while many sea creatures have disappeared. He aims to understand what happened in the past, and he wants to convince people to change their behaviour to improve his present. To do this, he provides information and suggestions using quizzes and games for players to realise how important it is to change and how to do it [13].

The game trials produced positive feedback considering the game format, interaction with the character and content and information provided, as participants found the experience enjoyable, entertaining, and instructive. However, they also highlighted room for implementing improvements before conducting tests with the final users' group. These included aspects regarding the interface, interaction and instruction administered, and clarification on the questions and information provided [13].

2.5 Trash Attack

It is an action-puzzle game where players take control of Julie. She is a potent environmentalist with a mission to promote environmental awareness by cleaning the environment using her special gun. Increasingly complex waves of trashes appear in front of the player in an endless game mode. The player must try to survive it. The player shoots using the appropriate coloured gun, Green for Biodegradable wastes, Yellow for Non-Biodegradable waste and Blue for Recyclable wastes [14].

The proponents developed the video game over three to four months using Unity Engine, Photoshop, Illustrator, Autodesk Maya, and other multimedia editing applications. Game assets such as waste images, characters, and backgrounds were designed using comic-style art as the inspiration. The game storyline utilised voice-acting dialogues to ensure that the players could interact with the game naturally [14].

The game was evaluated using MEEGA+ [15]. Based on the total ratings, the video game performed well in all dimensions of the survey instrument. Most importantly, the results proved that:

1. The game promoted awareness of the environment while being fun and engaging.
2. The game performed efficiently during runtime, showing little or no frame rate issues and inconvenience to players.
3. The game was successfully ported to mobile devices.

2.6 noPILLS jam (NPJ)

This is a European research project-based game jam focusing on the long-term aim of reducing pharmaceutical micro-pollutants in the water cycle. This was a two-day-long game jam consisting of 10 participants from which three games were produced; Sewer Sweeper, Polluted and Purity [16].

"Sewer Sweeper" is a first-person shooter aiming to teach generic nuances of water filtration. The player shoots at particles representative of micropollutant elements as they move continuously through the pipe environment and learns about these micropollutants through a quiz-like format as the level progresses.

Scores are calculated based on the number of particles shot and removed and the number of correct answers to the related questions [16]. Overall, the game is focused more on teaching theoretical aspects of water filtration than the practical process associated with it.

"Polluted" teaches young players that the fishes have been exposed to water pollution caused by irresponsible disposal methods of humans. The game drives the player to manoeuvre a small fish through the treacherous waters, taking shelter from waste materials under seaweed. Players must also avoid capsules within the water, which causes specific camera effects and control manipulation to make the objectives more difficult. Overall, the

game presents a mixture of narratological and ludological stimuli and allows players to understand pollution's cause-and-effect realities on a sympathetic level [16].

"Purity" is a management simulation tool aimed to be used by professionals or final year University students to understand water treatment plants with a focus on filtration methods such as carbon filtration and UV treatment [16].

These prototypes, and noPILLS as a whole, have informed the development of a research project aiming to identify serious games as an effective method for engaging the public in social policy [16].

2.7 SEAJAM

This game jam was held from October 29th 2021, to November 29th 2021. It directed more people to the cause of the #TeamSeas campaign mentioned under the "River Cleaning Initiatives" section above. It was an online game jam which received 670 game entries by its end [17]. I will discuss three games from these entries: Pond Pirates, Beach Watch, and Team Oceans.

Pond Pirates is a game about two boys on a self-made pirate ship on a mission to clean the pond. The gameplay mechanics of the game consists of plastic spawn enemies (Plastic Bottles & Dorito Packets), A big boss fight, and Two sellers that help you get upgraded for the boss fight. One is a blobfish that eats up your plastic, and the other is a goose that rewards you for recycling enough plastic if your ship is below a certain plastic contamination level. Overall, the game balances fun, entertaining gameplay with a strong message.

BeachWatch is a game where the player must segregate items that end up at the shore into recycling bins. The player must align the trash in a specific orientation before disposal, and there is a time limit for executing these actions. The game does an excellent job of conveying the message of segregation and recycling, but it makes the gameplay a bit cumbersome. Players must type all their actions as well as the item's name. It would have been nice if players were allowed to use the mouse as one of the input methods.

Team Oceans is a game that teaches players to return the trash thrown at the shore to its owner and clean up the water by picking up trash. The player has to decide between rebounding the trash thrown & cleaning up the water body giving the game fascinating game mechanics. The player has two characters to control using WASD and Arrow Keys. The game provides many opportunities to mix and match tactics with each character. The sound effects are also well thought out.

Thus, we can see that exploration of the serious game under the game jam banner has been done on both levels Online Game Jam (Low Budget – Large Community) and Incentivised Game Jam (Large Budget – Small Community) [16].

3 Project Design Approach

Categorising the above-related work according to the target audience shows us that games like "SimBasin" are developed keeping scientists & policymakers in mind, whereas games like "Eco Champian", "SeAdventure", "Contact From the Future", and "Trash Attack" are more focused on small children (age 6-11). Both of these categories are fine for the preparation of river conservation. But we are way past the preparation time and urgently need appropriate actions. Thus, this research proposes a focus on the age group of 18 to 30 years old capable of leading and operating actual ground works in river cleaning initiatives.

Conservation games can be misleading if their modelled or synthesised environments oversimplify or misrepresent

real-world problems [18]. Focusing on the "SimBasin" game, we can see that It tries to encompass many aspects of water basin management into one package, which results in the oversimplification of its gameplay elements. Thus, this research focuses on the specialisation of concepts related to river waste recycling rather than generalisation.

All the games stated above lack connection to the environment because they do not provide visual realism; instead, they depend on animation and cartoonist visuals. The project under this research is built using Unreal Engine 5. Unreal Engine 5 (UE5) enables game developers and creators across industries to realise next-generation real-time 3D content and experiences with greater freedom, fidelity, and flexibility than ever before [19]. Thus, it is possible to achieve a greater level of hyper-realism.

If today's young adults are trained in a fun realistic simulated environment about how to clean their river bodies, much improvement in river body health can be expected. For impactful results, the research aims to choose a specific region and target the nearby residents and their needs. It is proven that experiencing a geographically and temporally close river yields more positive environmental outcomes than experiencing a distant river [20]. For effective environmental communication, it is necessary to tailor a message and make it more relevant to the individual [21, 22, 23].

A lot of serious games like "SeAdventure" are heavily based on quizzes and textual interactions. This project focuses more on visual interactions to keep the gameplay engaging.

Early research articles have highlighted that a balance between fidelity and play must be considered to prevent the game from achieving the "chocolate-covered-broccoli" designation [24, 25]. The serious issue-related mechanisms portrayed in the game will be as close as possible to the real world. Any gameplay element that doesn't relate to the real world will be abstracted from realism using visual abstractions (different look and feel for real-like and totally-virtual gameplay elements). At the same time, as the developers of "Trash Attack" pointed out, any good serious game should create gameplay mechanics that appeal to hardcore gamers [14]. Thus, one of the goals of this project is to climb up to the game library list of mainstream gamers.

"Eco Champian" was developed with a game script created with the help of seven years of experience from the Eco fund organisation [11]. Similarly, this project will seek help from local organisations and NGOs for future deployments and upgrades.

Many games developed as part of research projects are no longer accessible or technically maintained soon after project termination. Digital media, especially computer games, strongly

depend on the underlying technical implementation platform. The older the game, the less likely it is still operational. For example, in the last decade, Java Applets and Adobe's Shockwave browser plugins have been chosen for many game implementations but are becoming increasingly outdated and unsupported, and thus, some valuable but older games have disappeared [11]. Thus, this project will keep long-term compatibility in mind and focus on tools that support backwards compatibility and are guaranteed to be future-proof.

Game Jams discussed in the related work section are not well suited for a fully functional serious game. Nevertheless, they are a good tool for presenting proof of concept, as proved by noPILLS jam. On the other hand, SEAJAM failed to display serious factors in its games but highlighted pretty exciting gameplay elements that can be used to add entertaining factors to the serious game.

This research binds its approach with the "Gee's three identity model". The model states that in a complex video game, the player will develop three identities, a virtual within game space, a real outside game space and a projecting identity for establishing a connection between the virtual and the real identities [21].

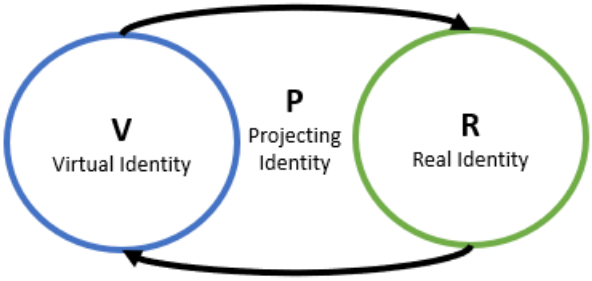


Figure 2: Gee's three identity model

Projecting identity can be split into two parts. The forward-projecting identity Pf is responsible for mapping the real onto the virtual identity, and the back-projecting identity Pb is for mapping the virtual onto the real identity. Thus, the virtual identity can be seen as

$$V = P_f(R),$$

and the real identity as

$$R = P_b(V),$$

Which is equivalent to

$$R^{n+1} = P_b\left(P_f\left(R^n\right)\right) = G(P_f, P_b).$$

The above equation describes a recursion in which each change in real identity is immediately fed back into the system. When equilibrium is reached, R^{n+1} will be equal to R^n. This value of R is called an eigenvalue of the projecting function. To conclude, the complex video game will influence the player so that the newly obtained real identity of the player will represent an eigenvalue of its projecting identity [22].

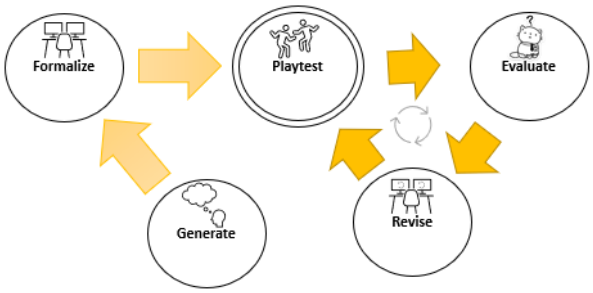


Figure 3: Iterative design model [22]

Thus, this project was accomplished using an iterative design process that includes playtesting to heuristically optimise the recursive process described by $G(P_f, P_b)$ toward a stage that supports predefined learning outcomes. Our project will support autonomous learning methods by giving the player complete control over his actions without implementing any time limits or sequential arrangements [22].

4 Project Implementation

This section will outline the implemented parts of the game and the reasoning that has been followed while choosing an approach throughout this project.

4.1 Finalising River Body for Project Analysis and Contacting Residents

During the initial investigation, Indonesia's Citarum river was chosen for this project. I later realised that despite being the world's most polluted river, it would be unsuitable for this project due to two main constraints: Language restrictions and timezone differences. The next candidate came out to be the Philippines. It has more than 50 dead rivers. People in the Philippines speak English, and the timezone difference is manageable too. Thus, a list of most polluted rivers was referred to, and amongst them, the marilao river was selected.

Residents near the marilao river were contacted via social media such as Facebook, discord and Reddit. Two youngsters came forward to help in the end. I asked them to canvas the area and show me the spread of river waste. One of them went a few km away to show me a region where a lot of garbage dump was present. I selected that region as my target area and directed my research toward it.

4.2 Constructing Nearby Landscape for the game

Accurately modelling a region requires laser scanning for the landscape. It was not feasible for me to go to the Philippines physically. Thus, I decided to use the next best option. Blenders OSM – Open Street Map for Blender. It was a fantastic plugin that helped me replicate the selected Bulacan region's heightmap data

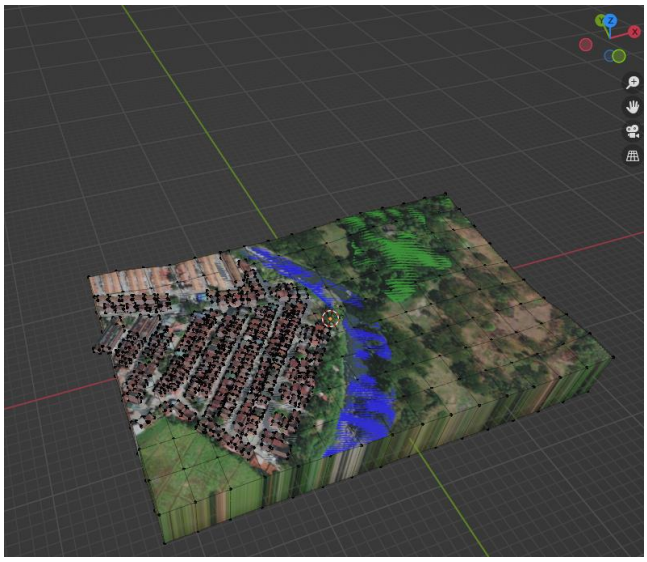


Figure 4: Marilao, Bulacan Region Landscape Built Using Blender

and added pathways and buildings. The buildings look like just a bunch of brick walls, but due to monetary constraints, I had to keep it that way.

4.3 Planning River System, Trash and Basic Trash Tool

UE5s Experimental water system was chosen because of its unique look and inbuild physics support for making objects float with the help of pontoons. Cubes in the default third-person map were chosen as placeholders and tested using UE5's Buoyancy Component.

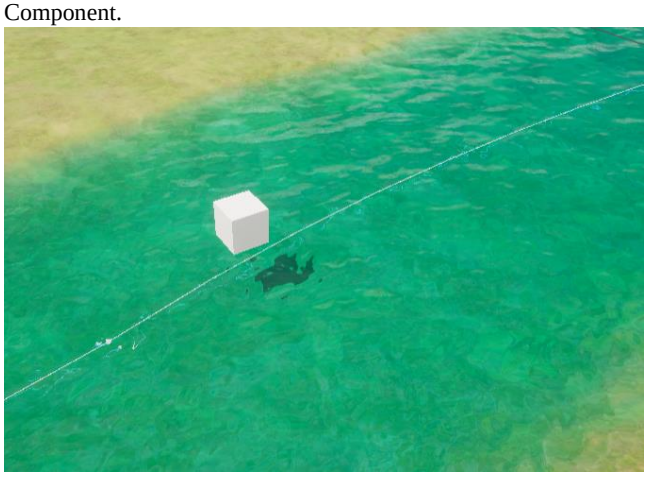


Figure 5: Initial Setup To Test Buoyancy & River System

Then a free character was imported from Adobe's Mixamo as the main player. A cylindrical rod was attached to its chest to mimic a trash picker tool. Socket attachments of Rod and Trash were tested at a fundamental level. Bugs related to the physics actor attachment process were resolved. We will explore the final trash tool in an upcoming section.

4.4 Planning out Target-Specific Goals and Features for the Game

Once the target area and target audience were finalised. Appropriate localised goals were needed to be established, and those features were plotted using sticky notes onto the printed methodology circle (Figure 6) [23]. The following picture displays the four fundamental aspects initially decided to be implemented, covering Storytelling, Gameplay, User Experience and Learning.

Figure 6: The Art of Serious Game Design methodology circle Implemented [23]

At this point, it was apparent that my project would require more design skills than I had. So, I hired an animator/3d artist. He helped me design multiple assets, trash objects and the trash picking tool.

4.5 Backbone of the Game: The Trash Picker

The Trash Picker is a crucial tool the player gets from the shop. The fate of the whole world lies in the hand of the player. The player needs to contain river waste levels before it's too late. The skeletal mesh has a trigger & grabber system. At the centre of the grabber, I added a socket to hold the river trash.
I have implemented the following states for the trash picker:

1. Equipping: This state plays the very first animation of equipping.
2. Idle_Empty: This state represents an empty trash picker ready to pick trash.

3. PullOutOfTheBag: This state represents getting trash items out of the bag for dumping into the bin.

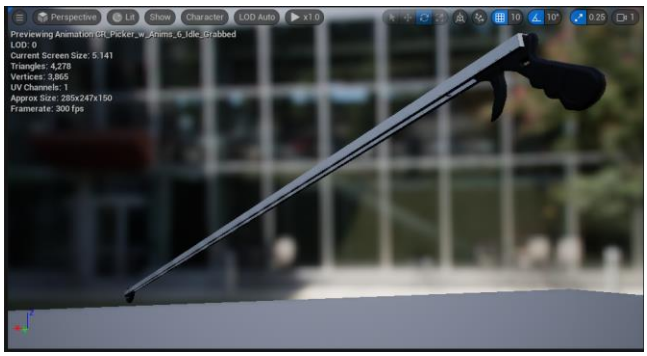


Figure 7: Trash Picker Skeletal Mesh in Idle Grabbed Position

4. PutTrashIntoBag: This state represents collecting trash into the trash bag that the player is carrying.
5. Pickup_Trash: This state represents picking up trash. Updating its properties (Like turning off physics since it's no more in water)
6. Idle_Trash: This state represents a player holding the picker with a trash object attached. This state is achieved when a player is near the bin.
7. Empty_Trash: This state represents putting the trash into the bin.

4.6 Custom Shader to Prevent Clipping

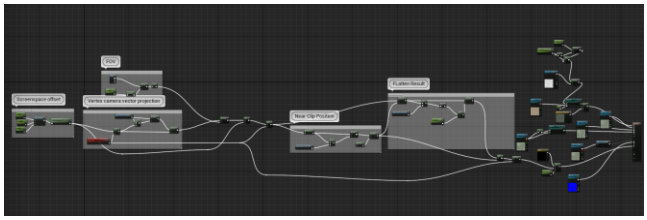


Figure 8: Toolfix Shader Material (Used for Creating Material Instances)

Since the landscape was built from the satellite heightmap data of the actual area, Regions were of different heights, which caused the tool to be clipped along with the trash (if present). Thus I found a custom shader that draws all the scene objects first and, in the end, draws the object with the custom shader material. However, the object is physically present at the same position, so all the rest of the game logic remains intact.

4.7 Adding Residents

Since one of the primary goals of the research was to let the player interact with other people and bring in behavioural change, I added functionality for the Bulacan Residents. For adding third-person basic animation functionality, I took the UEs default Third-Person Blueprint and Retargeted it for my newly imported Mixamo characters.

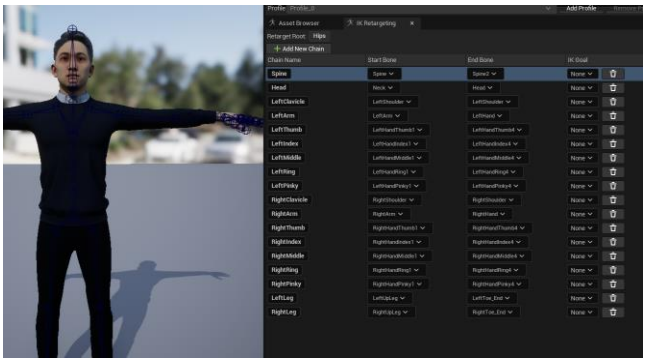


Figure 9: Trash Picker Skeletal Mesh in Idle Grabbed Position

The game contains guiding actors called NPC_points. Initially, residents used to do a sphere trace to go to the next point. It was inefficient, and the resident NPC got lost (No NPC_point could be traced). I added a new mechanism that took the help of nav mesh to navigate. Now only 4 NPC_points are acting as a guiding points.

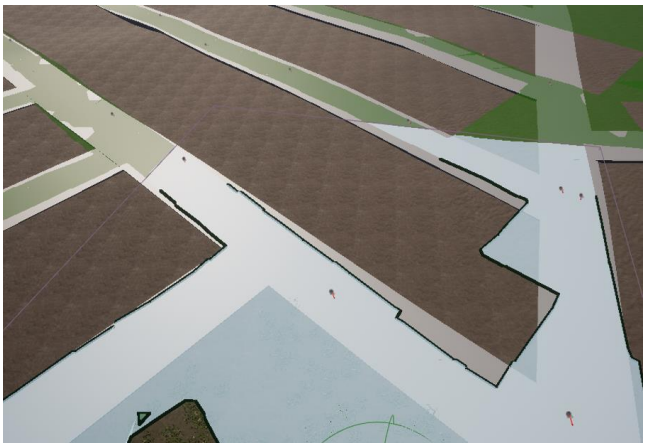


Figure 10: Nav Mesh (Green & Blue) along with NPC_points

The NPC_points near the river edge guide residents where trash must be thrown. Other NPC_points are potential spawn locations, representing residents coming out of their houses. Initially, most residents who can't see the bin throw trash in the river. Once players start teaching them, they start respecting the environment and throwing trash in the bin. Regional language sound cues are present to provide a personal touch.

4.8 Developing Environment

Many foliage and landscape-related assets were acquired from the Quixel bridge plugin or the UE sample projects. Foliage

Figure 11: Foliage & Landscape

only renders when the player is within a specific range for optimum performance.

4.9 First Stop: The Shop

Figure 12: The Shop

The shop is the very first place player is expected to go. The shop contains picker tools & gloves. The shop has a shopkeeper who waves at the player whenever an item is available to pick from the shop. On the side of the shop, there are segregation instructions for the trash.

4.10 Game Theme

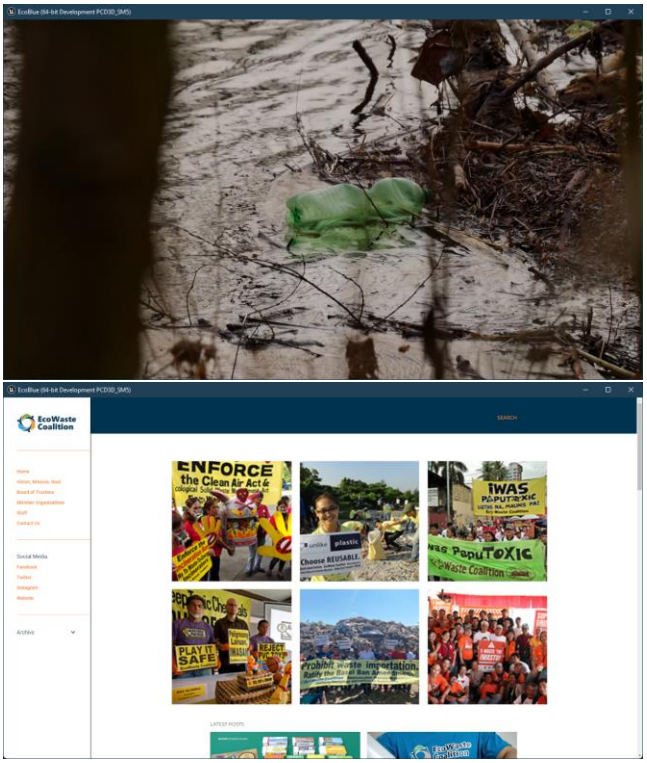


Figure 13: Intro Video and Game End Advertisements to Convey the Message.

The whole game revolves around protecting the river marilao from getting polluted and conveying the message to prevent river pollution. The game ensures that things look as realistic as possible, i.e. more of a simulation and less of a game. No game menu, No reviving after dying.

5 Evaluation

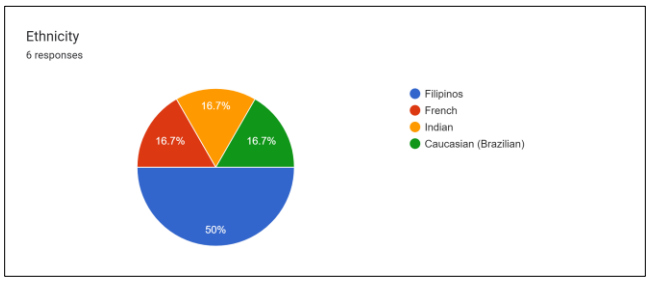
The MEEGA+ model is used to evaluate this project since it is a renowned evaluation model for educational games.

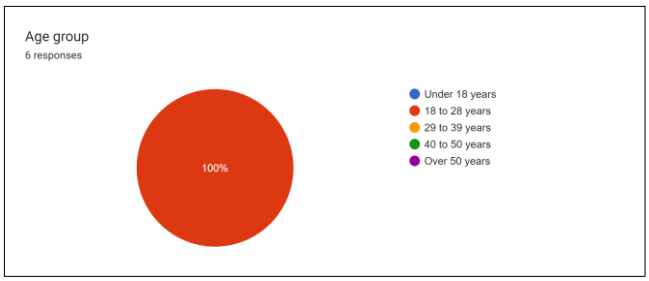
Figure 14: The MEEGA+ model [24]

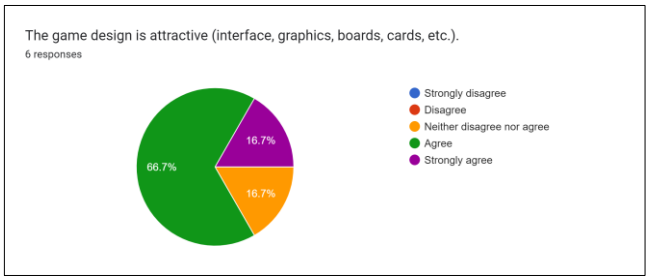
The model is divided into two quality factors, "Usability" and "Player Experience", and their dimensions (Figure 5). Usability is the degree to which the targeted audience can use the product to achieve specified goals effectively and efficiently in a specific context of the use, consisting of the following dimensions: aesthetics, learnability, operability, and accessibility. Player experience is a quality factor that includes deep involvement of the player in the gaming task, including their perception of learning, feelings, pleasures, and interactions with the game, environment and other players, consisting of the following dimensions: focused attention, fun, challenge, social interaction, confidence, relevance, satisfaction, and perceived learning [25].

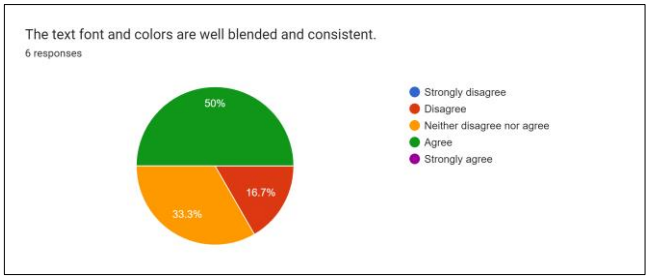
GQS Software Quality Group's website provides a ready-to-use kit (including a questionnaire and analysis spreadsheet) for the MEEGA+ model. It is applied in a one-shot and post-test research style and can be used quickly in a non-intrusive way after the application of the game, thus making it the best suitable option for evaluating our educational game [24].

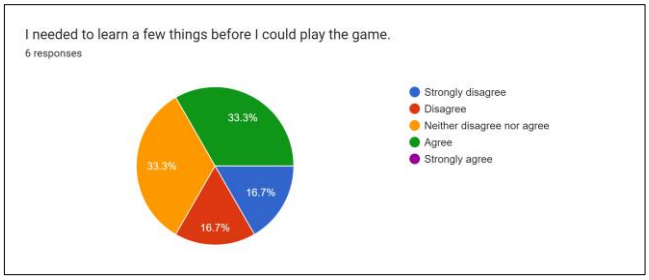
The results of the evaluation are shown below:

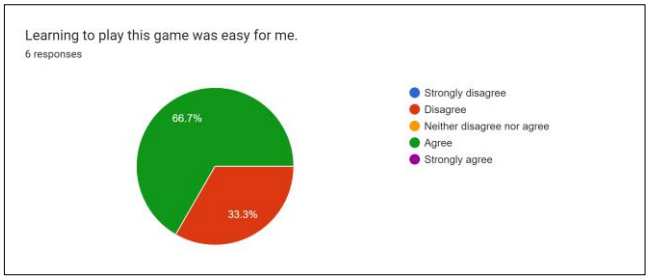


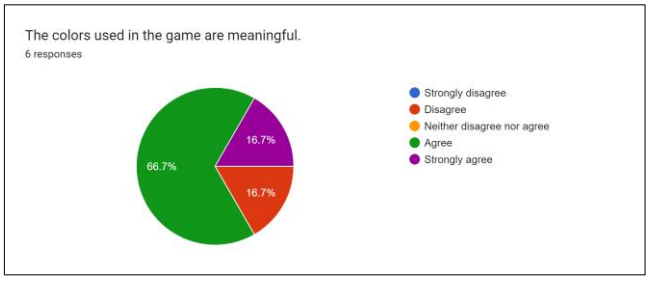












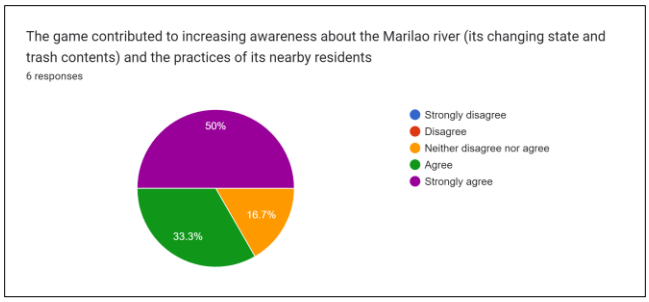


Figure 15: Analysis Based on the MEEGA+ model

6 Conclusion

The game captured the attention of quite a wide audience and can spread across the world with versions for different rivers. Some improvements suggested by players include font styles, reducing motion blur and adding good cinematics.

This project could be handed over to NGOs or governments.

Humans can be replaced by metahumans for more realism.

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