INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO
MESTRADO EM ENGENHARIA INFORMÁTICA




Conceção e Desenvolvimento de um Advergame para a Sensibilização para as Alterações Climáticas

JOÃO MIGUEL RANGEL ALVES
Setembro de 2024

POLITÉCNICO
DO PORTO

ISEP INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO

Designing and Developing an Advergame for Climate Change Awareness

João Alves

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Computer Science and Engineering, Specialisation Area of Games, Graphical and Interactive Systems

Supervisor: Carlos Vaz de Carvalho

Evaluation Committee:
President:
Dr. Alberto Sampaio, Professor, DEI/ISEP

Members:
Dr. Isabel Azevedo, Professor, DEI/ISEP
Dr. Carlos Vaz de Carvalho, Professor, DEI/ISEP
Dr. Bertil P. Marques, Professor, DEI/ISEP

Porto, September 15, 2024

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Dedicatory

To my family and friends, whose support during these past few years has been indispensable in reaching my goals.

Abstract

Climate change is causing severe impacts on both human communities and ecosystems. More frequent and intense extreme weather events are leading to loss of life, displacement, and economic hardship, while agricultural productivity is declining, threatening food security and farmers' livelihoods. Additionally, climate change disrupts ecosystems, causing species and habitat loss and altering animal migration and breeding cycles. These far-reaching consequences highlight the urgent need for global efforts to reduce greenhouse gas emissions, protect vulnerable habitats, and promote sustainable practices to preserve biodiversity for future generations.

Numerous individuals lack interest in climate change due to its complexity and the perceived lack of immediate impact. This hinders public action and efforts to address the issue, despite decades of awareness campaigns that have yet to significantly influence the population.

Taking this into consideration, this document explores the various methods by which information regarding climate change, and its subsequent impact on environmental sustainability, is presented. Each method has been analyzed regarding its effectiveness in transmitting the mentioned information to individuals not particularly well versed in such a matter. After the analysis, one of the methods was chosen, a game, more specifically an advergame. This advergame was created with the objective of stopping the spread of misinformation and to better represent the negative consequences of climate change to individuals who play the created advergame.

The results obtained from this work show that the game had an impact on the players. This impact was less than would have been hoped for, but it is nonetheless a contribution towards raising awareness of the issue of climate change.

Keywords: Climate Change, Environmental Sustainability, Game, Advergame, Awareness, Climate Scepticism

Resumo

As alterações climáticas causam graves impactos tanto nas comunidades humanas como nos ecossistemas. Os fenómenos meteorológicos extremos, mais frequentes e intensos, provocam a perda de vidas, deslocações e dificuldades económicas, enquanto a produtividade agrícola diminui, ameaçando a segurança alimentar e os meios de subsistência dos agricultores. Além disso, as alterações climáticas perturbam os ecossistemas, provocando a perda de espécies e de "habitats" e alterando os ciclos de migração e reprodução dos animais. Estas consequências de grande alcance realçam a necessidade urgente de esforços globais para reduzir as emissões de gases com efeito de estufa, proteger os "habitats" vulneráveis e promover práticas sustentáveis para preservar a biodiversidade para as gerações futuras.

Muitas pessoas não têm interesse nas alterações climáticas devido à sua complexidade e à perceção da falta de impacto imediato. Este facto dificulta a ação pública e os esforços para resolver a questão, apesar de décadas de campanhas de sensibilização que ainda não conseguiram influenciar significativamente a população.

Tendo isto em consideração, este documento explora os vários métodos de apresentação de informação sobre as alterações climáticas e o seu subsequente impacto na sustentabilidade ambiental. Cada método foi analisado quanto à sua eficácia na transmissão da informação mencionada a indivíduos não particularmente versados nesta matéria. Após a análise, foi escolhido um dos métodos, um jogo, mais concretamente um *advergame*. Este *advergame* foi criado visando parar a disseminação da desinformação e de representar melhor as consequências negativas das alterações climáticas aos indivíduos que jogam o *advergame* criado.

Os resultados obtidos deste trabalho mostram que o jogo teve impacto nos jogadores. Este impacto foi menor do que seria desejado, mas de qualquer forma é um contributo no sentido de despertar as consciências para a questão da mudança climática.

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Chapter 1

Introduction

1.1 Context

Climate change is already having dramatic consequences on many people's lives. Rising global temperatures have led to more frequent and intense extreme weather events, such as hurricanes, droughts, heatwaves, and floods. These events have devastated communities around the world, causing loss of life, displacement, and economic hardship. Moreover, changing weather patterns and reduced rainfall have affected agricultural productivity, leading to food shortages and threatening the livelihoods of farmers and rural communities. The urgency to address climate change is evident as its impacts continue to unfold, highlighting the need for immediate action to mitigate its effects and build resilience in vulnerable areas.

Climate change has had profound implications for ecosystems and biodiversity. It has disrupted delicate ecological balances, leading to the loss of species and habitats. For example, melting glaciers and shrinking ice caps contribute to rising sea levels, endangering coastal ecosystems and the species that rely on them. Additionally, changing climate patterns have altered the migration patterns and breeding cycles of various animals, affecting their survival and disrupting entire ecosystems. The consequences of climate change are far-reaching and extend beyond human communities, underscoring the urgent need for concerted global efforts to curb greenhouse gas emissions, protect vulnerable habitats, and promote sustainable practices to preserve the planet's biodiversity for future generations.

1.2 Problem

However, there is still a widespread lack of interest in this issue, either because it is notoriously difficult to fully understand or because many people still don't feel its impact. This lack of understanding or awareness of the scale of the impact that climate change can have on the planet's environmental sustainability makes it difficult to take public action or carry out actions that help limit the scale of this problem. Unfortunately, the problem of climate change has been known for several decades. There have been numerous interventions to raise awareness of the problem, but they have not yet had an impact on the population.

1.3 Objectives

The primary objective of this work is to make the player aware by presenting the obviously negative consequences of climate change more clearly.

Additionally, there are secondary objectives:

- Fighting disinformation about climate change.
- Changing the perception of climate change of all individuals.

1.4 Research Questions

In order to better organize the research efforts, some research questions have been formulated:

- What is climate change and subsequent effects on the planet?
- What are the methods used to conscientize individuals about climate change and environmental sustainability?
- What is the most successful method of conscientizing individuals about climate change?
- Are video games a good method of showcasing/teaching the impacts climate change on environmental sustainability?
- Does playing a game about the impacts of climate change make players more climate conscient?

1.5 Research Methodology

The research methodology used, in order to obtain answers to the mentioned research questions, involved an extensive analysis of existing scientific literature on the subject. This analysis included a detailed examination of research papers, with a particular focus on studies that researched the efficacy of using video games as a medium for communication and teaching about climate change. By utilizing this approach, it allowed a more complete understanding of the topic, drawing on the findings and conclusions of previous research in the field.

In addition to the mentioned methodology, the concept of the project, its design and development, and subsequent evaluation also contributed to the acquirement of answers to the established questions.

1.6 Activity Plan

The necessary steps that were taken to not only achieve the final product of this paper are exemplified in the following diagram:

Figure 1.1: Activity Diagram

An approximation of time for each step is as follows:

- Ideation: 29th of January to 5th of February
- Consolidation of ideas: 5th of February to 9th of February

- Development: 12th of February to 9th of June
- Testing and bug corrections: 10th of June to 28th of June
- Game release: 30th of June

1.7 Work Motivation

One important factor that helped, or at least did not hinder, the work was motivation. The reason for the existence of this dissertation/thesis was not only my innate interest in climate change, but also my love for video games in general. When I say video games, such as "Endling - Extinction is Forever" that combined these two aspects together, compounded with the presentation of the devastation that humanity has on the world, I was inspired in all honesty. There is a part of me that wants to help resist the rising tide, or rather tsunami, that is climate change, and regardless of the area of specialization I am in, I wish to better the world just a bit. A very improbable goal, which I am very well aware of. The product of this dissertation/thesis is not only for academic reasons, but also personal ones, to see if I have what it is required to get into the video game industry, but also if I have what it takes to combine it with my goal of combating climate change and reduce animal, and human suffering that results from it. Only time will tell.

Chapter 2

State of the Art

2.1 Climate Change

Climate change is a long-lasting alteration of global and regional climate patterns. Even though, in recent decades, it has been used to refer to the increase in global temperatures.

Climate change refers to the enduring modification of temperature and usual weather patterns in a location. This change can lead to unpredictable weather patterns, posing challenges for regions dependent on farming, as the anticipated temperature and rainfall levels become unreliable.

It also correlates with other harmful weather phenomena, such as more frequent and severe hurricanes, floods, heavy rains, and winter storms. In polar areas, the escalating global temperatures linked with climate change have led to ice sheets and glaciers melting at a faster pace from one season to the next. This contributes to rising sea levels across various regions of the world. Coupled with the expansion of ocean waters due to increasing temperatures, the subsequent rise in sea level has started to harm coastlines through heightened flooding and erosion.

The primary cause of the current climate change is predominantly human activity, including the combustion of fossil fuels, natural gas, oil, and coal. The burning of these substances emits greenhouse gases into the Earth's atmosphere, leading to a rise in the planet's temperature, a phenomenon known as global warming.

For the whole of the Earth's history, the climate has been in a constant state of change. When this change occurs naturally, it is a slow process that unfolds over hundreds and thousands of years. However, the climate change influenced by human activities that we are witnessing now is happening at a significantly faster pace.(*Climate Change* n.d.)

With this in mind, what are the historical milestones that have led us to the current state of the climate crisis?

To comprehend the origins of this climatic crisis, we need to trace back over a century and a half. However, it was not until the 1950s that scientists initiated in-depth studies of carbon activities in the atmosphere. From the 1960s onwards, researchers began to construct extensive computer models, which currently shed light on the intensity of the alterations.

In the 1850s, Eunice Newton Foote, a hobbyist scientist residing in New York, conducted an experiment, in which led her to ponder the connection between carbon dioxide, our planet, and heat. She proposed in the 1856 paper, summarizing her results, that "An atmosphere composed of this gas would result in a higher temperature for our earth."(*How scientists found out that climate change is real and dangerous | Science News* n.d.)

Three years after Foote's discovery, John Tyndall, an Irish physicist, independently demonstrated the same fundamental concept but with greater specificity. Via of his experimentation, he proposed that gases like carbon dioxide could retain heat within the Earth's atmosphere, akin to how glass panned in a greenhouse trap heat, thereby influencing the climate.

The commencement of the 19th century marked a significant shift in human influence on the atmosphere, coinciding with the rise of the Industrial Revolution in Britain. This period was characterized by the extensive burning of coal in factories and the revolutionary impact of the steam engine, powered by fossil fuels, on transportation and various other sectors. Subsequently, fossil fuels, including oil and natural gas, have been exploited to fuel a global economy. These cumulative activities result in the emission of gases into the atmosphere.

Svante Arrhenius, a Swedish physical chemist, in 1896, posited that a 50% reduction in atmospheric carbon dioxide could potentially trigger an ice age, while a twofold increase could elevate global temperatures by approximately 5 to 6 degrees Celsius.

Despite the prevailing skepticism, one investigator, Guy Stewart Callendar, a British engineer and self-taught meteorologist, deemed the concept worthy of further exploration. Through his meticulous research, he attributed the temperature escalation to the combustion of fossil fuels. Callendar approximated that the burning of fossil fuels had contributed to billions of metric tons of carbon dioxide to the atmosphere since the late 19th century.

Echoing the sentiment of many contemporaries, Callendar did not perceive global warming as a detrimental phenomenon. He postulated that an increase in carbon dioxide would invariably enhance plant growth and facilitate agricultural expansion into new territories, thereby indefinitely postponing the resurgence of destructive glaciers. However, his research rekindled debates, originating from the works of Tyndall and Arrhenius, about the planetary system's response to alterations in atmospheric gas concentrations. Furthermore, it initiated a shift in discourse towards the potential impact of human activities on these changes.

The outbreak of World War II in the subsequent year significantly reshaped the scientific research landscape. Pivotal wartime technologies, such as radar and the atomic bomb, paved the way for large-scale scientific studies that unified nations to address globally significant questions. This shift facilitated the emergence of contemporary climate science.

A notable initiative was the International Geophysical Year (IGY), an 18-month endeavor in 1957-1958 that encompassed a broad spectrum of scientific field campaigns. Although climate change was not a primary research focus during the IGY, a group of scientists in California, spearheaded by Roger Revelle of the Scripps Institution of Oceanography, capitalized on the surge in funding to initiate a long-desired project. The objective was to measure carbon dioxide levels accurately and consistently at various global locations.

The responsibility was assigned to geochemist Charles David Keeling. The most important measurements that resulted of this effort were the Mauna Loa measurements. Consequently, one of the most emblematic datasets in scientific history was established - the "Keeling curve", which chronicles the escalation of atmospheric carbon dioxide. As the curve ascended over time, it played a crucial historical role in alerting people to the issue of climate change and without surprise the curve continues its upward trajectory each year. (*How scientists found out that climate change is real and dangerous | Science News* n.d.)

Concurrent with the initiation of Keeling's measurements, Revelle contributed to the development of a significant argument asserting that carbon dioxide from human activities was

accumulating in Earth's atmosphere. In 1957, Revelle and Hans Suess published a paper that traced the flow of radioactive carbon through the oceans and the atmosphere. Their findings indicated that the oceans were incapable of absorbing as much carbon dioxide as previously assumed, suggesting that a substantial portion of the gas was likely being retained in the atmosphere.

"Currently, humans are conducting a large-scale geophysical experiment of a magnitude that could neither have occurred in the past nor be replicated in the future," wrote Revelle and Suess in their paper. This statement has become one of the most renowned in the field of earth science. It encapsulates the fundamental understanding of modern climate science: the levels of atmospheric carbon dioxide are rising, and human activities are the primary cause. Revelle and Suess's work was the final piece in a puzzle that began with Svante Arrhenius and John Tyndall.

Throughout the latter half of the 20th century, observational data collected by researchers progressively enhanced our understanding of how human activities were altering the planet. The evidence of such dramatic climate shifts dispelled any remaining notions that global climate change would be slow and unlikely to occur within a timeframe that should concern humans.

Further evidence of global change was provided by Earth-observing satellites, which have offered a global perspective on global warming since the 1960s. From their vantage point in space, satellites have measured the rise in global sea level, as well as the rapid decrease in ice left floating on the Arctic Ocean each summer at the end of the melt season.

Observations of temperature at global weather stations substantiate that we are experiencing the warmest years in recorded history. The top ten hottest years have all transpired since 2005, with nine of them occurring post-2010.

By the 1960s, the undeniable warming of the planet was evident. However, comprehending the implications of these changes, including risks to human health and welfare, necessitated more than just observational data. Future projections relied on computer simulations, which involved intricate computations of energy flow within the planetary system.

Climate modeling began with Lewis Fry Richardson's idea of global forecasts during WWI, realized post-WWII with computational advancements. The meteorologist Jule Charney's team made the first computer-driven weather forecast in 1950. By 1956, Norman Phillips developed the first general circulation model. Syukuro Manabe and Richard Wetherald made a significant advancement in 1967 by modeling Earth's surface and atmosphere interconnections. This led to precise predictions of global warming effects, culminating in the 1979 "Charney report" on the implications of increasing carbon dioxide levels. In the subsequent decades, climate modeling has become increasingly complex. As the science of climate change solidified, it also emerged as a political issue.(*How scientists found out that climate change is real and dangerous | Science News* n.d.)

2.2 Climate Change Disinformation

Regrettably, the internet, while a valuable tool for accessing information about climate change, also serves as a platform for spreading misinformation. This false information, often linked to cynicism, denial, and opposition, is frequently disseminated by various entities including governments, religious and political groups, certain industries, right-leaning media outlets, and the public, particularly those with conservative political views. This leads to four types of climate change denial:

- Denial of the trend (disputing significant warming)
- Denial of attribution (denying human involvement)
- Denial of impact (disputing significant human or environmental effects)
- Denial of consensus (disputing agreement among climate scientists)

The effects of this denial manifest in ongoing conflicts between climate change activists and deniers, hindering the implementation of solutions. This can also lead to apathy among observers.

However, there are strategies to counter misinformation, including:

- Inoculation against misinformation
- Fact-based responses to misinformation
- Early detection of malicious accounts
- Use of ranking and selection mechanisms

These strategies have been thoroughly examined by experts. The first, inoculation, aims to preemptively provide correct information or warnings about potential misinformation. However, this approach requires knowledge of the misinformation to be spread and access to the target audience.

The second strategy acknowledges that people are more likely to resist corrections that threaten their cultural identity. Therefore, science communication must respect cultural identities.

The third strategy involves early detection of malicious accounts like bots and spammers, potentially through partnerships between social media platforms and academic researchers.

The fourth strategy suggests that tech developers have a responsibility to combat misinformation, possibly through crowdsourcing to assess news quality and adjust ranking algorithms accordingly.(Treen, Williams, and O'Neill 2020)

It's important to note that these strategies rely on accurate information from various sources, including books, scientific articles, documentaries, TV shows, and even video games. The effectiveness of some of these sources will be discussed in the following chapter.

2.3 Methods of Information Presentation

As indicated previously, the information regarding climate change can be acquired from various sources, such as films, documentaries and, in recent years, via the use of smartphone applications. In other worlds, more traditional methods. However, how effective are these sources overall when it comes to, not only the dissemination of information, but most importantly, in the raising of awareness regarding the climate crisis or other factors related to it. Each source will be discussed with the support of a study that explored it.

2.3.1 Documentaries

This study explored the problem of marine waste, especially plastic rubbish, and how human actions can help mitigate this issue. The nature documentary series "Blue Planet II" by the BBC is recognized for heightening consciousness about plastic pollution in the UK. The series, with its potent conservation theme, purportedly sparked public curiosity and shifts in plastic usage habits, a trend referred to as the "Blue Planet Effect". Nonetheless, the proof backing this effect is primarily anecdotal or reliant on self-reported conduct, which may lack accuracy. Consequently, the researchers proposed that a solid experimental framework and significant behavioral metrics are essential to genuinely comprehend the series' influence.

The research conducted aimed to assess the influence of the conservation messages in the "Blue Planet II" documentary series on the plastic usage habits of its viewers. This research is a reaction to the growing reliance on media interventions to encourage environmentally friendly behaviors, especially in city dwellers with scarce exposure to nature.

The findings of this study revealed no substantiation to back the assertion that the conservation messages in "Blue Planet II" brought about a shift in viewers' plastic usage habits. This challenges the widely held belief in the "Blue Planet Effect". Similar outcomes have been observed in past research, where documentaries heightened viewers' consciousness but failed to instigate enduring behavioral modifications. Media interventions like "Blue Planet II" are prone to swift acceptance and subsequent disregard, underscoring the need to evaluate the longevity of any immediate behavioral impacts. The follow-up experiment in this study aligned with earlier research indicating high recurrence rates of the initial positive effects of an intervention. Nonetheless, these results lack statistical significance due to the limited sample size.

Nonetheless, the evaluation of "Blue Planet II" is influence showed that it notably enhanced viewers' understanding of environmental matters, but it didn't necessarily prompt action. This reinforces the idea that mere understanding is not enough to bring about behavioral change, and that various factors are required. The research did not discover any positive impact of environmental documentaries on individual environmental attitudes.

While it's essential to consider individual change when evaluating interventions, the study indicates that the impact of films and documentaries should also take into account wider societal effects. The series under scrutiny heightened public conversation about marine plastics, possibly leading to policy alterations. For example, it was cited in the UK government's 25-year environmental plan, which proposed actions to combat plastic pollution. However, the study overlooked the potential impact of interpersonal interactions sparked by the series on behavioral modification. Past research implies that merging various intervention tactics can effectively maintain behavioral change in an environmental setting.(Dunn, Mills, and Veríssimo 2020) Hence, future research should contemplate both individual behavioral

change and broader societal shifts, like interpersonal or governmental policy-level changes, for a more holistic understanding of impact.

As nature documentaries gain popularity and pivot towards conservation-oriented themes, this research is pioneering in its examination of the effects of this narrative shift on viewers' eco-friendly behaviors, employing a solid experimental framework. The study advocates for more research on evaluating the impact, specifically focusing on nature documentaries and other mass media strategies related to biodiversity.(Dunn, Mills, and Veríssimo 2020)

2.3.2 Films

Despite criticisms of their representation, natural history films have emerged as a medium for reestablishing people's connection with nature. This study formulated a framework to comprehend how these depictions can foster ecological consciousness, using natural history films as a case study. This framework was put to the test with "Planet Earth 2", a series that garnered record viewership but was criticized for its unrealistic portrayal of the natural world.

The research carried out both qualitative and quantitative evaluations of the program's content and utilized extensive data from Twitter and Wikipedia to gauge viewer responses and involvement. Acknowledging the fleeting nature of television and other media communications, the research also probed whether the program induced enduring shifts in public consciousness and proactive actions post-broadcast. The influence of "Planet Earth 2" on viewers was subsequently juxtaposed with that of wildlife consciousness campaigns.

In terms of results, the research discovered that a mere 6% of the "Planet Earth 2" script was devoted to conservation topics, which had a minimal impact on viewer response, as evidenced by less than 1% of all tweets referencing these topics. The absence of a clear conservation message in the show led the investigators to concentrate on the animal species highlighted in each episode. They observed an overemphasis on mammals and a lack of representation of all other groups.

In relation to Twitter engagement, the research identified a notable positive relationship between the duration of species' screen time per episode in the show #PlanetEarth2 and the audience's response.

The study also revealed that 44% of the species showcased in "Planet Earth 2" saw a substantial rise in Wikipedia page visits six months after the broadcast, in comparison to control species. This indicates a sustained enhancement in audience consciousness for these species.

Nevertheless, the examination of contributions to the charities Born Free and Arkive showed no discernible link between the airing dates of the show and the donations received.

Moreover, the research found that the degree of information engagement, gauged by Wikipedia page visits, following the airing of "Planet Earth 2", were comparable to the engagement seen during worldwide species days.

To draw this section to a close, the study indicates that natural history films with an entertainment focus can cultivate a bond with nature and heighten public curiosity in environmental matters. Such films, like "Planet Earth 2", can draw in a wide viewership, encompassing even those who aren't already environmentally aware.(Fernández-Bellon and Kane 2020) The engagement of the audience is propelled by the screen time allocated to the species,

irrespective of their appeal. However, these films don't necessarily prompt proactive measures such as charitable contributions, as these actions are swayed by multiple factors and might transpire after a considerable lapse of time.

The influence of these films on viewer awareness can endure past the airing timeframe. Programs with a distinct conservation focus may have lasting effects and could potentially encourage behaviors favoring conservation, particularly when associated with prominent personalities or wider platforms such as online streaming services or social media initiatives.(Fernández-Bellon and Kane 2020)

2.3.3 Smartphone Applications

The analyzed study's research underscores the significance of information in the 21st century, especially in molding eco-friendly mindsets within Generation Z. It draws attention to the link between consumption habits, climate change, and shifts in media. Furthermore, it accentuates the contribution of eco-applications towards realizing the United Nations' sustainable development objectives, including quality education, innovation in industry, responsible consumption, and climate action.

This research sought to comprehend the role of eco-applications as a novel information source for eco-friendly behavior among young individuals studying in Poland, and its influence in molding environmentally conscious attitudes. Despite the ubiquity of media access and the prominence of environmental issues, there remains an escalating need for understanding human-nature relationships. Environmental education, necessitating trustworthy information sources, is vital for enhancing environmental quality. The study revealed that the younger demographic views the internet as more reliable than their older counterparts, sourcing their environmental knowledge from both contemporary and conventional media. The research also aimed to pinpoint the most prevalent eco-friendly behaviors among students, ascertain the awareness of eco-apps among students, and highlight the eco-app design elements anticipated by students.

Simultaneously, the paper concentrated on several eco-apps, chosen due to their eco-friendly emphasis and popularity within the student cohort. The apps in focus were ZeroWasteApp, ZdroweZakupy, ToGoodToGo, Ingred, GdzieWyrzuci´c, Vinted, Veturilo, BlaBlaCar, and HappyCow. However, the least recognized apps (ZeroWasteApp, Ingred, and HappyCow) were omitted from subsequent examination.

Regarding the findings, the study identified notable disparities in eco-friendly practices between individuals residing in rural and urban areas. Those in rural areas were more inclined to segregate waste, whereas urban dwellers were more prone to utilize environmentally friendly transportation options. Income level also played a role in shaping behavior, with lower earners more likely to opt for public transportation. The research further explored the recognition and usage of eco-applications among students. Vinted emerged as the most recognized and utilized application, followed by Veturilo. Apps like ZdroweZakupy and GdzieWyrzuci´c were valued for their informative content, while ToGoodToGo and Vinted aided in making purchase decisions. However, all the applications analyzed received comparatively low ratings in terms of prestige and differentiation within the peer group.(Balińska, Jaska, and Werenowska 2021)

The study also uncovered notable gender disparities in the perceived utility of different applications. Applications such as ZdroweZakupy, GdzieWyrzuci´c, Vinted, and Veturilo were deemed more beneficial by women compared to men. This finding is consistent with

research conducted by B. Saboy de Aragão., which concluded that women are more actively involved in eco-friendly consumption.

The study also investigated the ideal design attributes of eco-apps. Survey participants favored apps that provided current and trustworthy information, were user-friendly and quick, utilized straightforward language, and were compatible with multiple devices. The necessity for the app to be in Polish was not a top priority for the respondents. Women had notably greater expectations for all app design elements, with the exception of the app focusing solely on one area of eco-friendly activities.

Bringing this section to an end, the paper underscores the pivotal role of mobile apps in diverse sectors including health, economics, environmental conservation, and management of small to medium-sized businesses. The authors highlight the potential of these apps in fostering environmentally friendly practices, thereby aiding in the preservation of nature. The conducted research offers valuable insights into the creation of effective mobile apps that inspire eco-friendly behaviors. The study reveals a preference among users for eco-apps that provide trustworthy information, frequent updates, and user-friendly interfaces. It also indicates that app content should be tailored to the user's gender, while the necessity for the app to be in the local language was deemed less critical. The findings are beneficial for entrepreneurs and developers aiming to create eco-apps for a younger demographic.(Balińska, Jaska, and Werenowska 2021)

2.4 Games as Tools of Information Presentation

With the exploration and analysis of the mentioned sources concluded, two essential questions need to be answered. What is a serious game and what is an “awareness raising game”?

2.4.1 Serious Games and Awareness Raising Games

Serious games, which are utilized in areas such as corporate training, education, and healthcare, are designed with specific goals in mind. Their purpose is to boost the performance and cognitive abilities of players in a variety of contexts, both real and simulated. These games encourage players to take responsibility for their success, incorporate high-quality content, stimulate active participation, and convert errors into chances for learning.(Almeida and Simoes 2019)

“Awareness raising games” fall under the wider category of serious games. These games enable players to interact with intricate systems and dynamics in a risk-free environment, allowing them to experiment with decisions and strategies without real-world repercussions. They are frequently employed in the context of complex issues such as climate change and sustainable development.(Rebolledo-Mendez et al. 2009)

With these inquiries answered. How do games compare when it comes to the dissemination of information and the raising of awareness of climate change? For this endeavor, various scientific articles that ponder upon this subject were analyzed.

2.4.2 Study: "Resources, Scenarios, Agency: Environmental Computer Games"

The study proposes that computer games could serve as a perfect platform for environmental consciousness, given their frequent requirement for players to interact with their surroundings. However, it also recognizes that such interactions can lead to adverse outcomes. Furthermore, it points out that the inherent assumptions and narratives in many games restrict their capacity to engage with intricate environmental issues like climate change or biodiversity loss in a detailed manner.

The study starts by criticizing games such as "SimCity 4", "Civilization 4", and "Minecraft" for reinforcing ecologically detrimental beliefs. It proceeds to discuss the game "Fate of the World", which underscores environmental concerns, but might demotivate players by highlighting the magnitude of the challenge and leaning towards technocratic solutions to climate change. It then investigates how games like "World Without Oil" can contest these beliefs. The study concludes by scrutinizing modding and “expensive play” in Minecraft, unveiling unforeseen ecocritical playing strategies.

The research scrutinizes the influence of environmental historian David Nye’s narrative on the "SimCity" and "Civilization" game series. Both games, centered around constructing a city or civilization from a natural setting, utilize a grid for gameplay structuring and advocate for the exploitation of resource-abundant landscapes. The research concedes that the grid layout could be attributed to technical constraints, but even with these constraints resolved, the cultural backdrop of the designers continues to be impactful.(Smith 2017) The games frequently depict nature and animals as mere scenery to the anthropocentric narrative. The

research also delves into the concept of "procedurality" in these games, which endorse a western capitalist value system and perceive nature as a commodity.

Subsequently, the article shifts its focus to the game "Fate of the World", in the context of the contribution of computer games to environmental education. This game empowers players to manage global policies to counteract climate change, providing a realistic simulation grounded in actual data. The author observes that such a game can act as a potent instrument for involving the public in intricate environmental matters.

Nonetheless, "Fate of the World" has its shortcomings. The game favors a top-down approach, emphasizing state-level policy mechanisms for instigating change, which may contradict its objective of involving players in real-world environmental crises. Interactions with natural processes are conveyed through news reports or data, and even environmental perspectives are represented in a policy card. Despite its merits, there's a risk that it could undermine the player's sense of agency due to its focus on centralized policy mechanisms.

The game "World Without Oil" was the next one to be examined. This game provided a distinctive method of tackling societal issues through gaming. In contrast to games that are policy-focused, "World Without Oil" was a collaborative project where players shared their responses to a simulated energy crisis through various media forms. The game lasted for 32 days, symbolizing the initial 32 weeks of a worldwide oil crisis. Players recorded both actual and imagined actions, along with their emotional reactions, as the crisis worsened.

As the game's crisis deepened, the narratives transitioned from inconvenience and cost to accounts of riots and violence. However, a pivotal moment happened when players started concentrating on solutions and community resilience, such as cultivating their own food. The game concluded with a focus on community cooperation and experimentation with alternative lifestyles. This shift demonstrates the potential of such games to encourage community resilience and problem-solving in response to societal challenges.

Games of alternate reality like "World Without Oil" influence player engagement with environmental and social issues. The blending of real and virtual elements in the game made it more serious for players, enabling them to envision scenarios in the context of their own lives and futures. This personal engagement is vital as it overcomes the typical obstacle of environmental issues appearing too vast. The game also enabled players to take on an empowered role, focusing on local lived experiences rather than wider regional responses. These aspects - the personal, the everyday, and the local - are crucial to understanding the success of "World Without Oil" in engaging with large-scale environmental issues. "World Without Oil" was viewed as a "participatory governance" experiment, beginning with the collaborative envisioning of futures, and it effectively engaged players with the subject of environmental sustainability by empowering them to craft stories about their personal reactions to environmental change. This approach stands in contrast to games like "Fate of the World".

The last game to be scrutinized was the sandbox game, "Minecraft". It adopts a resource-focused approach, where the environment is made up of uniformly sized cubes that can be mined and converted into useful items. This approach amplifies the utilitarian perspective of land, with every element of the environment being a resource for extraction.

However, players have the ability to challenge and critique the game's procedural rhetoric and its ecological implications.(Smith 2017) A prime example is the "Minecraft"-mod project "Resourceful", which substitutes the textures of resources with the logos of corporations that

utilize those materials. This acts as an environmental statement about preserving natural resources and heightens awareness about the ecological impact of our consumption habits, which are often facilitated via global corporations with dubious ethical and ecological records.

While the game's design promotes resource extraction without adverse consequences, it also accommodates environmentally conscious approaches, such as vegetarian and vegan challenges. The game's vast, procedurally generated world elicits environmental responses in players, with some embarking on extensive journeys across the landscape. One player, "kurtjmac", initiated a journey to the edge of the game world in 2011, chronicling his progress in a series of videos that have morphed into a travel documentary. His journey, which has garnered substantial funds for charity, mirrors a "Thoreauvian" engagement with the game's environment, prioritizing exploration and survival in a pristine wilderness over the developed cities of multiplayer servers. This indicates that "Minecraft" is environmental dynamics are intricate, permitting both resource exploitation and more sustainable interactions.

The last aspect of this game that was analyzed was the role of landscape and non-human actors in its narrative. The game facilitates profound player engagement, with instances such as a player taming a wolf that becomes a central character. The narrative also delves into the emotional impact of the game, with players recounting intense reactions to in-game events. Another project, "Towards Dawn," is spotlighted as an instance of a travel narrative within the game, with the player-character abandoning a mining life to explore the game's environment. This narrative exhibits an ecocritical attitude, acknowledging the ability of the game's landscape to incite reflection on the environment. Due to this merging of boundaries between real-world experiences and the virtual environment of the game, it was clear to see that the experiences within the game can have deep emotional impacts on the players.

Drawing this section to a close, the paper explored how video games can foster ecological awareness and critique. It posits that while certain games perpetuate ecologically backward norms, others, such as "World Without Oil" and "Minecraft", enable vibrant interaction with environmental issues and stimulate changes in individual behavior. The study underscored the significance of ecocritical scholarship in game studies and envisions a future where ecological involvement is integral to game design and play.(Smith 2017)

2.4.3 Study: "Premediating Climate Change in Videogames: Repetition, Mastery, and Failure"

This paper highlights that the exploration of climate change in video games is an expanding area within environmental media studies. Previously, video games addressing climate change were scarce and lacked commercial appeal. Now, such games are featured in social impact game competitions, independent development, and high-budget production. Although research on video games and climate change is still limited, it underscores the unique ways in which video games can depict climate change issues. Video games, being interactive and procedural media entities, offer players the opportunity to experiment with game-like temporalities. This interactivity is advantageous, facilitating simulations of large-scale processes such as climate change from perspectives that aren't human-centered. Simulation games frequently promote replayability, enabling players to investigate various outcomes and themes such as contingency and responsibility.(Beke 2021)

Furthermore, video games, especially those addressing climate change, act as instruments for simulating real-world processes and results. The idea of "procedural rhetoric" is introduced, referring to the argumentative assertions made through game simulations. However,

this method has been critiqued for its reductionist nature and for neglecting the player's role in interpreting and manipulating game rules. The author proposes that aesthetics can subtly propose alternative future visions, circumventing conscious resistance to challenging simulations. The critique also encompasses the failure of simulation games to recognize the "affective economy" that facilitates persuasion. The author stresses the importance of considering the power of repetition, agency, and the affective context in discussions about climate change video games and their prospective visions.

Further into the study, the video game "Fate of the World" is examined. This game is notorious for its extreme difficulty, which acts as a form of procedural rhetoric, advocating for the feasibility of certain decisions over others. However, the main experience for the majority of players is not triumph, but hardship and defeat. The game's difficulty has been criticized for disempowering players, potentially leading to frustration, resentment, and "dark play", a phenomenon where players indulge in ethically dubious actions for amusement. It's suggested that the game's challenging nature could provoke players to scrutinize the game's presumptions about handling climate change.

The game "The Stillness of the Wind" is also examined in the study. This game resonates with Roy Scranton's idea of learning to die in the Anthropocene, moving the emphasis from securing a future to reconciling with the present. The game portrays a narrative of decline and tests the player's instinct for productivity and expansion, implying that such an approach is unproductive in the face of an impending disaster similar to climate change. The game depicts an elderly woman, Talma, leading a monotonous life on a dilapidated farm with no prospects for growth or profit. Rather than concentrating on routine tasks, the game promotes exploration and the nurturing of memory, utilizing memory as a tool to comprehend the present and uncover the past life on the farm. Following Talma's death, the game ends with a depiction of the farm and its previous residents, recontextualizing the narrative in terms of memory and loss, challenging the traditional growth-focused model of games and underscoring the need for a paradigm shift in the Anthropocene era.

The study concludes that video games lack sufficient engagement with climate change and often depict militaristic techno-futures, limiting the range of potential futures. The author criticizes the forgiving nature of games and suggests that allowing players to experience failure could cast doubt on simulations that prioritize quick fixes over systemic solutions. Using "Fate of the World" and "The Stillness of the Wind" as examples, the author illustrates how failure in games can highlight the futility of the usual approach in a drastically changed environment. The author concludes that video games can foster a temporality that addresses climate change more meaningfully.(Beke 2021)

2.4.4 Study: "Effectiveness of Gaming for Communicating and Teaching Climate Change"

This article underscores the promise of simulation games as tools for communicating and educating about climate change, providing players with an opportunity to navigate the intricate dynamics of the climate system and experiment with decisions devoid of real-world repercussions. Despite this, there is a scarcity of empirical data on their efficacy and the impact of their rule-design on learning and the alteration of beliefs. This study broadens the scope of current research by quantitatively evaluating the effectiveness of a simulation game in altering players' perceptions about international climate politics, examining the transformation of these beliefs through gaming, and analyzing the influence of decisions made within the game on belief systems.(Meya and Eisenack 2018)

Therefore, a study was conducted to evaluate the effectiveness of the simulation game, "KEEP COOL", in communicating and teaching international climate politics. The game, which is based on a sophisticated science-based climate-economic model, requires players to balance their regional economic interests against contributions to global public goods, such as avoiding dangerous interference with the climate. Players must choose between climate-friendly (cooperative), and climate-damaging (non-cooperative) moves each round, leading to the evolution of an in-game climate governance regime.

Moreover, there is also discussion in regard to the potential of simulation games as tools for communicating and teaching complex system dynamics. Simulation games foster hands-on learning by enabling active participation and direct experience of abstract concepts. They offer a risk-free platform to experiment with decisions and observe the resulting system dynamics, thereby facilitating learning from failures without any real-world repercussions. These games assist players in identifying inconsistencies between their mental models and the complexities of system dynamics, leading to a transformation in their mental models and addressing obstacles to public involvement in climate change. By demystifying science and establishing a shared language, simulation games can serve as a conduit between science and policymakers.

When comes to the conducted research's finding. It was discovered that engaging in the simulation game, "KEEP COOL", significantly influences players' perceptions about international climate politics. Players grow more confident in the ability of politics to alleviate climate change, more hopeful about successful international collaboration on climate change, and view themselves as more accountable for mitigating climate change. Interestingly, players do not directly apply their in-game choices to their views on international climate politics. On the contrary, those who make non-cooperative choices in the game become more hopeful about international cooperation in climate politics, highlighting experiential learning as a crucial advantage of climate change games. These results endorse the notion that simulation games, particularly "KEEP COOL", can serve as effective instruments for educating and conveying information about international climate politics.

With these findings, the study suggests that climate games do not need to require climate protection as a winning condition for players. Instead, allowing players to win with non-cooperative decisions can help them learn about barriers to sustainable development and the need for cooperation. What's more, the findings also highlight the potential of gaming in communicating and teaching about climate change, complementing conventional methods and helping develop beliefs about sustainable development.(Meya and Eisenack 2018)

2.4.5 Study: "Video Game Visions of Climate Futures: ARMA 3 and Implications for Games and Persuasion"

The study starts by discussing “ARMA 3”, a military simulation game that serves as a “massive military sandbox”. It is noted for its open-world design, allowing players to move freely without traditional game constraints like levels or checkpoints. The game's setting, the island of "Altis" features numerous renewable energy installations, which are highlighted as a significant aspect of the game's landscape. The game's near-future setting is detailed through its design choices, which include futuristic weaponry and vehicles. The author suggests that “ARMA 3” presents a vision of the future where a transition to renewable energy has occurred, offering a subtle yet compelling challenge to current theories about the game's ability to persuade or influence players on issues like climate change.(Abraham 2018)

The study continues, exploring the concept that neoliberalism has led to a gradual erosion of our collective vision for the future. It discusses how, historically, the future was associated with progress and optimism, but under neoliberalism, this has shifted to a sense of inevitability and stagnation. Arguing that our cultural and imaginative relationship with the future has been altered, leading to a loss of credibility in progressive models for the future. This has resulted in a cultural focus on nostalgia and the return of familiar forms, rather than the creation of new ones. The study proposes that the current political and economic conditions have transformed our expectations and ability to conceive of different futures, further complicated by the looming threat of climate change. Positing that the future, or at least our cultural conception of it, has been compromised, leaving us in a state where envisioning a different future outside of capitalist realism is incredibly challenging. Ultimately, it calls for a reimagining of our relationship with the future, emphasizing the importance of alternative visions that challenge the status quo.

Afterwards, the study talks over the role of video games in addressing environmental issues, particularly climate change. It examines various games that incorporate environmental themes and explores how games can influence players' understanding of ecological and climate-related challenges. Furthermore, it also critiques the effectiveness of games in prompting reflection and action on environmental policies and practices, suggesting that games with environmental simulations could potentially alter players' perceptions of real-world issues. The discussion highlights the importance of designing games that can engage players meaningfully with sustainability and climate change, while acknowledging the complexities of translating these issues into compelling gameplay mechanics.

Moreover, the study discusses the theoretical approaches to understating how video games can influence players' beliefs and behaviors, particularly in relation to ideological issues like climate change. It examines the limitations of games as persuasive tools and the challenges they face in addressing complex and contentious issues. It argues that games can be more effective in ideological critique by presenting aesthetic visions rather than relying on gameplay mechanics, which may be rejected by players due to ideological resistance. It also explores the concept of "simulation fever", where players resist the game's representation of reality, and emphasizes the importance of appealing to players' sensibilities to enable ideological critique. The study uses "ARMA 3" as an example to illustrate how aesthetic presentation can bypass players' ideological defenses and provoke reflection on climate change.

Further in the study, it discusses how "ARMA 3" presents a vision of the future where renewable energy has become the norm. The game's aesthetic, rather than its mechanics, subtly challenges players' perceptions of climate change and the feasibility of renewable energy future. This approach is contrasted with other games that directly simulate climate change effects, which can be overwhelming and lead to player disengagement. It suggests that "ARMA 3"'s method may be more effective in influencing players' ideologies by bypassing direct confrontation and allowing for a more personal and contemplative engagement with the topic. The discussion also touches on the broader cultural and political implications of climate change and the difficulty of imagining alternative futures within the current neoliberal framework.

This study concludes by emanating the unique approach of "ARMA 3" in presenting a vision of a future where renewable energy is the norm, without explicitly focusing on gameplay mechanics related to climate change. This aesthetic presentation allows players to experience a world where the transition to renewable energy has occurred, potentially influencing their perceptions and ideologies regarding climate change and energy use.(Abraham 2018) The

game's depiction contrasts with other games that directly simulate climate change effects, offering a subtle yet impactful form of engagement with the topic. The author suggests that this method may be more effective in bypassing players' ideological resistances than traditional persuasive techniques.(Abraham 2018)

2.4.6 Study: "A Framework for Climate Change Engagement through Video Games"

This paper discusses the challenges in effectively communicating and educating about climate change, especially to young people. It emphasizes the importance of engaging youth as they are the future policymakers, and their behavior can influence family and community. It critiques traditional education methods for being too one-sided and lacking in critical approaches and participatory opportunities. It also highlights the issue of climate change misinformation, proposing using video games as interactive tools to engage the youth, given their widespread use and potential for immersive learning experiences. This paper's objective is to identify attributes of video games that can maximize engagement with climate change issues among young players.

Furthermore, the paper discusses the various interpretations of engagement in social science research. It emphasizes the importance of engagement in climate change communication, particularly the cognitive, emotional, and behavioral aspects. The authors adopt a definition that encompasses these three dimensions, arguing that simply knowing about climate change is insufficient for engagement, individuals must also care about it and be motivated to act. The complexity of the relationship between these dimensions is acknowledged, with the recognition that people may adopt different roles in climate change mitigation and adaptation, influenced by various interests and discourses.

The paper afterwards outlines the qualitative, interpretative methodology used to develop a framework for climate change engagement through video games. It involves grounded theory, starting with data collection and gradually building categories, then forming a theory before corroborating it with literature. The process is cyclical, with constant analysis and revision of data. Interviews with experts were conducted to identify game attributes, followed by a group discussion with teenagers for validation. The analysis included initial coding of interview transcripts, conceptualizing to form broad concepts, categorizing into core categories, and theorizing to find connections between categories, emphasizing the importance of achieving consensus validity and content validation for the proposed framework.

The methodology used in the study that helped in the development of the framework was succinctly outlined, detailing the coding procedures, starting with initial coding of interview transcripts, followed by focused coding to group codes into concepts, and the theoretical coding to integrate concepts into core categories. This section also describes the iterative process of analysis, the use of word clouds for preliminary analysis, and the validation of the framework through a group discussion with teenagers. It emphasizes the importance of engagement in game design and the need for games to appeal to players' cognitive, emotional, and behavioral aspects to effectively address climate change. What's more, in the following portion of the paper, the framework itself is discussed. It emphasizes the importance of creating games that are not only educational, but also fun and engaging. The framework consists of three dimensions: cognitive, emotional, and behavioral, each with specific attributes that games should possess to effectively engage players.(Ouariachi, Olvera-Lobo, et al. 2019) This portion highlights the need for games to provide achievable challenges, credible information, and meaningful narratives that resonate with player's identities and

experiences. It also stresses the importance of feedback, rewards, and social interaction in enhancing engagement. The goal is to inspire players to learn about climate change and motivate them to take action in the real world.

The paper concludes with a reflection on the potential of well-designed video games to engage young people with climate change issues. It presents the framework based on expert input, comprising three dimensions and 15 attributes, to guide the creation and analysis of climate change games. The paper acknowledges the blurred lines between the dimensions of engagement, noting the convergence among experts and students on effective game attributes, suggesting a preference for constructivist approaches in game design over traditional drill-and-practice methods. The authors encourage further research to test the framework and recommend replication with larger and diverse samples to validate the findings. They conclude by expressing hope that the paper offers new insights and lays the groundwork for future research in the field.(Ouariachi, Olvera-Lobo, et al. 2019)

2.4.7 Study: "Can Serious Games Help to Mitigate Climate Change? Exploring their Influence on Spanish and American Teenagers' Attitudes"

In the beginning of this study, there is discussion on the potential of online games as strategic tools for communication and education, particularly in the context of climate change. It explores how serious games, designed with a purpose beyond entertainment, can engage the 'interactive generation' or 'digital natives' in environmental issues. It highlights the challenges of making climate change information appealing to youth and suggests that serious games offer experiential learning, transforming passive information consumers into active participants. These games aim to raise awareness, provide knowledge, and encourage action on global warming. This beginning section also reviews the progress of serious games in the last decade, especially those available online, and presents "2020 Energy" as a case study to examine its influence on teenagers' attitudes towards climate change. The findings suggest that while the game did not significantly change attitudes, it did lead to some positive changes in specific behaviors related to energy conservation. Additionally, there is acknowledgment of the limitations of the study and the need for further research with larger and more diverse groups.

Furthermore, in a later section of this study, the impact of the serious game "2020 Energy" on Spanish and American teenagers' attitudes towards climate change was examined. The study used a pretest-post test design with experimental and control groups. Results showed no statistically significant differences in attitudes after playing the game. However, a closer look at individual factors revealed some positive changes, particularly in self-efficacy among Spanish students and in intentions to engage in low-carbon activities among American students. The study suggests that while the game did not significantly alter overall attitudes, it may have influenced specific aspects of climate change mitigation behavior. The authors discuss potential reasons for the limited impact of the game, including pre-existing environmental attitudes and cultural differences in media portrayal of climate change. They also highlight the importance of game design and suggest that incorporating better graphics and interactive elements could enhance engagement. Additionally, expressing caution against generalizing the results due to the small and homogenous sample size and reliance on self-reported data.

In this study's closing remarks, it found no significant differences in attitudes between those who played the game and those who did not.(Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo 2018) However, closer examination revealed some positive changes, particularly in Spanish

students' self-efficacy and American students' intentions towards energy-saving behaviors, finding that the game had a greater impact on American students' willingness to engage in low-carbon activities. Noting that the game's influence may be limited by teenagers' existing attitudes and the 'awareness-action gap', suggesting that the game's messages must resonate with players' values and cultural backgrounds, and that game design is crucial for engagement. The limitations present in the study were also brought into light which include a small and homogenous sample size, reliance on self-reporting, and a short playing session, indicating that future research could explore larger and more diverse groups to build stronger evidence. The authors conclude that serious games have potential as educational tools, but must be carefully designed to effectively influence attitudes and behaviors.(Ouariachi, Gutiérrez-Pérez, and Olvera-Lobo 2018)

2.4.8 Study: "Adaptive and Interactive Climate Futures: Systematic Review of 'Serious Games' for Engagement and Decision-Making

This paper starts by discussing the already evident adverse effects of climate change, such as higher temperatures and increase in climate variability, which impact ecosystems and human-environmental systems. Despite a better scientific understanding of climate change impacts and the need for adaptation across various sectors, there is a gap between knowledge and action to catalyze adaptation behaviors. The paper suggests that serious games can bridge this gap by enhancing learning opportunities and encouraging proactive behavior change. Serious games provide an interactive way to explore climate futures, build capacity for complex challenges, and socialize adaptation priorities with diverse audiences. This beginning section sets the stage for the systematic review that follows, aiming to assess the literature on serious games for climate change adaptation and their impact on engagement and decision-making.

The methodology used is showcased in the following section of the paper, outlining the systematic review process used to gather, screen, and analyze literature on serious games for climate change adaptation. It details the steps taken to define the review strategy, including the establishment of inclusion and exclusion criteria, and the use of search terms across various databases. It also describes the data extraction and analysis process, which involved organizing literature based on predefined criteria and manually coding to identify emergent themes. Additionally, it explains the use of a social learning-based evaluation framework to assess the effectiveness of games in promoting cognitive, normative, and relational learning among participants. The methodology aimed to summarize existing evidence, identify research gaps, and measure advances in understanding serious games' impact on climate change adaptation.

The results of the application of the presented methodology highlights the recent emergence of this research field, with most publications occurring since 2010, noting a diverse geographic distribution of research activities and a range of publishing journals, although few papers are well-cited. The USA, Netherlands, France, UK, and Germany are the top countries for lead author affiliations. The research focuses on various scales, from global to regional, and covers topics like water resource management, farming, risk management, and environmental governance. It emphasizes the dispersed nature of serious games research and its growing prominence in addressing climate change adaptation.

Later, the paper focuses on the characteristics and effectiveness of serious games for climate change adaptation.(Flood et al. 2018) It identifies common features of these games, such as their ability to capture complexity, challenge existing beliefs, and the importance

of skilled facilitation and communication. This section also highlights the role of reflexive learning, collaboration, dialogue, negotiation, conflict resolution, autonomous learning, and the integration of local knowledge. Furthermore, it assesses the learning outcomes of serious games, emphasizing cognitive, normative, and relational learning. There is additional discussion in regard to the challenges in designing and engaging with serious games, the importance of evaluation, measuring impact, and the potential of serious games to drive collective intelligence and action for climate change adaptation.

In the closing remarks, the paper emphasizes the importance of serious games in engaging and educating individuals about climate change adaptation. It highlights that serious games are effective in generating collective intelligence and promoting rapid adaptation actions. There is also acknowledgment of the challenges in designing and effectively engaging with serious games, such as capturing complexity and planning under uncertainty. The authors also discuss the need for ongoing engagement beyond one-off interactions, and the importance of evaluating the impact of games through participant feedback. Moreover, the authors note the effectiveness of serious games in achieving social learning outcomes, fostering interdisciplinary perspectives, and inspiring action among stakeholders.(Flood et al. 2018)

2.4.9 Study: "Playing for a Resilient Future: A Serious Game Designed to Explore and Understand the Complexity of the Interaction among Climate Change, Disaster Risk and Urban Development"

The study starts by discussing the global trend of urbanization and its impact on ecological degradation and disaster risk due to climate change. It highlights the complex interaction between urban development and disaster risk, noting that rapid urban development increases disaster vulnerability, while disasters can hinder further urban development. It also emphasizes the importance of understanding the drivers of disaster risk in the context of climate change for sustainable risk management and policies. It introduces the concept of trade-offs between urban development and disaster risk reduction in a climate change context, and the need for professionals to navigate these trade-offs effectively. The study aims to explore these trade-offs through a serious game designed for education for sustainability, simulating different scenarios to understand decision-making processes in urbanization and disaster risk reduction. The game involves undergraduates who are future policymakers, combining questionnaire surveys, participant observation, and interviews to analyze their decision-making. This introductory section sets the stage for the study's objective to improve the relationship between risk-generating development and disaster risk in the current climate change context, integrating disaster risk reduction and resilience for sustainable development.

In the subsequent section of this study, it describes the setup and execution of a serious game designed to explore the trade-offs between urban development and disaster risk reduction in the context of climate change. The game was set in the historical context of the Yudai Trench in Guangzhou, China, and involved 107 undergraduates as players, who are future policymakers. The game consisted of 20 rounds, each taking about 5 minutes, and was based on historical climate disasters and urbanization progress. Data collection methods included questionnaires, interviews, and in-game observations to evaluate the educational effectiveness of the game and the decision-making process of the players. Statistical analyses were performed using SPSS, with t-tests to analyze the data. The results aimed to assess the impact of knowledge, economic level, and policy incentives on players' decisions regarding urban development and disaster risk reduction.(Gao, Guo, and Jiang 2021)

Afterwards the results of the evaluation of the serious game as an Education for Sustainability method was presented. It exposed the findings from paired t-tests that show significant enhancement in students' knowledge levels after playing the serious game. Feedback from players indicates that the game was easy to understand, engaging, and effective in teaching about socio-ecological systems and climate hazards. This section also analyzes decision-making between urban development and climate disaster risk reduction, highlighting the influence of risk knowledge, economic development level, and policy incentives on players' decisions. Players with risk knowledge built better resilience, and those with higher economic levels devoted more resources to safety. Policy incentives were shown to significantly increase green infrastructure development during their effect period.Overall, the serious game was found to be a promising method for educating about socio-ecological decision-making.

In closing remarks of the study, it discusses the effectiveness of a serious game as an educational method for sustainability, highlighting that the serious game successfully increased players' knowledge about socio-ecological systems and climate hazards. The game allowed players to experience trade-offs between social, economic, and environmental values through counterfactual scenarios. Feedback from players indicated that the game was engaging and informative, particularly for those less familiar with climate hazards. There is also analysis of decision-making between urban development and disaster risk reduction, noting that risk knowledge, economic development level, and policy incentives significantly influence players' decisions. Players with risk knowledge built better resilience, while those with higher economic levels invested more in safety measures. Policy incentives were found to increase green infrastructure development, demonstrating their impact on decision-making. Overall, the serious game was deemed an effective tool for educating about socio-ecological decision-making and increasing awareness of climate hazards.(Gao, Guo, and Jiang 2021)

2.4.10 Study: "Games on Climate Change: Identifying Development Potentials through Advanced Classification and Game Characteristics Mapping"

In the introductory section of this paper, it discusses the significant challenges posed by climate change, emphasizing the need for immediate and drastic measures to meet international climate targets. It highlights the importance of various forms of knowledge in addressing climate issues and the necessity for societies to develop "transformative literacy" through a transdisciplinary approach. This section also points out the limitations of current mental models regarding climate change and advocates for alternative, interactive approaches to increase transformative literacy. Games, particularly educational ones, are presented as effective tools for facilitating experimental learning and increasing engagement with climate-related problems. Further outlining the potential of games to contribute to climate change mitigation and adaptation beyond education, such as data collection, communication enhancement, and creativity stimulation.

In a later section of the paper, it outlines the development of a new climate game typology and the process of mapping and reviewing climate games, detailing the creation of the typology based on literature and expert knowledge, ensuring it is applicable to a wide range of games and conceptually consistent. The mapping review involved searching various platforms for climate games, applying inclusion/exclusion criteria, and classifying the identified games using the new typology. The review aimed to provide an overview of climate games, classify them, and identify areas for future development.(Gerber et al. 2021) The typology includes dimensions such as authorship, purpose, target audience, and more,

each with specific characteristics. The search for games was extensive, covering digital and analogue platforms, and the selection process was thorough, ensuring games focused on climate change and offered a gameplay experience. The classification was based on available game information, and the results were summarized using descriptive statistics and mapping graphs. This process aimed to update and expand the knowledge base on climate games, highlighting their potential in climate change mitigation and adaptation.

Later, the paper discusses the development of a climate game typology and the classification of 115 identified climate games. It presents the typology with dimensions and characteristics, which is used to provide an overview of existing climate games and identify gaps for future development. Including a summary of the games' characteristics, such as authorship, purpose, target audience, and more. Additionally, it highlights the increasing number of climate games released over time, with a peak in 2017. The games are available in various languages and formats, with some requiring facilitation.

With the discussion of the results realized, the paper reflects on the developed climate game typology, the findings from the game classification, and potential areas for future climate games. Emphasizing the importance of games in climate change mitigation and adaptation, noting the limitations of previous studies and how this study advances the field by providing a more detailed and updated overview of climate games. It also highlights the potential of games to contribute to a climate-neutral society and their relevance for both researchers and practitioners. The authors discuss the need for games that address specific professional needs and create direct impacts outside the game environment, suggesting that experimenting with game abstraction could be a promising area for future development.

In the conclusion of this paper, a reflection is carried out on the potential of games to contribute to climate change mitigation and adaptation. It emphasizes that well-designed games can go beyond entertainment and play a significant role in addressing climate challenges. The paper highlights the need for future climate games to explore uncharted areas and to develop games that can create a direct impact outside the game environment. The authors suggest that experimenting with game abstraction levels could offer new opportunities for game development. Overall, concluding that climate games are a valuable tool for both researchers and practitioners in the field of climate action.(Gerber et al. 2021)

2.4.11 Study: "Examining the Use of Serious Games for Enhancing Community Resilience to Climate Risks in Thailand"

This study commences by discussing the evolution of games from entertainment to serious games, which are used for education and engagement. It highlights the potential of serious games in urban planning and participatory design, emphasizing their role in facilitating community engagement and learning about climate risk resilience in Thailand. This study aims to explore how serious games can increase community engagement and enhance disaster risk awareness, which are crucial for building resilience in low-income communities facing climate risks. The authors introduce the "Kin Dee You Dee" toolkit, a set of serious games developed for this purpose, and outline the challenges it addresses in disaster risk resilience. The toolkit's effectiveness in raising awareness and encouraging deliberation among players is also examined, with further research needed to assess its long-term impact.

In a later section, the study discusses the use of serious games for participatory planning and community engagement to enhance disaster risk resilience.(Marome, Natakun, and Archer 2021) It explains that serious games, which balance learning and fun, can be powerful tools

for engagement and participation. They facilitate ideation and stimulate discourse on key issues, leading to a pedagogical shift from passive to active learning. The study highlights the increasing use of serious games in architecture, urban design, and planning, as they support participatory design and planning activities. This allows communities to speculate about their living environment and future development, fostering community resilience through social learning and capacity building. There is also the definition of community resilience and discussion on the importance of considering social structures within a community when analyzing resilience. Emphasizing the potential of serious games to involve community members in meaningful ways, enabling them to innovate and adapt for sustainable development.

Afterwards, the study discusses the development of the 'Kin Dee You Dee' toolkit, designed to enhance community resilience to climate risks in Thailand. It details the background of the toolkit, its objectives, and the participatory approach taken in its creation. The toolkit includes three interrelated serious games that progressively introduce players to key concepts, encourage application to real-life contexts, and culminate in strategic planning. The development process involved collaboration with community architects and iterative testing with local communities to refine the toolkit's design, ensuring it was engaging, educational, and user-friendly. The toolkit's effectiveness was evaluated through workshops and feedback from participants, highlighting its potential as a tool for policymakers and community engagement in disaster risk resilience. Offering additional insights on the toolkit's application in different contexts and its adaptability for various stakeholders. Following this presentation of the methodology, the study discusses the feedback from participants after using the 'Kin Dee You Dee' toolkit. The feedback was largely positive, with participants appreciating the toolkit's ability to introduce new concepts and foster enjoyable and reflective discussions. It was noted that the toolkit could be useful for government agencies to understand community needs better. However, some concerns were raised about the toolkit's length and complexity, and the need for skilled facilitators to create an open environment for discussion. The toolkit's flexibility and scalability were highlighted, and its potential as a tool for policymaking and participative planning was recognized by government actors. Limitations included the lack of a systematic approach to obtaining feedback and the challenge of ensuring inclusivity in the game application workshops. Overall, the toolkit was seen as effective in achieving broad goals related to community-based adaptation to environmental risks.

The study concludes by discussing the effectiveness of the 'Kin Dee You Dee' toolkit in enhancing community engagement and risk awareness in Thailand. It highlights the toolkit's success in facilitating community-based adaptation and participatory planning, particularly in low-income communities facing climate risks. The toolkit's games encourage discussion, learning, and strategic planning, leading to actionable plans for resilience. Feedback from participants indicates that the toolkit increases understanding of resilience concepts and is enjoyable, promoting open expression of opinions. The toolkit also aids researchers and external actors in understanding community perspectives on risks and potential solutions. Challenges include ensuring participant diversity and overcoming initial reservation in discussions. The toolkit's flexibility allows adaptation to different contexts, and its potential as a policy tool is recognized by government agencies.(Marome, Natakun, and Archer 2021)

2.4.12 Study: "Let Us Save Venice"— An Educational Online Maze Game for Climate Resilience"

The beginning section of this paper discusses the significant impact of climate change, particularly water-related events like floods and rising sea levels, on coastal areas, highlighting

Venice as an iconic city facing frequent and severe flooding challenges. This section introduces the "MOSE" project, which aims to develop proactive strategies for coping with these extreme weather conditions, shining a light on the need for professionals in various fields to understand and prepare for climate resilience strategies. This section sets the stage for exploring the educational potential of serious games in raising awareness and preparing for climate resilience, particularly through the design and implementation of the game “Let us save Venice” within the "e-Creha" project. The game is intended to engage students in learning about climate resilience and the protection of built heritage, using Venice as a case study.

With this in mind, the paper proceeds to discuss the concept of serious games, their educational value, and their application in climate change and sustainability. It introduces the "e-Creha" project, which aims to develop multidisciplinary knowledge for building a culture of prevention and mitigation regarding climate change, focusing on the resilience of architectural heritage. The paper also reviews existing digital games related to climate change and built heritage, noting the limited number and scope of such games. It emphasizes the importance of user-centered design in educational video maze games, highlighting the need for games that are easy to learn, engaging, and provide a meaningful educational experience. The authors propose a structured approach to game creation, from setting learning objectives to testing and validation with target users. The section stresses the potential of well-designed serious educational games to enhance learning about climate challenges.

In the following section of the paper, it discusses the design and evaluation process for the educational video game “Let us Save Venice”. It details the creation of a 3D educational maze game enriched with mini-games that represent various didactic tasks. The game was developed within the "e-Creha" project, using the APOGEE platform. Outlining the steps taken from setting learning objectives to testing and validation with target users. It also describes the survey and semi-structured interview methods used to evaluate the game’s learnability and user experience, emphasizing the importance of these evaluations in validating serious games for learning.

The outcomes of testing the educational maze game “Let Us Save Venice” are discussed following its exposition, detailing the process of game validation, exploring the data and visualizations obtained from the results. The paper highlights the main findings, which include the significant role of immersion, positive affect, and competence as experience factors that contribute to raising awareness about climate resilience and built heritage sustainability. Additionally, it provides insights into the players’ performance metrics such as final game scores, number of hidden objects found, and total playing time. Furthermore, a summary of the next steps and future work directions for game improvement is established by the paper.

With the results of the testing analyzed. The paper reflects on the main findings from the game “Let Us Save Venice,” highlighting that immersion, positive affect, and competence are key factors contributing to awareness of climate resilience and heritage sustainability. Suggesting further improvements for the game and outlines future work directions, emphasizing the importance of user-centered game design in creating engaging educational experiences. The discussion also considers the broader implications for serious games in climate change education and the potential for such games to foster skills like creativity and problem-solving.(Bontchev et al. 2022)

In the closing remarks, the paper summarizes the next steps and future work following the study on the educational video maze game “Let Us Save Venice.” It highlights the

importance of the user-centered design approach in the game development and evaluation life cycle, which has shown a positive effect on the design and creation of educational video games. Emphasizing the cyclical nature of the approach within the APOGEE platform, which benefits from the advantages of user-centered design. The conclusion also sets the path for future work, indicating that the findings and methodology from this study will be applied to the design and development of three more games within the "e-Creha" project.(Bontchev et al. 2022)

2.4.13 Study: "Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices"

This paper starts by discussing the early warnings about carbon dioxide emissions leading to global warming, which were not taken seriously due to skeptics and economically driven policies. Emphasizing the importance of public support and understanding for effective climate change policy, highlighting the need to expand awareness and empower people to address climate change. This beginning section also suggests that current communication and education processes should be improved to engage people in developing environmental solutions and introduces gamification as an innovative way to educate and engage citizens, especially the youth, in pro-environmental behavioral change.

Later, the paper discusses the shift in climate and environmental education from merely providing information to transforming values and behaviors for environmental problem solutions. It emphasizes a holistic approach that encourages concrete action through stimulating interest, understanding, and participation. The participatory approach values experience and feeling as part of a process of experimentation, not just knowledge relay. Highlighting the importance of creating processes for citizen participation that imply shared decision-making and responsibility for global sustainability. Different models are presented to explain this new paradigm, focusing on various factors like knowledge, skills, values, identity, and action, which are crucial for building a better planet. Interactive and engaging teaching methods, such as gamification, role-plays, and simulations, are identified as effective strategies for this modern pedagogy.

Furthermore, the paper discusses the concept of gamification, defined as the use of game design elements in non-game contexts to make activities more engaging. It exposes the role of gamification in motivating behavior change, distinguishing between extrinsic motivation (external rewards) and intrinsic motivation (internal satisfaction). The paper additionally examines the effectiveness of points, badges, and leaderboards in changing behavior and emphasizes the importance of satisfying psychological needs for long-term engagement. The application of gamification in various fields, particularly in promoting pro-environmental actions, is explored. Suggesting that a combination of extrinsic and intrinsic motivational strategies is ideal for achieving lasting behavior change.

In the following section, the paper discusses two models for evaluating gamification in education and behavioral change. The first is the Octalysis Framework, which analyzes motivation through eight core drives, categorizing them into white hat (positive) and black hat (negative) motivators, as well as left-brain (extrinsic) and right-brain (intrinsic) motivators. The second is the Climate Change Engagement through Games Framework, which identifies 15 key game attributes across three dimensions: cognitive, emotional, and behavioral involvement, to maximize player engagement in climate-change-related issues. Both frameworks aim to understand and improve how gamification can motivate pro-environmental behavior.(Ouariachi, Li, and Elving 2020)

In addition, the paper describes an exploratory study using qualitative research methods to investigate the role of gamification in promoting pro-environmental behavior change. The study involved two stages: identification and selection of gamification platforms, followed by qualitative content analysis. Initially, a literature review and web search were conducted to identify relevant platforms, which were then narrowed down to a final sample based on specific criteria. The selected platforms were analyzed using the Octalysis Framework and the Climate Change Engagement through Games Framework to assess their potential to motivate behavioral change. The analysis aimed to discover underlying issues and evaluate the phenomenon from different angles, with a focus on achieving consistency of interpretation and methodological soundness. The study's insights are intended to assist educators in selecting best practices and gamification designers in creating effective tools for behavioral change.

Bearing this in mind, the paper discusses the results of the study and the effectiveness of gamification platforms in promoting pro-environmental behavior. It highlights that platforms with educational purposes are popular, especially on mobile devices, and often focus on energy saving, efficiency, waste management, and recycling. The analysis using the Octalysis Framework shows that platforms like SaveOhno and JouleBug score higher due to their motivational design and balance between extrinsic and intrinsic motivations. These platforms engage users cognitively, emotionally, and behaviorally towards environmental action. The Climate Change Engagement through Games Framework further supports these findings, indicating that attributes such as achievability, challenge, credibility, feedback orientation, and meaningfulness are crucial for cognitive, emotional, and behavioral engagement in climate-change-related issues. Concluding that the more attributes a gamification design includes, the stronger the connection with participants and the greater the potential to influence behavior change.

In the closing remarks of the study, the paper reflects on the shift in climate and environmental education from simply imparting knowledge to fostering actions that stimulate interest and participation. Emphasizing that gamification can effectively engage people not just cognitively and emotionally, but also behaviorally. The paper identifies SaveOhno and JouleBug as successful examples of gamification platforms that balance intrinsic and extrinsic motivations and include game attributes that encourage real-life action. The presented analysis suggests that including more attributes in gamification design strengthens the connection with participants and influences behavior more effectively. However, the paper acknowledges methodological limitations and suggests that its insights can guide educators and designers in creating impactful gamification experiences for behavioral change.(Ouariachi, Li, and Elving 2020)

Chapter 3

Game Concept, Design, and Technical Development

With the in-depth research about serious games and its application on climate change awareness finished, the functionalities and relevant information about the created game will be exposed and explained.

3.1 Game concept

3.1.1 Overview

In this 3D Adventure game created in Unity, players must navigate through various areas that were devastated by climate change, as they control a wolf trying to survive.

The game's main objective is to expose the consequences and impacts of climate change.

3.1.2 Objectives of the game

This serious game is designed to present the impacts of climate change, it aims to increase awareness of its effects and hopefully change individuals' minds.

The game serves as a platform for players to understand the consequences of climate change and its impact on various ecosystems. Through gameplay and storytelling, players will be exposed to it.

The game's objective is not only to educate players on the effects of climate change, but also to inspire them to act in real life to promote climate change policies.

3.1.3 Description of the game

In this adventure game created in Unity, players control a lone wolf named Lerina. In the beginning of the story, Lerina loses her pack due to a wildfire, an effect of climate change. In her dying breath, her mother says the word "Rocabarraigh", which is a myth, a place on this earth that is a haven. The objective is to reach this place; however, the story will end with her not reaching this mythical place, due to it being a myth, and with her death. The reason being for narrative purposes, but also to make the impact of climate change somewhat personal to players.

The player will have the experience of playing a 3D adventure with somewhat realistic graphics that will be pleasing on the eyes.

The game is designed for Windows (PC) and aims to educate and inspire players to take action in real life.

Its target audience is anyone above the ages of 15/16.

3.1.4 Key features of the game

The main features of the game are as following:

- A strong narrative that drives players to explore and engage with the game world, while also highlighting the impacts of climate change on the natural world.
- Distinct environments, such as forests, lakes and snowy mountains.
- Game mechanics that monitor hunger, stamina, the possibility of hunting prey and attacking threats to the main character.

3.2 Design

3.2.1 Use Case Diagram

The following diagram present the various use cases of the project.

Figure 3.1: Use Case Diagram

3.2.2 Conceptual Game Map

In the following concept diagram, the overview of the game is displayed, showing a general flow of it.

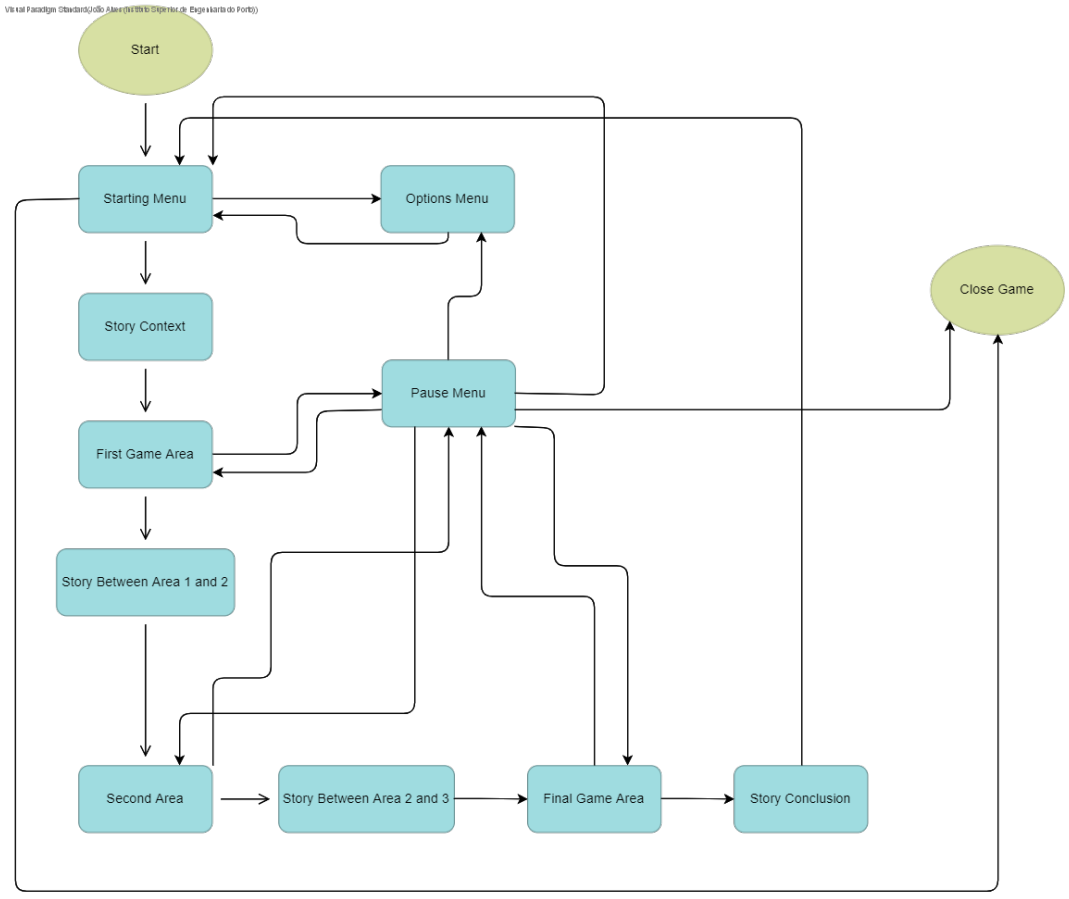

Figure 3.2: Game Concept Map Diagram

3.2.3 Component Diagram

The following component diagram presents the logic view of the project. It is possible to verify that the user video device, in this particular case a PC, interacts the component that is responsible for the interaction that the user as with the game. This component in turn manipulates some of the visual objects that are displayed to the user. Additionally, these two components have various scripts attached to them in order for the game to properly function. The objects in turn are display in the graphics component that encompasses all things visual and in turn is rendered by the visual rendering component directly to the user's video device.

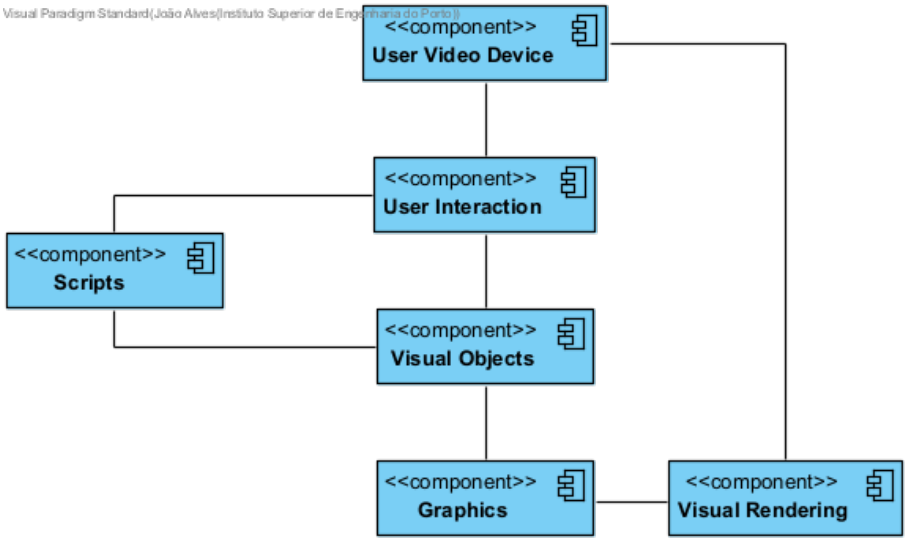

Figure 3.3: Component Diagram

3.2.4 Deployment Diagram

The following deployment diagram presents the physical view of the project. It is possible to verify that the user views all the visual aspects of the game that are provided by the Unity game engine.

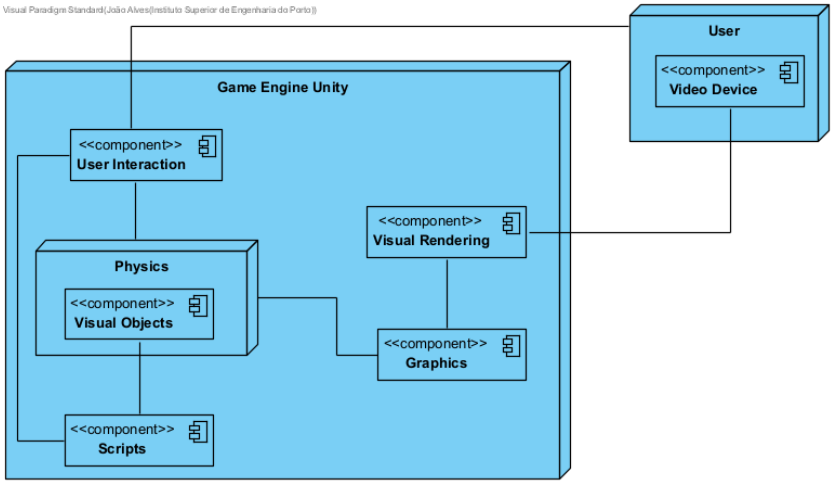

Figure 3.4: Deployment Diagram

3.3 Technical Development

3.3.1 Unity

The main, and only, technology utilized in the construction of this project was the unity game engine.

Unity is a versatile and widely used game engine that supports the development of both 2D and 3D games. It allows developers to create games for different platforms, including Windows, macOS, Android, iOS, and various gaming consoles. One of Unity's strengths is its real-time development capabilities, which enable developers to see changes and updates as they make them, streamlining the development process.

Unity primarily uses C# as its scripting language, which allows for robust and efficient coding. It supports object-oriented programming, which help in organizing and managing complex game logic. Furthermore, Unity provides a comprehensive API that allows developers to control almost every aspect of their game, from physics and graphics to audio and input.

3.3.2 Use Case 1: Starting Menu

In the implementation of the main or starting menu, a specific scene was created to contain it. Additionally, a script was created, *MenuController*, that controls all aspects of the menu.

The menu has four buttons: start, load, options and exit, each with a specific function implemented in the mentioned script. The start button, as the name suggests, starts the game, the load button loads the game using the last used save, the options button opens the options menu, and the exit button closes the game.

Furthermore, the player can click the buttons with a mouse or use the up or 'W' and down or 'S' keys or the corresponding arrow keys to navigate the menu and the button is clicked when the 'Enter' key is used. Said navigation is displayed by a white arrow, in which its position and functionality is controlled by the script.

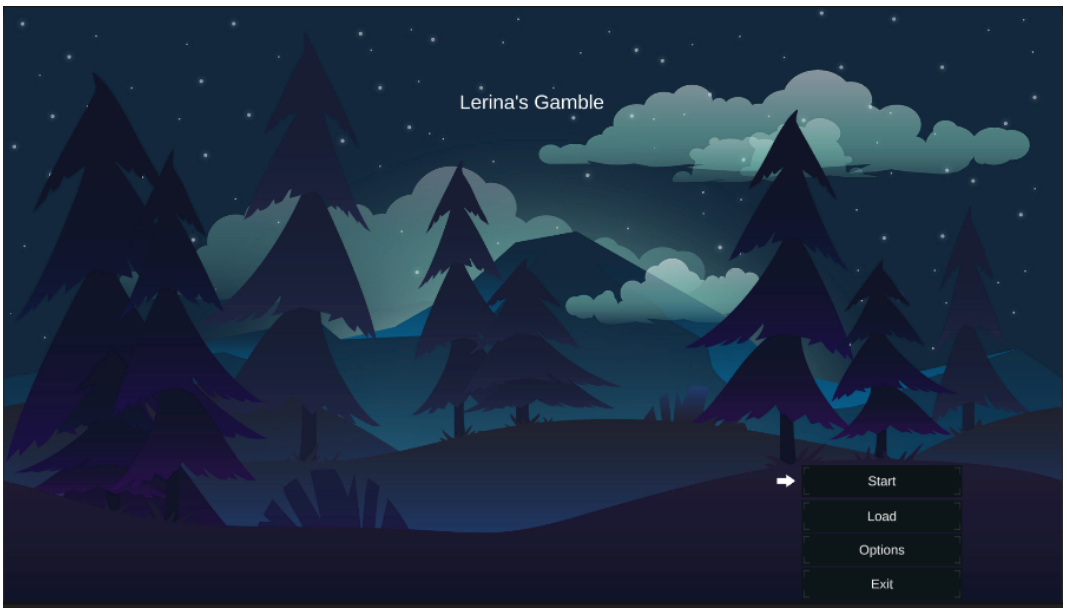

Figure 3.5: Starting Menu

3.3.3 Use Case 2: Options Menu

In the original starting state of this use case, a scene was being used to contain the options menu, similar to the main menu. However, during the development of the game and the creation and implementation of the game areas, this solution was clearly the incorrect one. The most efficient application is the use of a canvas to contain the options menu. In addition to the canvas, a script is associated with this menu, called *OptionsController*.

In the options menu, the player can change the resolution of the game, change the screen mode of the game, change the music and sound effects' volumes and enable or disable *Vsync*. Obviously, the changes can be applied using the 'Apply Changes' button and, of course, the player can exit this menu using the 'Back' button. All the described aspects of the options menu are controlled by the mentioned script.

The options menu is accessible in the starting menu and in the pause menu, using the related button.

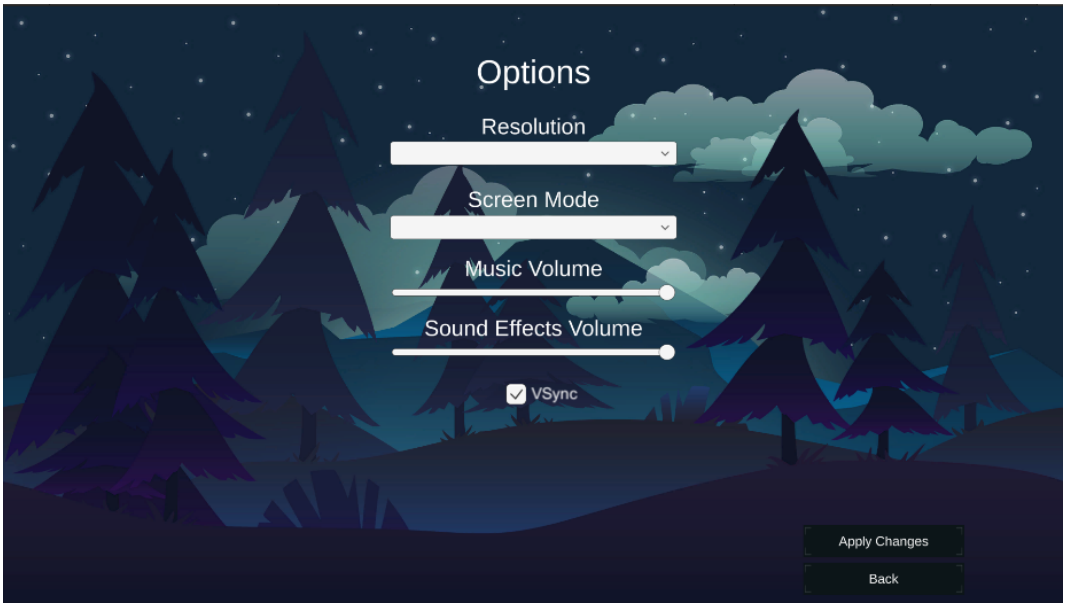

Figure 3.6: Options Menu

3.3.4 Use Case 3: Pause Menu

The pause menu has a similar implementation has the options menu, this similarity being the use of a canvas to contain it and the use of a specific script to control it, in this case being the *PauseController*.

It is a very simple menu that contains only buttons, these being: save, load, options, exit and back. The save button, as the name suggests, saves the game, the load button loads the game using the last used save, the options button opens the options menu, the exit button closes the game, and the back button returns to the game area the player is currently.

Furthermore, just like the starting menu, the player can click the buttons with a mouse or use the up or 'W' and down or 'S' keys to navigate the menu or the corresponding arrow keys to navigate the menu and the button is clicked when the 'Enter' key is used. Said navigation is displayed by a white arrow, in which its position and functionality is controlled by the *PauseController* script.

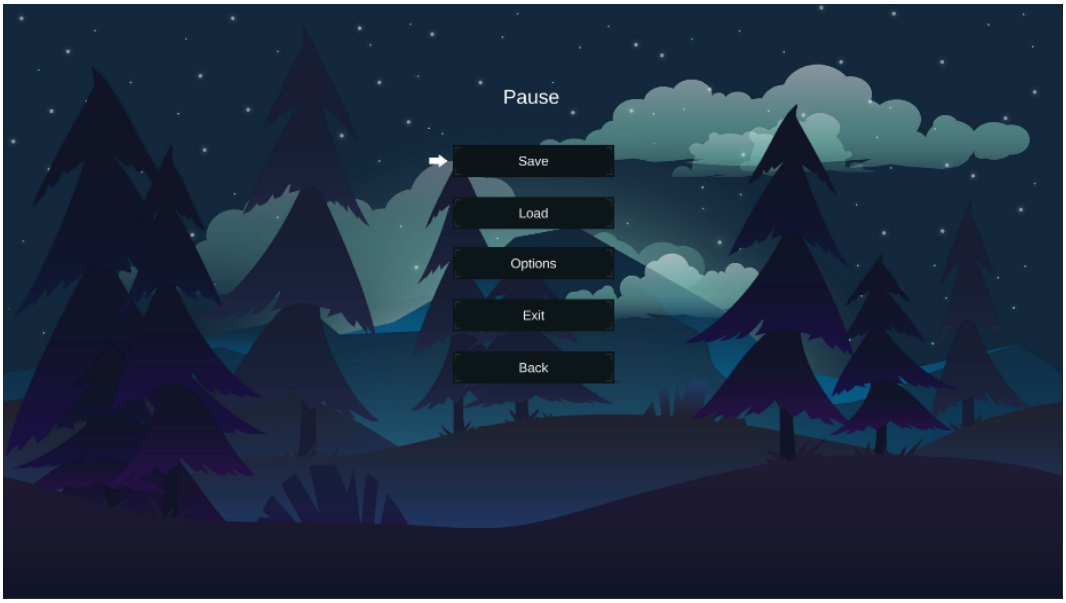

Figure 3.7: Pause Menu

3.3.5 Use Case 4: First Game Area and Use Case 10: First Game Area Weather

The first game area is a burned forest. It displays burned trees and grass, rocks, dead animals and some alive forest animals as well. The tree objects have a fixed position, while the rocks and dead animal corpses do not. These objects have specific scripts associated with. The *Area1DeadAnimalsPlacement* script is responsible for the placement of the dead animal *NPCs* in each terrain, while the *Area1RockPlacement* is responsible for the rock object placement. These placements are random, which gives the players similar, yet different interactions with the game area. To help with placement of these object, the area was divided in various terrains. There are two terrains in which the player moves in, while the others are beyond the invisible wall that contains the player to the two main ones. All the terrains have trees placed on them to guarantee a consistent design of the burned forest, and only the two main terrains possess the dead animals and rock objects. This approach was chosen was a way to not impact the game's performance.

In terms of connecting the story with the area, there are deceased *NPCs* related to the main character located near them. This approach was taken for the purpose of showcasing a story element during gameplay, however brief it may be.

Now focusing on actual living *NPCs*, there are animals present in the area. The animals chosen to populate the area were: stags, foxes, hares, and boars. These animals move about in the area and new ones are periodically spawned to it in specific coordinates, so that the player has the possibility of hunting them and replenish the main character's resources, such as hunger and health.

One important thing to note is the player can explore the playable area in its entirety, but the player should move in the direction that the character is pointing towards. Why is that? In terms of the story, the main character must travel north, pointed by the provided compass (the white arrow), towards their destination, in terms of game mechanics, there is an invisible

wall that the player can walk through that changes the scene to another one that has story exposition and connects to the next game area.

The exposed information as in relation to the fourth use case, regarding the tenth use case, a simple particle system was attached to the main character. This particle system is responsible for the rain effects presented during gameplay.

Figure 3.8: First Game Area

3.3.6 Use Case 5:Health, Stamina and Hunger Mechanics

The player character has a health, stamina, and hunger system associated with them. These systems are represented using colored horizontal bars located in the upper left corner of the screen, in which the red bar represents health, the green bar stamina and the blue bar hunger.

The hunger bar is constantly being depleted, and the player needs to hunt/look for prey in order to replenish it. The health only depletes in two specific situations: one in which the player character receives damage and the other where the hunger bar is completely empty, enabling constant depletion. The health bar is replenished when the player character consumes its prey. In the case of the stamina bar, it only depletes when the player character runs and regenerates when not.

Figure 3.9: Health, Hunger, and Stamina Bars

3.3.7 Use Case 6: Hunting Mechanics

The hunting mechanics relate to the mentioned health and hunger systems. These mechanics encompass of a group of attacks that the player character can perform to damage and kill its prey. There are currently four attacks available each associated with a specific button, these being: a bite attack triggered by the *'H'* button, the left mouse button triggers an attack from the right side, the right mouse button triggers an attack from the left side and the middle mouse button triggers a frontal attack. Attacks are not the only aspect that the player has access to, it has the possibility of consuming the slayed prey. By using the *'Q'* key, it allows the player character to consume the dead prey.

The aspects presented till now concern the player, however the hunting mechanics also include aspects related to the animal *NPCs*. Such as a health and food systems connected with each *NPC* and presented by bars floating above the *NPC*. The red bar presents the health of the animal and the blue bar the amount of food that the animal possesses. When the player attacks an animal, it loses a specific amount of health. As soon as the player complete depletes the animal's health, it is only then the player is allowed access to the food that the animal possesses. When the main character eats an animal, it only eats a specific amount associated to it, meaning the player can consume the prey until the bar runs out. The *NPC* having no more resources to give, the bars located above them disappear, giving a visual indication to the player that the dead prey is no longer useful.

This cycle of hunting and consuming prey is the main method in which the player can survive long enough to reach the end of the game. The already dead prey is also useful, even though the amount of food it processes is not displayed and only the player's hunger bar indicates is the only means to see its effects. These aspects force the player to move and simultaneous search for prey (dead or alive) in order to reach their objective.

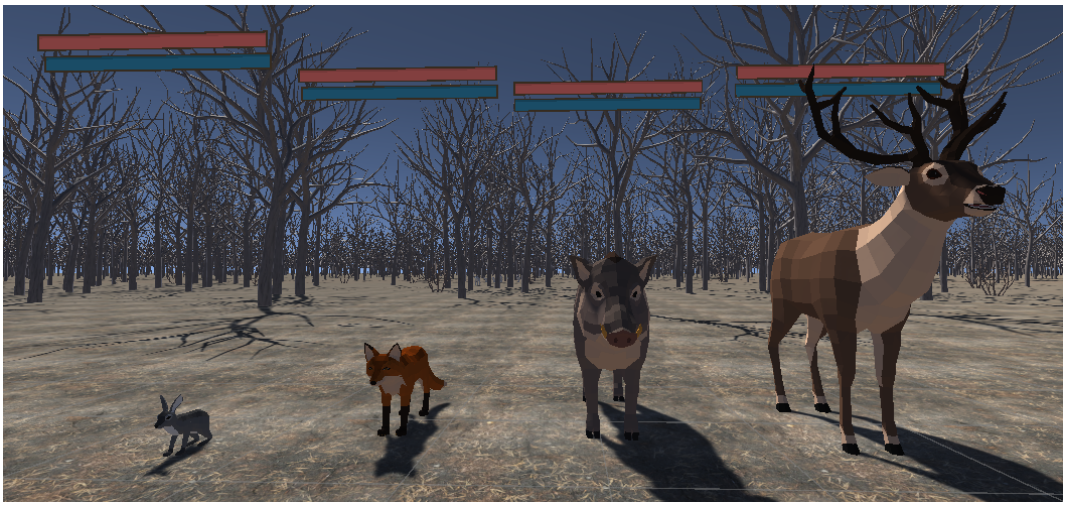

Figure 3.10: Various Prey

3.3.8 Use Case 7: Player Character Movements and Animations

A very important element introduced into the game is obviously the main character that the player controls. Thankfully the model chosen for the main character possessed already constructed animations, however the triggering of these animations and what animations to be used had to implemented. A handful of animations were chosen, such as walking, running, eating, various attacks, receiving damage, etc. The chosen animations are only utilized in specific situations, for example when the player makes the character move via the *'WASD'* keys the character triggers the walking animations and when the player holds the *'Left Shift'* key while the character is moving, the running animation is triggered. One obvious thing to note is that the game has clear internal verifications as to when an animation should be used, as a way to prevent multiple animations being used at the same time and bugging out the character.

Moving on to the briefly mentioning of the character movement. As said, the character moves using the *'WASD'* keys. The game internally does not check if each key was pressed but uses a more general verification of horizontal and vertical inputs, meaning that the arrows keys can also be used if the player so wishes. When it comes to speed of the movement and the use of the correct angle of the movement, it is all internal and not visible to the player.

Use Case 8: Prey Movements and Aniamtions

A similar implementation of the application of the player character animations was taken on the animations of the animal *NPCs* was taken. Just like the main character model, the *NPCs'* models also possessed already constructed animations. For each animal, a handful of animations were chosen to fit the needs of that specific animal. For example, the fox and hare are the only ones that need the running animation, unlike the others. As stated before, the chosen animations are only utilized in specific situations, a good example is that the hare only triggers the running animation when the player character is in range of the hare, in front of them and if the hare still has stamina. As we can see, these animations are only triggered in very specific situations connected to very specific internal verifications, so that the animal character does not display incorrect interactions with the player.

Regarding the movement of these *NPCs*, their movement is controlled by internal algorithms, however there is some variation. All the *NPCs* walk around the area they are in, avoiding obstacles such as rocks and trees. In the case of the hare and fox, they run away if they spot the player character within a specific range, while the stag and the boar start immediately following the player with the intention of killing them. One important notion to point is the fox and hare only run if they have stamina. In the case that they do not possess sufficient stamina, and they are not running away, they can enable a resting period, with an animation tied to it, in order to regain it and give the player a window of time that they are able to attack these animals. To note, the hare and the fox are the only ones that possess this stamina system for the reasons stated previously.

3.3.9 Use Case 9: Prey Spawner

This functionality consisted of the creation of spawners that introduce the animal *NPCs* in specified timed intervals. These spawners were introduced only in the first and second areas, and were implemented in various coordinates of said areas.

The reason for the implementation of these spawners is to provide the player a somewhat steady source of resources that can help them manage the main character's hunger and health. Without this vital system, the player may have trouble surviving due to the fact the already dead prey may not be sufficient in help them. But of course, it depends on the player's management of resources.

3.3.10 Use Case 11: Second Game Area

The second game area is a river/riverbank that was affected by a severe oil spill. It possesses no grass, plants, or trees due to the horrific effects of the oil spill. Similar to the first area, this one also possesses dead animal corpses with a specific script associated to it that controls the random placement of these objects. Due to the nature of this area, the placement of the dead animals is contained only to the ground in order to avoid the objects being spawned in the riverbed. The structure of this area is different from the first area, it consists of one main terrain that the player can navigate in, surround by invisible walls that contain the player in it. Four additional terrains circle the main terrain and help guarantee a consistent design of the area by containing much of the river.

In terms of story connection with the area, the previous visible scene gave exposure of the inner thoughts of the main character in relation to the first area and reinforcing the need of their journey towards their objective.

Just like the first area, there are living animals present in the area. The animals are the same as the first one, these being stags, foxes, hares, and boars. These animals move about in specific subareas and new ones are periodically spawned to those same subareas, to avoid the water regions of this game area.

As a reminder, the player can explore the entirety of the playable area, but the focus should be to move in the direction that the compass is pointing towards, northwards, to reach and invisible wall that the character can walk through that changes the scene to another one that has even more story exposition and connects to the final area of the game.

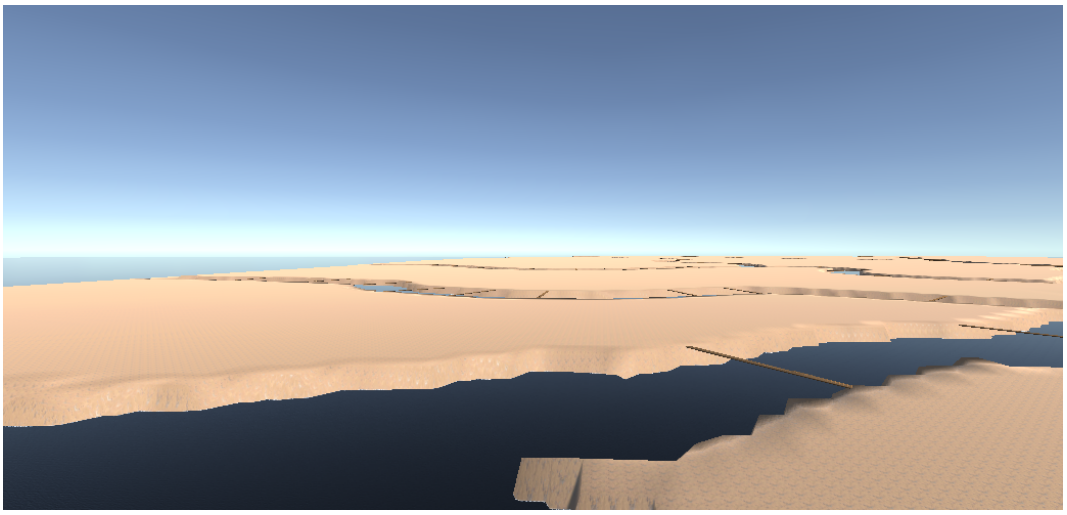

Figure 3.11: Second Game Area

3.3.11 Use Case 12: Final Game Area and Use Case 13: Final Game Area Weather System

The final game area is a melted snowy mountain. It possesses no plant life nor animals, living or dead, it's an every empty area devoid of life. The structure of this area is similar to the second area, one main terrain that the player can navigate in, surround by invisible walls that contain the player in it. Four additional terrains circle the main terrain and help guarantee a consistent design of the area by containing much of the river.

In terms of story connection with the area, the previous visible scene gave exposure of the inner thoughts of the main character in relation to the second area and further reinforcing themes of this game. However, due to this area being the final one, the player character is meant to die in it. The story reason for it is to essentially crush the main character's hopes of surviving the devastation that they experienced and to, some extent, ignite an emotional reaction from the player. Via of the character's death, a new presented scene is triggered, that gives the player a sense of the main character's final thoughts before they embrace oblivion and again, hopefully, elicit an emotional reaction, however small.

The player can explore the entirety of the playable area, but due to the fatalistic nature of this area, this is not possible by design. The player will eventually run out of health due to not being able to satiate the main character's hunger, triggering the final scene of the game, as explained previously.

The exposed information is in relation to the twelfth use case, regarding the thirteenth use case, a simple particle system was attached to the main character. This particle system is responsible for the snow effects presented during the brief gameplay section.

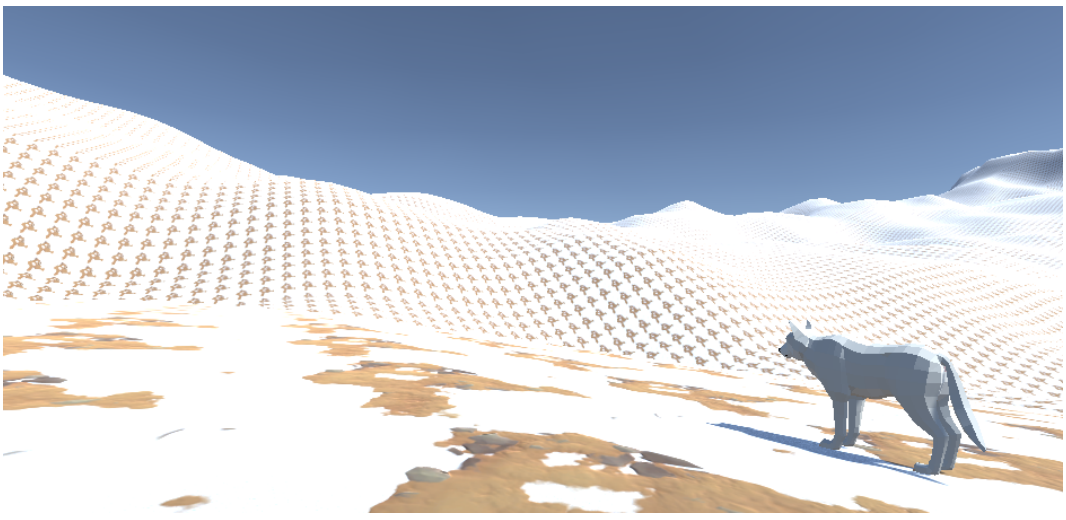

Figure 3.12: Final Game Area

3.3.12 Use Case 14: Death Menu

The death menu has a similar implementation has the pause menu, the containment of the menu in a canvas and the use of a specific script to control it.

It is an even more simple menu containing only two buttons: the load and exit buttons. The load button loads the game, and the exit button closes the game.

On top of that, just like the pause menu, the player has access to the same type of menu navigation, either using the mouse or the afford mentioned buttons that control the white arrow.

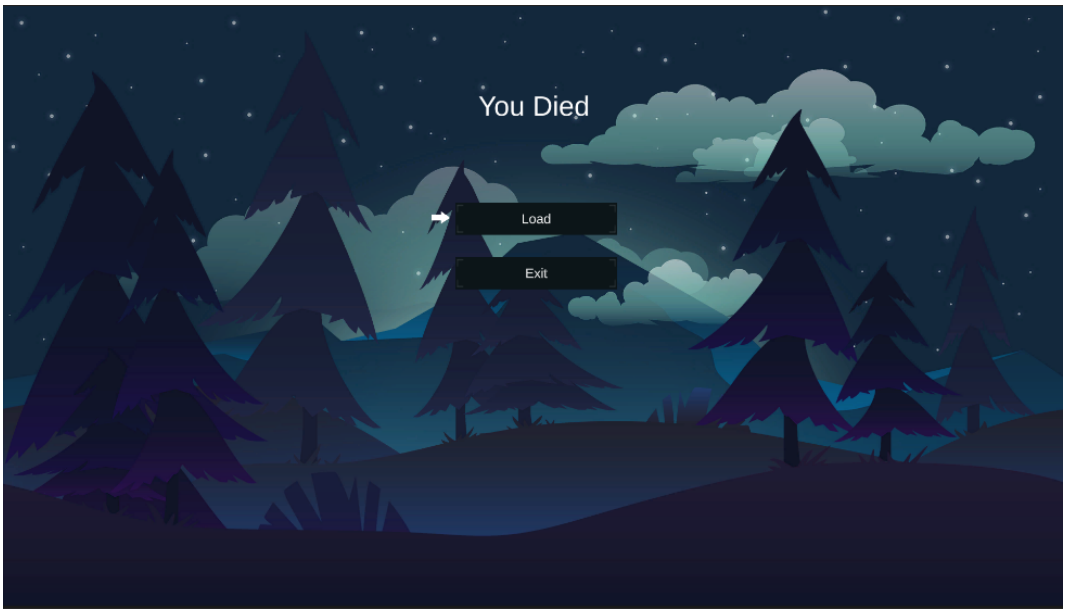

Figure 3.13: Death Menu

3.3.13 Use Case 15: Load Game and Use Case 16: Save Game

The game posses' a very simple save and load systems. At any point during the gameplay, the player can save the current state of the game utilizing the save button that the pause menu holds. The information that is saved is the index of the current scene, the player character's current health, hunger and stamina, and the player's position in the specified scene. This information is saved in a text file, where the information may or may not be encrypted.

When the player loads the game either from the start, pause or death menus, the information of the text file is obtained, decrypted if needed and dispersed to the necessary internal components that are responsible for the correct use of the acquired information.

3.3.14 Use Case 17: Change to Game Scenes and Use Case 18: Story Context and Story Between Areas

A very important implementation that impacts the flow of the game is changes of game scenes. As explained before, various aspects of the game are divided into various scenes, such as game areas, the start menu, etc. The change of scene can either be triggered via a button, in the case of the starting menu that allows the presentation of the story context scene via the start button, or via an invisible wall present in the game area that allows said change.

In relation to the eighteenth use case, due to the necessity of the story to be presented consistently, it is mainly presented in different scenes. Immediately in the start of the game, the context of the story is presented to the player alongside the game's controls and additional info. More story is only presented in the scenes in between game areas. The

reason for this approach is due to limited resources and not to clutter the game areas with unnecessary implementations that could waste precious development time. The story scenes are very simple and contain only one button that can only be controlled via the mouse.

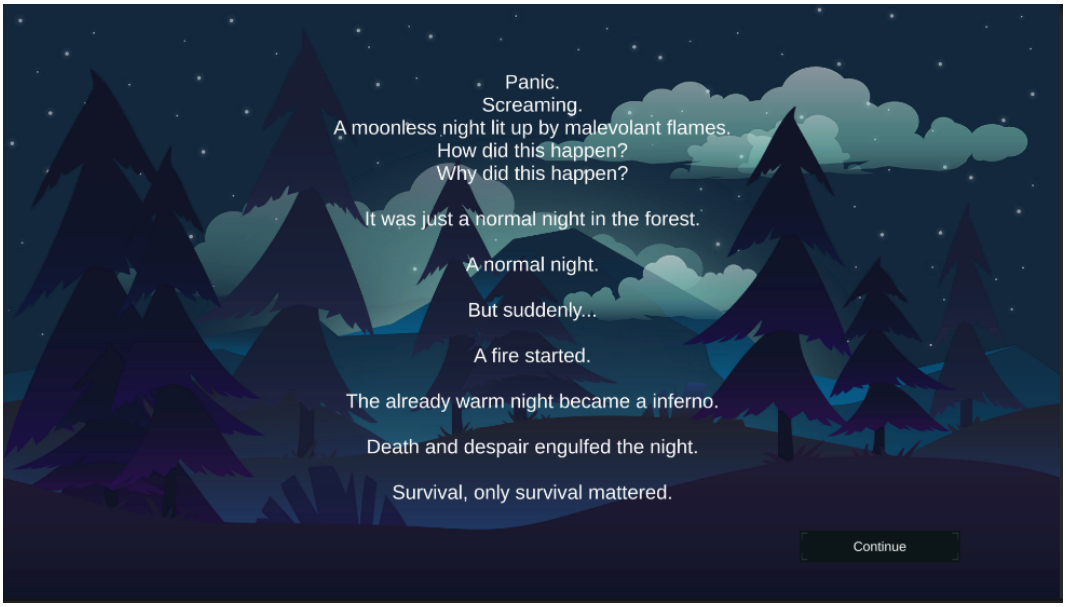

Figure 3.14: Story Context 1

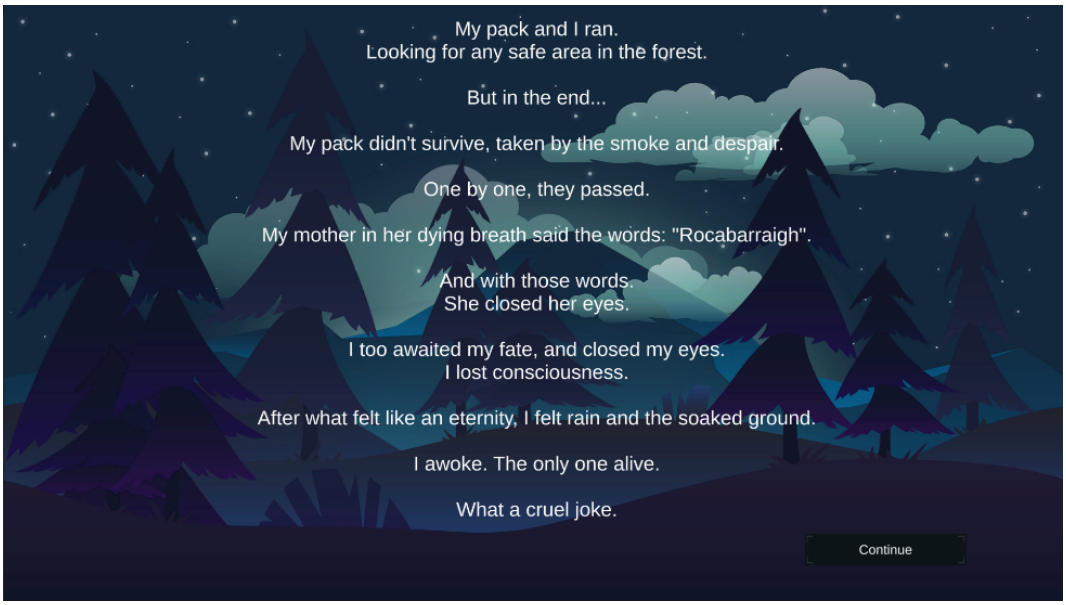

Figure 3.15: Story Context 2

Figure 3.16: Story Context 3 - Game Controls

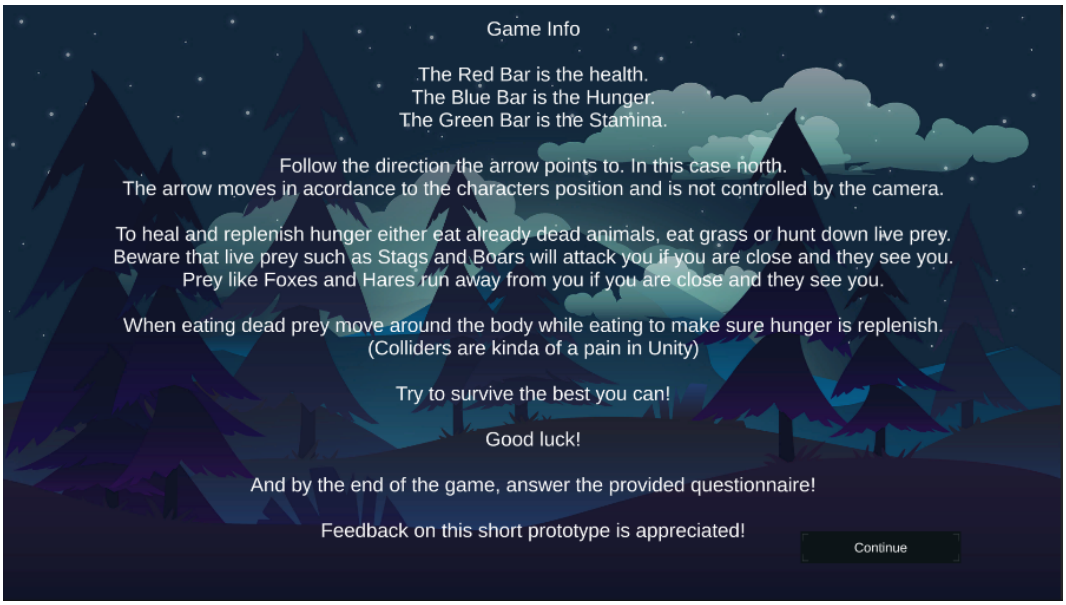

Figure 3.17: Story Context 4 - Game Info

Figure 3.18: Story Between Area 1 and 2

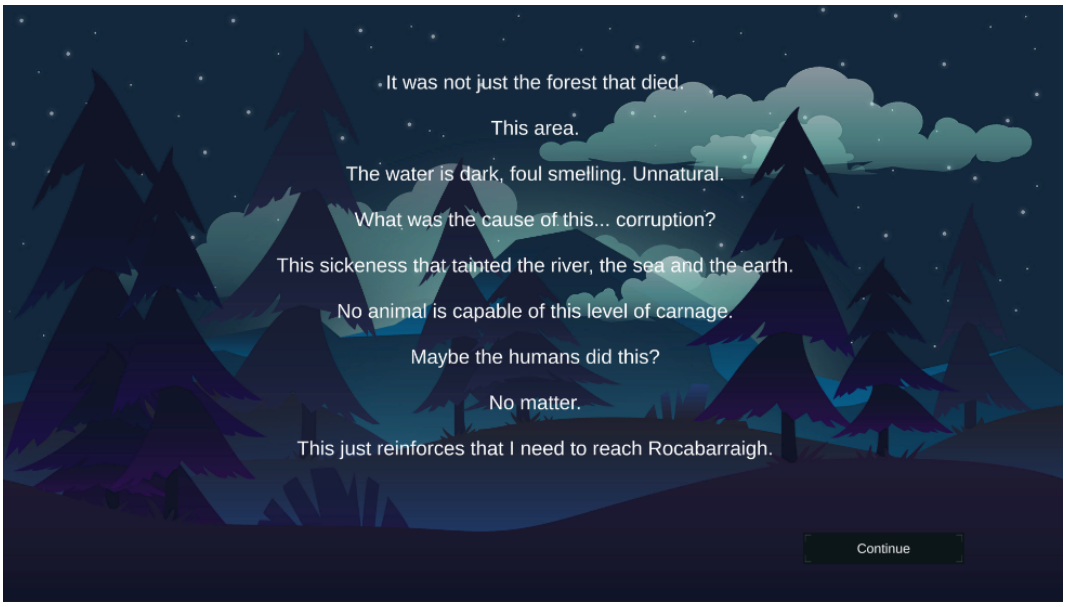

Figure 3.19: Story Between Area 2 and 3

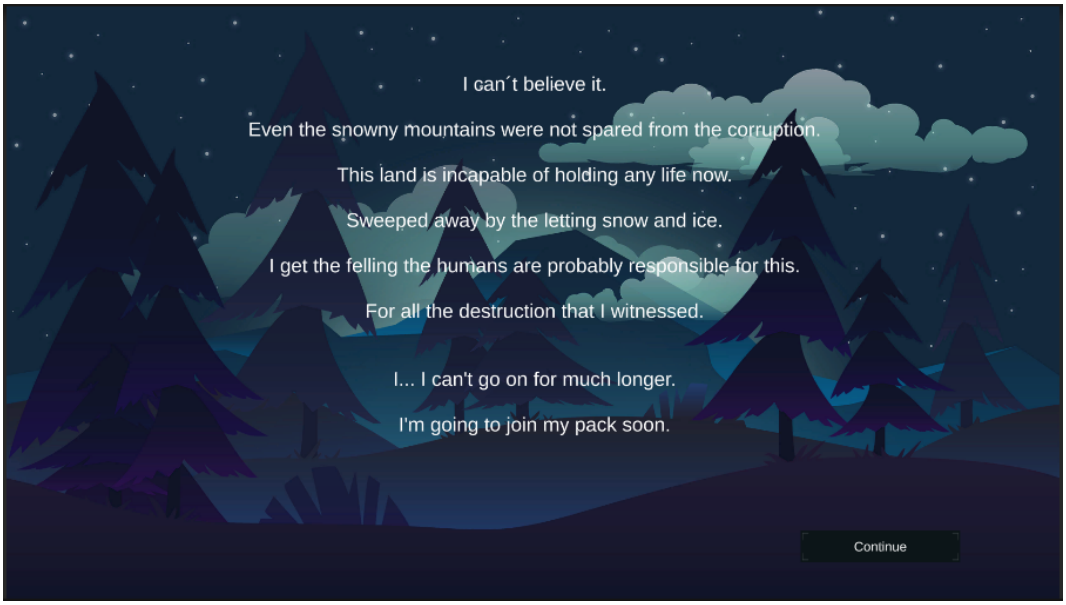

Figure 3.20: Story Conclusion 1

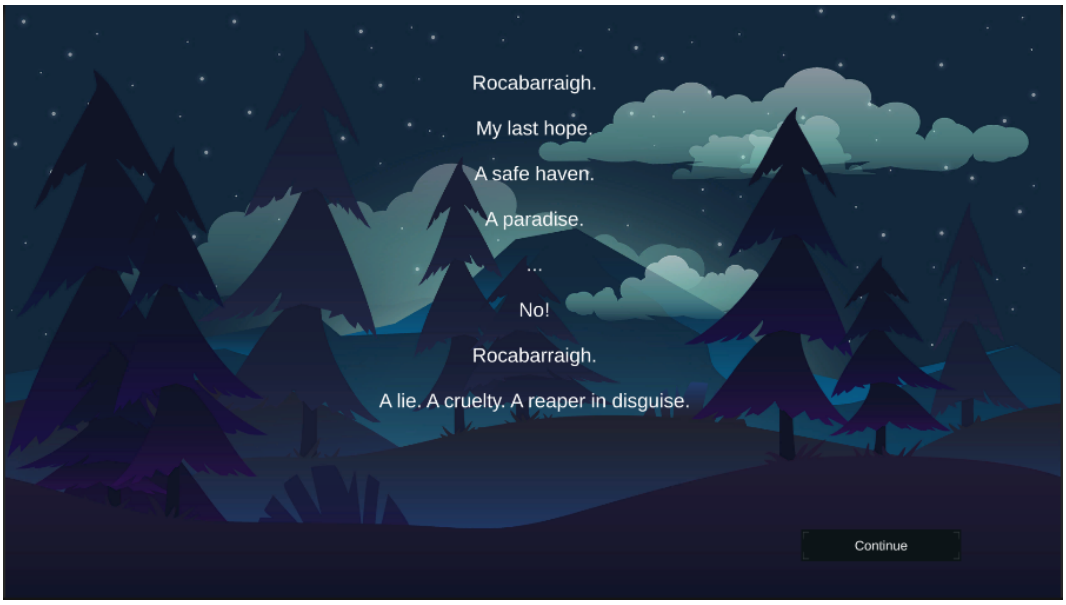

Figure 3.21: Story Conclusion 2

Figure 3.22: Story Conclusion 3

Chapter 4

Evaluation of the Serious Game

4.1 Context

With the finalization of the presentation of the game's design and technical implementations, one important aspect needs to be taken into consideration. And that is analyzing the user's experience, feedback, and thoughts in regard to the game itself. In a way, it can be seen as quality assurance in order to determine if the game does, or does not, in fact reach the established objectives.

Be that as it may, there is a need to utilize efficient means of quantifying the mentioned aspects besides relying on the pre-established research questions. Two methods have been selected: the Game Experience Questionnaire and the System Usability Scale.

4.2 Game Experience Questionnaire

The Game Experience Questionnaire (*GEQ*) is a self-report measure designed to assess players' experiences after playing video games. Developed by researchers at Eindhoven University of Technology, it consists of three modules.

The initial module is the cornerstone of the *GEQ*, evaluating game experience across seven dimensions: Immersion, Flow, Competence, Positive and Negative Affect, Tension, and Challenge. To ensure a comprehensive assessment, each dimension requires five items. Recognizing that translating questionnaire items can occasionally lead to less-than-ideal scoring patterns, an additional item was included for each dimension. Following the first application of the translated *GEQs*, scale analyses will be conducted to determine if any items need to be discarded or replaced.

The second module focuses on social presence, examining the player's psychological and behavioral engagement with other social entities, whether they are virtual (such as in-game characters), mediated (like other online players), or physically present. This module should be used only when the game involves at least one of these types of co-players.

The third and final module is the post-game module, which evaluates players' feelings after they have finished playing. This module is particularly useful for assessing naturalistic gaming, where players choose to play voluntarily, but it can also be relevant in experimental research settings.(IJsselsteijn, de Kort, and Poels 2013)

All three modules are meant to be administered immediately after the game-session has finished and in the presented order. However, for this particular case, only the in-game version was utilized.

The in-game version of the *GEQ* is a streamlined adaptation of the core questionnaire. It maintains the same component structure and includes selected items from the original module. This version is designed to evaluate the game experience at various points during a game session or playback session.(IJsselsteijn, de Kort, and Poels 2013)

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

Figure 4.1: GEQ - Scale

1 I felt content	18 I felt imaginative
2 I felt skillful	19 I felt that I could explore things
3 I was interested in the game's story	20 I enjoyed it
4 I thought it was fun	21 I was fast at reaching the game's targets
5 I was fully occupied with the game	22 I felt annoyed
6 I felt happy	23 I felt pressured
7 It gave me a bad mood	24 I felt irritable
8 I thought about other things	25 I lost track of time
9 I found it tiresome	26 I felt challenged
10 I felt competent	27 I found it impressive
11 I thought it was hard	28 I was deeply concentrated in the game
12 It was aesthetically pleasing	29 I felt frustrated
13 I forgot everything around me	30 It felt like a rich experience
14 I felt good	31 I lost connection with the outside world
15 I was good at it	32 I felt time pressure
16 I felt bored	33 I had to put a lot of effort into it
17 I felt successful	

Figure 4.2: GEQ - Core Module

1 I empathized with the other(s)

2 My actions depended on the other(s) actions

3 The other's actions were dependent on my actions

4 I felt connected to the other(s)

5 The other(s) paid close attention to me

6 I paid close attention to the other(s)

7 I felt jealous about the other(s)

8 I found it enjoyable to be with the other(s)

9 When I was happy, the other(s) was(were) happy

10 When the other(s) was(were) happy, I was happy

11 I influenced the mood of the other(s)

12 I was influenced by the other(s) moods

13 I admired the other(s)

14 What the other(s) did affected what I did

15 What I did affected what the other(s) did

16 I felt revengeful

17 I felt schadenfreude (malicious delight)

Figure 4.3: GEQ - Social Presence Module

1 I felt revived

2 I felt bad

3 I found it hard to get back to reality

4 I felt guilty

5 It felt like a victory

6 I found it a waste of time

7 I felt energized

8 I felt satisfied

9 I felt disoriented

10 I felt exhausted

11 I felt that I could have done more useful things

12 I felt powerful

13 I felt weary

14 I felt regret

15 I felt ashamed

16 I felt proud

17 I had a sense that I had returned from a journey

Figure 4.4: GEQ - Post-Game Module

1	I was interested in the game's story	GEQ Core – 3
2	I felt successful	GEQ Core – 17
3	I felt bored	GEQ Core – 16
4	I found it impressive	GEQ Core – 27
5	I forgot everything around me	GEQ Core – 13
6	I felt frustrated	GEQ Core – 29
7	I found it tiresome	GEQ Core – 9
8	I felt irritable	GEQ Core – 24
9	I felt skilful	GEQ Core – 2
10	I felt completely absorbed	GEQ Core – 5
11	I felt content	GEQ Core – 1
12	I felt challenged	GEQ Core – 26
13	I had to put a lot of effort into it	GEQ Core – 33
14	I felt good	GEQ Core – 14

Figure 4.5: GEQ - In-Game Version

After the completion of all the modules, the score needs to be calculated, thankfully the following figure presents the scoring guidelines for each module.

Scoring guidelines GEQ Core Module

The Core GEQ Module consists of seven components; the items for each are listed below.

Component scores are computed as the average value of its items.

Competence: Items 2, 10, 15, 17, and 21.

Sensory and Imaginative Immersion: Items 3, 12, 18, 19, 27, and 30.

Flow: Items 5, 13, 25, 28, and 31.

Tension/Annoyance: Items 22, 24, and 29.

Challenge: Items 11, 23, 26, 32, and 33.

Negative affect: Items 7, 8, 9, and 16.

Positive affect: Items 1, 4, 6, 14, and 20.

Scoring guidelines GEQ In-Game version

The In-game Module consists of seven components, identical to the core Module. However, only two items are used for every component. The items for each are listed below.

Component scores are computed as the average value of its items.

Competence: Items 2 and 9.

Sensory and Imaginative Immersion: Items 1 and 4.

Flow: Items 5 and 10.

Tension: Items 6 and 8.

Challenge: Items 12 and 13.

Negative affect: Items 3 and 7.

Positive affect: Items 11 and 14.

Scoring guidelines GEQ Social Presence Module

The Social Presence Module consists of three components; the items for each are listed below.

Component scores are computed as the average value of its items.

Psychological Involvement – Empathy: Items 1, 4, 8, 9, 10, and 13.

Psychological Involvement – Negative Feelings: Items 7, 11, 12, 16, and 17.

Behavioural Involvement: Items 2, 3, 5, 6, 14, and 15.

Scoring guidelines GEQ Post-game Module

The post-game Module consists of four components; the items for each are listed below.

Component scores are computed as the average value of its items.

Positive Experience: Items 1, 5, 7, 8, 12, 16.

Negative experience: Items 2, 4, 6, 11, 14, 15.

Tiredness: Items 10, 13.

Returning to Reality: Items 3, 9, and 17.

Figure 4.6: GEQ - Score Guideline

4.3 System Usability Scale

The System Usability Scale (*SUS*) was created in 1986 by John Brooke as a way to measure the usability of new computing systems.

To determine the *SUS* score, participants answer 10 statements that assess their perception of the system's usability. Each statement is rated on a scale from 1 to 5, indicating the level of agreement or disagreement. These ratings are then used to calculate an overall score.(Betteridge 2024)

System Usability Scale Questionnaire	**Strongly Disagree**				**Strongly Agree**
1. I think that I would like to use this product frequently.	1	2	3	4	5
2. I found the product unnecessarily complex.	1	2	3	4	5
3. I thought the product was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this product.	1	2	3	4	5
5. I found the various functions in the product were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this product.	1	2	3	4	5
7. I imagine that most people would learn to use this product very quickly.	1	2	3	4	5
8. I found the product very awkward to use.	1	2	3	4	5
9. I felt very confident using the product.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this product.	1	2	3	4	5

Figure 4.7: System Usability Scale

4.3.1 Calculating the System Usability Scale (SUS) Score

Transforming questionnaire responses into a *SUS* score involves multiple steps. However, there are various calculators available to simplify the conversion process.(Betteridge 2024)

Nevertheless, the score can be calculated following quickest and most simple steps:

- Step 1: Convert the scale into a number for each of the ten questions, as presented in the previous image.
- Step 2: Calculate:
  - X = Sum of the points for all odd-numbered questions – 5
  - Y = 25 – Sum of the points for all even-numbered questions
  - *SUS* Score = (X + Y) x 2.5

The reasoning behind the calculations is straightforward. The total score is 100, with each question contributing 10 points.

Since the odd-numbered questions are phrased positively, a response of "strongly agree" should receive the maximum score of ten points per question. Conversely, a "strongly disagree" response should receive the minimum score of zero. To achieve this, subtract one from each odd-numbered question's score to ensure the minimum is zero. Then, multiply the result by 2.5 to ensure the maximum score is ten for each question.

Conversely, for the even-numbered questions, which are phrased negatively, a response of "strongly agree" should receive the minimum score of zero points per question. Similarly, a "strongly disagree" response should also receive zero points. To achieve this, subtract each question's score from five to ensure the minimum is zero. Then, multiply the result by 2.5 to ensure the maximum score is ten for each question.(T 2016)

4.3.2 Interpreting the System Usability Scale (SUS) Score

The *SUS* can evaluate the usability performance in terms of effectiveness, efficiency, and overall ease of use. While each response generates a score ranging from zero to one hundred, it's important not to interpret this as a percentage or percentile.

The average *SUS* score is 68, which places you at the 50th percentile. The following figure presents a general guideline for interpreting *SUS* scores.(T 2016)

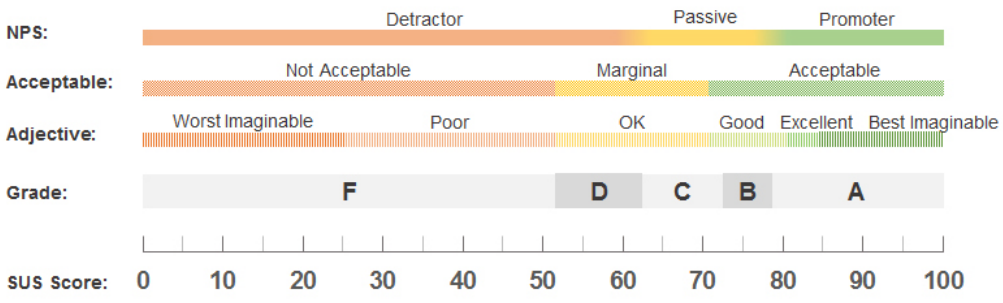

Figure 4.8: System Usability Scale - Grading System

4.4 Serious Themes Questionnaire

The usability of the game and the game experience were not the only aspects that the needed to be analyzed. The game in terms of presenting climate change and its effects on environmental sustainability also needed to be examined.

As such, a small group of statements was created in order to help with the examination. Each statement is rated on a scale from 1 to 5, indicating the level of agreement or disagreement. They are as follows:

Serious Themes Questionnaire	Strongly Disagree				Strongly Agree
The presentation of the effects of climate, i.e., the burned forest, the severe oil spill and the melted snowy mountain. The presented environments were suitable in their representation.	1	2	3	4	5
The presented environments were effective in the presentation of the effects of climate change.	1	2	3	4	5
The elements in the environments, such as the dead animals, were sufficient representations of the effects of climate change.	1	2	3	4	5
The environments were effective in triggering an emotional response, regardless of intensity.	1	2	3	4	5
The dead animals were effective in triggering an emotional response, regardless of intensity.	1	2	3	4	5
The games' story was effective in presenting the impact of climate change.	1	2	3	4	5
The game was successful overall in presenting the effects and impacts of climate change.	1	2	3	4	5
The game, overall, was successful in changing your mind about climate change.	1	2	3	4	5
A game was a good method of showcasing the impact of climate change.	1	2	3	4	5

Figure 4.9: Serious Themes Questionnaire

In addition to this questionnaire, an open question to ask for suggestions for improvement was presented to further the improvement of future versions of the game.

4.5 Results

The game and the constructed questionnaire were distributed to several individuals. Unfortunately, only twenty people played and responded the provided questionnaire.

With the acquired data and subsequent analysis of each section of the questionnaire, these are the results.

4.5.1 Game Experience Questionnaire - Results and Analysis

The following figure displays the distribution of the mean of results of each component that constitutes the game experience questionnaire.

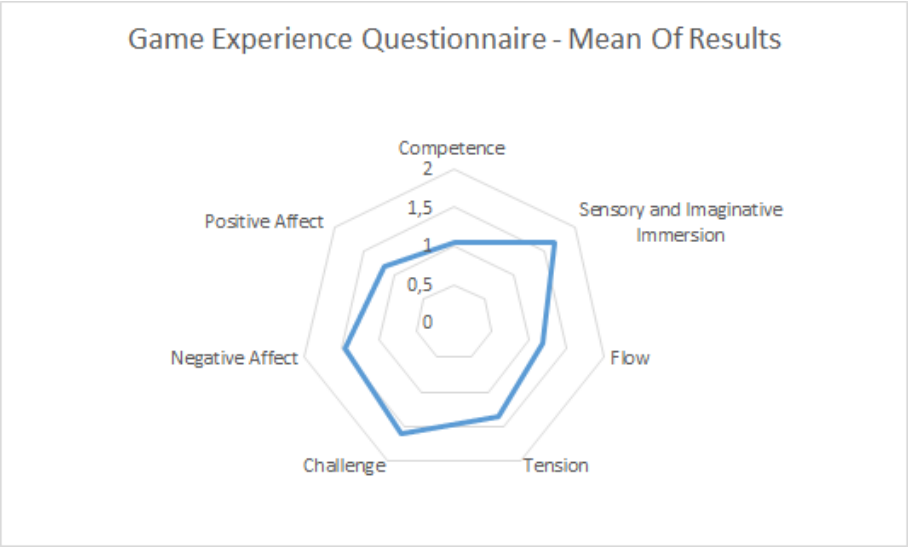

Figure 4.10: GEQ - Mean of Results

As we can see, the mean of the results for each component is not particularly high. However, significant meaning can be obtained by such values in each presented component:

- The mean of the results of the Competence component (1.05) shows that participants felt only slightly competent while engaging with the game. This suggests that players might have found the game somewhat challenging or felt they lacked the skills to succeed.
- The mean of the results of the Sensory and Imaginative Immersion component (1.675) indicates that participants experienced a level of immersion that was between slightly and moderately. They were somewhat drawn into the game's world, but the experience wasn't deeply immersive.
- The mean of the results of the Flow component (1.175) suggests that participants were only slightly engaged in the game. They might have found it difficult to stay fully absorbed or experienced frequent interruptions.
- The mean of the results of the Tension component (1.35) shows that participants felt a low to moderate level of tension. This indicates that the game had some stressful moments, but it wasn't overly intense or anxiety-inducing.

- The mean of the results of the Challenge component (1.6) shows that the game was perceived as slightly to moderately challenging. This suggests that the difficulty level was somewhat appropriate, but it could be adjusted to better match player skills and expectations.
- The mean of the results of the Negative Affect component (1.45) indicates that participants experienced a low to moderate level of negative emotions while playing. This could include feelings of frustration or disappointment, indicating areas where the game might be causing unnecessary stress.
- The mean of the results of the Positive Affect component (1.175) suggests that participants experienced only slight positive emotions. The game provided some enjoyment, but it wasn't consistently engaging or rewarding.

Due to the prototyping nature of this game, and the fact that there were limitations during the development of the game, one of these limitations was the use of game assets of third parties, mainly the animal assets. The results of the calculation of each component for each player and subsequent mean of those results per component were expected to have low to moderate values. To reiterate, these results are not at all surprising when taking into consideration what was said previously. However, it is not all negative, or, in other words, the work done was not without success. The acquired meaning of these mean values is not the only significant data that can be extracted. These values can also be incredibly useful in terms of both game design and research.

In terms of game design, it helped identify the strengths and weaknesses of the game. The components with low mean values, such as Competence (1.05), indicate an area where players feel less engaged or capable. The designer can focus on improving these aspects to enhance the overall experience. For components like Sensory and Imaginative Immersion (1.675) and Challenge (1.6), the designer can explore ways to further enhance these experiences, making the game more immersive and appropriately challenging.

Another aspect of the game's design that was identified, is the balancing of the game's elements. Understanding the balance between Flow (1.175) and Tension (1.35) helps in creating a game that is engaging without being overly stressful. What's more, balancing the Positive Affect (1.175) and the Negative Affect (1.45) ensures that the game is enjoyable while still providing enough challenge to keep players interested.

These mean values provide specific feedback on different aspects of the game, allowing the game's designer to make targeted improvements rather than broad, unfocused changes.

Focusing on the research element, researchers can use these mean values to compare different versions of the game, identifying which elements contribute most to a positive or negative experience. Tracking these values over time can help in understanding how changes in game design affect the player experience.

On top of that, by correlating these mean values with other data, for example, time spent playing, researchers can gain insights into different aspects of the game that can influence player behavior and satisfaction.

These mean values can contribute to developing or refining theoretical models of game experience, helping to better understand what makes this game engaging and enjoyable.

By leveraging these results, a future version of this game can provide a better gaming experience and display higher player engagement.

4.5.2 System Usability Scale - Results and Analysis

The results of the application of previously presented formulas for the System Usability Scale were utilized to calculate a mean score and associated grade to better evaluate the usability of the game.

System Usability Scale	Value
Score Mean	62,5

Figure 4.11: System Usability Scale - Mean Of Results

The calculated mean score is 62.5. This score falls into the "Marginal" category on the acceptable scale and is labeled as "Ok" on the Adjective scale. It corresponds to a grade of "D" on the Grade scale. This indicates that the system's usability is below average, and players likely found it somewhat difficult to play it, with various usability issues affecting their overall experience. This struggle with the game led to frustration, impacting the players' satisfaction and retention.

The only silver lining that should be taken into consideration, however, is that the calculated mean is close to reaching the grade of "C", indicating that there are some aspects of the game are somewhat properly implemented. Understanding what these aspects are may help enhance the overall player experience.

Nevertheless, there are obvious aspects of the game that can be improved, such as the user interface, which can be improved by cleaning up and simplifying the design to avoid overwhelming players. The navigation of the game's menus can also be improved, ensuring that they are clearly labeled, for example. The interaction between the player and the character they control can also be improved. The game's performance should also be a focal point for improvement. As well, the personalization of the game's settings should also be enhanced and provide accessibility options to the player.

In improving the elements that the game is lacking, in enhancing the elements of the game that are well implemented, alongside with a general improvement of some discussed areas. The overall usability of the game will improve, making it more intuitive and enjoyable for players.

4.5.3 Serious Themes Questionnaire - Results and Analysis

The following figure presents the mean of the results for each question of the serious themes questionnaire.

As illustrated, the mean of the results for each question are moderate values. Be that as it may, these values have been thoroughly examined and present important findings in each question:

- The mean of the results of the first question (3.6), shows that the presentation of the effects of climate change, such as the burned forest, severe oil spill, and melted snowy mountain, was considered suitable. This score indicates a moderate to strong agreement, suggesting that these visual elements were well-received.
- The mean of the results of the second question (2.4), indicates that the presented environments were less effective in conveying the intended message.

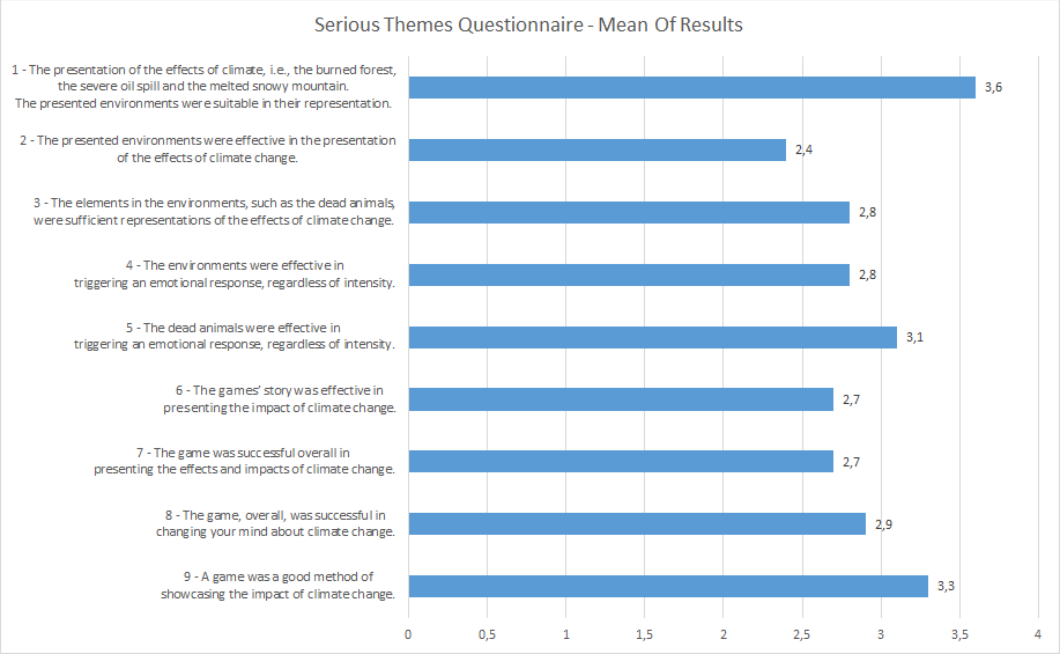

Figure 4.12: Serious Themes Questionnaire - Mean Of Results

- The mean of the results of the third question (2.8), shows that the elements in the environments, such as dead animals, were seen as close to neutral in representing the effects of climate change. Players found these elements somewhat adequate, but not particularly strong representations.
- The mean of the results of the fourth question (2.8), indicates the environments in the game were close to neutral in triggering an emotional response. This score suggests that the environments had some emotional impact, but were not highly effective.
- The mean of the results of the fifth question (3.1), shows that the depiction of dead animals was slightly above neutral in triggering an emotional response. This score indicates a slight agreement, suggesting that this element of the game was somewhat impactful in evoking emotions.
- The mean of the results of the sixth question (2.7), shows that the game's story was close to neutral in presenting the impacts of climate change. The score suggests that the narrative was somewhat engaging but could be improved.
- The mean of the results of the seventh question (2.7), shows that the game was close to neutral in presenting the effects and impacts of climate change. The players found the presentation somewhat effective, but not particularly compelling.
- The mean of the results of the eighth question (2.9), indicates that the game was close to neutral in changing the players' minds about climate change. This suggests that the game had a limited impact on altering opinions.
- The mean of the results of the ninth question (3.3), indicates that players generally felt neutral to slightly agreeing that the game was a good method for showcasing the impact of climate change. Suggesting that while the game was somewhat effective, there is room for improvement.

Overall, the various means reveal that while the game has some effective elements, particularly in visual presentations like the burned forest and dead animals, there are areas for improvement, especially in changing players' minds about climate change.

4.5.4 Player Feedback

The final item of the Serious Themes Questionnaire allowed players to provide suggestions for the game's improvement. Obviously, not all participants answered this section due to its non-mandatory nature, but very important feedback was given that will help plan out the future work of this project.

Here is the provided feedback in a more concise form by player:

- Player 1:
  - Needs improvement of camera movement.
  - Needs improvement in the ability to eat animals and replenish stamina.
  - Needs improvement in the ability to defeat animals.
  - The game needs more indicative text in the *UI* and provide more game information.
  - The objective is not interesting for a good gaming experience.
- Player 3:
  - This player thinks that both the player character and the story, plus the environment, all tie together storytelling wise, and encourages the author to pursue the game idea further.
  - The game needs sound.
  - The game is missing credits (author details) and attributions where applicable (e.g., in case free/paid assets were used, mention source and author of those)
  - Animation transitions are nor working properly, for example when triggering attack/eat/drink while walking or jumping and running, it's easy to at times trigger the wrong animation while still performing a different action. *NPC's* animations at times also don't work properly.
  - It's possible to trigger a state where the player's animation stops completely.
  - The burnt forest and the second area should have some terrain differences and perhaps some effects such as fire and smoke.
  - Suggests making use of view fog.
  - Potentially addition of recognizable landmarks. For example, how mountains or terrain structures are used to provide both distance and subtle interest points in open world games. This would in turn help in not having to provide the player with a compass.
  - Tweaking the amount of dead carcasses available and live animals could better support the environmental story telling.

  - When the player character is starving or close to death, convey that with visual effects, such as blur.
  - Eating should be automatic, to avoid an extra player input.
- Player 4:
  - The control of the camera with the mouse is tricky due to its sensitivity.
  - The food replenishment is a little difficult if the animal is small.
  - Additional enemies should be included, for example hunters.
  - New challenges should be provided in each area, for example in the first area there could be an active fire that is getting closer to the player character.
  - In the final area, the addition of a group of mountain hikers that save the wolf, giving a final scene where the group protests and actively fights for environmental reasons to convey to the player that we can still change the world for the better.
- Player 5:
  - Improve the flow of the controls. When the player quickly clicked the attack button several times, the player character got stuck and couldn't do anything but walk.
  - The scenarios were very repetitive, and the player got bored because it was always the same.
  - The stamina bar could be bigger, or the recovery rate could be increased.
  - The sound did not exist, the player did not know if it was a bug.
  - The player quickly realized that the game's message was about climate change, but as the game was always the same, they did not get too attached. However, they liked the story.
- Player 6:
  - It could use a lot more work in conveying the mechanics more clearly, outside of text.
  - It lacked feedback when performing actions such as eating. There was not a visual representation that you ate any of the animals.
  - The "game feel" could use more work.
  - A few bugs were encountered that made playing with the intended mechanics difficult, such as animations getting stuck, being able to move during the eating animation, or animations breaking if too many actions are performed at the same time.
  - The stamina felt like it wasn't enough and make running feel like more of a quick dash.
  - The concept is there, and for a concept, the idea is conveyed pretty clearly. The player suggests working on putting more emphasis on climate change concepts and effects in the gameplay and environment, and then prop that up with story learned through that gameplay.

- Player 7:
  - The mouse always being on the screen was slightly distracting, and, if possible, more optimization to the forest level would be welcomed to improve the game's performance.
- Player 8:
  - This player points that it's difficult to present this game being about climate change without alluding to a noticeable, day to day change. The fire being a single event isn't easy to directly tie to the long-term phenomenon. The player suggests talking about the life before the fire and the days becoming hotter and dryer. This would help both with giving the wolf's family a bit of exposition and understanding the nature of the story without spelling things out directly. A good title for the game can also help.
  - The technical aspects of the game need to be improved.
- Player 9:
  - In the intro of the game, the player found many typos.
  - In the options menu, on the drop-drown for the resolution, the scroll bar is very slow when you use the mouse wheel. Clicking on the scrollbar is fine.
  - Mouse sensitivity and inverting the Y-axis on the camera would be very good options in the options menu. Also, there seems to be no mouse locking for windowed mode.
  - In the options menu, the text for *"VSync"* is very pixelated compared to the rest of the text.
  - In terms of controls, in general there seems to be a few buttons that could be condensed to a context-sensitive interact button. i.e., Bite Attack, Eat Prey, and Drink would probably not be used in overlapping times, so they could probably be done as a single action. The different styles of attacks would also probably go over more smoothly as an attack-combo mapped to a single button.
  - If you repeatedly take any action too fast (i.e., spamming jump or attack), you lose the ability to take any other actions and you slide around.
  - You can move while attacking, but you can't attack while moving.
  - Your stamina depletes when running even if you do not move.
  - Walking into an enemy does damage and snaps you on top of them. You can kill them this way.
  - If you fall in the river in the desert level, you are locked. No death, respawn, or swimming.
  - Reloading once from this took me back to the beginning of the level. Reloading again fixed it. Seems hard to replicate.
  - Looking ahead with the camera seems to result in frame skips. Looking at Task Manager, player says that they do not appear to be bottlenecked, but they do

see this game takes up like 70-80% of their CPU. Frame skips resolve when the camera is looking at the ground.

- The way the arrow works is super confusing and would probably be better tied to the camera. A visual indicator that it's pointing North would also make it clear it's a compass. Compass graphics would be even more polished but unimportant for a prototype.
- When your bars run out, there are mysterious symbols on the left side.
- The snowy mountain texture is a bit hard to look at.
- The forest level ending has a typo.
- The mountain level ending has some typos.
- The game wants to convey the widespread destruction caused by climate change, but it doesn't do much to show the root cause of it. The most you get is the wolf telling you about it from their perspective, but game stories are much more effective when you can interact with and see the impacts of that story. Even being able to show more elements that people are even there would make things more effective. For example, in the river with the oil spill, it could be made a lot more clear of where the oil is coming from. Because of the lack of human anything, it's a little weird the wolf knows what a human is and can attribute them as the root cause. I think showing the impacts of climate change goes over a little better but is definitely challenging to convey in a prototype.

- Player 10:
  - The controls are not very intuitive, especially having the camera tied to the mouse. The player having used a high *DPI* mouse, this made the game almost unplayable without lowering the *DPI* a considerable amount.
  - Using the forward/backward motion of the mouse to bring the camera closer/-farther away isn't as intuitive as one would think as well, the player kept wanting to use their scroll wheel to make that work.
  - The game would benefit from providing the possibility of using a Xbox or PlayStation controller.
  - The movement is very slow when not running, and running is so short from stamina it doesn't make it worth it to actually use it.
  - The environments felt very bland. The forested area didn't feel like it was a burned forest, but just a forest entering/exiting a winter season, and it felt way too big and repetitive, which caused the player not to be sure they were actually making progress. The same can be said of the second area.
  - The player is not sure where the oil spill or melted snow actually is, but they don't believe they actually encountered it.
  - The player had no idea this game was about the impacts of climate change as it currently stands. The impact of the story was heavily lost because the gameplay was not intuitive with the current control scheme.

- The player couldn't get all the way to the end of the game because the controls were hindering the gameplay to the point that they had to stop.

As we can see, a significant amount of feedback was given despite the low number of participants that decided to provide it. With this very important and enlightening feedback, a structured plan of future work can be more easily outlined. What's more, not only the technical implementations will be improved, such as controls, player experience, and game design, but also the game's story telling will improve. This will provide a better emotional connection with the player and transmit the game's themes more effectively.

Chapter 5

Conclusions and Future Work

Throughout this dissertation, I have aimed to not only prove that video games are an effective means of raising awareness of climate change and its consequences on the planet's environmental sustainability. But to also display an additional tool that provides a more interactive and somewhat personal experience with the individual that interacts with it.

In order to achieve this, climate change and historical milestones that led to our current state of the climate crisis were exposed. Alongside the brief discussion of climate change disinformation. Not only that, but also traditional methods of presenting climate change information were discussed to contrast the non-conventional use of video games as such a tool. Relying on various studies that scrutinized them on this matter to achieve a better understanding of video games' capabilities on this subject.

However, relying on pre-existing studies and data was not sufficient. Only by creating a game from scratch would help in my endeavor. Every aspect of the game — its concept, design and technical development — was presented to ensure a comprehensive understanding of the game's nature.

In addition, evaluation methodologies had to be chosen and explained to guarantee the acquirement of accurate and reliable data to determine if the established objectives were in fact reached.

Regardless of the prototyping nature of this project, several positive outcomes were achieved. The visual presentation, the burned forest and the dead animals, were notably effective. This element successfully conveyed the serious themes, that were intertwined with the established objectives. Additionally, the neutrality observed in the serious themes questionnaire indicates that the game managed to avoid polarizing opinions, which can be seen as a foundation for further development. On the other hand, the game experience questionnaire and the system usability scale presented lower scores. These scores were anticipated given the prototype status of the project. It's important to recognize that these scores do not reflect the full potential of the game, but rather highlight areas for future improvement. The project achieved an average success, which, despite its name, signifies a meaningful accomplishment. It suggests that the game was able to engage players to some extent and raise awareness about climate change among certain individuals. This is a significant step forward, as even partial success in changing perceptions can contribute to broader efforts in climate education and advocacy.

Naturally, while the game did not achieve widespread change in perception, it laid a solid groundwork for future iterations. The visual elements were particularly effective, and the overall experience provided valuable insights for enhancing the game's impact.

In order to better this impact on players, future work needs to be done to achieve one hundred percent effectiveness.

Some immediate implementations for futures work come to mind:

- The acquirement or creation of better game assets, for example acquiring realistic animal and environmental assets.
- Improving the main characters mechanics and animations.
- Improving the *NPCs'* movement, animations, and mechanics.
- Improvements towards the user interface.
- Improvement in each areas' level design.
- Improvement of weather systems.
- Implementation of music and sounds effects.
- Implementation of additional control methods, for example gamepads.
- Improvements towards each areas' environmental storytelling.
- Improvements towards the story of the game.

Of course, these improvements were already thought about when the development stage of the game was concluded. As well, the feedback given by players must also be taken into consideration if the game is to reach its potential.

All these elements, the results and the future implementations, will help in providing a more complete and effective game that not only better raises awareness of climate change more competently, but also helps combat climate change disinformation and change its perceptions of all individuals who play it.

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