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A serious game to increase children's knowledge about the vital role of sharks in marine ecosystems

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TECHNOLOGY
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Department of Information Science and Technology

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I dedicate this dissertation to my parents, grandparents, sister and friends who supported me and provided everything I needed throughout the process of development and writing of the dissertation

Acknowledgment

Finalizing this master's degree is a significant milestone in my life, representing years of dedication, hard work, and perseverance throughout this journey.

I dedicate this dissertation to my family, whose support and encouragement have been my guide throughout this journey. To my parents, for their love, for instilling in me the importance of education and research and for always believing in me. To my sister, for her constant support and belief in me and to my grandparents, for their unwavering love and encouragement that I have received since the day I was born.

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Resumo

Face à alarmante diminuição das populações de tubarões devido à sobrepesca e práticas insustentáveis, torna-se essencial aumentar a consciencialização pública sobre esta crise ambiental. Neste contexto, foi desenvolvido um jogo educativo composto por dois mini-jogos, cujo principal objetivo é mudar as percepções negativas que as crianças possam ter em relação aos tubarões.

O jogo pretende educar os jovens sobre o papel vital dos tubarões na manutenção da saúde dos ecossistemas marinhos, utilizando atividades interativas para que as crianças compreendam os desafios que estas espécies enfrentam devido às ações humanas. Os mini-jogos foram desenhados para serem simultaneamente educativos e divertidos, com mecanismos adaptativos que ajustam a experiência às diferentes características dos jogadores. Esta abordagem permitiu analisar como diferentes perfis de jogadores interagiram com o jogo, avaliando se os dados recolhidos indicavam padrões consistentes ou diferenças significativas entre perfis. A dissertação contribui para o campo dos jogos educativos focados na conservação, promovendo uma mudança positiva nas atitudes das crianças em relação aos tubarões.

Os testes realizados com 38 crianças, com idades compreendidas entre 9 e 11 anos, demonstraram um aumento significativo no conhecimento sobre tubarões e uma mudança positiva na sua perceção. Além disso, observou-se que o jogo se adaptou adequadamente aos diferentes perfis de jogadores, permitindo que todos, independentemente da idade, género ou competências, completassem as tarefas de forma intuitiva. O estudo reforça o papel dos jogos educativos na promoção de comportamentos mais responsáveis e sustentáveis na conservação dos oceanos.

Palavras Chave: *Jogos Sérios*, *Perfis de Jogadores*, *Conservação dos Tubarões*, *Mudança de Percepção*, *Percepção das Crianças sobre os Tubarões*

Abstract

Given the alarming decline in shark populations due to overfishing and unsustainable practices, it has become essential to raise public awareness about this environmental crisis. In this context, an educational game was developed, consisting of two mini-games, with the main goal of changing the negative perceptions children may have about sharks.

The game aims to educate young players about the vital role sharks play in maintaining the health of marine ecosystems, using interactive activities to help children understand the challenges these species face due to human actions. The mini-games were designed to be both educational and fun, incorporating adaptive mechanisms that adjust the experience to the different characteristics of the players. This approach allowed for an analysis of how different player profiles interacted with the game, evaluating whether the collected data showed consistent patterns or significant differences between profiles. The dissertation contributes to the field of educational games focused on conservation, promoting a positive change in children's attitudes towards sharks.

Tests conducted with 38 children, aged between 9 and 11, showed a significant increase in their knowledge about sharks and a positive change in perception. Additionally, it was observed that the game adapted well to the different player profiles, allowing all participants, regardless of age, gender, or skills, to intuitively complete the tasks. The study highlights the role of educational games in fostering more responsible and sustainable behaviors in ocean conservation.

KEYWORDS: *Serious Games*, *Player Profiles*, *Shark Conservation*, *Perception Change*, *Children's Perception of Sharks*

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CHAPTER 1

Introduction

This chapter is structured to provide a comprehensive foundation for the study. It begins with an overview of the motivation behind the research (Section 1.1), explaining the critical ecological role sharks play and the urgent conservation challenges they face due to human activities. The objectives, presented in Section 1.2, outline the dual goals of the study: to educate children about sharks and to transform any negative perceptions they may hold. The research questions presented in Section 1.3. explore the key questions guiding the investigation, focusing on the educational impact of serious games and their ability to shift children's perceptions of sharks. Afterwards, in Section 1.4, the research hypotheses are presented with the aim of guiding the evaluation of results and conclusions. Finally, Section 1.5, highlights the significance of the research across educational, societal, and practical domains, emphasizing its potential contributions to environmental awareness and conservation efforts.

1.1. Motivation

Sharks, as apex predators, play an indispensable role in maintaining the health of marine ecosystems globally with more than 500 different species. Their ability to thrive in a wide range of environments across the world's oceans, from warm tropical waters to cold polar regions, and from deep-sea areas to shallow coastal zones, depicts their significance in regulating marine populations by preying on weak and sick individuals all over the globe [3], [4].

A comprehensive understanding of shark conservation requires considering ecological, economic, and social dimensions. Sharks have existed for over 400 million years, surviving multiple mass extinction events due to their adaptability and the crucial role they play in marine ecosystems [5].

Ecologically, sharks play a crucial role in maintaining the balance of marine ecosystems. Their absence can trigger uncontrollable population growth of prey species, which in turn overconsume organisms that feed on plankton. This chain reaction can lead to overgrazing of seagrass beds and coral reefs, causing the degradation of these vital habitats [5].

Economically, sharks contribute to various industries, including fishing and tourism. Shark ecotourism has become a significant industry in many regions, where live sharks are valued more than dead ones. For example, shark tourism in the Bahamas has created jobs and generated substantial revenue [6]. However, economic incentives for shark fishing, especially for fins, liver oil, and meat, continue to drive overexploitation. Despite

international efforts to regulate and reduce shark finning, demand for shark fins, primarily for shark fin soup, remains a significant threat [7].

Socially, cultural narratives and media portrayals have shaped the public's perception of sharks. Often depicted as dangerous predators in films like *Jaws* and sensationalized media reports, this negative image influences public attitudes and complicates efforts to garner support for shark conservation. Education and awareness campaigns are critical to shift public perception and to highlight the ecological importance and plight of sharks [8].

The legal and policy context is also crucial in shark conservation. International agreements, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), have listed several shark species in order to regulate their trade and ensure sustainability. Regional fisheries management organizations (RFMOs) and national governments have implemented measures, such as fishing quotas, marine protected areas (MPAs), and bans on shark finning. However, enforcement remains a challenge due to the high value of shark products and the often illegal nature of the trade [9].

Additionally, habitat destruction aggravates these threats. Coastal development, pollution, and climate change are degrading critical shark habitats like coral reefs, reducing their quality and availability. Sharks also fall victim to bycatch, i.e, accidental capture in fishing nets intended for other species, further threatening their survival. These combined pressures have pushed many shark species toward extinction, highlighting the urgent need for comprehensive conservation efforts [10], [11].

Given sharks' crucial role in marine ecosystems, their extinction could have severe and far-reaching effects on multiple environments [12] as mentioned before. Engaging children in learning about these challenges is part of the solution. Innovative educational strategies are essential for raising awareness and promoting conservation actions.

The ongoing digital revolution is reshaping education, with children increasingly using technology in their daily lives, beyond traditional classroom settings [13]. Early education is vital for raising awareness about pressing issues, such as shark conservation. According to Piaget's stages of development, the Concrete Operational phase, occurring between ages 7 and 11, is characterized by enhanced logical thinking and organization [14]. This phase presents an ideal opportunity to address important topics, like shark conservation. Children often perceive sharks negatively, viewing them as aggressive and dangerous [15]. Changing these perceptions can not only increase knowledge but also influence family attitudes towards these animals [16], potentially advancing the field of perception change through interactive digital tools. Serious games offer a compelling method to achieve this by providing engaging and enjoyable learning experiences that tap into children's natural curiosity and motivation [17].

Exploring the potential of universal and adaptable games according to diverse player types could enhance engagement and effectiveness. This personalized approach aims to

align with varied motivations, promoting effective learning and fostering a deeper understanding of conservation issues [18].

Serious games, which integrate entertainment with educational content, represent a promising approach to engaging audiences, particularly children, during their formative years when behavioral changes are most likely [19], [20]. These games can address complex issues like shark conservation in an engaging and effective manner.

This dissertation presents a serious game designed and developed by the author with the goal of enhancing children's understanding and appreciation of sharks. The goal is to evaluate the effectiveness of this game in altering perceptions and increasing knowledge about sharks. Targeted at young audiences, the game aims to foster early awareness and positive attitudes towards shark conservation by addressing negative views and enhancing knowledge. Through interactive gameplay, the game provides engaging learning experiences that challenge misconceptions about sharks and highlight their vital roles in marine ecosystems. The game unfolds through various stages, each crafted to educate players about shark biology, behavior, and conservation challenges.

1.2. Objectives

The primary objective of this study is twofold: first, to increase children's awareness of the critical role sharks play in maintaining the health and balance of marine ecosystems, and second, to challenge and transform any negative perceptions they may have about these essential ocean creatures. To achieve these goals, an interactive and fun serious game was developed by the author in the context of this dissertation, featuring two engaging mini-games, designed to address different issues sharks are currently facing, including misconceptions that are still prevalent among the public.

In addition to educating children, this research aims to verify if there is any correlation between user preferences based on their individual user-type profiles and game parameters. To ensure that the game is automatically adequate for different player types, a set of adaptive mechanism were included.

Ultimately, the overarching goal of this dissertation is to advocate for the conservation of sharks and to contribute actively to efforts aimed at preventing their extinction as well as contribute to the use of serious games to not only change perceptions of children about certain subjects and possible behavior change but to also explore the possibility of using it as tool for marine conservation. By empowering children with knowledge and fostering a sense of responsibility towards marine conservation, this research aims to inspire not only individual action but also broader societal awareness and support for protecting shark populations and preserving marine biodiversity.

1.3. Study relevance

The relevance of this study spans several domains, which will be elaborated in the paragraphs that follow. In terms of educational impact, the dissertation aims to raise environmental awareness among children. By correcting misconceptions and using games

as a medium for learning, it provides an engaging approach to introduce young learners to a complex environmental topic.

From a research perspective, this interdisciplinary study intersects fields, such as education, environmental science, psychology, and game design. It seeks to contribute new insights into how gamification can influence attitudes and behaviors towards conservation. Thereby contributing to shark conservation efforts.

On a societal level, the study supports conservation efforts by educating future generations about the importance of marine ecosystems and sustainable practices. By engaging communities through schools and educational programs, it promotes broader awareness and action towards achieving global sustainability goals, such as life below water and quality education.

Practically, integrating serious games into schools offers a structured approach to complement traditional teaching methods. It encourages parental involvement by fostering discussions at home about environmental issues, thereby reinforcing learning beyond the classroom.

In conclusion, this study seeks to address critical questions about children's perceptions of sharks and the potential of serious games. Additionally, this dissertation focuses on the broader implications for education, research, society, and sustainable development. By leveraging gamification methods and interdisciplinary approaches, it aims to make a positive impact environmental education, conservation efforts and use serious games for changing children's perception about sharks.

1.4. Research Questions

The questions guiding this study are the following:

R1 - Can serious games contribute to educating children about the vital role of sharks?
R2 - Can serious games change children's perceptions of sharks?
R3 - Can serious games adapt to every user type and skill level?
R4 - How do children aged 7 to 11 perceive sharks?

These questions reflect the aim of this study to explore and address several critical aspects, which will be detailed in the following paragraphs. First, the study seeks to determine whether serious games can effectively educate children about the essential role of sharks in marine ecosystems. Sharks are often misunderstood and unfairly depicted as dangerous predators, which has contributed to a lack of concern for their conservation. By immersing children in interactive gameplay, these serious games aim to counteract these misconceptions. Through engaging narratives and challenges, children can learn about the ecological significance of sharks, fostering a deeper understanding and appreciation for marine life. The ultimate goal is to cultivate environmental awareness and a sense of care from an early age, empowering the next generation to take active roles in conservation efforts.

Secondly, the study explores whether serious games can be effectively used to alter children's perceptions of sharks. Serious games, designed with educational purposes in mind, have the potential to provide engaging, interactive experiences that go beyond traditional learning methods. By integrating educational content into gameplay, these games can create immersive environments where children learn about sharks' ecological importance and conservation needs in a fun and memorable way.

Understanding how games can influence attitudes is essential, as this approach offers a unique opportunity to address broader concepts related to conservation. If serious games prove successful in changing perceptions about sharks, this model can be adapted to other environmental and conservation issues. The underlying principle is that interactive and engaging content can foster empathy, knowledge, and positive behavioral changes in children.

Additionally, the study investigates the potential correlations between different user types and specific game parameters. By analyzing these relationships, the research aims to use adaptation mechanisms throughout the experience to make the game useful and engaging for every player type. This understanding could then be applied to design games that are adaptable and can motivate multiple player-types, enhancing both engagement and educational effectiveness.

Lastly, the study seeks to provide a comprehensive overview of how children aged 7 to 11 currently perceive sharks. Understanding these baseline perceptions allows for the development of targeted educational strategies within the game, ensuring that the content directly addresses the most prevalent fears and misunderstandings. Furthermore, this understanding of children's initial perceptions is vital for evaluating the impact of the game; by comparing pre- and post-game attitudes, the study can assess how effectively the game has reshaped children's views and contributed to a more informed and positive perception of sharks. Ultimately, this aspect of the study aims to contribute to broader educational goals, using the case study of sharks to explore how serious games can influence young minds and foster a deeper understanding of complex environmental issues.

1.5. Research Hypotheses

The following hypotheses guide the investigation into the educational benefits of serious games, particularly in the context of marine life conservation. This research focuses on how these games might influence children's understanding and perceptions of sharks, and how they can be adapted to different user types and skill levels. The hypotheses address the educational impact, perceptual shifts, adaptability, and pre-existing attitudes among children aged 7 to 11.

H1 - Serious games contribute to educating children about the vital role of sharks.

This hypothesis is based on the principle that interactive and immersive learning experiences can enhance both understanding and retention of information, as supported by several studies [21] [22] [13] [17] [18]. This research specifically

investigates whether serious games can effectively educate children about the crucial ecological role of sharks, extending the general findings on interactive learning to a specific context.

H2 - Serious games positively change children's perceptions of sharks.

Building on the first hypothesis, this one explores whether serious games can not only educate but also shift children's perspectives on sharks. While the educational efficacy of games is documented, there is limited research on their ability to alter perceptions, particularly about sensitive topics like sharks, which may evoke fear.

H3 - Serious games can adapt to various user types and skill levels through adaptation mechanisms.

This hypothesis regarding the adaptability of serious games to various user types and skill levels was made because personalization and adaptivity can be used in order enhance user engagement, motivation, and acceptance. For heterogeneous user groups, such as children with varying skill levels, customized experiences that respond to individual traits are particularly beneficial. By incorporating adaptation mechanisms, serious games can be tailored to meet the diverse needs of children, enhancing both their educational impact and inclusivity. [23]

H4 - Children aged 7 to 11 have negative preconceptions of sharks before playing the game.

This hypothesis is designed to establish a baseline of children's attitudes towards sharks prior to engaging with the educational game. It is based on the assumption that cultural influences and media portrayals contribute to negative preconceptions among children in this age group. Identifying these pre-existing attitudes will allow for a clearer measurement of the game's effectiveness in changing perceptions and improving understanding.

These hypotheses provide a structured framework for evaluating the impact of serious games on children's knowledge, perceptions, and engagement in marine life conservation. By addressing these aspects, the research aims to enhance understanding and foster a positive attitude towards sharks and conservation efforts.

1.6. Academic Work Dissemination

In July of 2024, a paper was submitted and accepted to be presented at the 2024 International Conference on Computer Graphics and Iteration (ICGI) with a detailed explanation of the study and its findings. The paper is structured to offer a thorough overview of the research conducted and the results obtained, highlighting the contributions made to the field.

The paper begins with an introduction to the study's subject, setting the context and outlining the significance of using serious games for marine life conservation, particularly in altering children's perceptions of sharks. This section provides a foundation for understanding the objectives and scope of the research.

Following the introduction, the paper includes a review of relevant literature and previous work that informed the development of the game. This review situates the study within the broader academic discourse, identifying key studies and theoretical frameworks that guided the research approach and design decisions.

A substantial portion of the paper is dedicated to detailing the game design and development process. This section offers technical insights into the creation of the serious game, covering aspects, such as design principles, development methodologies, and implementation strategies. It provides a clear narrative of how the game was developed to meet the educational objectives of the study.

The final section of the paper presents an evaluation of the game's impact on children's knowledge and perceptions of sharks. This evaluation includes an analysis of the data collected through pre- and post-game assessments, offering insights into how effectively the game met its educational goals and influenced children's attitudes towards sharks. Additionally a video was made show casing a game playthrough [24].

1.7. Organization of the dissertation

The dissertation is organized into chapters that collectively examine the use of serious games in shark conservation education. Chapter 2 lays the groundwork by discussing the ecological significance of sharks, the threats they face, and the potential impact of serious games on children's perceptions. It introduces Marczewski's Hexad framework for aligning gaming experiences with personality types and highlights additional essential related work pertinent to this study.

Chapter 3 details the project's overview and the various phases of game development. This chapter includes technical specifics, the technologies used, and the crucial aspects necessary to create a realistic and engaging game.

Chapter 4 covers the experimental design, ethical considerations, and study results, focusing on changes in children's perceptions and knowledge of sharks, as well as the game's effectiveness as an educational tool. It also examines the relationship between game parameters and player types.

Finally, Chapter 5 summarizes the study's contributions to shark conservation education. It also suggests directions for future research, providing insights into how the study could be expanded or refined.

CHAPTER 2

Related Work

This chapter covers key concepts foundational to the dissertation, including the ecological role of sharks, threats, and conservation efforts. It explores the use of serious games in education, their impact on children's perceptions, and aligns gaming experiences with personality types using Marczewski's Hexad framework. The chapter concludes with the impact and applications of serious games in education.

There are 4 crucial areas in this dissertation: serious games, game personality types, sharks and children. The scheme depicted in Figure 2.1 shows in detail how all the important areas fit into the dissertation. It depicts how each area connects and their intersection results and support the main idea of the dissertation and its different components.

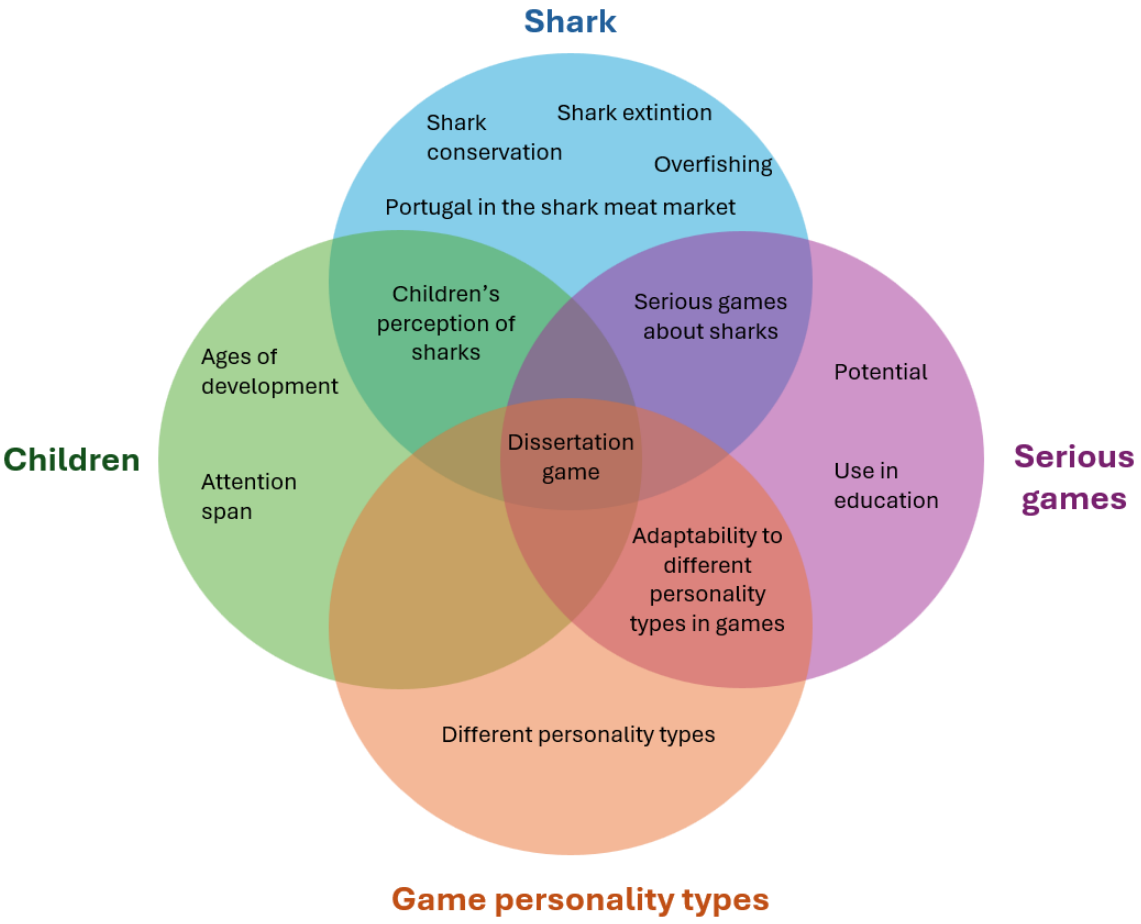

FIGURE 2.1. Scheme depicting the areas in interdisciplinary approach of this dissertation

2.1. Sharks: Ecological Significance, Threats, and Conservation Efforts

Many populations of different shark species, occupying mostly the role of apex predators, have a pivotal role in maintaining marine ecosystems globally. Their adaptability spans diverse habitats, ranging from tropical seas to polar regions, highlighting their significance in regulating marine populations [3]. With over 500 species, sharks exhibit remarkable diversity in morphology, behavior, and ecological functions, enabling them to manage prey populations effectively, preventing overpopulation, and ensuring a balanced food web. By targeting weaker individuals, sharks enhance the overall resilience and health of marine communities [4].

However, despite their ecological importance, sharks face multiple threats from human activities, the most significant of which is overfishing. Overfishing occurs when too many fish are caught, causing a populational loss. This can result in fewer fish, and although the population might stabilize, it remains in an overfished condition. Extreme overfishing, where the hunting that causes a decline consistently surpasses any increase, can lead to continuous population decline and even potential extinction [25].

Historically, during the 1940s, the emergence of several target shark fisheries was driven by the demand for vitamin A [26]. Later, around 1980, there was a rise in pressure on shark and ray populations, coinciding with an increased demand for shark fins [27]. This global phenomenon resulted in a rise in both targeted and incidental shark catches, reaching its peak in the early 2000s. During this apex year, 63–273 million sharks were hunted for various purposes, including meat, fins, gill plates, and liver oil. As concerns over the impact of overfishing on shark populations and marine ecosystems escalated, warnings about the potential extinction of sharks emerged [28].

Portugal, along with Spain, France, and the UK, holds a significant role in European chondrichthyan (shark and rays) fisheries, contributing to the top 20 shark-catching nations worldwide. In 2020, Portugal was ranked 2nd among European Union nations for shark fin imports as shown in Figure 2.2, which demonstrates its high involvement in shark fisheries [1]. The EU is a major supplier of shark fins to Asian markets, with discrepancies in the reports that range from 1,650.08 to 2,318.18 metric tons of fin exports than the ones reported [1], this difference is depicted in the Figure 2.3. Shark catches are considered 3-4 times higher than the ones recorded by the United Nations Food and Agriculture Organization (FAO) [29].

The impact of overfishing on shark populations has become a significant concern. The extensive declines observed in many widely distributed shark species suggest that local recovery efforts may be challenging. These declines are indicative of a broader issue, signaling a gradual weakening of shark populations. This weakening increases the risk of extinction for these species within the global marine environment. Addressing this issue requires a deep understanding of the potential for localized recovery and the broader implications for global shark conservation.

	Reported sources	Total reported trade (metric tons)
1st	Spain	51795
2nd	Portugal	642
3rd	Netherlands	621
4th	France	295
5th	Italy	25

FIGURE 2.2. Top five EU member state sources for shark fin imports into Hong Kong SAR, Singapore, and Taiwan province [1]

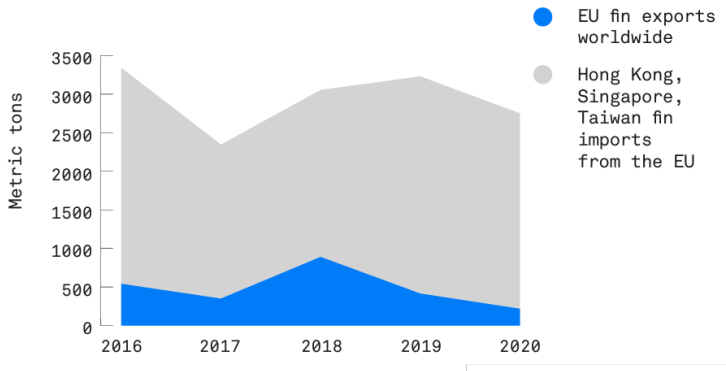

FIGURE 2.3. Data discrepancies between import data from Hong Kong SAR, Taiwan province, and Singapore compared to the EU export data [1]

Chondrichthyans represent one of the oldest and most diverse vertebrate lineages, with their origins dating back approximately 420 million years ago, this group contains animals like sharks. Research indicates that at least 28 of these populations more specifically sharks are locally or regionally extinct, with some species not sighted for several decades. This highlights the urgency of addressing the threats facing these animals to prevent further losses in biodiversity and ecosystem function [9].

To address these threats, it is essential to develop innovative educational strategies that raise awareness and encourage conservation efforts. Serious games, which blend entertainment with educational content, are a promising approach for engaging audiences, especially children, as this is a critical period for fostering behavior change [20]. By focusing on young audiences, the game developed in this dissertation aims to build early awareness and positive attitudes toward shark conservation, enhancing children's knowledge and shifting any negative perceptions they may have about these animals.

2.2. Understanding Children's Development and Perception of Sharks

Serious games have emerged as a dependable and efficient tool in educational methodologies, offering benefits across multiple areas, such as education, psychology, and medical fields. They enhance learning by making scientific concepts more accessible, improving thinking skills, and fostering a positive and effective learning environment [21]. Users tend to feel more motivated and exhibit better retention of concepts through serious games

compared to traditional methods, highlighting their potential to transform educational practices.

In the context of education, serious games allow for flexible learning experiences that cater to diverse learning styles and preferences. They promote collaborative learning, cross-cultural communication skills, and teamwork, enhancing both learning outcomes and satisfaction [22]. Despite some drawbacks, such as potential increases in mental workload, the overall benefits of serious games outweigh these concerns, making education a more engaging and interactive experience.

In addition to education, serious games have the potential to address critical conservation issues, including shark conservation. However, serious games specifically focused on sharks are relatively scarce. Many existing studies incorporate sharks as part of broader marine conservation efforts rather than as the sole focus [30]–[32]. Incorporating sharks into serious games can effectively raise awareness and educate the public about the importance of shark conservation, leveraging the interactive and immersive nature of games to engage audiences of all ages.

Children often perceive sharks as "bad" animals that simply feed on and attack marine organisms. In a study conducted with children aged 9 to 10 [15], they were asked to draw sharks and list three words that came to mind when they thought of these animals. Initially, the majority of words were negative, and drawings often showed sharks in aggressive behaviors, such as eating prey. However, after being introduced to a textbook that provided more information about sharks, many children changed their initial opinions. When asked to list another three words, they used more positive ones, such as "like me", "cool" and "amazing" and fewer negative ones like "vicious" "mean" and "scary". This study highlights the impact of education and knowledge on children's perceptions of sharks, showing that with the right information, they can develop a more positive and informed view of these animals, although the study notes that it represents only a small portion of students and the long-term effects are still unknown.

To better understand the potential for educational interventions to change children's perceptions of sharks, it is important to consider the stages of child development as outlined by Swiss cognitive theorist Jean Piaget [14]. Piaget defined multiple stages of development:

- **The Sensorimotor Stage** (Birth to 2 years old): Infants and toddlers engage in cognitive processes through their sensory and motor interactions, including their eyes, ears, and hands.
- **The Preoperational Stage** (2 to 7 years old): There is a significant increase in mental capabilities.
- **The Concrete Operational Stage** (7 to 11 years old): Children become more logical, flexible, and organized. Their reasoning is sharpened, becoming more similar to adults'.

- **The Formal Operational Stage** (11 years old and up): There is a development of abstract and scientific thinking.

Focusing on children aged 7-11 years old is particularly useful because their reasoning abilities are approaching those of adults. Additionally, they have the potential to influence their family's behavior. At this age, they are mature enough to comprehend the significance of sharks and their conservation efforts, making them the ideal target audience [14].

Another important consideration is children's attention span. Studies indicate that attention spans increase with age [33]. Research findings show that children aged 5-7 typically have an attention span of approximately 15 minutes, which extends to around 20 minutes for those aged 7-10, and fluctuates within the range of 25-30 minutes for children aged 10-12. However, pinpointing an exact duration for attention spans in children is challenging since it varies individually [34]. Considering this, the decision was made to ensure that the mini-games being developed last no longer than in total approximately 30 minutes, as this aligns with the upper limit of the desired attention span range for children aged 7 to 11.

By targeting young audiences, these educational interventions aim to instill early awareness and positive attitudes toward shark conservation. The goal is to increase children's knowledge and address any potential negative perceptions they may have about these animals, thereby fostering a generation that values and actively engages in conservation efforts.

2.3. Personality Alignment in Gaming

Marczewski introduced a framework containing six distinct user types [2], each exhibiting varying degrees of motivation from intrinsic (e.g., self-realization) or extrinsic (e.g., rewards) factors as it is depicted in Figure 2.4. The user types and their corresponding game design elements proposed by Marczewski will be now outlined:

- Philanthropists find their drive in purpose, with a proposed framework including collection and exchange, giving, sharing knowledge, and administrative responsibilities.

- Socializers are fueled by a sense of connection, with the suggested design elements consisting of guilds or teams, social networks, social comparison, social competition, and social discovery.

- Free Spirits are driven by a desire for autonomy, with the suggested design elements encompassing exploratory tasks, nonlinear gameplay, Easter eggs, unlockable content, creativity tools, and customization.

- Achievers are inspired by a quest for competence, with the suggested design elements including challenges, certificates, acquiring new skills, quests, levels or progression, and epic challenges.

- Players are driven by external rewards, with the suggested design elements comprising points, rewards or prizes, leaderboards, badges or achievements, virtual economy, and lotteries or games of chance.

- Disruptors are propelled by instigating change, with the suggested design elements including innovation platforms, voting mechanisms, development tools, anonymity, and rebellious gameplay.

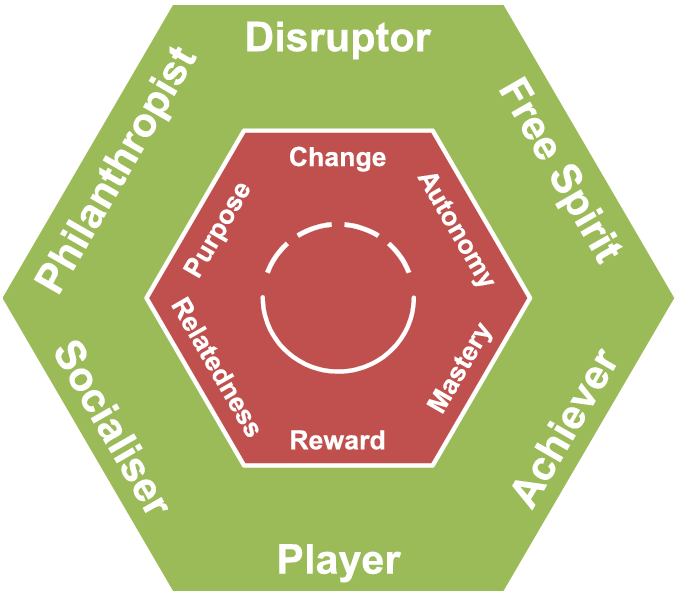

FIGURE 2.4. Gamification User Types Hexad [2]

While some motivations underlying these user types are interrelated, there is slight overlap among the user types themselves. Achievers and Players share a motivation for achievement, yet they diverge in their focus: Players prioritize extrinsic rewards, whereas Achievers prioritize competence. Similarly, Philanthropists and Socialisers both seek interaction with other players, but their motivations differ; Socialisers are driven by the interaction itself, while Philanthropists are motivated by interaction to assist others. Lastly, Free Spirits and Disruptors are both motivated by autonomy and creativity. Free Spirits stay within the system's rules without wanting to change them, while Disruptors want to go beyond those rules to make changes.

Finally, it was decided for this dissertation to develop two mini games that seek to satisfy the needs of every player with no biases for a specific type [2].

2.3.1. Personality alignment with the game being played

The user type model in use in this dissertation is the Hexad user type, which has over 700 mentions in articles and it is a more expanded version of the initial one made by Bartle. Utilizing the Hexad model to personalize games involves identifying users' predominant user types and selecting appropriate game design elements for each player type. This approach has shown promising outcomes in terms of enhancing user acceptance and user performance. Nevertheless, despite these benefits, the broader benefits of utilizing the hexad model in gamification research remain uncertain. There is still doubt on whether the investment in tailoring a game according to this model justifies the expected motivational

and behavioral effects since a recent study has shown no substantial advantages [35]. This dissertation study explores the correlations between user types and the mini-game that the user likes the most, playing frequency and game parameters. This seeks to validate the game as a tool that satisfied and involved, in similar ways, all different player types that participated in the study, through the use adaptability mechanisms.

2.4. The Impact and Educational Applications of Serious Games

In the realm of education, serious games facilitate flexible learning environments that cater to diverse learning styles and preferences. They encourage collaborative learning and cross-cultural communication, essential skills in today's interconnected world [22]. Despite some disadvantages, such as potentially increasing mental workload without proportional gains in learning effectiveness, the overall benefits of serious games in education are substantial [22].

However, uncertainties remain regarding the optimal integration of serious games into formal education systems, pointing to the need for further research and development in this area [21]. This ongoing interest underscores the potential of serious games to enhance educational outcomes and engage learners more effectively than traditional instructional methods.

In the context of environmental education, serious games focused specifically on shark conservation are limited. Many studies incorporate sharks as part of broader marine conservation efforts rather than as the central theme [30]–[32]. Integrating sharks as focal points in serious games is expected to raise awareness and foster positive attitudes toward shark conservation among diverse audiences.

In conclusion, while serious games have shown promise in various educational contexts, including environmental education, their full potential to transform learning experiences and foster conservation behaviors requires further exploration and development. This is especially true in the context of shark conservation, where the unique challenge of overcoming the fear factor adds a distinct dimension to the broader application of serious games in marine conservation efforts.

2.5. Teaching about sharks with serious games

This section explores a spectrum of additional/previously mentioned articles and studies relevant to the development of the present study, focusing on the utilization of serious games to alter children's perceptions and enhance their knowledge about sharks. While the literature lacks a specific focus on serious games and sharks, several studies provide valuable insights into environmental awareness and conservation efforts. Each of the following paragraphs will further explain studies that related to this dissertation and provide a strong foundation about the current literature on the subject.

Nicole Warren and Rachel Yoho conducted a study [15] to assess how storybooks could change children's negative perceptions of sharks. Using a pre-test/pos-test design, children read a book about Sand Tiger Sharks [36], incorporating personal connection text

and factual information. The study found that incorporating personal connection text in storybooks about Sand Tiger Sharks led to more positive perceptions among children. After reading the books, children used terms like "helpers" and "boss of the ocean" to describe sharks, indicating a shift towards viewing them in a more favorable light.

Rossano et al. [37] introduced a serious game designed for primary school children to educate them about marine litter and endangered species in the Mediterranean Sea. The game aimed to cultivate ecological skills and positive environmental attitudes among students, with initial findings from pilot studies showing strong appreciation and perceived usefulness among both students and teachers. Their study highlighted the effectiveness of the game in enhancing ecological knowledge and fostering environmental attitudes among primary school students.

Veronica and Calvano [38] developed a serious game and an explanation video to promote sustainability behaviors among children, specifically addressing marine litter Mediterranean sea. Evaluations demonstrated that these educational tools effectively increased children's awareness and knowledge of marine conservation issues, highlighting the potential of game-based learning to foster sustainable practices and environmental stewardship.

Additionally, the study titled "Point of Contact: Investigating Change in Perception through a Serious Game for COVID-19 Preventive Measures" offers relevant insights [39]. This research examined how a serious game could alter people's perceptions and behaviors regarding COVID-19 preventive measures. The study found that serious games could effectively enhance participants' awareness and adherence to preventive practices, such as social distancing, mask-wearing, and hygiene. The game led to significant improvements in participants' understanding of these measures and observed behavioral changes. Furthermore, it was noted that serious games increased engagement and motivation compared to traditional educational methods, suggesting they are a valuable tool for public health education.

Lastly, the study with the title "Shark Conservation: An Educational Approach Based on Children's Knowledge and Perceptions toward Sharks" [40] investigated the perceptions of 11 to 12-year-old primary school students in Hong Kong regarding sharks and their ecological significance. The study highlighted that these students had limited knowledge and held misconceptions about sharks. The study emphasized the need for long-term educational efforts to improve public understanding and manage the demand for shark fins, especially given the cultural context in Hong Kong. This research provides important baseline data for designing effective educational interventions aimed at enhancing shark conservation awareness among younger generations.

These findings collectively indicate that interactive educational tools, such as serious games, can effectively enhance children's understanding of environmental issues and encourage positive attitudes towards conservation efforts.

2.6. Discussion

A discussion about the previously mentioned studies reveals common themes and insights into the use of serious games in environmental education:

(1) **Current perception and knowledge and their correlation:** The study conducted by Nicole Warren and Rachel Yoho examines children's perceptions and knowledge about sharks, identifying a correlation between the two [40]. In contrast, this dissertation takes an active approach by employing an engaging educational tool designed to correct misconceptions and enhance knowledge, with a specific aim to improve children's perceptions of sharks.

(2) **Perception change through serious games vs. traditional methods:** Serious games have demonstrated notable advantages over traditional educational methods in facilitating changes in perception. For instance, research on COVID-19 preventive measures revealed that serious games were more effective in improving understanding and adherence to health practices, showcasing greater engagement and retention than conventional methods [39]. Similarly, studies on environmental education by Rossano et al. and Veronica and Calvano [37], [38] found that serious games promoted higher ecological awareness and behavioral changes compared to traditional teaching methods. While these studies do not specifically address sharks, they establish a foundation for how serious games can positively influence perception changes, which is relevant to this dissertation.

(3) **Effectiveness of personal connection and the use of three words to reflect perception:** Creating personal connections through positive narratives and emotional engagement has proven effective in altering children's perceptions. Warren and Yoho's study [15] showed that children responded more positively when they felt emotionally connected to sharks through storytelling. Additionally, using a straightforward method, such as asking children to list the first three words that come to mind when thinking about sharks can effectively gauge their perceptions. This previous study employed a textbook approach to change perceptions, using the straightforward three-word method to retain children's views, which made the process more accessible. This method was also adopted in this dissertation. However, as highlighted in other research, serious games provide a more dynamic and interactive tool for effectively influencing children's perceptions than traditional methods like books.

(4) **Engagement and perceived usefulness:** Research by Rossano et al. and Veronica and Calvano [37], [38] demonstrated high levels of engagement and perceived usefulness of serious games among students and educators. These previos studies found that interactive learning experiences not only capture children's interest but also enhance their retention of ecological knowledge and promote sustainable behaviors. While these studies address conservation broadly, they do

not specifically target shark conservation, which often involves additional fear factors. Furthermore, these studies do not explore player types or their correlations with various parameters.

(5) **Impact on behavior change:** Veronica and Calvano's [38] research highlighted that serious games can lead to observable changes in children's environmental conservation behaviors. By increasing awareness and knowledge, these games empower children to take proactive steps towards environmental protection, such as reducing marine litter. Although this study demonstrates a general impact, this dissertation applies principles specifically to shark education and focuses on changing children's perceptions of an animal that many fear. Unlike the broader studies, this dissertation also explores correlations between player types and different parameters within the serious game in order to access how it can be played and enjoyed by players of all types.

(6) **Educational potential:** The studies reviewed emphasize the educational potential of serious games in complementing traditional teaching methods. By offering interactive and immersive learning experiences, serious games cater to diverse learning styles and motivations, leading to effective educational outcomes. This approach is particularly valuable for changing children's perceptions of sharks by fostering a personal connection between virtual sharks and children, as shown in various studies [15], [37], [38]. Additionally, this dissertation investigates the technological aspects by examining correlations between in-game and out-of-game data to study its universality and accessibility.

The importance of this dissertation lies in its innovative approach to addressing gaps in existing literature on environmental education, particularly regarding children's perceptions of sharks. While previous research has explored the use of serious games and educational tools to promote environmental awareness and behavior change, there is a notable absence of studies focusing specifically on altering children's perceptions of sharks through interactive media. Sharks are often misunderstood and feared, which can inhibit conservation efforts. By integrating serious games as a tool for education, this study aims to fill this gap by directly addressing these misconceptions.

Moreover, this dissertation builds upon existing research that has demonstrated the effectiveness of serious games in shifting perceptions and enhancing knowledge in various environmental contexts. For example, previous studies have shown that serious games can effectively raise awareness about marine conservation and promote sustainable behaviors among children. However, these studies have not specifically targeted sharks, an area where fear and misinformation are particularly prevalent. This dissertation project, therefore, contributes to the field by not only focusing on shark education but also by exploring the role of personality types in shaping how children interact with and learn from serious games. This dual focus on sharks and serious games puts the study in a

place to offer insights into how educational technologies can be leveraged to foster a more positive and informed perception of sharks among younger generations.

CHAPTER 3

Shark Heroes: Game Design and Development

This chapter begins by a detailed explanation of the participatory design process. This process involved a brainstorming session conducted at schools, where children's input helped shape the game's direction. The chapter then explains the final version of the game, incorporating the children's ideas, and discusses the development iterations conducted to achieve the game's final version, to make it more playable and enjoyable. Subsequently, it explores the technologies employed in the study, detailing the processes of terrain generation and environment post-processing. It then focuses on the design of sea creatures' behavior and the organization of assets within the game. Finally, the chapter provides an in-depth overview of the game's functionalities, including a detailed explanation of the controller's use and how it integrates with the gameplay mechanics.

3.1. Participatory Design Approach

3.1.1. Participation of schools

In order to provide a more comprehensive and well-rounded study, several schools were selected to participate in different phases of the research process. Each institution played a pivotal role in contributing valuable insights and feedback, which were essential for refining and validating the educational game developed in this study. By involving multiple schools, the study aimed to gather data from a diverse range of students, ensuring that the results would be broadly applicable and reflective of various educational settings.

Figure 3.1 illustrates the different schools that participated in this study, highlighting the specific iterations in which each school was involved. It also details the number of children who took part in each phase.

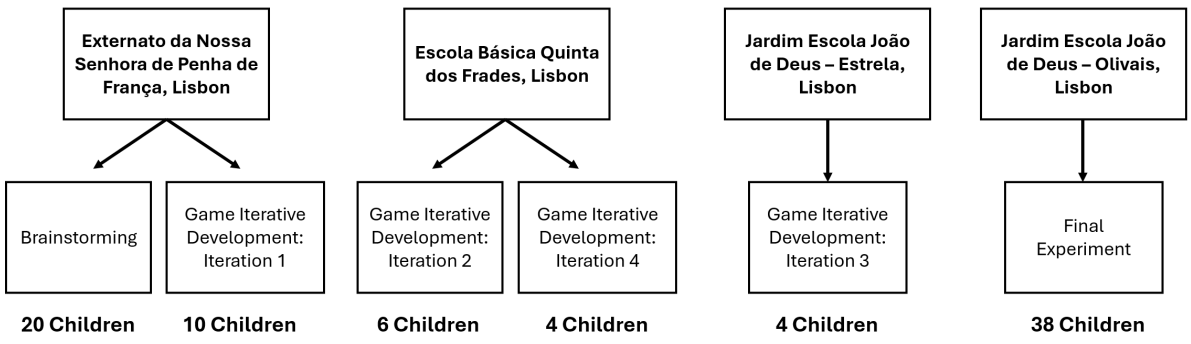

FIGURE 3.1. Scheme showing the different phases throughout the schools

Figure 3.1 underscores the collaborative effort across various educational institutions, showcasing their involvement in the study. It also highlights the diverse group of participants who contributed to the development and refinement of the game.

3.1.2. Brainstorming in schools

Initially, several ideas were internally discussed (Annex A). However, concerns arose about the potential complexity for children, leading to the decision to adopt a participatory design approach instead. The participatory design approach not only made the game development process more inclusive but also sought to enrich the game's content, to make it both educational and engaging. The active involvement of children in brainstorming and iterative development phases ensured that the final product was well-suited to foster positive perceptions of sharks among young players.

The general idea of the serious game was designed and developed with active participation from a group of 20 children, comprising 12 girls and 8 boys with ages between 8 and 10, ($AVG = 9.10$, $STD = 0.64$, where AVG stands for average and STD for standard deviation of the ages). Only four of the children are non-Portuguese, with the majority being Portuguese children. The participatory design approach was used during this phase, which took place in the children's schools to ensure they were as comfortable as possible. This also helped maintain their parents' comfort with the children participating in the experiment, ensuring the game's engagement and effectiveness for the target audience [41]. The process began with a brainstorming session aimed at understanding children's perceptions of sharks and gathering their ideas for a game that could help change negative perceptions and increase some previously not obtained knowledge.

During the initial brainstorming session, the children were asked their opinions about sharks. They were questioned about their views on sharks, estimated how many sharks they think die in an hour, and identified some of the biggest threats sharks face today. This approach was designed to surprise the children, increasing their curiosity and awareness of the importance of sharks in marine ecosystems, while addressing common misconceptions about their danger to humans. This discussion aimed to inform and inspire the children, setting the stage for their creative input. The children were then encouraged to share their ideas for a game that would educate other kids about sharks and promote a more positive image. To facilitate discussion, a shark stuffed animal was passed around, allowing children to speak one at a time in an orderly manner. All proposed ideas, regardless of their relevance to the study, were recorded on a board. Positive feedback was given to each suggestion to encourage children to share their thoughts openly. Later, these ideas were compiled and saved in an Excel sheet for data analysis.

The framework for presenting the ideas given from the children follows a suggestion-relevance model, as shown below in the Table 3.1. Notable suggestions included tracking sharks and monitoring their behavior through players placing trackers on them, arresting illegal fisheries by taking on the role of marine protectors, and removing plastic from the

ocean to raise awareness about marine pollution and directly link environmental conservation with shark protection.

TABLE 3.1. Proposed game ideas by the children

Ideas	**Relevancy to the study**
Tracking sharks and fish	Very relevant
Boat of sharks	Not relevant
Police can arrest illegal fisheries	Very relevant
Help sharks go back to the water	Okay
Destroy illegal fishing boats	Okay
Board games for sharks	Not relevant
Shark soccer	Not relevant
TV shows for sharks	Not relevant
Program to help sharks reproduce	Okay
Give money to sharks	Not relevant
Educate sharks to not bite people	Not relevant
Tell fisherman to not fish sharks	Okay
Arrest people that hunt sharks	Very relevant
Pet sharks	Relevant
Feed sharks	Very relevant
Become friends with sharks and swim on top of them	Not relevant
Shark day	Not relevant
Take plastic out of the sea	Very relevant
Stop who fabricates weapons to catch sharks	Not relevant
Birthdays and funerals for sharks	Not relevant
Labyrinth with surprises on how to save sharks	Okay
Sharks play with people	Okay
Give them food	Very relevant
Help remove trash from sharks	Very relevant
New year for sharks	Not relevant
Minecraft for sharks	Not relevant
Funk dance with sharks	Not relevant
Shoe of sharks	Not relevant
Search inside a shark's mouth	Not relevant
Have a security for sharks to not be hunted	Not relevant
Clean fishes teeth	Not relevant
Help take out trash stuck on sharks	Very relevant
Feed sharks	Relevant
Give shelter to homeless sharks	Not relevant

Among the numerous suggestions, the most relevant ones were selected for inclusion in the game. The final decision on which mini-games to incorporate was based on three key factors:

(1) Effectively conveying knowledge through the game;
(2) Ensuring the game is engaging, fostering a personal connection between the children and the sharks;
(3) Be fun.

In addition to gameplay ideas, feedback was sought on the initial game environment. Using the same framework, these ideas are presented in Table 3.2. Children suggested various enhancements to make the game world immersive and engaging. Among their recommendations were adding assets like whales, large ships, more turtles, a wide variety of fish, and diverse species to enrich the game setting. All the suggestions from the children were carefully reviewed, and those deemed most relevant were incorporated into the game environment.

TABLE 3.2. Purposed additional game elements by the children

Suggestions	**Relevancy to the study**
Huge boat underwater	Very relevant
Plates that say "Do not catch sharks"	Okay
Plates that say "Do not pollute the ocean"	Okay
Add more different species of animals underwater	Very relevant
Add whales	Very relevant
Add a Megalodon skeleton	Not relevant
More turtles	Very relevant
More fish and sharks	Very relevant

Following this collaborative design phase, development focused on creating two mini-games that encapsulated the most promising ideas. These ideas aimed to maximize both enjoyment and educational value for the players.

3.2. Final Game Version

After the brainstorming session, there was the selection of the two final mini-games to be included in the main scene. Then development began. This section offers an overview of the game's final version and components, which were a result of continuous refinement throughout the iterative development phases, discussed in the next section.

The game, developed using the Unity engine, was designed to deliver a comprehensive and immersive experience tailored to be used with a PlayStation 2 controller (DualShock 2). The decision to use a computer connected to a DualShock 2 controller was made due to its flexibility, portability, and the higher engagement it offers, particularly for children. Early stages of the study demonstrated that this setup was quickly adopted, intuitive and enjoyed by the target audience. The game features a structured progression through three distinct scenes, each crafted with specific educational and gameplay objectives to ensure that players remain engaged while also learning valuable information. Additionally, considering that the mean attention span of children between the ages of 7-10 is around 20 minutes and 10-12 year olds is between 25-30 minutes, the decision made was that the mini-games being developed last no longer than 30 minutes in total, as this aligns with the upper limit of the desired attention span range for children aged 7 to 11.

After this brief introduction to key game design decisions, the following sections will detail the game environment, phases of the game and additional gameplay features and educational enhancements as well as how the data collection was done in-game.

3.2.1. Game Environment

As previously mentioned, the children provided additional suggestions for the game environment, outlined in Table 3.2. The final game environment is depicted in Figure 3.2, showcasing how their recommendations were incorporated into the design. This visual serves as an example of how the children's input shaped the overall look and feel of the game. Sharks, different fish species, algae and sunken boats are components present in this environment and the panel at the top depicts a counter for the first mini-game, which will be described in the following sections.

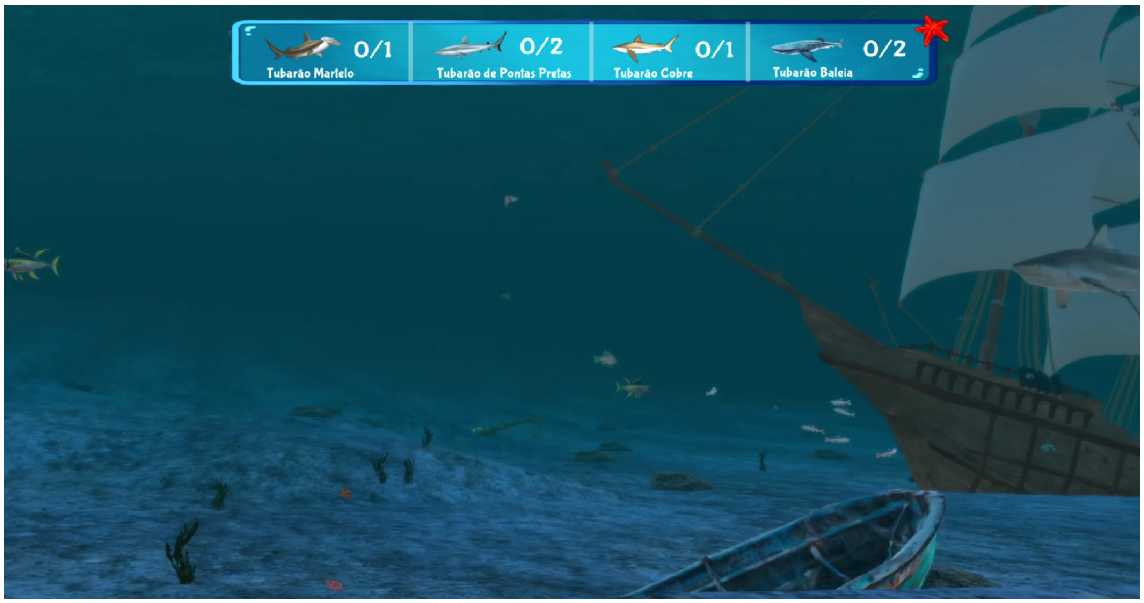

FIGURE 3.2. Game environment

3.2.2. Initial Scene

The initial scene serves as an introduction to the game's educational content, where players encounter a shark knowledge and perception questionnaire. This initial interaction is crucial for setting the stage for the learning experience and the scene, depicted in Figure 3.3, was crafted to engage and captivate players.

The initial scene features a water shader that realistically simulates an oceanic environment, complemented by a skybox that enhances the authenticity of the sky. A boat, scripted to simulate wave motion, further immerses players in the environment. Central to this scene is the diver character, who represents a marine biologist acting as a helper, by giving instructions and motivation to the player throughout the game. This character is animated with series of animations, randomly selected from a predefined set whenever the dialogue text changes. This initial scene not only provides players with instructions but also was made to immerse the players in the game's setting, preparing them for the challenges that lie ahead. The workflow of this scene, illustrating the sequence of events the player experiences and needs to finish in order to move to the next scene, is presented in Figure 3.4.

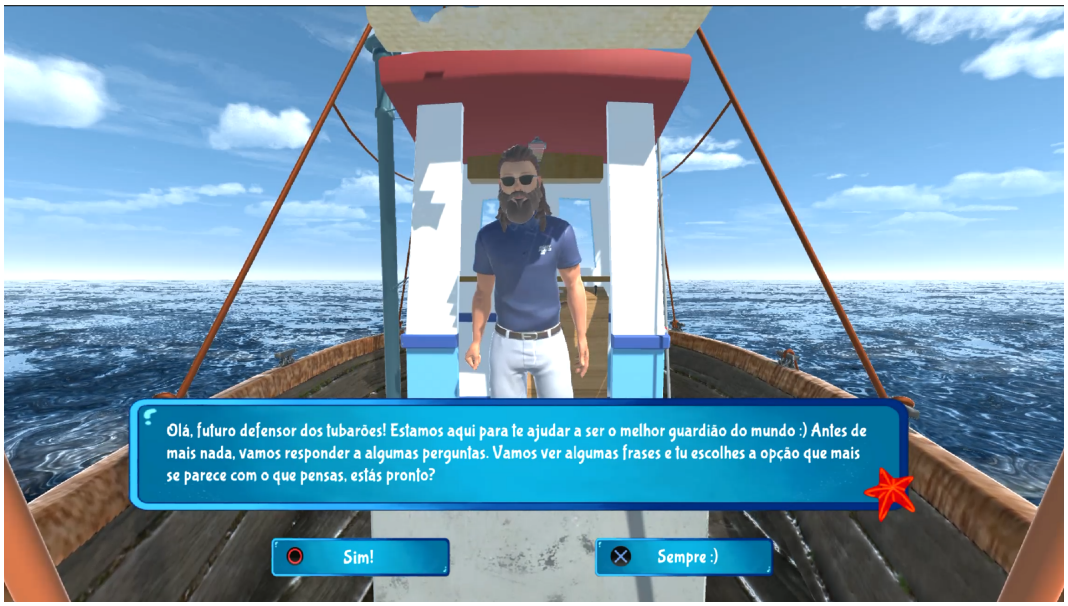

FIGURE 3.3. Initial scene with an embedded questionnaire - A diver explains how the initial scene will proceed and asks the player if they are ready

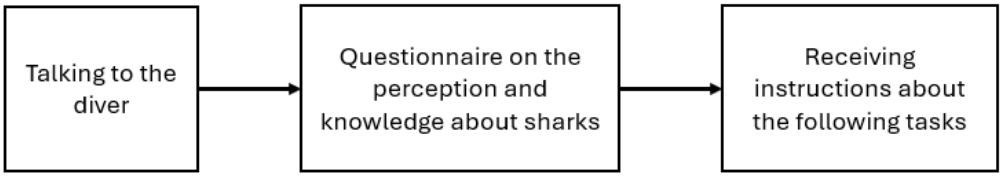

FIGURE 3.4. Initial Scene Workflow

3.2.3. Main Scene

The main scene is enriched by high-quality models and animations imported from Sketchfab [42] via a Unity plugin, ensuring detailed and realistic visual representations. Initially, a broader variety of fish species was included, but these were later removed after a specialist in marine sciences identified that such species would not naturally coexist in the depicted environment.

Upon entering the main scene, the player is presented with a set of instructions from a diver, who will assist them throughout the mini-games. After the player presses a button following the final dialogue, the first mini-game begins.

The first mini-game, *Tracking Sharks*, depicted in Figure 3.5, has players attach tracking devices, equipped with an antenna and a health status light, to different shark species. These devices provide real-time feedback on the sharks' conditions. The tracking process is initiated when the player approaches an untracked shark. Upon detection, a canvas

prompts the player to press a button on the DualShock 2 controller, activating a secondary camera view that follows the shark from the side, allowing the player to monitor the tracking process. The tracker is designed to make contact with the shark's fin using a collider mechanism to ensure it remains attached. If the player fails to track the shark successfully, the tracker encounters a secondary collider, triggering a motivational message to encourage persistence before resetting to its original position. Success in tracking shifts the camera back to the diver's original perspective. To complete this task, players must successfully track a diverse range of sharks, including two blacktip sharks, two whale sharks, one copper shark, and one hammerhead shark, each presenting unique tracking challenges, such as velocity of the tracker and distance to the shark. As players track a specific shark, random facts about the species appear on the left side of the screen for a few seconds, allowing enough time for the player to read and absorb the information. Later, some of these facts are turned into questions during the second task, reinforcing the educational material and testing the player's retention in an interactive way.

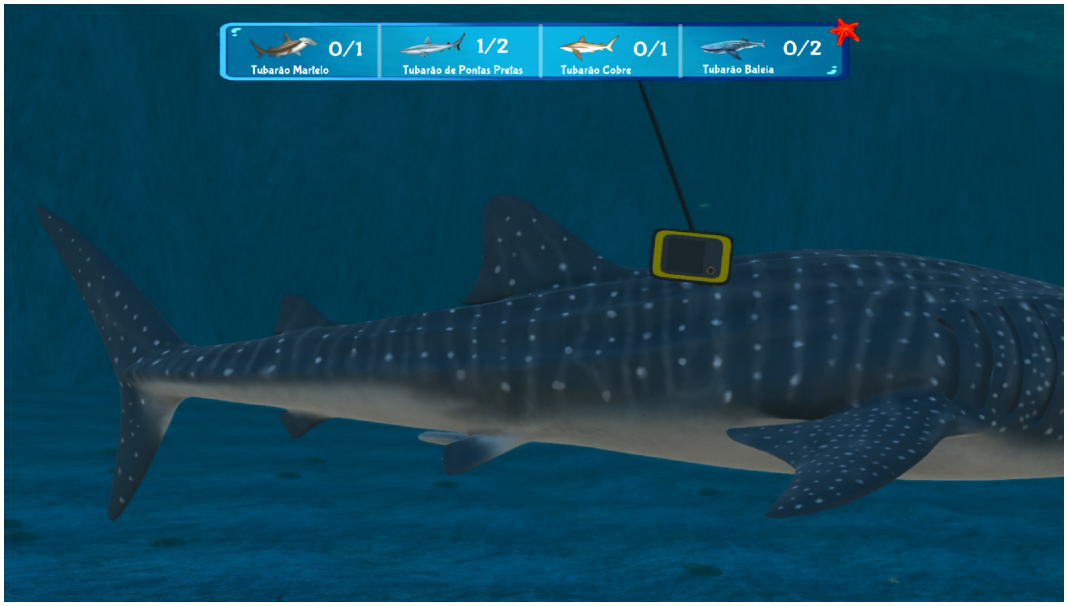

FIGURE 3.5. First mini-game: Tracking shark task

Figure 3.5 depicts a side view of a whale shark as the player attempts to attach a tracker to its dorsal fin. The tracker, represented by a yellow device, is created using a pre-made model and a cylindrical object to simulate the antenna. Additionally, a sphere with an internal light has been added for enhanced detail.

After tracking a shark, players can monitor its movements. They can also check the shark's health level based on the color of the tracker's light (red for injured, green for healthy as shown in Figure 3.6).

The first mini-game seeks to create a personal connection between the player and the shark by performing a proximity action. Throughout the game, facts are presented to enhance the players' knowledge and understanding of sharks.

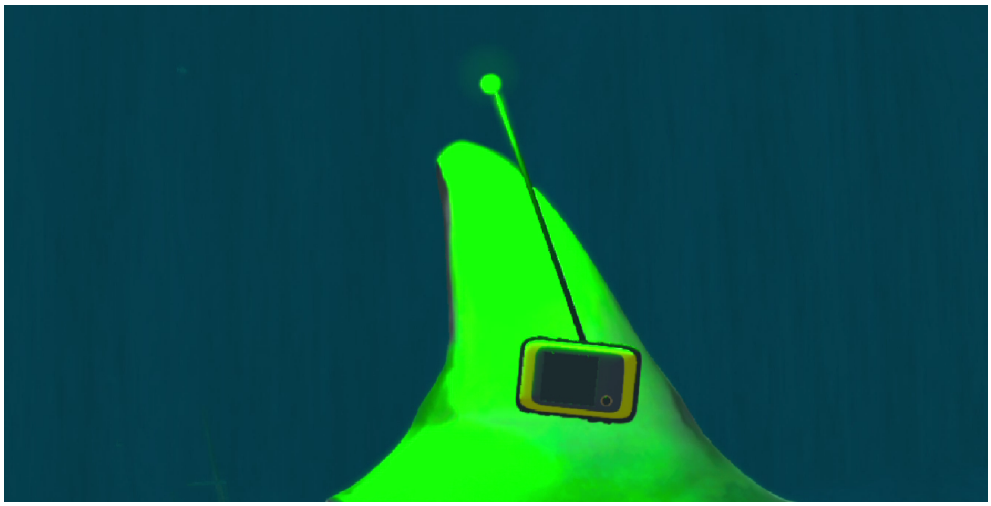

FIGURE 3.6. Tracker showing green light meaning the shark is in a healthy state

After the tracking mini-game, players progress to rescuing injured sharks in the second mini-game, *Helping sharks*. Children proceed to search for a boat in order to retrieve a radar, which displays the locations of tracked sharks on a canvas centered in the player's view. The radar reveals previously hidden objects, such as hooks and fishnets, with injured sharks marked by a red tracker color to denote urgency. This phase emphasizes the conservation message by highlighting the need for timely intervention. Players must locate and interact with these injured sharks to provide assistance.

When a player approaches an injured shark, a canvas appears, prompting the player to begin a questionnaire related to saving the shark. This questionnaire, depicted in the Table 3.3, composed of questions drawn from a list of educational content, has been reviewed and approved by an expert to ensure accuracy and relevance.

TABLE 3.3. Questions that can be asked during the second task.

ID	Question asked
SQ1	What do whale sharks have at the surface of their eyes?
SQ2	What is the length of a whale shark?
SQ3	Sharks survived how many mass extinctions?
SQ4	How many shark species are there?
SQ5	What's the biggest fish in the world
SQ6	What are blacktip sharks known for?
SQ7	Human kill how many sharks per hour?
SQ8	Are sharks older than dinosaurs?
SQ9	Sharks usually bite for...
SQ10	Sharks are usually killed by the value of their...
SQ11	The shark meat market has a value of...
SQ12	How do shark help maintaining the health of the oceans
SQ13	Why are sharks considered the guardians of the ocean?
SQ14	What would happen if sharks disappeared?

These questions are answered by choosing one of two options, one being right and the other wrong. If players answer incorrectly, motivational audio cues are played to keep them engaged and encourage continued effort.

Successfully answering three consecutive questions results in the removal of the nets or hooks. The tracker's color changes back to green, both on the physical tracker and the radar, signaling the successful completion of the rescue. Once all three injured sharks are rescued, players receive a congratulatory message, marking the transition to the final scene.

This mini-game, *Helping Sharks* highlights the impact of pollution on marine life and increases the environmental education. By trial and error in some of the questions or using previously gained knowledge children can finalize the task while retaining the knowledge they previously did not have. Figure 3.7 shows the player answering the questions as well as the radar described previously, indicating where the tracked sharks are located, in the right upper corner of the image.

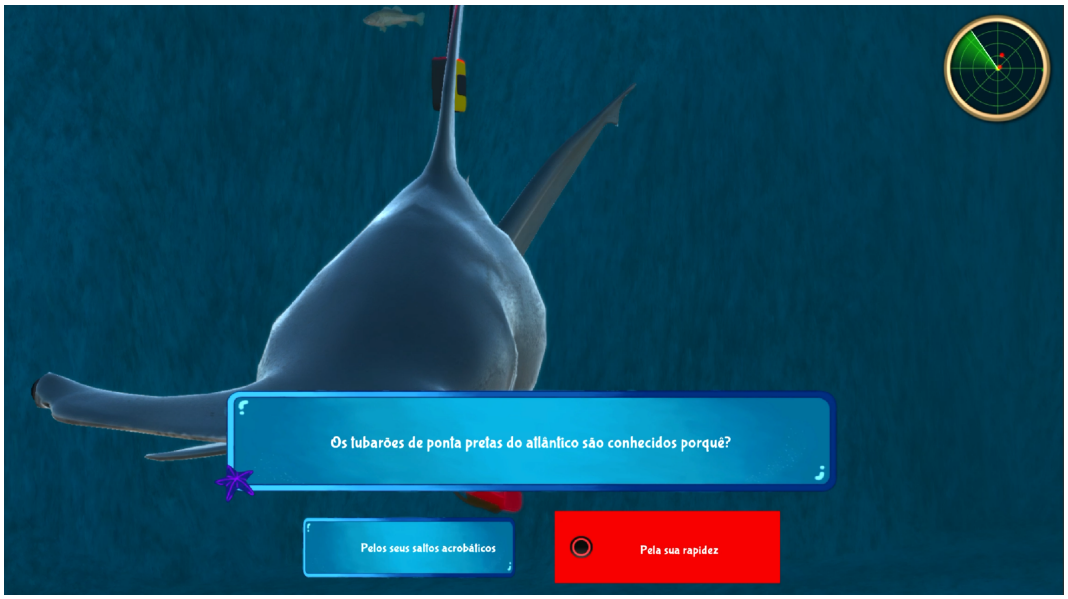

FIGURE 3.7. Second mini-game: Saving sharks by answering to questions about them - The question asked is: What are the blacktip sharks are known for? And the player wrongly answered "For their velocity"

Figure 3.8 depicts the sequence of tasks the player goes through in order to advance to the next scene, once the player finishes all, they move to the next scene (Final scene). This includes the initial instructions provided by the diver, tracking six sharks of the specified species, receiving additional instructions for completing the second mini-game, retrieving the radar from the boat, locating and saving three sharks, and finally receiving instructions and congratulatory messages to proceed to the next scene.

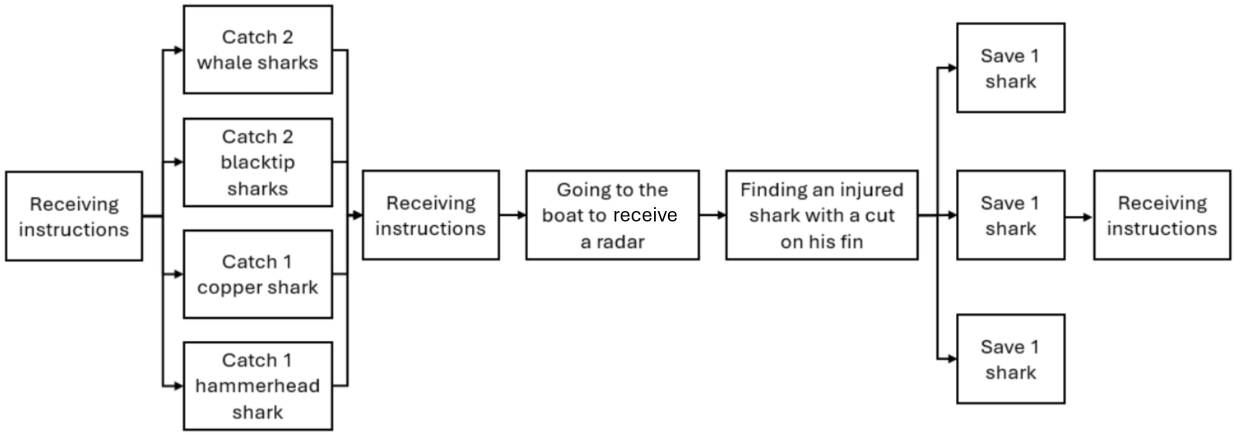

FIGURE 3.8. Main Scene Workflow

3.2.4. Final Scene

In the final scene, depicted in Figure 3.9 , players complete a follow-up questionnaire to assess their knowledge and perceptions of sharks after playing the game, allowing for comparison with their pre-game responses.

FIGURE 3.9. End scene that has a questionnaire embedded into it - Diver congratulates the player on finishing the tasks and asks if they are ready to recieve a certificate

Additionally, the sky now showcases a sunset, contrasting with the initial scene and indicating that the player has spent several hours in the water completing tasks. This choice was made not only to visually differentiate the two scenes for the player but also to enhance the overall realism of the experience.

After completing the questionnaire, children are awarded a certificate and a pamphlet, as shown in Figures 3.10 and 3.11, respectively. The certificate recognizes achievement,

while the pamphlet offers valuable information on shark conservation. The certificate was modified, retaining only its original background, while the pamphlet was entirely created by the author of this dissertation.

FIGURE 3.10. Certificate

FIGURE 3.11. Pamphlet

The certificate acknowledges the player as a shark guardian. It serves as a reminder of their commitment to protecting sharks and ensuring a safe future for these creatures.

In addition to this recognition, the pamphlet provides practical and actionable ways for players to contribute to shark conservation efforts in their everyday lives. It suggests avoiding shark meat and refraining from purchasing products made from shark parts. Players are encouraged to check labels for scalene, a shark-derived substance often found in cosmetics and other products, helping them make informed decisions. Furthermore, the pamphlet highlights the importance of sharing knowledge about sharks with friends and family, fostering a broader awareness of shark conservation issues.

In order to visualize the sequence of events in the final scene, a workflow was created, similar to those developed for the other scenes. This workflow is presented in Figure 3.12.

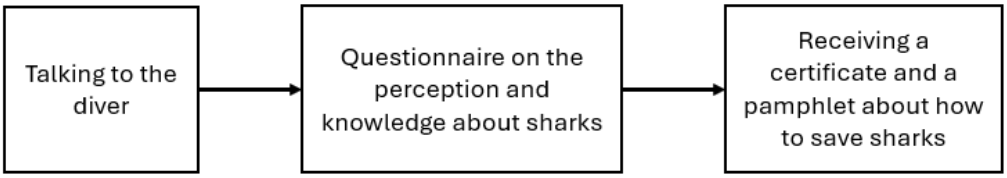

FIGURE 3.12. Final Scene Workflow

3.2.5. Game workflow

A clear understanding of the game's structure is essential to grasp the progression of in-game activities. Figure 3.13 depicts the workflow of the game, highlighting each distinct stage.

The Figure 3.13 separates the different activities performed within the game environment, providing a comprehensive overview. This depiction helps to understand the sequence of actions in-game activities.

3.2.6. Additional Gameplay Features and Educational Enhancements

The main scene is bounded by four planes forming a box around the play area, ensuring players remain within the designated space. If players approach these boundaries, they are redirected to the center of the game area with a warning message to maintain smooth gameplay. Additionally, the boundaries act as an adaptive mechanism: if a player fails to track a shark within 60 seconds, either from the previous tracking or the start of the game, the boundaries will shrink. This reduces the playable area, increasing the likelihood of encountering a shark.

For added immersion, players can swim to the water's surface, a transparent plane simulates the water line, simulating a realistic scenario of reaching the water surface. When players reach the surface, the audio environment transitions to simulate outside world sounds like seagulls and wind. Diving back into deeper waters shifts the audio to reflect the deep ocean environment, enhancing immersion and realism.

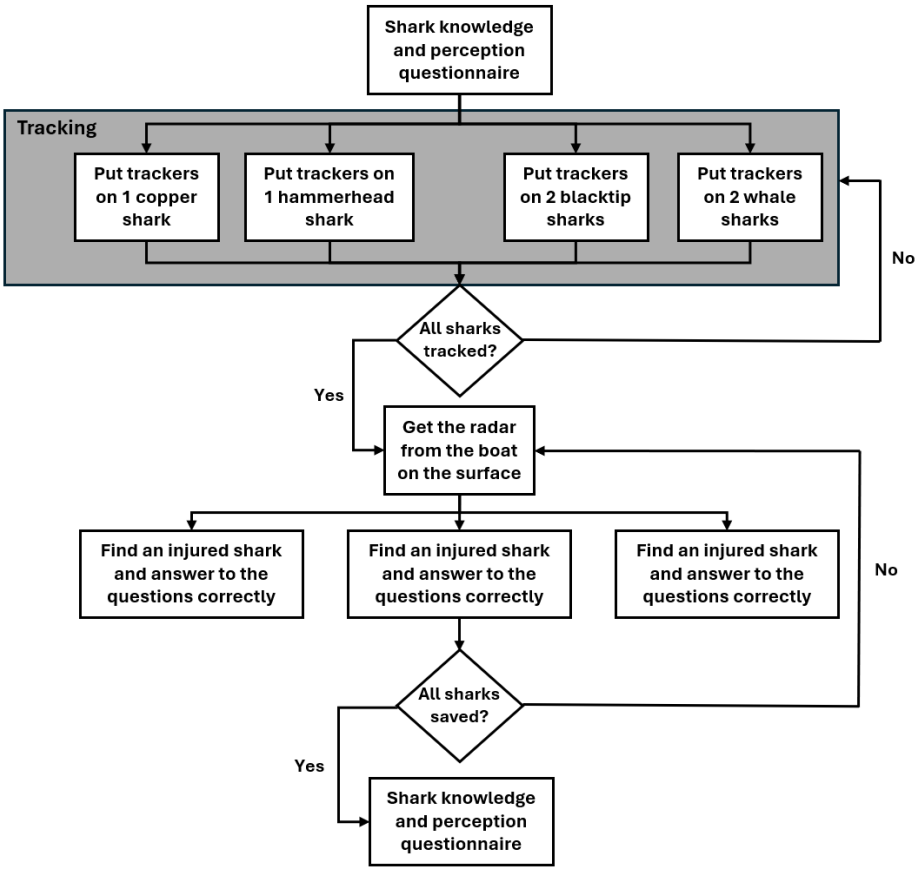

FIGURE 3.13. Workflow of the game

An additional scenario was introduced, as outlined in previous sections, to address a knowledge gap children had regarding sharks being targeted for their fins and to raise awareness about this critical issue. In this scenario, if the camera captures a specific shark, it zooms in to reveal a noticeable cut on the shark's fin. This visual cue indicates that the shark was targeted by a fisherman attempting to remove its fin but managed to escape. To further emphasize the message, a text panel is displayed, informing players that millions of sharks are killed annually for their fins, often to make Chinese shark fin soup.

3.2.7. Data Collection

The game systematically collects player data, which is recorded in CSV files for each task and questionnaire, as outlined in Table 3.4. Data from the same session is appended to the existing line, while new sessions generate a new line.

These data is analyzed to explore relationships with player types, providing insights into player behavior and learning outcomes. The analysis aims to confirm that no significant correlations were found, indicating that, for this sample of participants, no notable differences in gameplay were observed. If confirmed, this would indicate that the game successfully adapted to the different player types within the sample.

TABLE 3.4. Game parameters retrieved

ID	Game parameter
P.1	Time that it takes to conclude task 1
P.2	Number of times the borders were shrinked
P.3	Number of times the player misses the fin while trying to track a shark
P.4	Additional sharks the player tracks
P.5	Number of wrong answers while trying to save shark number 1 (In the second task)
P.6	Number of wrong answers while trying to save shark number 2 (In the second task)
P.7	Number of wrong answers while trying to save shark number 3 (In the second task)
P.8	Time that it takes to conclude task 2

3.3. Game Iterative Development

The final version of the game presented in the previous section (Section 3.2) resulted from a series of iterative phases aimed at refining and enhancing the gameplay experience. Each phase included thorough evaluations and the incorporation of feedback into the subsequent versions of the game. The various iterations will be explored in the following sections.

3.3.1. Iteration 1

The initial version of the game was tested with a group of 10 children who had not participated in the brainstorming sessions to avoid biases. By selecting children who were not involved in the development process, the feedback was more likely to be objective and reflective of a typical user experience. The initial version of the game had several bugs that significantly affected the user experience. One major issue was related to the game barriers, an adaptable feature that makes the game area shrink overtime depending on the time taking to track a shark, which caused problems with player rotation and movement. Players found themselves unable to navigate the game space properly, which detracted from the overall enjoyment and playability of the game. Additionally, there were technical difficulties with placing trackers on hammerhead sharks, which often resulted in the trackers being lost. This issue was particularly frustrating as it disrupted the gameplay and the objectives that required tracking these sharks.

These bugs were identified and addressed in subsequent versions of the game. Improvements were made to the game borders to ensure smooth and seamless player rotation and movement. The issue with tracker placement on hammerhead sharks was also resolved, ensuring that the trackers remained securely attached and functioned as intended. These fixes greatly enhanced the gameplay experience, allowing players to fully engage with the game without encountering these disruptive issues.

Moreover, one of the children playing the game suggested a relevant modification: removing the barriers so that people could pass through them but still send an alert.

This suggestion was taken into account, and the barriers were modified accordingly. In the game's final version, while the barriers no longer physically block the players, they still serve a purpose by keeping players within a designated area. If a player attempts to move away from the game area, an alert is triggered, and the game automatically rotates the player back toward the center. This approach maintains the intended boundaries of the game while allowing more freedom of movement and enhancing the overall player experience. During this session, the questionnaires were not shown and validated, this step was done in the next sessions.

3.3.2. Iteration 2

The second version of the game was tested with six new children from a different school. Feedback indicated that the children were becoming increasingly frustrated with the second task. The task included a loud noise and had a strong negative connotation whenever the children failed to answer a question correctly, leading the children to feel they should have known the answers, and resulting in a sense of inadequacy and perceived lack of intelligence.

To address these issues and improve engagement, several changes were made in the third prototype. Firstly, different audio cues were introduced to replace the loud noise. These new audio cues were designed to be more positive and encouraging. Additionally, reassurances were added to let players know that it was perfectly fine to make mistakes and that they would have another chance to answer correctly if they failed. This approach aimed to create a more supportive and less intimidating learning environment.

The audio cues were integrated into the game through a script, where they were listed and picked randomly whenever a player answered a question incorrectly. This randomness helped to keep the experience fresh and prevent the children from becoming accustomed to a single response.

Additionally, several questions were revised to better assess children's perceptions and knowledge about sharks before and after the main scene. To ensure the revised questions were appropriate and effective, they were validated by an expert in education and marine science, confirming their alignment with educational objectives and design standards. The questionnaire, which is integrated into the scene, was initially designed to be answered using a Smileymeter (depicted in Figure 3.14).

FIGURE 3.14. Smileymeter

This tool was originally considered more intuitive for children. However, after this session, it became clear that the original (Smileymeter) was better to be changed to text

form and the "full scale" (From "Totally Disagree" to "Totally Agree") format needed adjustments to improve clarity. The neutral option, "Neither agree nor disagree," which was frequently chosen by children unsure of how to respond, was removed to prevent ambiguity. This change was made in cohesion with the Progress in International Reading Literacy Study (PIRLS) [43], a validated questionnaire designed for children aged 9-10, aligning well with the target population of this study.

These improvements were designed to enrich the learning experience, making it more engaging and less frustrating for children. By incorporating positive reinforcement and minimizing the negative impact of incorrect answers, the third prototype aimed to create a more supportive environment.

This approach motivated children to engage with learning about sharks and marine conservation, fostering both curiosity and awareness. It also provided them with the opportunity to answer questions in a manner that reflected their individual thoughts and comprehension of the subject matter.

3.3.3. Iteration 3

The third version of the game was tested with another four children, revealing an issue with the question "I do not like sharks" presented in the initial and ending scene of the game to access children's knowledge and perception about sharks (Table 4.2). The negative phrasing of this question caused confusion among the respondents, as they were unsure whether agreeing or disagreeing indicated a positive perception of sharks. To address this confusion and improve clarity, the question was revised to "I hate and fear sharks." This change aimed to clearly convey the negative perception within the sentence, making it easier for children to understand and respond accurately.

During game testing, it became clear that many children still did not understand that sharks are being targeted for their fins. To address this and raise awareness about this critical issue, a new scenario was added to the second task of the game, as described previously, it depicts a shark swimming with a cut on his fin, alerting for the on going issue of shark finning.

This educational moment is designed to help children understand the severity of the issue in a more accessible and impactful way, ensuring that they grasp the real-world implications of shark finning and the urgent need for conservation efforts.

3.3.4. Iteration 4

In the fourth version of the game, with more four children who had no previous contact with the game, significant changes were made to the questions in the second task (Table 3.3) to place a stronger emphasis on the ecological importance of sharks. This iteration aimed to deepen children's understanding of sharks' role in marine ecosystems by framing questions that highlighted their vital contributions, such as maintaining the balance of oceanic food webs and controlling the populations of other marine species.

This iteration revealed notable improvements in the children's knowledge and perceptions about sharks, indicating that the modifications effectively enhanced the educational impact of the game.

The results from this iteration confirmed that the fourth version of the game is the definitive version, designated for use in the experiment. This final iteration incorporates essential improvements based on prior feedback and testing, to make the game more engaging and effective for participants. A description of this final version is provided in Section 3.2.

3.4. Technological Tools

3.4.1. Unity3D

The Unity3D [44] game engine was chosen for this study due to several key factors. Firstly, Unity is highly accessible, offering a user-friendly interface that allows developers to quickly prototype and iterate on game ideas. Its extensive documentation and large community make it easier to troubleshoot issues and find tutorials. Additionally, familiarity with Unity3D gained from previous coursework played a significant role in its selection. This experience allowed for a smoother development process and made Unity the most suitable choice for the studies' requirements, particularly when balancing efficiency and functionality in creating an immersive game environment.

3.4.2. Blender

Blender [45], an open-source 3D modeling software, was integral in manipulating and sculpting a pivotal model used in the game to convey a powerful message regarding marine conservation. Specifically, a 3D model of a blacktip shark was meticulously altered to represent a shark with a dorsal fin cut, symbolizing the devastating impact of shark finning. Shark finning, a practice in which sharks are caught, their fins removed, and the rest of the body discarded, leads to the death of millions of sharks annually. This practice poses a significant threat to marine ecosystems and biodiversity.

Using Blender's advanced sculpting tools, the dorsal fin of the shark model was carefully cut to simulate the brutal reality faced by many sharks in the wild. After cutting the fin, the exposed areas were refined using Blender's smoothing and filling tools, ensuring that the model maintained a lifelike appearance. This attention to detail was crucial in delivering a model that not only visually aligns with reality but also evokes a strong emotional response from the audience.

The final model, shown alongside the original model in Figure 3.15, captures the essence of vulnerability experienced by sharks subjected to finning. By focusing on the fin removal, the study aimed to raise awareness about the controversial practice, such as the production of shark fin soup, which continues to fuel demand for shark fins. The careful design and execution of this modified model serve as a visual agitator, encouraging players to engage deeply with the conservation message presented in the game.

FIGURE 3.15. Results of the modifications made in Blender

3.4.3. Ready Player Me

Ready Player Me [46], an online avatar creation platform, was employed to design the main character in the game. The platform's wide range of customization options allowed for the creation of a character that embodies the persona of a marine biologist. Key decisions in the character's design were made to align with the narrative and technical needs of the game. For instance, a beard was chosen to cover the character's facial region, effectively masking the mouth area and making the non lip-syncing less noticeable with the accompanying audio. The overall appearance was kept casual, aiming for an outfit that would logically fit the role of a marine biologist working in aquatic environments. The final character design contributed to the game's immersion by providing a visual representation of the protagonist that complemented both the story and gameplay mechanics.

3.4.4. Mixamo

Mixamo [47], a free online service for 3D character animation, was used to generate the animations needed for the game's characters, as it is shown on the Figure 3.16.

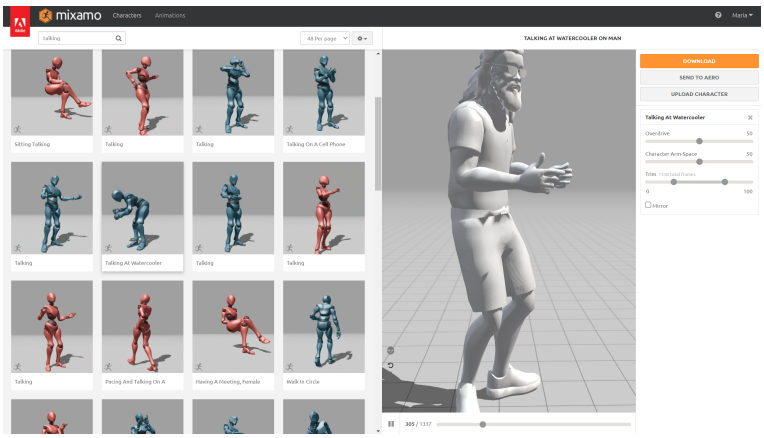

FIGURE 3.16. Mixamo layout with the avatar create in Ready Player Me.

These animations were imported into Blender, where they were adjusted to fit the specific movements of the player character. After fine-tuning the animations to ensure fluidity and compatibility with Unity3D, they were incorporated into both the opening and closing scenes of the game. This combination of Mixamo for animation generation

and Blender for refining movements allowed the game to deliver smooth and realistic animations, enhancing the overall player experience and contributing to the emotional impact of the narrative.

3.5. Game Controls

Figure 3.17 illustrates the controller used and the designation of its buttons. This visual representation helps clarify the controller's layout and indicates which buttons should be pressed as described in the previous subsections. This section will assist in understanding how each button is mapped and utilized within the game.

FIGURE 3.17. Joystick

3.5.1. Initial Setup and Controls

- Controller Setup
  - Connect the DualShock controller to your gaming system.
  - Ensure the controller is properly configured to interact with the game.
- Starting the Game
  - Launch the game from your gaming system's menu.
- Navigation Menus
  - Use the circle, triangle, square or x button (as indicated on-screen) to select options.

3.5.2. Scene 1: Shark Knowledge and Perception Questionnaire

- Objective
  - Complete a questionnaire presented by a diver character to assess knowledge about sharks.
- Gameplay Mechanics
  - Listen to the diver's instructions and respond using the controller's action buttons (circle or x as indicated).

  - Respond to the questionnaire by using a mix of R1 or L1 to navigate through the options and the x button to lock the option.
- Visual and Audio Features
  - Enjoy realistic ocean and skybox visuals with a water shader for immersive effects.
  - Experience wave motion on the boat, simulating ocean waves for a lifelike environment.

3.5.3. Scene 2: Main Gameplay - Tracking and Rescuing Sharks

- Objective
  - Track and rescue injured sharks using specialized equipment and tools.
- Gameplay Mechanics
  - Use the left stick to move and the right stick to rotate
  - Track at least 6 sharks of the species indicated by the diver
  - Use the radar to locate tracked sharks and identify injured ones.
  - Approach injured sharks and answer educational questions to remove hazards (hooks, fishnets).
- Special Features
  - Realistic boundary management with planes ensuring players remain within the gameplay area.
  - Adaptable boundaries throughout time to make sure the players are able to track all sharks.
  - Immersive audio transitions between underwater and surface environments for enhanced realism.

3.5.4. Scene 3: Final Questionnaire and Awards

- Objective
  - Complete a follow-up questionnaire to acquire any learning about shark conservation and changes in perceptions.
  - Respond to the questionnaire by using a mix of R1 or L1 to navigate through the options and the x button to lock the option.
- Reward System
  - Receive certification and educational pamphlet.
  - Enjoy the final scene's visuals and reflect on the overall gameplay experience.

3.5.5. Game Controls (DualShock 3)

- Left Stick: Move character.
- Right Stick: Rotate player.
- Symbol Buttons (Circle, X, Square, Triangle): Interact with objects, answer questions.
- R1, L1: Navigate through options in the questionnaires or add and remove scuba goggles.

3.6. Terrain Generation

Creating a realistic and engaging terrain was a crucial aspect of the game's development, as it contributed significantly to the immersive environment. The terrain was based on real-world geographic data to provide a natural yet dynamic landscape that would support the gameplay experience. To achieve this, a heightmap was utilized, which allows for a replication of a real world scenario, ensuring both aesthetic appeal and functionality in the game world.

3.6.1. Heightmap Generation

For the terrain generation, a heightmap was created using a free online tool, *Terraining - Heightmap Generator for Cities: Skylines*. This tool provided the ability to extract geographic data from specific locations around the world, generating a heightmap in the form of a PNG image. The selected location was carefully chosen based on several key factors:

- **Irregular Terrain Features:** The terrain needed to exhibit some degree of irregularity, as completely flat or overly symmetrical landscapes would lack the realism necessary for the game. However, it was also important to ensure that the irregularities did not appear too extreme or unnatural.
- **Moderate Elevation Differences:** The variation between the highest and lowest points of the terrain had to be moderate. A terrain with excessive elevation differences could potentially disrupt gameplay or limit movement, while too little variation could render the environment visually uninteresting. Striking this balance allowed for a more natural and immersive experience.

After carefully evaluating various locations, the terrain that best fit these criteria was selected. The heightmap, depicted in Figure 3.18, was then downloaded in PNG format. This particular image was chosen as the final due to the factors previously mentioned, irregular terrain but not in an overwhelming way for the game. Moderate elevation differences with no abrupt differences.

The resulting heightmap was imported into Unity3D, where it served as the foundation for the game's terrain. Unity's terrain generation tools allowed for further refinement, including adjustments to the terrain's textures, vegetation placement, and environmental lighting. This ensured the final landscape was both functionally appropriate for gameplay and visually engaging for players. The use of real-world geographic data, combined with manual adjustments, helped create an immersive environment to enhance the overall player experience. The result of these actions is showned in the Figure 3.19.

3.6.2. Mapping

The heightmap generated from the external tool was then imported into Unity3D via its terrain tools, serving as the foundation for the game's landscape. This image provided the elevation data needed to model the terrain, where lighter areas represented higher elevations and darker areas indicated lower regions. Once the heightmap was successfully

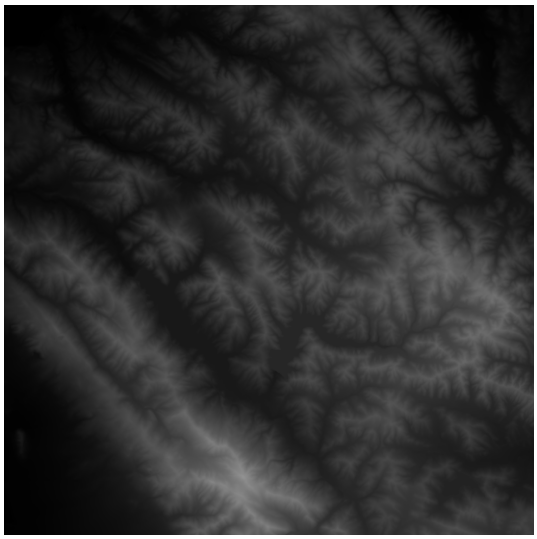

FIGURE 3.18. Heightmap used for the generation of the terrain.

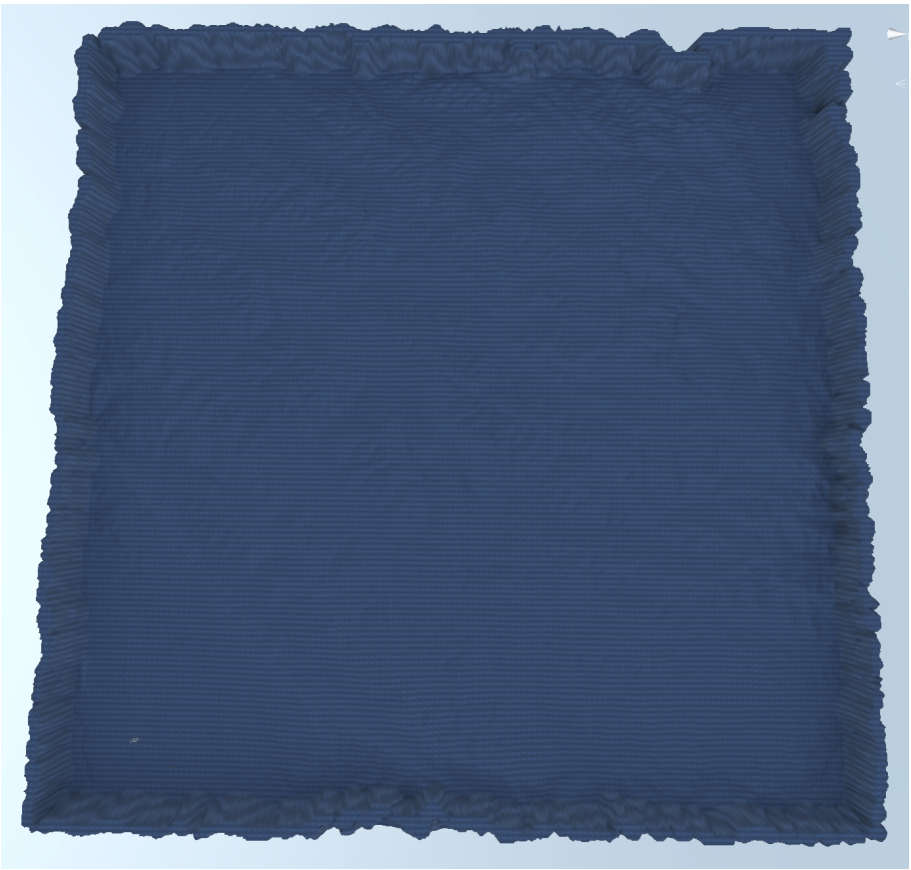

FIGURE 3.19. Resulted terrain - Displayed in an enlarged format to highlight the details shown by the irregularities of the terrain

applied, Unity automatically translated the grayscale image into a 3D terrain model, creating a natural, uneven surface based on real-world data.

The terrain generated from the heightmap was defined with dimensions of 1720 pixels (px) in both length and width, while the height, or vertical elevation, reached a maximum of 150 px. These dimensions were derived from the heightmap itself, as calculated by the

website used to generate the PNG. By using real-world geographic features, the resulting terrain felt organic and realistic, which was crucial for creating an immersive game environment.

After the terrain was generated, additional customization steps were taken. One of the most important modifications involved coloring the terrain. A subtle blue tint was applied across the landscape, designed to represent the deep ocean floor. This coloration was chosen to evoke the quiet yet mysterious atmosphere of an underwater environment.

3.6.3. Adjustments

To enhance the realism of the game, additional steps were taken to prevent players from encountering the limits of the terrain. A barrier was strategically created along the edges of the terrain to ensure that, under no circumstances, would the player be able to see or reach the boundaries of the game world. In Figure 3.20, the elevated edges of the terrain are shown, highlighting how the terrain was adjusted to increase the height along the boundaries, as it is explained in the following paragraph.

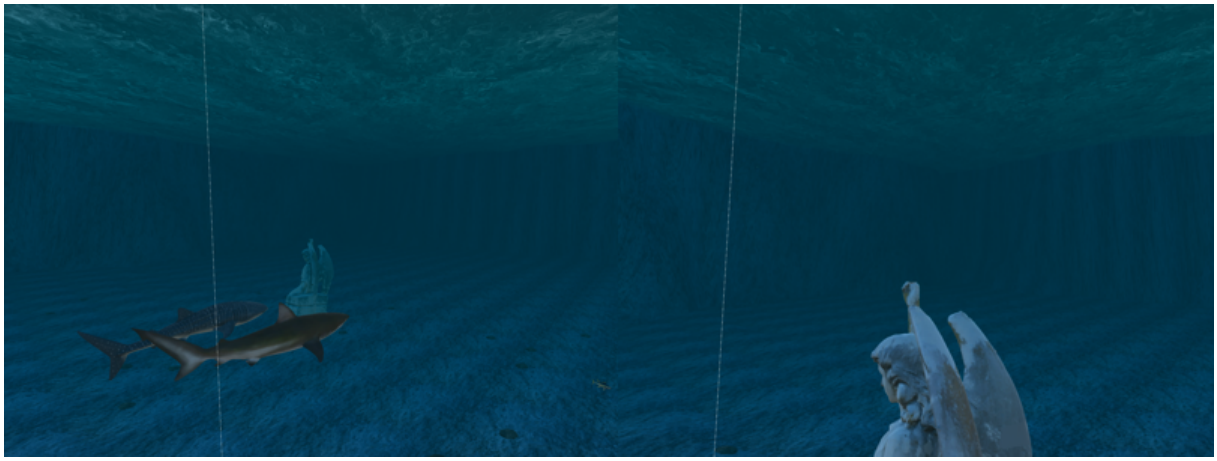

FIGURE 3.20. Edges of the terrain

This approach helped maintain the illusion of an expansive, continuous environment, contributing to a more realistic and engaging experience. Without such barriers, players could inadvertently break engagement or sense of being in the underwater world by witnessing the abrupt end of the terrain, which would diminish the overall sense of depth and continuity in the game world. To create these boundaries, the terrain tools in Unity3D were utilized to manipulate the edges of the terrain, elevating them significantly to form barriers.

3.7. Post processing

3.7.1. Fog

Whenever people are observing the underwater world there is no sense of ending. It is not possible to see fully into distance. Virtual fog was added to the scene in order to simulate this phenomenon. This fog has the color dark blue in order to replicate the real

life as best as possible. It uses an exponential function with a density value of 0.01, as this value was the most appropriate for the given scenario. The graph that depicts the function used for the fog is depicted in Figure 3.21.

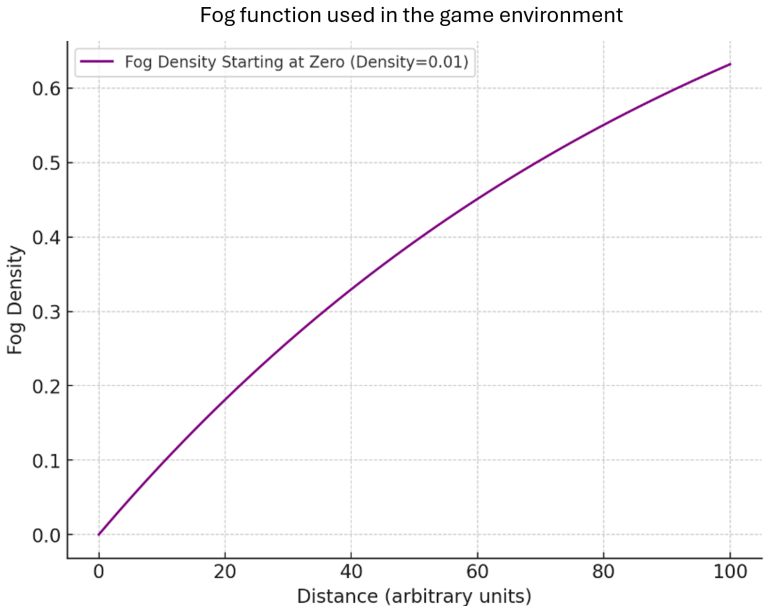

FIGURE 3.21. Fog function

3.7.2. View in water

In order to enhance the visual quality and immersion of the game environment, several pos-processing techniques were implemented. These adjustments were crucial in creating an authentic and engaging underwater atmosphere, with the goal of allowing players to feel more connected to the oceanic world presented in the game.

Multiple techniques were used in order to replicate an underwater environment. Color grading was used in order to adjust the color balance and overall tone of the scene. Specific adjustments were made to the hues and saturation, with an emphasis on cool tones, such as deep blues and aquas, to mimic the natural colors found in underwater environments.

In addition, depth of field effects were applied to simulate the way objects in the distance appear slightly blurred, as is typical when viewing underwater scenes. The depth of field effect was calibrated so that the farther an object was from the player's point of view, the greater the blur became. This created a sense of depth and realism, reflecting how visibility decreases in water as distance increases.

Additionally, a lens distortion effect was incorporated to simulate the experience of viewing the game world through goggles. This distortion added a slight curvature to the edges of the screen, mimicking the natural visual warping that occurs when looking through the curved lenses of diving goggles. By introducing this type of optical distortion, the game achieved a more authentic underwater visual style, as players would perceive the environment in a way that closely resembles real-world scuba diving or snorkeling

experiences. The combination of these effects, including color grading, depth of field, and lens distortion, worked in harmony to increase cohesiveness and engagement in an underwater atmosphere for players.

3.8. Sea Creatures Behaviour

3.8.1. Orientation Control

The Sketchfab imported model's initial orientation is taken into account as input through the degrees of rotation in relation to an original defined orientation, as different models possess varying default directions. This factor is crucial for maintaining consistency during the sea creature's movements and rotations. Ensuring the correct orientation throughout these transformations is essential for realistic behavior, especially when the animal moves randomly from one point to another. The underlying movement system relies on specific mechanisms, which will be described in detail in the following subsections. By accounting for the model's original direction, smooth transitions and rotations are achieved, preventing any abrupt or unnatural shifts in the animal's movement trajectory.

3.8.2. Linear Velocity Control

An important parameter in the animal movement algorithm is the input float value representing the speed of the animal. This value plays a crucial role in differentiating various species of animals by their respective movement behaviors. Each species is assigned a unique speed value that reflects its natural movement characteristics. For instance, faster animals, such as sharks would be given higher values, while slower animals like sea turtles or certain fish species would have lower speed values.

This float velocity value remains consistent throughout the game. By maintaining a species-specific speed, the game aims to achieve a more realistic simulation of animal behavior.

3.8.3. Angular Velocity Control

In a similar manner to the velocity float value, the rotation speed value is also provided as an input and varies among different species and animals. This parameter determines how quickly an animal rotates to face a new destination when it reaches its current target and selects a new point to travel to.

If the rotation speed were constant across all species, the movement might appear unrealistic for some animals, as different species have inherently different turning capabilities. By varying the rotation speed according to each species' characteristics, the game achieves a more authentic representation of animal behavior.

3.8.4. Way Point Selection

In order to manipulate the sea creature's movement random points in the game area space are selected, then the animal is going to move forward into that direction. The algorithm for the multiple sea creature's movement proceeds as the following:

- Defining Bounds: The bounds (min/max) are defined using four planes. This establishes a rectangular region within which the animal can move.
- Selecting Random Point: A random X and Z point is chosen within those bounds, keeping the Y-coordinate constant.
- Moving to the Point: The object moves and rotates toward the target point.
- Repeating the process: Once the object reaches the target, a new random point is selected, and the process repeats.

The script governing the behavior of the sea creatures the angular velocity, linear velocity and initial orientation as inputs. Each of these values has been thoroughly explained in detail in the previous subsection.

3.9. Organization of Unity Assets

In order to maintain organization within the game's main scene, Unity assets are categorized and grouped under corresponding empty objects, each representing a different category. Figure 3.22 illustrates the organization of these assets. This structured approach ensures efficient asset management and contributes to smoother game development and optimization processes.

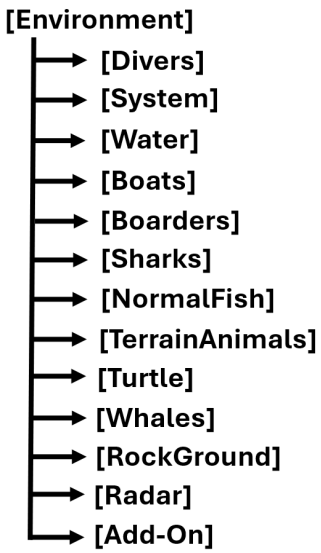

FIGURE 3.22. Unity assets in-game organization

CHAPTER 4

Evaluation

The final game, developed through four iterative cycles as described in Section 3.3, integrates feedback from each stage to enhance its engagement and educational impact. This process aims to create a more effective learning experience for players.

This chapter details the experimental design used to assess the educational impact of the game's final version, described in Section 3.2, on Portuguese children, as well as the its results. It outlines the evaluation study's methodology, which involved an initial questionnaire, an in-game survey, and post-game evaluations as well as any ethical considerations that had to be taken.

The key components of this experiment include tracking children's perceptions about sharks, engaging them in interactive gameplay, and analyzing shifts in their knowledge and attitudes towards shark conservation. Changes are examined in children's knowledge and perceptions of sharks by analyzing their questionnaire responses and the words children used to describe sharks before and after playing the game. Additionally, the relationship between different player types and their game performance is explored.

It is also crucial to emphasize the importance of ensuring that the final experiment was conducted with children who had not previously worked closely with the game. This precaution was necessary to eliminate any potential biases that could arise from prior familiarity with the game's content and mechanics.

4.1. Experiment design

The final study included 38 Portuguese children, comprising 23 boys and 15 girls, with ages ranging from 9 to 11 ($AVG = 9.4$, $STD = 0.55$), each doing this experiment individually in a classroom. The experiment began with each child completing an initial questionnaire aimed at gathering demographic information. This questionnaire included questions about the child's age and gender for statistical analysis purposes. To understand the child's initial mindset and preconceived notions about sharks, the questionnaire also included a section where children were asked to list three words that come to mind when they think of sharks. Additionally, the child's player type was determined using the questions in Table 4.1, which enabled the investigation of correlations between their preferred aspects of the game, retrieved parameters, and their user type according to the Hexad model, a framework categorizing users into distinct types based on their motivations and preferences in gamified systems [48]. In order to ensure that the children understood well the questionnaire, it was first translated by a bilingual person to Portuguese and then translated back by another in order to ensure that the translation would be as valid as

possible. In addition to this, children also observed the questionnaire and answered the questions in order to check whether they were easily understood by children or not.

TABLE 4.1. Questions to assess user's Hexad player type

ID	Question
Q1	It is important to me to follow my own path
Q2	Being independent is important to me
Q3	I enjoy emerging victorious out of difficult circumstances
Q4	I enjoy group activities
Q5	It makes me happy if I am able to help others
Q6	I like being part of a team
Q7	Rewards are a great way to motivate me
Q8	I see myself as a rebel
Q9	If the reward is sufficient, I will put in the effort
Q10	I dislike following rules
Q11	I like mastering difficult tasks
Q12	The well-being of others is important to me

The in-game segment follows next, which was thoroughly discussed in Section 3.2 and will now be briefly summarized. The upcoming description highlights the key elements of the game.

Following the initial questionnaire (Table 4.1), the child participated in an in-game survey. This in-game survey, shown in Table 4.2, was tailored to assess the child's existing perceptions and knowledge about sharks. Previously validated by a specialist in the area of education and marine science this questionnaire included questions designed to evaluate children's awareness of sharks' roles in marine ecosystems, their understanding of the threats sharks face, and any misconceptions they might hold about these sea creatures.

TABLE 4.2. Questionnaire to assess children's current perception and knowledge of sharks

ID	Question
SQ1	All sharks are dangerous to humans
SQ2	Sharks are important to maintain the ocean's health
SQ3	If I come across a shark I will always be attacked
SQ4	It is necessary to protect sharks
SQ5	Humans are shark's favourite food
SQ6	I hate sharks and I am scared of them
SQ7	The ocean's health stays fine without sharks
SQ8	I want to know more about sharks
SQ9	Sharks are bad animals and we should kill them all
SQ10	Many sharks are captured for the value of their fins

The responses were evaluated on a scale from -2 to 2, based on the Likert Scale ranging from totally agree to totally disagree. For example, if a child answered "totally agree" to the statement "all sharks are dangerous to humans," the response would be assigned a value of -2, indicating a negative perception. This approach differs from the usual 0 to

5 classification, emphasizing whether the perception is negative or positive, as well as if the knowledge acquired is factually wrong or right by using the negative or positive signal with this intent. Additionally, the neutral option was removed to encourage children to make a definitive choice rather than opting for a neutral response.

Once the initial data collection was completed, the child was introduced to the game environment. The introduction included a brief oral explanation on the basic movement and rotation commands necessary to navigate the game.

The primary task for the child was to locate and place trackers on at least six different sharks: two blacktip sharks, two whale sharks, one hammerhead shark, and one copper shark. This activity familiarizes the child with different shark species and creates a sense of care for them.

After successfully placing the trackers, the child navigates to a boat positioned on the surface of the water. As soon as the child was close enough to the boat it was possible to retrieve a radar device that displayed the status of all the tracked sharks. Each tracked shark's health status is shown on the radar. This feature shows the importance of monitoring and protecting marine life.

The next phase of the game involved a rescue mission. The child needs to find each injured shark and answer three consecutive questions correctly to free a shark that was entangled in a hook or a fishnet. The child's learning was reinforced through trial and error about a constant list of questions that appear in a random order. The questions were about the child's knowledge about sharks, their ecological importance, and possible threats to their existence.

Upon completing the game, the child was prompted to retake the initial perception and knowledge questionnaire. This post-game survey was conducted within the game environment and aimed to measure any changes in the child's perceptions and knowledge about sharks. The results from this questionnaire provided quantitative data on the educational impact of the game.

In addition to the post-game survey, the child was presented with a pamphlet (Section 3.2.4 - Figure 3.11) containing practical tips on how to contribute to shark conservation in their daily life. This pamphlet served as an educational tool to extend the learning experience beyond the game. To recognize their efforts, the child received a certificate (Section 3.2.4 - Figure 3.10) naming them an official guardian of sharks, encouraging continued interest in shark conservation.

Finally, the child was asked to reflect on their game experience by writing three words that now come to mind when they think of sharks. This repetition aimed to capture any shifts in perception. They were also asked to draw their favorite and least favorite parts of the game providing qualitative insights into what aspects of the game were most engaging or challenging. In Figure 4.1 it is possible to see the workflow throughout the whole experiment, providing a visual guide to the sequential steps and activities children engage in, not only in the game but before and after as well.

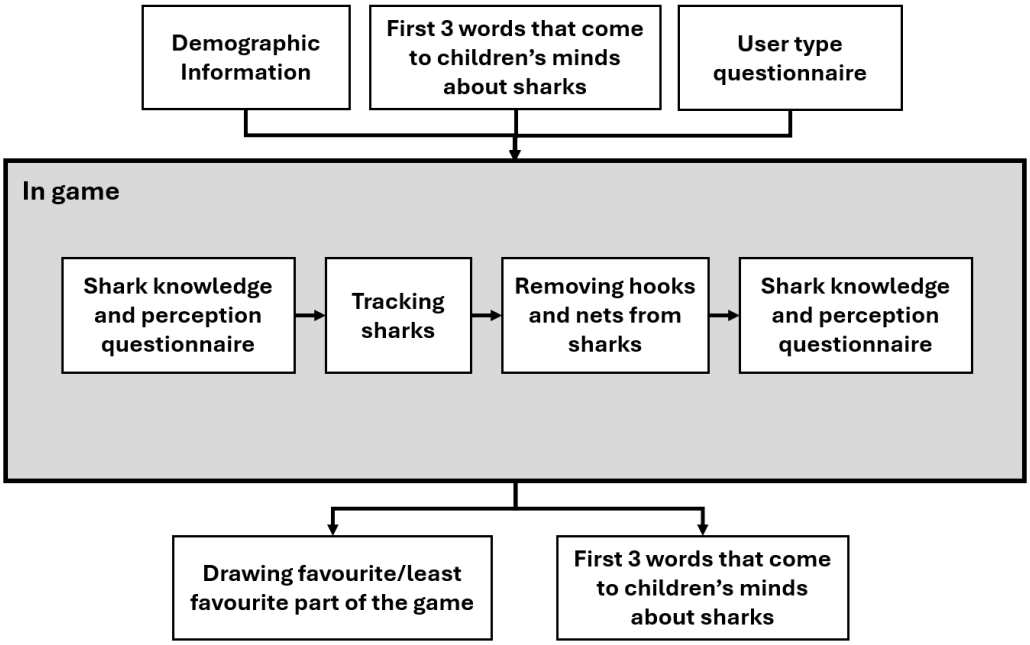

FIGURE 4.1. Workflow of the experiment

4.2. Ethical considerations

The dissertation, which involved a sensitive population of people, in specific children, underwent a thorough review process and was accepted by the ISCTE Ethics Committee. Furthermore it was also approved by the directors of each school that participated in the study and subsequently the tutors of the children. This was an requirement to ensure that the study was conducted with the essential ethical standards.

The primary objective of this review was to guarantee that the study would not only protect the rights and well-being of the children involved and ensure their parent's consent but also that any data collected would be handled with strict confidentiality and care. The Ethics Committee's role was to meticulously evaluate the study's methodology, ensuring that no sensitive data would be collected or that any data that was collected would be properly anonymized to prevent the identification of individual participants.

The data required from the children was limited to their age and gender, which were collected solely for the purpose of statistical analysis. To further protect the children's identities, the questionnaires were administered in paper format, and each was assigned a unique identification (ID) number. This ID was a random, non-repeating sequence generated by the investigator to ensure that no two questionnaires could be linked to the same child. The consistency of this ID across different stages of the study was crucial, it was used in the initial questionnaire, the in-game survey, the collection of game parameters, and the final questionnaire. By maintaining the same ID throughout the study, the author of this dissertation ensured that the data could be linked across different phases without revealing the identity of any participant.

Before any data collection began, the dissertation team sought and obtained formal authorization from all participating schools. This step was not merely a formality but a critical part of ensuring that the study had the support and approval of the educational institutions involved. The schools' cooperation was essential in facilitating the smooth execution of the study, and their approval signified that they were satisfied with the ethical considerations in place. Following the schools' authorization, the next step involved securing informed consent from the legal tutors of the children. To achieve this, an informed consent form was distributed to the teachers, who were responsible for passing it along to the children's legal tutors. This form provided detailed information about the study's purpose, the nature of the data being collected, and the measures in place to protect the participants' privacy. It also outlined the voluntary nature of the children's participation, ensuring that tutors understood they could authorize or deny their child's involvement without any repercussions.

The informed consent process was a critical component of the study's ethical framework. By obtaining explicit permission from the legal tutors, the author of this dissertation ensured that the participation of each child was voluntary and fully informed.

4.3. Perception and knowledge of sharks

In order to evaluate the impact of the educational game on children's knowledge and perception of sharks, both questionnaire responses and the three words children associated with sharks before and after playing the game were analyzed. This approach allowed for an assessment of changes in their understanding and attitudes towards sharks. Table 4.3 presents the means and standard deviations calculated in the subsequent paragraphs. This is done to provide a clearer understanding of the impact of the results.

TABLE 4.3. AVG and STD of the differences between various parameters before and after playing the game

Parameters	**Scale**	**AVG**	**STD**
Knowledge questions	[-10,10]	4.03	2.56
Perception questions	[-10,10]	1.61	2.47
Positive words	[-3,3]	1.34	1.12
Negative words	[-3,3]	-0.87	0.93

The knowledge and perception scores ranged from -10 to 10, allowing for the quantification of changes in these areas. The differences in knowledge scores before and after for each child were calculated, and then the mean difference across all children was determined. The results show a significant increase in knowledge ($AVG = 4.03$, $STD = 2.56$), a detailed statistical analysis of these results is made in the following pages.

Changes in perception were assessed by calculating the mean difference in perception scores. The analysis revealed the following results ($AVG = 1.61$, $STD = 2.47$), indicating a more positive view of sharks after the game.

The words the children provided before and after gameplay were categorized as positive, negative, or neutral. Neutral words, which carried no positive or negative connotation and were simply descriptive, are represented in gray in Figures 4.2 and 4.3.

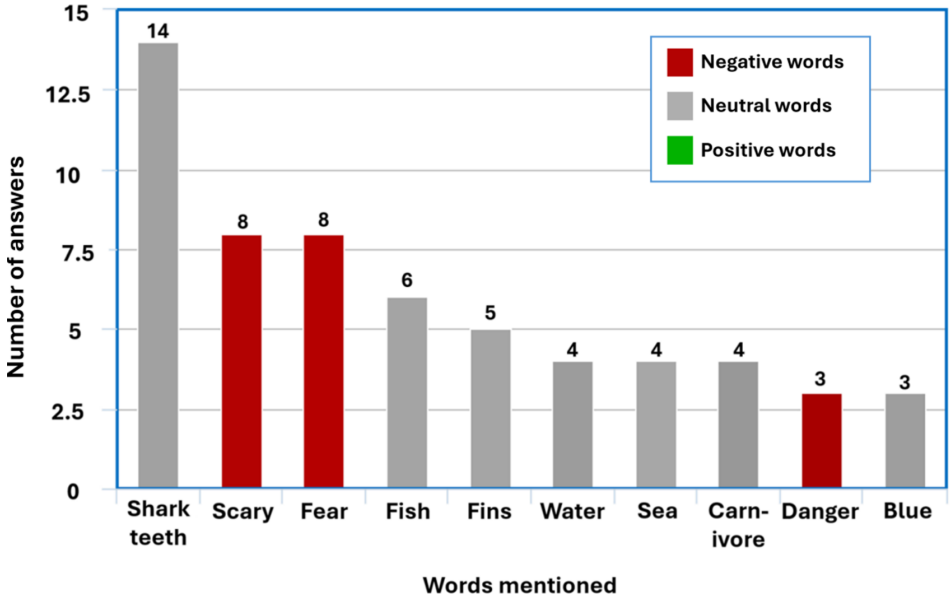

FIGURE 4.2. Top 10 words before game

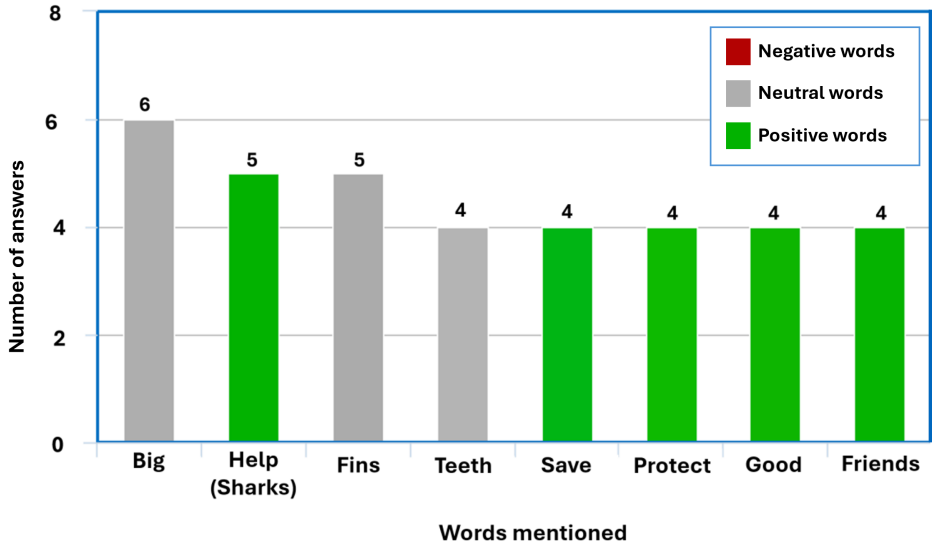

FIGURE 4.3. Top 10 words after game

The difference in the number of positive and negative words was then calculated before and after gameplay. The results of the difference between before and after the child played the game were ($AVG = 1.34$, $STD = 1.12$) for positive words and for negative words ($AVG = -0.87$, $STD = 0.93$).

The most commonly used negative words were "scary" and "fear," each mentioned by 21.05% of the children (highlighted in red in Figures 4.2 and 4.3). The positive word "help," used by 13.16% of the children, conveyed the idea that sharks need assistance as explained by the children when questioned about it (positive words are shown in green in Figures 4.2 and 4.3). Figures 4.2 and 4.3 display the top ten words used before and after gameplay, respectively.

These data show the educational game's effectiveness in enhancing children's knowledge about sharks and fostering more positive perceptions of these important marine creatures. These results suggest that the educational game was effective in enhancing children's knowledge about sharks and positively influencing their perceptions.

To determine the statistical significance of these results, the Shapiro-Wilk Test was used to assess whether the perception data followed a Gaussian distribution, given its effectiveness for smaller to moderately sized samples (up to around 50). The results showed a possibility of the data following a Gaussian distribution since $p > 0.05$ ($p = 0.052, n = 38$).

In order to further confirm if the data followed a normal distribution, a Q-Q plot was created, as illustrated in Figure 4.4, with dots representing the predicted residuals and the line representing the line of identity. If the data follows a normal distribution, the points will align along the 45-degree reference line, deviations from this line indicate a non-normal distribution. A paired *t-test* was performed to compare perception scores before and after the game, and Confidence Intervals (CI) were calculated accordingly. The results showed statistically significant changes with more than 99% confidence as $p < 0.01$ ($p < 0.01$, $CI = [0.74, 2.36]$, $n = 38$).

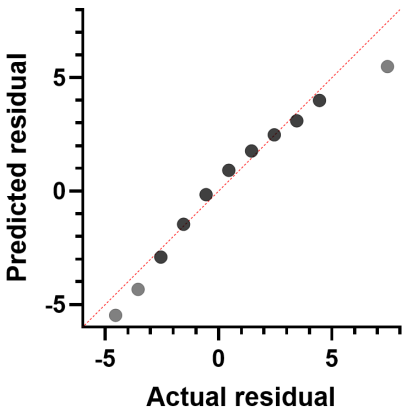

FIGURE 4.4. Q-Q plot illustrating the distribution of perception differences

The knowledge results did seem to follow a Gaussian distribution as well according to the Shapiro-Wilk test since $p > 0.05$ ($p = 0.497, n = 38$). Using Figure 4.5, a Q-Q plot was created, with dots representing the predicted residuals and the line indicating the line of identity, to further assess whether the data followed a normal distribution. The

plot shows that the dots align with the line, indicating that the data passes the normality test.

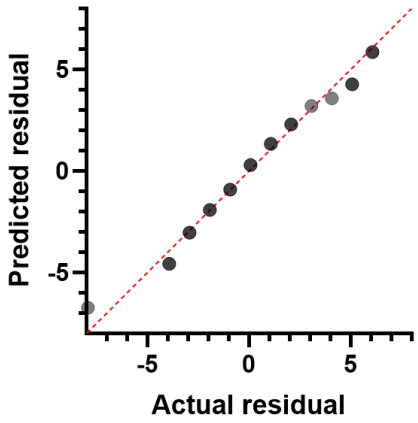

FIGURE 4.5. Q-Q plot illustrating the distribution of knowledge differences

A paired *t-test* was then performed and indicated the output is statistically significant with a confidence level of more than 99% ($p < 0.01$, , $CI = [2.93, 4.92]$, $n = 38$). Both statistical tests confirmed the significance of the differences.

In order the check if the values had a practical significant the Cohen's d value was used. Cohen's d was calculated for both knowledge and perception differences. The knowledge data had a Cohen's $d = 1.33$, indicating a large effect size (Cohen's $d \geq 0.8$), while the perception data had a Cohen's $d = 0.64$, indicating a medium effect size ($0.5 \leq$ Cohen's $d \leq 0.8$) [49] [50].

4.4. User player type and retrieved metrics

In addition to its primary objectives, the study also investigated the relationship between different player types and their game performance and parameters. Firstly the distribution of different player types was analyzed and is depicted in the Figure 4.6.

It is important to mention that each child might have multiple player types, explaining why the numbers added surpass the number of participants in the phase. As seen in the Figure 4.6, a significant amount of children have the Philanthropist (68.42%) as their player type based on the Hexad Model, followed by Socialiser (47.37%) and Achiever (42.10%) and very few children were identified as Disruptor (5.26%).

The next goal was to check if the game was effectively adaptable to every player independently of their player type and skill level. Due to the low number of Disruptors, this player type was removed from the performance in these tests.

This decision allowed for a clearer evaluation of how the game accommodates the more prevalent player types, ensuring no biases and that the adaptability and engagement of the game can be accurately measured across a broader spectrum of participants.

An evaluation of this relationship was done using a platform called *Jamovi* [51]. For this analysis, the Kruskal-Wallis One-Way ANOVA test was chosen. This test is used to

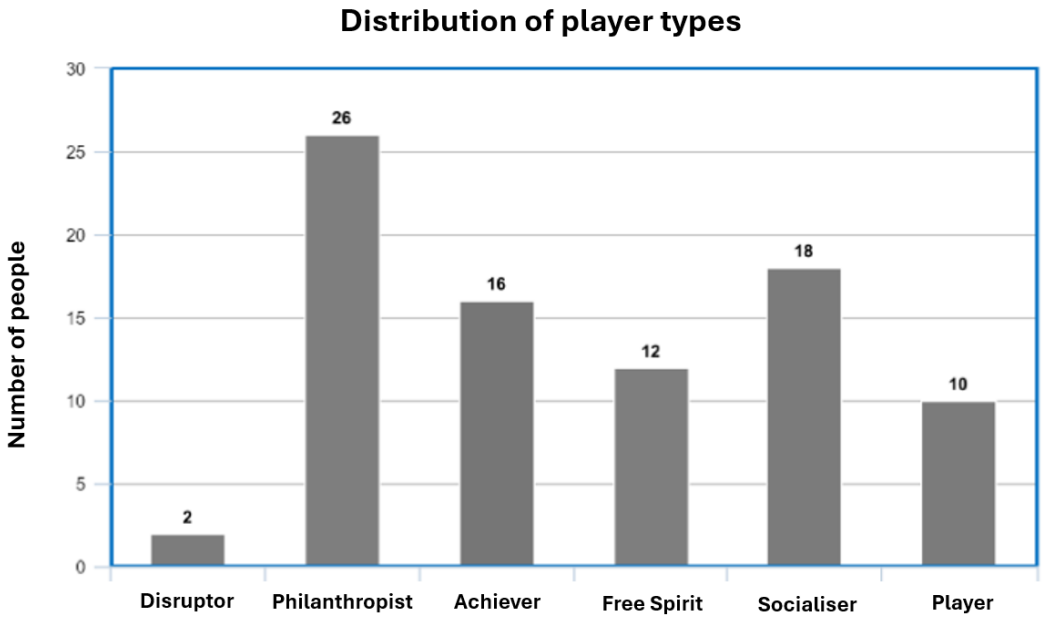

FIGURE 4.6. Distribution of the different player types in 38 children

find out if there are significant differences among three or more groups based on a specific variable which is the focus of interest. This variable should be continuous, meaning it can assume any value within a range. It is acceptable if the data is not perfectly normal or is skewed. However, the spread or variability of this variable should be similar across all the groups being compared.

In this analysis, each player type was assigned a specific number. If a player fell into more than one type, they were treated as if they were a different player but with the same characteristics. This allowed the test to consider all variations among the different player types.

Table 4.4 shows the p-value, which is the result from the Kruskal-Wallis test. The p-value helps determine if the differences among the groups are statistically significant in each parameter, meaning if they are likely due to something other than random chance.

Based on the analysis presented in the Table 4.4, it is seen that there are no statistically significant differences between the various player types with respect to any of the game parameters examined. That is, the Kruskal-Wallis One-Way ANOVA test results reveal that all p-values are considerably higher than the significance threshold of 0.05. Specifically, the p-values range from 0.529 to 0.986, indicating that the observed differences are not statistically significant.

This outcome suggests that several game parameters, including gaming frequency, the time required to complete tasks, the number of sharks caught or missed, responses to in-game questions, and demographic factors, such as age and gender, do not differ meaning that there's a possibility of no differences between player types. In other words, whether a player is a novice or an experienced gamer, younger or older, or of any particular gender, their interaction with the game remains largely consistent across these variables.

TABLE 4.4. p-values resulted from the Kruskal-Wallis One-Way ANOVA test the relationship between game parameters and player types

Game Parameter name	***p*-values**
Gaming frequency	0.909
Taken time to complete Task 1	0.937
Sharks caught	0.985
Fins missed while tracking	0.813
Additional sharks caught (besides the ones initially asked to)	0.794
Answered to wrong questions in the 1st Shark	0.986
Answered to wrong questions in the 2nd Shark	0.529
Answered to wrong questions in the 3rd Shark	0.876
Taken time to complete Task 2	0.947
Answer shark questions again?	0.628
Tracking sharks again?	0.841
Looking for injured sharks again?	0.559
Save them by answering questions again?	0.722
Repeat receiving the certificate?	0.559
Age	0.681
Gender	0.552

The results imply that the game has been designed with a degree of adaptability and inclusivity. It shows that the game's mechanics, challenges, and overall experience are effectively balanced and universally engaging, regardless of the player's background or skill level. This design shows that all players that participated in this experiment, irrespective of their demographic or experiential differences, can engage with the game on a similar level. One example of the game's adaptability features is its dynamic adjustment of the game area. If a player is unable to locate a shark to attach a tracker to within a specified time limit, the boundaries of the game area gradually shrink. This reduction in area makes it easier for the player to find a shark, as the space where the shark could be located becomes progressively smaller, bringing the player closer to their target.

Furthermore, the lack of significant variation in performance and experience among different player types suggests that the game does not disproportionately favor any specific group. This is a mathematical proof of the game's balanced and fair design, which provides an equitable gaming experience. The adaptability of the game shows that it remains engaging and accessible to a broad audience.

In summary, the findings suggest that the game is both adaptable and inclusive, catering to a diverse range of players without showing significant differences in performance or experience. Additionally, it is shown significant positive outcomes in terms of perception change and knowledge acquisition throughout the experiment.

CHAPTER 5

Conclusions and Future Work

The global decline in shark populations underscores the urgent need for innovative educational strategies that enhance conservation awareness and promote sustainable practices across generations. Addressing this critical challenge, the dissertation involved the development of an educational tool that features two interactive mini-games, for children between 7 and 11 due to their currently acquired development phase, aimed at demystifying these apex predators and highlighting their vital role in preserving marine ecosystems.

Utilizing a participatory design approach, the initial phases involved 20 children in brainstorming and early game design sessions. This inclusive method ensured that diverse perspectives from the target group were considered, fostering creativity and inclusivity. By involving children, the aim was to create a game that ensured that it was both engaging and educational. The children's feedback was invaluable, helping us refine game mechanics, narrative elements, and educational content to better match their interests and learning styles.

The design of the mini-games, developed in Unity, within the educational tool was carefully crafted to balance fun with informative content. One mini-game focused on the ecological role of sharks, using engaging challenges to illustrate their importance in maintaining the health of marine ecosystems. The other mini-game allowed children to experience the life of a shark, emphasizing the threats they face from human activities, such as overfishing and habitat destruction. These engaging experiences were pivotal in helping players understand complex conservation concepts in a relatable and memorable way.

The final iteration of the game underwent rigorous testing with 38 participants, providing significant evidence of its impact. The findings demonstrate that the game substantially enhances participants' knowledge about sharks, as indicated by a notable increase in knowledge scores. Additionally, the game effectively cultivates positive perceptions of sharks, with participants showing improved perception scores post-gameplay. Qualitative insights from words associated with sharks before and after playing the game further validate these quantitative gains, revealing a significant shift towards more positive attitudes and decreased negative perceptions following interactive engagement.

While the study examined correlations between player characteristics and game performance metrics, no statistically significant relationships were found, highlighting the game's adaptability. Overall, the study confirms that the serious game is an effective educational tool, successfully increasing knowledge and improving attitudes towards sharks,

while demonstrating its ability to engage a diverse audience without being affected by individual differences in player profiles.

To guide this dissertation, the following research hypotheses were formulated and addressed based on the results. These hypotheses, along with the conclusions drawn from the findings, are outlined below:

- **H1** - The hypothesis that *"Serious games contribute to educating children about the vital role of sharks"* was confirmed, as an increase in knowledge was observed after the game was played.
- **H2** - The hypothesis that *"Serious games positively change children's perception of sharks"* was also supported by a measurable positive improvement in children's perceptions of sharks.
- **H3** - The hypothesis that *"Serious games can adapt to various user types and skill levels through adaptation mechanisms"* was validated. The game demonstrated inclusivity for all user types and skill levels, as the relationships between user types and game parameters were not significant enough to suggest any limitations.
- **H4** - The final hypothesis *"Children aged 7 to 11 have negative preconceptions of sharks before playing the game"* was likewise confirmed, particularly through analysing the three words children initially associated with sharks. The majority of the words were negative and stereotypical, reflecting common misconceptions and fears fueled by media portrayals, such as in movies.

In conclusion, the serious game, developed for this dissertation, represents an interactive educational tool that hopes to contribute significantly to environmental education and conservation efforts. By fostering empathy, deepening understanding, and promoting informed knowledge through engaging learning experiences, initiatives like this have the potential to inspire a generation of environmentally conscious citizens dedicated to safeguarding the biodiversity and ecological integrity of our oceans.

In future work it will be relevant to run more tests with more children in more diverse contexts to verify that the obtained positive results can be generalized to a broader population. It is also relevant to explore the correlation between gender and different interactions with the game; For example, girls were observed to try to put the tracker in the center of the fin, while boys were more directed towards attaching it and not caring so much about the position and centralization of it, as it was shown in preliminary observations. Additionally, the relationship between player types and various game parameters recorded during gameplay, such as the time taken to complete tasks and the number of attempts required to perform specific actions, like placing a tracker on a shark, would be interesting to be further investigated with a larger and more diverse population. Analyzing these correlations aims to gain deeper insights into player behavior and preferences, further informing the development of effective educational tools.

To enhance the educational impact, the potential use of Virtual Reality (VR) and Augmented Reality (AR) can be also considered. VR can provide an even more immersive

experience, allowing players to virtually dive into the ocean and interact with sharks in their natural habitat, while AR can bring elements of the game into the real world, enhancing engagement through interactive learning. These technologies offer exciting possibilities for deepening the learning experience, making the conservation message even more compelling and memorable.

Moreover, it will be important to expand the game's content and complexity based on feedback from both children and educators. This might include additional mini-games, more detailed information about different shark species, and scenarios that address broader environmental issues, such as climate change and plastic pollution. By continuously evolving the game it is expected that it keeps its relevancy and effectiveness as an educational resource.

The broader impact of this game hopes to extend beyond individual knowledge gains. Integrating it into school curriculums and community programs aims for the possibility of reaching a wider audience and foster a culture of conservation from an early age. Collaborating with environmental organizations and leveraging social media platforms can also amplify the message it brings, encouraging collective action to protect shark populations and marine ecosystems.

Overall, this dissertation highlights the power of interactive learning tools in shaping young minds and fostering a deeper appreciation for the natural world. Moving forward, the goal is to create even more impactful experiences that not only educate but also inspire action, helping to ensure a sustainable future for both sharks and the marine ecosystems they inhabit. By engaging the next generation through innovative educational strategies, including the potential use of VR and AR, it is possible to cultivate a global community that values and actively works towards the conservation of the Earth's marine biodiversity.

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APPENDIX A

Initial Ideas

This section examines a variety of initial ideas that were considered but ultimately set aside during the dissertation development process. Although these concepts were not incorporated into the final product, they provided valuable insights and lessons learned along the way.

One of the primary concepts considered was developing a virtual reality (VR) game. However, this idea presented several challenges. Firstly, since the target audience were children as well, there were concerns about bringing VR equipment into schools and requiring parental consent. Additionally, a 30-minute VR game could potentially lead to issues, such as cybersickness, which would not be ideal for young players.

The other ideas involved a simple 3D game. The initially thought narrative involved the following scenarios:

- Children celebrating their birthday and receiving as a gift a diving experience;
- The parents driving the children to a diving center;
- The child going in water with a diving master that would help them along the journey;
- During their dive, they would discover a mysterious clock;
- Upon touching the clock, they would be transported into the future, where they would witness the ocean in a severely degraded state;
- This shocking vision would serve as a wake-up call, prompting the children to return to the present with a mission: to save sharks and prevent the disastrous future they had glimpsed.

The initial storyboard, drawn by the author of this dissertation using a tablet and an application called *Sketchbook* [52], is illustrated in the accompanying Figure A.1, A.2 and A.3, which capture the essence of this storyline and outlines the sequence of events.

The initial game design included two distinct mini-games, each tailored to engage different types of players. The first mini-game, as it is shown on Figure A.2., involved the player taking on the role of a defender of marine life by stopping illegal fishing boats. In this game, players dived to the ocean floor to retrieve a pipe, which they then would throw into the boat's propeller to halt its movement. After successfully stopping the boat, the player would call the marine police to arrest the perpetrators. This mini-game was designed to appeal to several player types: Disruptors, who typically enjoy breaking rules and causing disruptions by stopping the boat; Free Spirits, who relish exploring the ocean environment to find useful objects like the pipe, enjoying the autonomy this

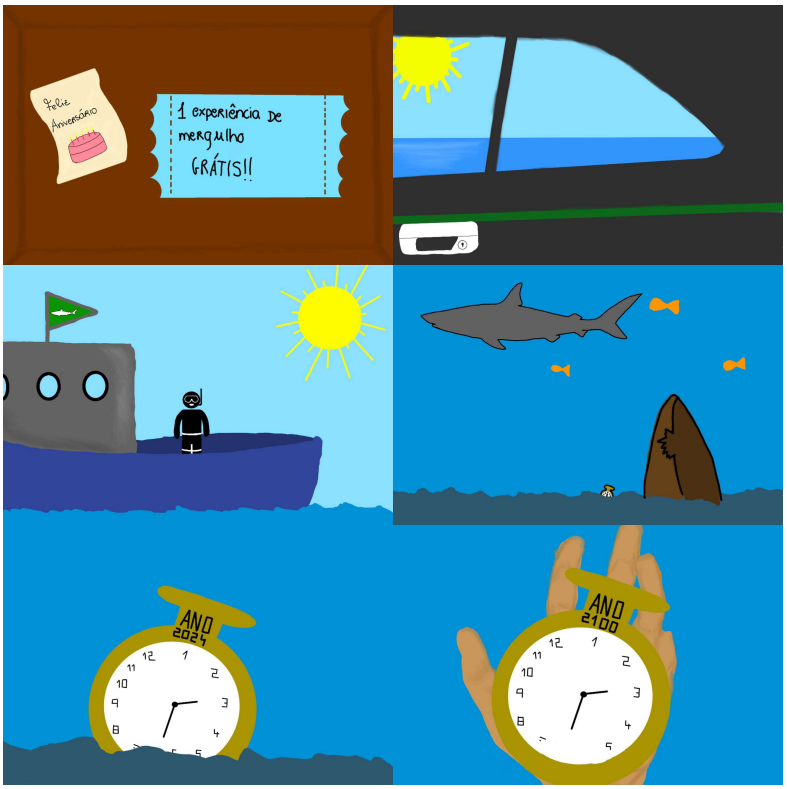

FIGURE A.1. First part of discovering the clock

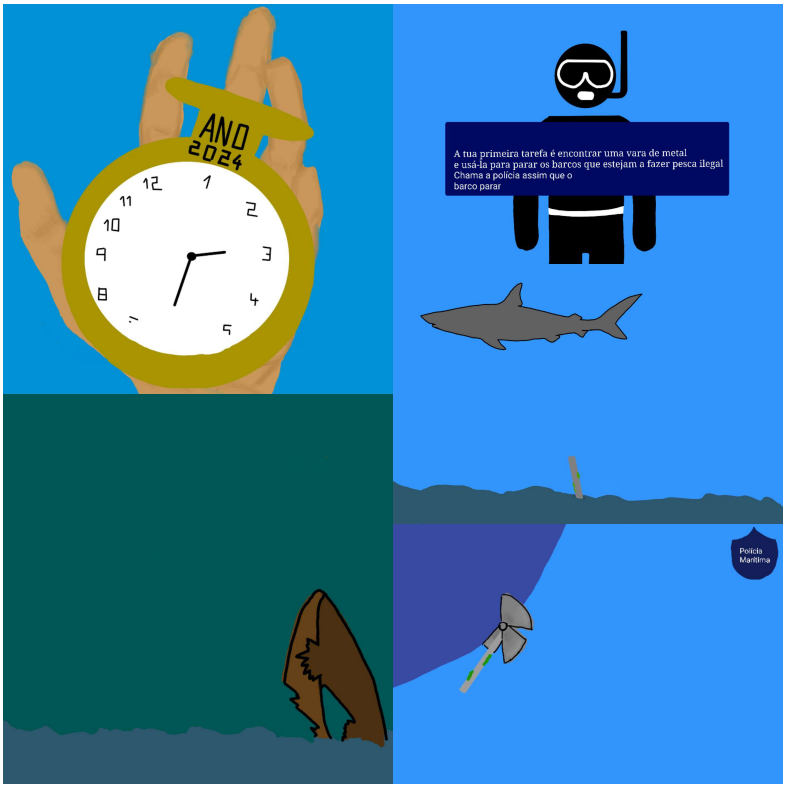

FIGURE A.2. First task is to stop illegal fishing boats

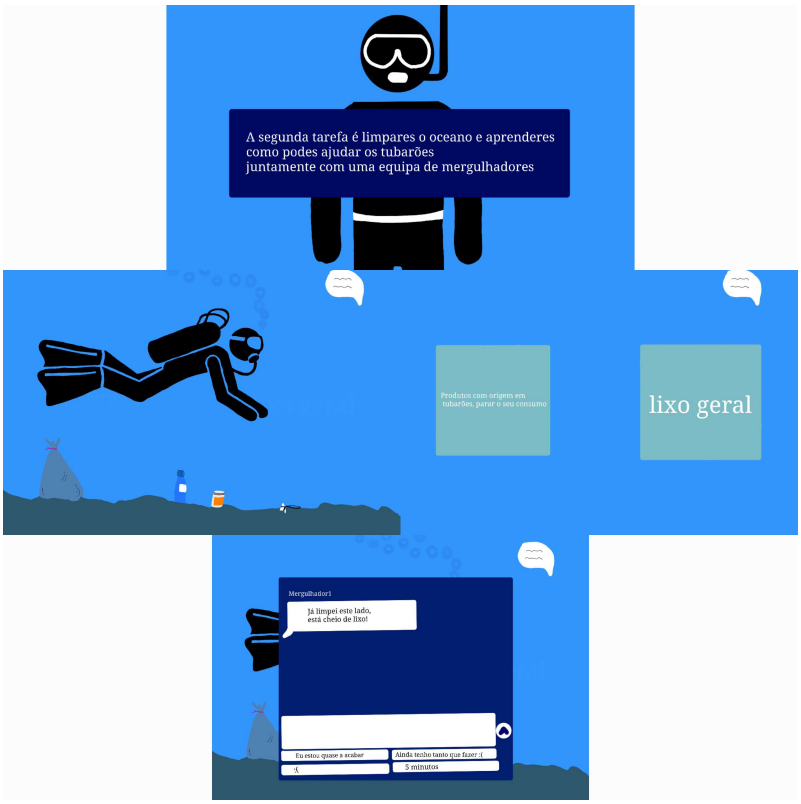

FIGURE A.3. Second task is to catch trash along with NPC players - There is also the ability to chat with them

gameplay offers; and Achievers, who are motivated by the challenge of mastering the skill of stopping multiple boats over time.

The second mini-game focused on finding and collecting sharks alongside non-playable characters (NPCs) as it is shown on the storyboard from Figure A.3. Players could connect and interact with these NPCs through a chat group, fostering a sense of community and collaboration. This game was primarily aimed at Socializers, who thrive on interacting with others, and Philanthropists, who are driven by the noble cause of saving sharks and other marine life. Players (the player type) do not have a specific game which they are assigned to since they do not have any rewards in both of the games. The goal of this scheme would be to see if the game the children liked the most could be predictable by their player types.

This narrative aimed to blend education with entertainment, offering children a memorable experience that conveyed significant lessons about ocean conservation and the pivotal role of sharks in marine ecosystems. Through active participation in a mission to safeguard the ocean, the game aimed to cultivate a sense of responsibility and environmental stewardship among its young players.

However, this idea ultimately was not chosen due to concerns over its complexity for children. It was decided that a participatory design approach would be more closely accessible for children since it was also designed by children.