Foster Empathy to Promote the Conservation of the Laurissilva Forest: An Interactive Experience

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Acknowledgements

Abstract

The Laurissilva forest was awarded UNESCO World Heritage status in 1999, thereby affirming its position as the largest surviving laurel forest in the world. Renowned for its rich and diverse ecosystem, this forest plays an important role in keeping Madeira Island ecologically balanced. Nevertheless, a critical gap exists in effectively informing the large tourism influx specifically drawn to the natural appeal of the island about its importance. Although supported by UNESCO, current awareness programs are limited in offering deep and engaging experiences. The purpose of this project is to help close that gap by developing an engaging, story-driven experience in virtual reality for future visitors. Through an empathic focus and recognition of the ecological significance of Laurissilva, the project aims to encourage the conservation of this critical ecosystem and to raise awareness to its importance and function in regards to the island.

This research was divided into three distinct phases, each with a different type of methodology. The exploratory phase consisted of a literature review, offering rich sources of information for extending the understanding of the complex needs of the project.

During the generative stage, the work transitioned from a collection of concepts and ideas into sketches and flow charts, which in turn drove the creation of narratives and storyboards that enabled the construction of working prototypes. In the end, this prototype was evaluated through diverse questionnaires, observations and a short interview which, not only allowed to evaluate the usability of the overall experience, but also the ability of the project to help in fostering empathy towards the forest.

The findings showed that experiencing the environment positively related empathy and stimulated interest for the Laurissilva forest.

Key words:

Resumo

A floresta Laurissilva foi classificada como Património Mundial da UNESCO em 1999, afirmando assim a sua posição como a maior floresta de lauráceas existente no mundo. Reconhecida pelo seu ecossistema rico e diversificado, esta floresta desempenha um papel importante na manutenção do equilíbrio ecológico da Ilha da Madeira. No entanto, existe uma lacuna crítica na informação efectiva sobre a sua importância para o grande fluxo turístico especificamente atraído pelas características naturais da ilha. Os turistas muitas vezes demonstram ações incorretas para com a Floresta, dificultando muitas vezes na sua preservação. Embora apoiados pela UNESCO, os actuais programas de sensibilização são limitados na oferta de experiências profundas e envolventes. O objetivo deste projeto é ajudar a colmatar essa lacuna, desenvolvendo uma experiência envolvente e orientada para a história em realidade virtual para futuros visitantes. Através de um foco na empatia e no reconhecimento do significado ecológico da Laurissilva, o projeto pretende encorajar a conservação deste ecossistema crítico e sensibilizar para a sua importância e função no que diz respeito à ilha.

Esta investigação foi dividida em três fases distintas, cada uma com um tipo de metodologia diferente. A fase exploratória consistiu numa revisão de literatura, oferecendo diversas fontes de informação para alargar a compreensão das necessidades complexas do projeto. Aqui veio a se ententer que uma das melhores formas de criar iniciativa nas pessoas para levar à preservação de ecossistemas é através da fomentação de empatia. Esta pode vir a ser desenvolvida através da imersão em realidade virtual e da utilização de narrativas complexas, que por sua vez tornam mais fácil a criação de uma ligação mais profunda entre os visitantes e a floresta. Foi também nesta fase que foram recolhidas informações sobre as diferentes espécies e factos que tornam este ecossistema único.

Durante a fase generativa, o trabalho passou de uma coleção de conceitos e ideias para esboços e fluxogramas, que por sua vez conduziram à criação de narrativas e storyboards que permitiram a construção de protótipos funcionais. Inicialmente uma narrativa foi desenvolvida, mas que durante a sua fase de prototipagem teve de ser repensada devido a algumas limitações, criando assim uma nova história que se adaptasse melhor aos recursos na altura disponíveis. O protótipo foi desenvolvido com a plataforma Unity, mais especificamente para realidade virtual, sendo optimizado para o Oculus Quest 2, que foi selecionado devido à sua portabilidade sem a necessidade de conexão a um computador externo.

O protótipo final coloca então o visitante num pequeno barco que percorre um caminho dentro de uma levada (pequeno canal de irrigação aberto ao ar livre acompanhado por um trilho) pertencente à floresta Laurissilva, conhecendo no seu interior um passageiro que o acompanha ao longo da sua viagem. Este passageiro que no final vem a se descobrir que é a alma da floresta, leva o visitante a resolver pequenos puzzles que desbloqueiam informação sobre a Laurissilva, desde a sua história e riqueza natural às causas da sua degradação. Esta última fase, através das imagens e narrativa que demonstram o quão frágil é o equilíbrio deste sistema, tem como função criar empatia para com a natureza, criando uma ligação entre a mesma e o turista. A resolução destes puzzles é também o que movimenta o barco. Este para se movimentar precisa de restaurar o "flow" que existe dentro da floresta, usando a palavra não só para referir à passagem de água como à própria passagem de informação e conhecimento. Assim, quando o puzzle é solucionado é também restauranda a energia interior da Laurissilva. Diferentes objetos são usados para demonstrar esta energia através de linhas azuis nas paredes que quando conectadas fazem com que o ambiente "ganhe vida". Ao chegar ao final da jornada, o participante antão depara-se com um portal que o leva a conhecer a identidade do seu companheiro, sendo lhe trasmitida a responsabilidade de guardião da floresta.

Todas as interações com o sistema foram desenvolvidas de forma a serem de fácil compreensão e de adaptação rápida, já que o público-alvo do turista pode apresentar diversas idades. Com isto foi então optado pelo uso de um único comando e da realização da experiência que permitisse que o participante permanecesse sentado, resolvendo também certos problemas relativamente ao acompanhamento da narrativa.

No final, este protótipo foi avaliado através de diversos questionários, observações e uma pequena entrevista que, não só permitiram avaliar a usabilidade da experiência global, mas também a capacidade do projeto para ajudar a fomentar a empatia para com a floresta e a transmitir informaçõs sobre a sua importância. Inicialmente foram feitos dois pré-testes para perceber se a experiência demonstrava alguns erros relativamente à sua usabilidade, que após realizados sem quaisquer problemas, pode então ser começada a avaliação com possíveis futuros turistas. Para a amostra foi tido o cuidado para não selecionar residentes da ilha da Madeira, já que este factor poderia vir a influenciar a recolha de dados quanto à eficácia de transmissão de informação relativamente a características da Laurissilva. Esta amostra compreendeu estudantes universitários com idades entre os 17 e os 25 anos. Os testes foram então divididos em quatro partes distintas: preenchimento do questionário pré-experiência, experiência interativa em realidade virtual, preenchimento do questionário pós-experiência e uma pequena entrevista. Foi decidido realizar duas

vezes o questionário de forma a obter dados que determinassem se a experiência teria ou não influência na empatia dos participantes. Nos questionários, para além da empatia, foram medidas escalas relativas à usabilidade do sistema, o nível de envolvimento do participante para com a experiência e a sua identificação com o corpo em realidade virtual. Durante a realização da experiência foi então realizada a observação através da partilha de ecrã do headset com o computador, podendo assim obter informações sobre complicações especialmente em relação à usabilidade.

Ao analisar os dados, apesar de um aumento discreto, o projeto acabou por conseguir bons indicadores para a eficácia da experiência interativa em promover maior conexão com a natureza. Esta criação de empatia pode vir a ter desdobramentos importantes, como o aumento de probabilidade de adoção de comportamentos pró-ambientais pelas pessoas. As entrevistas também vieram a realçar que a experiência conseguiu transmitir informação importante relativamente à floresta, despertando curiosidade nos participantes em relação à Laurissilva. Na observação podemos realçar que alguns dos participantes demonstraram dificuldade em perceber certas interações e até partes da narrativa devido à distração relativamente à sua adaptação ao ambiente virtual.

Apesar dos resultados terem mostrado em geral que a experiência do ambiente relacionou-se positivamente com a empatia e estimulou o interesse pela floresta Laurissilva, existem vários aspetos que podem vir a ser melhorados. Estudos futuros deveriam ser aplicados com um público-alvo mais vasto, selecionando pessoas de diversas origens, possibilitanto assim uma análise de resultados relativos a pessoas com uma menor sensibilidade com a natureza, o que poderia vir a demonstrar uma maior eficácia no impacto da experiência interactiva na sua empatia. A narrativa e a interactividade também podem vir a ser melhoradas através da introdução de elementos de história mais emocionalmente envolventes e immersivos. Tento isto em mente, o projeto também poderia vir a benificiar da criação de objetos e imagens únicas que fossem uma representação mais verídica do complexo e único ecosistema da Laurissilva. A criação destes assets e do prolongamento da experiência levaria o projeto a criar maior envolvimento do usuário com o conteúdo, fomentando um sentido de empatia mais profundo.

Palavras-chave:

Design de Interação;
Floresta Laurissilva;
Realidade Virtual;
Conservação da Cultura e Património;
Empatia com a Natureza

List of Acronyms and Abbreviations

CNS - Connectedness to Nature Scale
GEQ – Game Experience Questionnaire
TS - Transmedia Storytelling
VR – Virtual Reality
CA - Cognitive Absorption Scale
CNS - Connectedness to Nature Scale
VEQ - Virtual Embodiment Questionnaire
VRSUQ - Virtual Reality System Usability Questionnaire

Glossary

Levada - An irrigation channel or aqueduct specific to the Portuguese Madeira Island. Mostly bordering mountains but also going through them, with several stretches over rugged rocks its main purpose is to bring water from different sources to its intermediate or final uses.

Macaronesia – A set of archipelagos made of volcanic islands, situated north of the Atlantic Ocean, near the coast of Europe and Africa. More specifically, the Azores, Madeira, Canary Islands and Cape Verde.

Miocene - Epoch in the geologic time scale that extends from about 23.03 to 5.333 million years ago (before the "Ice Age").

Pliocene – Epoch in the geologic time scale that extends from 5.333 million to 2.58 million years ago (before the "Ice Age").

Conservation – "The protection of plants and animals, natural areas, and interesting and important structures and buildings, especially from the damaging effects of human activity." "Careful use of valuable natural substances that exist in limited amounts to make certain that they will be available for as long a time as possible" (Cambridge Dictionary, 2024).

Transmedia Storytelling – "A process where integral elements of a fiction get dispersed systematically across multiple delivery channels to create a unified and coordinated entertainment experience". (Jenkins, 2008)

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Chapter 1: Introduction

Introduction

In recent years, the tourism landscape in the region of Madeira has undergone a remarkable surge, witnessing a consistent growth that, at times, can reach ten times the civilian population. This surge, while a testament to the island's allure, has posed great challenges to the island's conservation efforts on Laurissilva, a rare biodiverse forest recognized as a world heritage site by UNESCO (Martins, 2023). Due to climate change, different forests around the world have been suffering major impacts in their biodiversity, existing a need for immediate action in order to preserve the different species and parts of the ecosystem (Heller & Zavaleta, 2009), and Laurissilva is no exception. The unique features of this precious ecosystem heighten the urgency for the development of more effective conservation strategies.

In the midst of Madeira's growing tourism sector, where the island's natural beauty is the major selling point, it becomes crucial to seek for out of the ordinary ways on how visitors can be made to feel responsible for their behaviors towards the fragile island environment.

Bilynets and Cvelbar (2022) highlight that creating a positive image of a destination's environment can strongly encourage tourists to adopt eco-friendly habits. This shows how important it is to share knowledge about a destination's ecological value before visitors arrival, offering a chance to spread important information beyond local boundaries.

Sobel (1996) argues that empathy can be a powerful way to inspire people to support conservation efforts. Storytelling, as defended by Manney (2008), is a strong tool for raising awareness about environmental issues thanks to its ability to build empathy even from a distance.

Building on these ideas, this project takes a different approach to the spread of information about the forest in Madeira. Instead of traditional methods that have already been used, it focuses on creating an immersive, interactive experience through virtual reality. Through the use of storytelling, the aim is to deepen tourists engagement, change their perceptions that may encourage actions driven by empathy. This project seeks to connect with future tourists while also promoting a sustainable balance between tourism and environmental preservation.

1.1. Problematization

Declared in 1999 a World Heritage Site by UNESCO, the Laurissilva of Madeira is the largest surviving area of laurel forest in the world, containing different endemic species and playing a key role in the maintenance of the hydrological balance on the Island of Madeira (Gouveia et al., 2005). This denomination brought more visibility for the ecosystem, creating more conscience about its importance, but its growth in popularity did not stop. After the 2019 pandemic, the large flow of tourists brought huge pressure on the local nature, lacking of better care for the overall environment (Quintal, 2023). Through a study, Oliveira (2023) discovered that some locals are in favor of implementing a tourist tax because they believe that it could help with the minimization of the negative impact that mass tourism has had on the island. They stated that the appearance of travelers normally accompanies not only an increase in rubbish on the trails as well as destruction of the forest.

The issue does not only lie on tourism, as in the latest years different cases of illegal fires have been caught by the forest police in Madeira (Lusa, 2018; Ferreira, 2023; Rodrigues, 2024). We can assume that these come from a lack of awareness, as they can increase the risk of fire given the extreme weather conditions, therefore putting the forest at risk.

Now more than ever, the divulgation about its richness and role within the island is crucial, as the sustainability of the forest rests on the awareness and responsibility of Madeira's residents and tourists.

After some thorough research, it was noted that there exist different conferences and tours around the forest. In addition to conferences, various projects related to Laurissilva have been initiated, however, the majority of these projects were noted to be simplistic, often revolving around educational programs in schools or focusing on in-situ rehabilitation of the natural habitat (Instituto das Florestas e Conservação da Natureza da Madeira, 2024). It is also worth mentioning that an educational game link was found ("Uma Floresta, um futuro", 2010), but unfortunately, it was unavailable, leaving a gap in potential interactive and engaging resources for educating the public about this unique ecosystem. Another interactive project developed has been "Fragments of Laura", created to engage tourists through transmedia storytelling, in order to teach more about the overall cultural and natural heritage of Madeira Island. This location based project focuses on creating a link between locals and

visitors through an entertaining and meaningful experience with a story based around Laurissilva.

Remarkably, there exists one museum that exclusively focuses on the forest, which is the Macaronesia Forest Centre. While other museums briefly mention Laurissilva (e.g. Madeira Story Centre, Natural History Museum of Funchal, Madeira Botanical Garden), all of them consist of mainly written information.

It was noted, that although the primary aim of most of these initiatives is to raise awareness about the significance of Laurissilva, none have ventured into providing a more immersive experience that could effectively engage users and foster greater empathy with the environment.

Over the last few years, there has been an increasing emphasis among environmental thinkers on acknowledging the role of empathy in conservation efforts (e.g. Sobel, 1996). In order to create empathy with nature, it is crucial to cultivate a strong emotional and cognitive connection between humans and the natural world (Geng et al., 2015), as empathy can change people's perceptions and emotions concerning nature, creating a closer connection between them both (Wang et al., 2022). It is also important to point out that empathy is cultivated through storytelling, proving to be not only the most effective method for fostering social empathy from a distance but also serving as the driving force behind social and cultural transformation (Manney, 2008).

This highlights the opportunity to create an immersive, narrative-driven playable experience in virtual reality centered on the Laurissilva forest, as these experiences can assist visitors in forging a deeper connection with the subject matter.

1.2. Starting Question

What is the impact of an interactive and immersive virtual reality experience on fostering empathy among potential visitors to the Laurissilva Forest of Madeira Island?

1.3. Objectives

1.3.1. Main objective

Develop an experience that educates tourists about the biodiversity and ecological importance of the Laurissilva Forest while fostering a sense of personal connection and responsibility.

1.3.2. Secondary objectives

- Evaluate the impact of the experience on fostering empathy in participants.

- Utilize storytelling techniques to communicate the ecological and cultural significance of the Laurissilva Forest.

- Introduce gamified elements to increase user engagement and support the dissemination of knowledge through the experience.

1.4. Argument

By creating an immersive, story-driven, interactive virtual reality experience, we can foster empathy for the Laurissilva of Madeira among tourists, potentially inspiring more ecologically conscious actions.

1.5. Research Design

Research Field
Interaction Design

↓

Theme
Story-driven experience in virtual reality to
foster empathy with nature

↓

Title
Foster Empathy to Promote the
Conservation of the Laurissilva Forest:
An Interactive Experience

↓

Research Question
What is the impact of an interactive and immersive virtual
reality experience on fostering empathy among potential
visitors to the Laurissilva Forest of Madeira Island?

Exploratory Phase

| Case Studies | Literature Reviews |

Theoretical Framework

↓

Argument
By creating an immersive, story-driven, interactive virtual reality
experience, we can foster empathy for the Laurissilva of Madeira among
tourists, potentially inspiring more ecologically conscious actions.

Design Process

Generative Phase

| Sketching | Narrative | Concept Maps |

Storyboard

Prototype — Refine

Evaluative Phase

Usability and User Testing

| Observation | Questionnaire | Interviews |

Conclusions

| Discussion of Results | Limitations | Future Recomendations |

Methodology was design and divided into three different parts: the Exploratory Phase, the Generative Phase and the Evaluative Phase as shown in the Organogram 1.

Exploratory Phase

A comprehensive literature review was conducted, involving the collection, selection, analysis, and synthesis of research across several areas of study. This phase aimed to identify essential aspects of the Laurissilva forest, explore theories on evoking emotions in users through storytelling and interactive experiences, examine how empathy toward nature can be cultivated, and determine effective strategies for informing the public on cultural heritage preservation.

Additionally, case studies of interactive projects were analyzed in detail. These projects shared a common goal of fostering empathy toward specific themes, providing valuable insights into the design of immersive narratives and techniques for eliciting empathetic responses from users.

Generative Phase

Building on insights gathered during the exploratory phase, various sketches, concept maps, and mood boards were created to organize the narrative and key information to be conveyed to the user. Once the narrative was established, attention shifted to defining the user interactions within the system, including the inputs, outputs, and how each interaction would support the story's flow. To visualize how these elements would be applied, storyboards were developed to illustrate different narrative paths and the user's engagement within the interactive experience.

With the overall experience defined, two prototypes were created to provide a tangible representation of the narrative. These prototypes helped identify errors and areas of concern, allowing for iterative refinement of both interactions and the narrative structure.

Evaluative Phase

In this phase, testing was conducted with potential future tourists to assess whether the project achieved its goal of fostering empathy. To measure this, participants completed the Connectedness to Nature Scale (CNS) both before and after the experience. The user experience within the VR system was evaluated using the Virtual Reality System Usability Questionnaire (VRSUQ), while the Virtual Embodiment Scale Questionnaire (VEQ) and the Cognitive Absorption scale (CA) assessed participants' sense of embodiment and cognitive engagement.

Observation was used as a method during testing to gather insights into the overall quality of the experience. This included noting any

challenges participants encountered while completing tasks, identifying areas for improvement, and evaluating participants' reactions to the narrative elements.

After testing, brief interviews were conducted to measure participants' recall of the virtual experience and assess their understanding of the messages conveyed.

1.6. Document Guide

The document is divided into five chapters: the first is the introduction, the second covers the exploratory phase of the research, the third focuses on the generative phase, the fourth addresses the evaluation phase, and the final chapter presents the project conclusions.

Chapter 1 – Introduction
The topic under investigation is introduced, describing the subject of study, the research problem, the research questions, the argument, the objectives, and the research design (methodologies).

Chapter 2 – Review and Contextualization
This section presents a review of relevant literature to explore key aspects of the Laurissilva forest, emotional engagement through storytelling, and strategies for fostering empathy toward nature.

Chapter 3 – Active Research
This section outlines the process of developing the narrative and interactions, including the creation of sketches, concept maps, mood boards, and storyboards. It also covers the creation of prototypes to visualize the experience, identify issues, and refine both the interactions and overall narrative.

Chapter 4 – Evaluation
This section presents the objectives, procedures, test results with potential future tourists, and the improvements made based on these results and the insights gathered from observations.

Chapter 5 – Conclusions
The conclusions of the project are presented, including final considerations, limitations, contributions to the field of research and the topic taking into consideration the problem, research questions, and argument, as well as recommendations for future studies.

Chapter 2:
Literature Review
and Contextualization

This chapter focuses on the literature review that started with the collection and selection of information through the consultation of various books, articles, websites, and interviews pertinent to the research. It was organized into three main themes. The first section explores the Laurissilva forest and its ecosystem, providing a comprehensive understanding of its ecological significance and the challenges it faces. The second section addresses the human factor of empathy, focusing on how it can be fostered and measured, particularly in relation to nature. The final section is dedicated to the system itself, examining interactive experiences, particularly virtual reality, and its potential to serve as a tool for creating empathy. It also discusses the role of storytelling as a powerful means of cultivating empathy, offering a holistic perspective on how to effectively approach this topic (Figure 1).
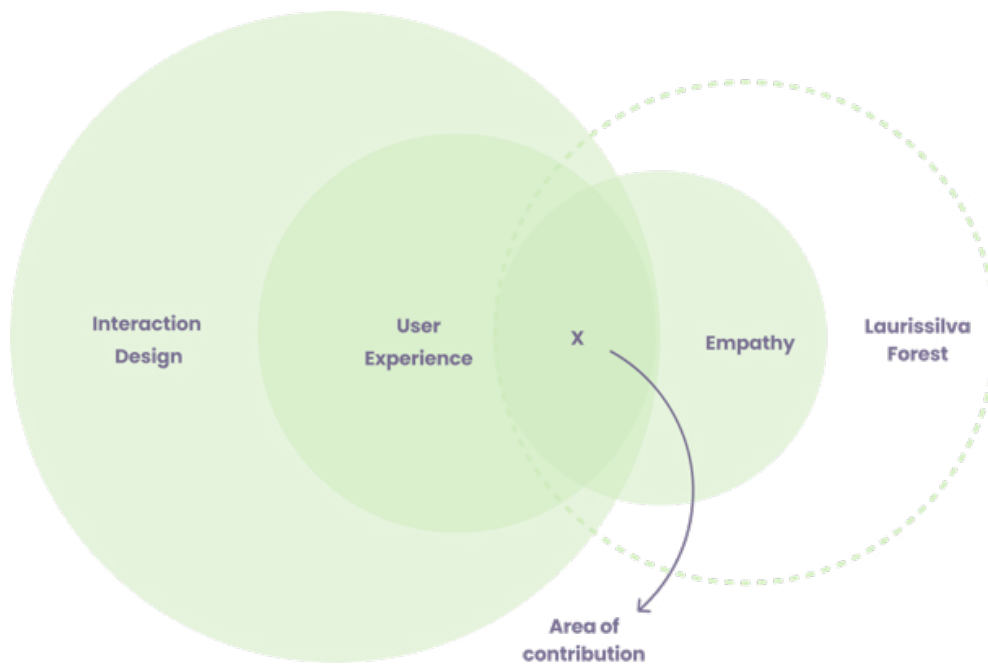
Figure 1 | Diagram of areas of investigation

2.1. The Laurissilva Forest Ecosystem

Covering around 20% of the island (Sousa, 2021), as seen in Figure 2, at approximately 20 million years old, the Laurissilva of Madeira stands as a testament to the Miocene and Pliocene periods, earning the distinction of a 'living fossil' due to its remarkable age. Covering most of the island when discovered, this forest represents the most expansive surviving domain of Laurel forest or "laurisilva," boasting an estimated 90% primary forest composition. Recognized as "an outstanding relic of a previously widespread laurel forest type, which covered much of Southern Europe 15-40 million years ago" (UNESCO, 2024), it was designated a UNESCO World Heritage site in 1999.

Laurissilva

Parque Natural da Madeira
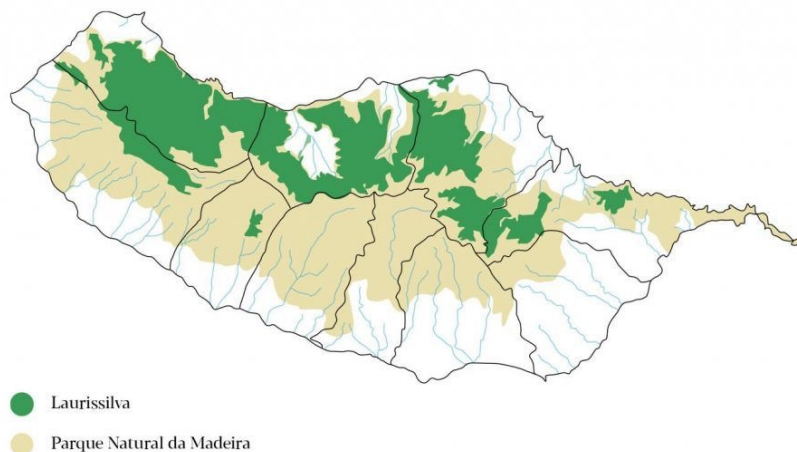
Figure 2 | Map of the Laurissilva Forest. Retrieved from "Florestas PT". https://florestas.pt/wp-content/uploads/2021/08/gra%CC%81fico-galeria-floresta-laurissilva-1-1024x683.jpg

This subtropical rainforest is predominantly inhabited by species endemic to Macaronesia, encompassing the Azores, Madeira, and Canary Islands. Distinguished by its rich biodiversity, the Laurissilva of Madeira hosts a unique array of flora and fauna (Cruz et al., 2009), surpassing other laurel forests with at least 76 endemic plant species and a variety of endemic animal species.

Situated within the expanse of the Parque Natural da Madeira (Madeira Natural Park), this forest assumes a pivotal role in maintaining the island's hydrological balance. It meticulously oversees the collection, retention, and filtration of water derived from both fogs and precipitation, as highlighted by Neves et al. (1997). The water, a precious resource, is then meticulously directed to the island's inhabitants through an ingenious system known as "levadas" (Figure 3).

Figure 3 | Levada do Rabaçal, Madeira. From "Wikipedia", by Unknown, 2006, https://en.wikipedia.org/wiki/Levada_%28Madeira%29#/media/File:Levada_Madeira.jpg

These slender and extensive aqueducts, predominantly crafted in stone and often exposed to the open sky, diligently gather water from the northern regions of the island. This area, adjacent to the island's mountains, serves as a primary location for cloud accumulation. The collected water is then transported through the system to the southern part, where a significant portion of the population resides. Here, it proves essential not only for human consumption but also for agricultural practices and the generation of electrical energy. This intricate interplay between the forest, water resources, and the levada system underscores the vital role of the Laurissilva of Madeira in sustaining both natural ecosystems and human livelihoods.

Unfortunately, due to various reasons, the forest is at risk. Due to climate change a lot of the forests worldwide are suffering major impacts in their biodiversity which means that there is a need for immediate action in order to preserve the different species and services of the ecosystem (Heller & Zavaleta, 2009).

Human intervention has been identified as a significant contributor to the extinction of several species, as noted by Kolbert (2021). The data reveals a stark reality, particularly on islands, where the extinction rate of vertebrates since 1600 has reached alarming levels. Islands bear the brunt with a staggering 95% loss in reptiles, 85% in birds, and 58% in mammals (Whittaker, 1998). Notably, Madeira has already witnessed the decline and near extinction of certain endemic bird and plant species, underscoring the critical importance of effective ecosystem management for their survival.

It's crucial to note that the surge in tourist numbers on the island after the 2019 pandemic has exerted pressure on the local environment. As Quintal (2023) highlights, certain vital forest areas are consistently overcrowded, leading to soil damage, littering, and complicating the overall ecosystem management. The growth of ecotourism, though well-intentioned, has posed a significant challenge to the island, particularly in the Levada areas utilized as walking paths in the forest. The biologist also underscores that the introduction of certain exotic plants in specific island areas may result from misinformation, potentially causing harm to the existing flora.

According to a study undertaken by Bilynets and Cvelbar (2022), findings indicate that when tourists perceive a destination as environmentally friendly, it correlates with improved environmental behaviour at the destination. The study advocates that destinations should focus on cultivating their environmental image to encourage tourists towards more environmentally friendly behaviours. This shows that the dissemination of information about the forest may have a positive impact on potential tourists.

2.1.1. Conservation and Awareness Projects

Various initiatives are underway to safeguard Laurissilva, with the "Programa de Educação Ambiental" standing out as a noteworthy program. This organization implements diverse programs with a primary emphasis on informing, raising awareness, and educating schools about preservation (Figure 4). Recognizing schools as pivotal in imparting knowledge to the younger generation about the forests' significance for the island, the program devises various courses, nature visits, campaigns, and initiatives such as plantation and habitat recovery.
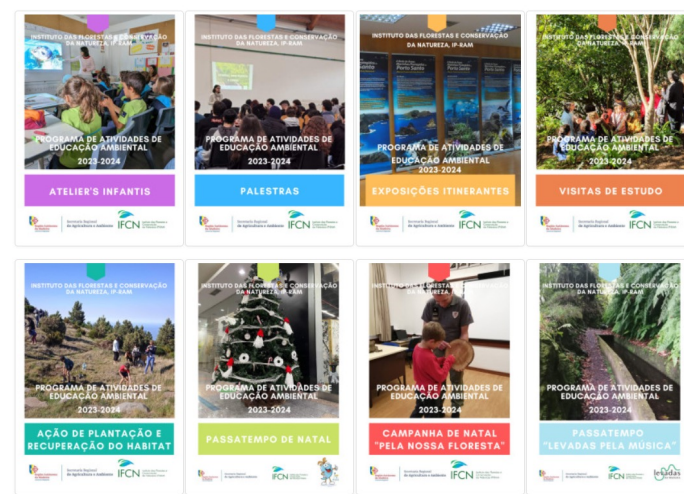
Figure 4 | Skierska, K. (2024). Activities available on the website for the "Programa de Educação Ambiental" [Screenshot]. Retrieved from https://ifcn.madeira.gov.pt/divulgacao/programa-de-educacao-ambiental.html

While schools receive the majority of attention, activities extend beyond, encompassing the monitoring of specific species like the "Pombo-tro-car" and "Bis-bis" (Figure 5) and organizing conferences to disseminate knowledge about plants, animals, and recommended actions.

Figure 5 | Left: A Trocaz pigeon in the laurisilva, Madeira. By Carlos Cabral.
Right: Bis-bis in the laurisilva, Madeira. By Rudi B., 2019. https://www.flickr.com/photos/148949036@N07/46700035064

It's essential to note that nature conservation shouldn't solely revolve around in situ activities conducted within the natural environment. As Gouveia et al. (2005) highlight, there's a need for ex situ activities, beyond the local setting.

Considering this aspect, the island has established a museum dedicated to the Macaronesia forest, known as the Macaronesia Forest Centre (Figure 6). This facility serves as a valuable resource for various information related to Laurissilva and its significance. Nestled within a park, the museum adopts a straightforward approach, primarily presenting written information supplemented by guided tours. While other museums briefly touch upon Laurissilva due to its cultural ties with Madeira, the information provided is often concise, and the significance of the forest can easily go unnoticed.

Figure 6 | Macaronesia Forest Centre. Reprinted from Instituto das Florestas e da Conservação da Natureza by Unknown, 2023, Retrieved from https://ifcn.madeira.gov.pt/divulgacao/centros-de-rececao/centro-florestal-da-macaronesia.html

There is a notable absence of more interactive and engaging methods for disseminating information in these museums. This presents a unique opportunity to introduce elements that can capture the attention of the target audience and enhance the overall visitor experience.

One project that could be found with a more interactive focus was Fragments of Laura, which is a "transmedia storytelling" (TS) experience designed to involve visitors in developing knowledge and awareness about the cultural and natural heritage of Madeira Island" (Dionisio & Nisi, 2021). This project is divided in two different components: a location aware multimedia story and a hypermedia portal. Both of these present 7 different themes/episodes about the cultural and natural heritage of the island, having various parts focused on the Laurissilva forest. Here the main goal is to create a more interactive way to discover different parts of the main city, Funchal, while the hypermedia platform serves as a way to introduce tourists to the TS experience. More specifically, the story takes place in 18th century Funchal, following the main character Laura, who is focused on discovering and documenting different properties of the Laurissilva.

2.2. Empathy with Nature

Different authors over the last few years have determined that the acknowledgement of empathy as a vehicle to increase conservation methods is essential (e.g., Sobel, 1996). Geng et al. (2015) determined that the creation of a good foundation through emotion and cognition between the humankind and nature are essential to create empathy, as empathy can change people's perceptions and emotions with nature, creating a closer connection between the two (Wang et al., 2022). This connection can be developed in different ways, through empathy with the fauna, the enjoyment of nature itself, and through a sense of unity and a sense of responsibility (Cheng & Monroe, 2010). Engaging with nature has the power to reshape an individual by fostering a profound sense of connection, challenging established notions of the separation of mind/body, and nurturing kinesthetic empathy (Schultz et al., 2004; Humberstone, 2013).

Scientific studies show that cultivating empathy toward animals not only enhances our understanding of their needs but also plays a key role in raising awareness about critical environmental issues (Voigt, 2020; Wu, 2018). Empathy is a complex phenomenon encompassing more than just the ability to feel; it extends to understanding and emotionally engaging with others, including nature (Graaff et al., 2015; Hosseini & Caragea, 2021). It is also important to point out that empathy is based on the need to share and comprehend others' emotions (Zhao et al., 2021).

With this, we understand that to cultivate empathy with nature, it is essential to foster a robust emotional and cognitive connection with the natural world. This involves nurturing a profound sense of unity and responsibility while concurrently deepening one's emotional connection and understanding of nature.

2.3. Virtual Reality and Empathy-Driven Experiences

Storytelling stands out as a potent method for nurturing empathy, proving itself not only as the most effective approach for cultivating social empathy from a distance but also as a catalyst for driving social and cultural transformation (Manney, 2008).

According to Talgorn & Ullerup (2023), people face the challenge of creating a deep connection with nonhuman elements, needing different tools to stimulate a connection to nature, something that is possible through the use of storytelling. Narratives possess the ability to encourage the adoption of various perspectives by involving readers or listeners in the experiences of the characters, thereby enabling engagement with alternative and unfamiliar environments (Donly, 2017; Forlano, 2017; Reddy et al., 2021).

As explained by Manney (2008), while books or movies offer glimpses into a character's life, it is video games that truly immerse us in those experiences. Certain video games, particularly those with intricate storylines, have been shown to evoke empathy in players (Wulansari et al., 2020). Greitemeyer & Osswald's (2010) study demonstrated that exposure to pro-social narratives in games enhances interpersonal empathy among players. Additionally, Hafner & Jansz (2018) found in their exploration of immersion in persuasive games that players experience deeper personal connections and stronger emotional engagement. Their research suggests that narrative depth, among other characteristics, contributes significantly to the overall immersive experience for players.

Wulansari et al. (2020) have asserted that games designed to evoke empathy, often referred to as "Empathy games," hold significant promise for raising awareness about various real-world issues.

The utilization of Virtual Reality (VR) is also a common practice in storytelling. VR storytelling enables users to immerse themselves in a virtually recreated scenario that conveys a narrative. It is reshaping conventional norms related to narrative structure, character development, and storytelling. The objective of VR storytelling is to craft a narrative capable of eliciting emotions that, in turn, have an impact on subsequent actions (Shin, 2017).

2.3.1. Examples of Interactive Experiences

There exist various interactive experiences that allow the user to create empathy with certain characters or environments mostly focusing on storytelling and simple interactions.

"The Key" (Figure 7) is a virtual experience that through metaphors creates empathy in the player towards the characters and their situation within the game. Here the use of VR becomes essential in creating an immersive experience, allowing the player to live the story in first person.

Figure 7 | The Key [Screenshots]

Another example is an experience developed for a study by Spangenberger et al. (2022) that shows that the immersion of players in a VR setting, as embodying a tree, can affect their relationship and care for the environment more than as a human, as the experience takes the player to develop a reflective process about its role within the conservation of the planet (Figure 8).

Figure 8 | Player during the immersion embodying a tree [Screenshot]

Through the use of an immersive storytelling medium of virtual reality, Holy City VR (Figure 9) is a fully interactive experience that poses an opportunity to nurture understanding and foster dialogue about one of the world's religious epicenters - Jerusalem. This experience focuses on educating, exploring and creating reflection about the spaces rich cultural history and narratives. Players are able immerse themselves into a different culture through taking the place of a local

and their experience of exploring a Holy site. This allows for a full immersion in this culture and for a celebration of its diversity, fostering a sense of humanity in participants.

Figure 9 | The Holy City VR [Screenshot].

Chapter 3:
Active Research

This chapter delves into the project's development phase, detailing each stage and its role in addressing the core research question. It is organized into three distinct sections. The first section focuses on the creation of a persona and the contextual framework in which the experience will unfold. The second section centers on the development of the narrative and storyboards, outlining various concepts and objectives that guide the final experience. Finally, the third section addresses the prototyping process, exploring its development and the challenges encountered during implementation.

3.1. Project development

3.1.1. Proto-persona and Context

To gain a deeper understanding of the experience's target audience, a proto-persona was developed based on insights gathered from the research. This persona helped to define the audience's goals, expectations, and frustrations, enabling the creation of an experience tailored to their needs (Appendix A). The context of the experience was designed to be applied in a museum setting, like for example, the museum of Macaronesia in Madeira Island, as to be a more interactive experience in a text-based information center.

The persona created represents a young tourist who may not be very familiar with the island but is open to learning and eager for new experiences. Based on this proto-persona, a user journey was also crafted to better understand the context in which the user would engage with the system. This journey map illustrates the user's actions, touchpoints, emotions, and thoughts throughout the experience.

3.1.2. Initial Narrative and Storyboard

3.1.2.1. Concept Design

The initial development of the virtual reality experience began with the creation of flow diagrams and sketches to explore different narrative directions and define the key elements that would form the foundation of the interactive experience (Appendix B). These visual tools played a critical role in organizing and structuring the core components of the narrative, ensuring that the story would be both engaging and informative while aligning with the project's educational goals. The purpose of this initial phase was to identify how narrative elements, interactive features, and educational content could best be interconnected and translated into a cohesive user experience.

As part of this phase, I conducted Ethnographic Studies, brainstorming sessions and co-design with island residents. Their firsthand observations offered invaluable insights into the impact of tourism on the Laurissilva forest, highlighting specific tourist behaviours and practices that contribute to environmental harm. This approach also helped in better reflecting the community lived experiences, ensuring that the project resonates with their cultural identity and

addresses relevant issues. By integrating these insights with data from the exploratory phase, I was able to further shape the narrative's direction. Flow diagrams were then used to organize the various ecological aspects of the Laurissilva forest and map out the intended narrative flow, allowing for a clearer visualization of the user's interactions with the environment and the educational journey embedded within the storyline (Figure 10 and Appendix B).
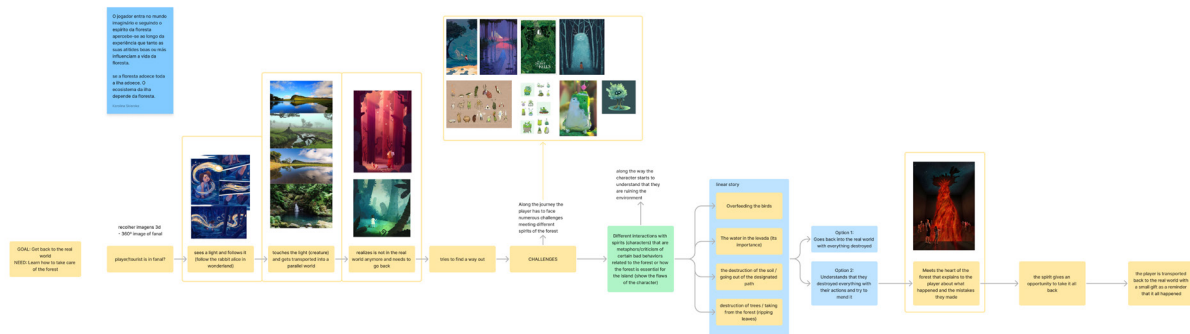
Figure 10 | Flow Diagram of the initial narrative

Once these initial visual and conceptual ideas were defined, the narrative itself was written based on the insights gathered. The story aimed to create an immersive, interactive, and emotionally engaging journey that would foster empathy for the Laurissilva forest. The primary goals of the initial narrative were:

- Develop a coherent and impactful narrative that not only educates users about the Laurissilva forest's biodiversity and ecological importance but also evokes a sense of personal connection and responsibility. Key information points were strategically selected to guide users through an immersive storyline that introduces the beauty and fragility of the forest ecosystem.

- Utilize sketches and concept maps for to explore and visualize different ideas and design directions. These visual aids helped to organize information, clarify how narrative elements, interactive features, and educational content would interconnect, and identify potential design issues early on. This process also provided a structured guide for subsequent prototype development.

- Foster empathy and awareness through interactive storytelling by placing the user in scenarios where they could witness the forest's beauty and challenges firsthand. Interactive scenes were crafted to encourage users to explore and interact mindfully with the environment, reinforcing a sense of empathy and stewardship toward nature.

- Introduce gamified learning elements such as environmental knowledge checkpoints or tasks like virtual tree planting, to increase user engagement and reinforce the educational aspects of the experience. These features aimed to create an enjoyable and meaningful journey through the forest, with each interaction reinforcing the storyline.

Once the goals were defined, an initial narrative was developed (Figure 11) to immerse users in a journey through Madeira's Laurissilva forest. In order to refine the text and make it sound more mystical, ChatGPT was used (Figure 12). The user, cast as a curious tourist, would begin by hiking along a traditional Levada, surrounded by serene and vibrant landscapes. This introduction was designed to evoke a sense of wonder and peace, making users feel at home in nature.

As the storyline progressed, users would encounter enchanted creatures symbolizing different aspects of the ecosystem. Through interactions—such as helping a rock-like creature collect rare stones or planting seeds for a protective mother figure—the user would gradually be led to understand the importance of each part of the forest. These interactions, carefully integrated with narrative and interactive elements, would aim to build empathy by illustrating how each action affects the delicate balance within the forest.

Toward the end of the journey, the tone would shift as the user was shown the forest's possible future—a vision of ecological imbalance and human impact. Guided by a small, flickering light symbolizing the forest's spirit, users woud witness a once-thriving landscape deteriorated by invasive species, parched Levadas, and displaced creatures. This somber scene would act as a wake-up call, underscoring the consequences of seemingly small actions on the ecosystem's overall health.

This storyline was crafted not only to inform users about the Laurissilva forest but to foster a meaningful emotional connection, encouraging a mindful approach to nature. Throughout the journey, the tourist remains unaware that their seemingly innocent actions are contributing to harm; only in the end, when each creature's true intentions become apparent, would they realize that these interactions represented the unintended consequences of human impact on the forest.

To effectively visualize the narrative and its visual elements, and to facilitate the implementation into a VR format, a storyboard (Figure 11) was created alongside moodboards. Additionally, AI-generated images were produced using prompts derived from the narrative, providing a clearer representation of the envisioned scenes and setting. This process helped establish a strong visual foundation for the development of the virtual reality experience.
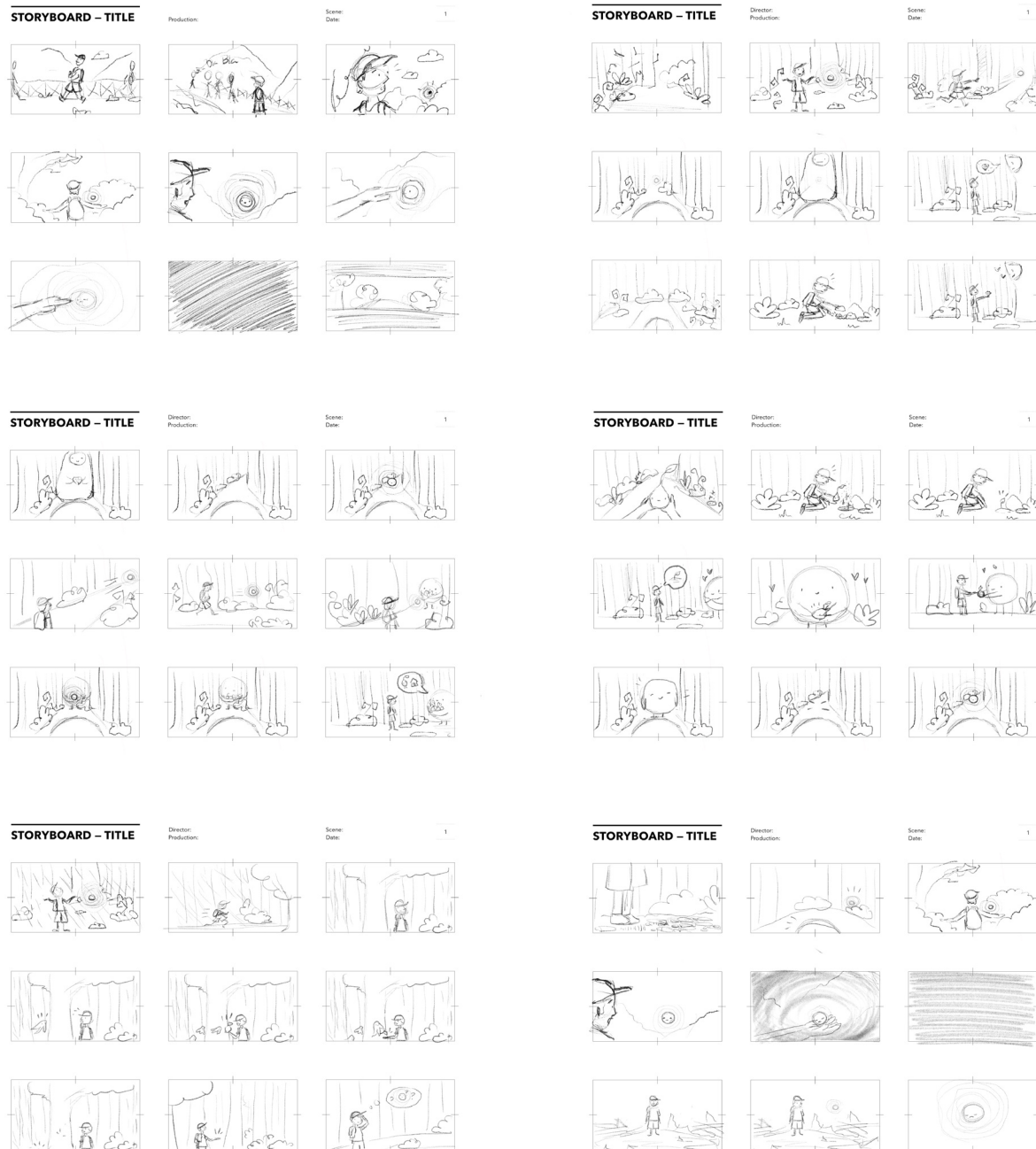
Figure 11 | Storyboard, Version 1
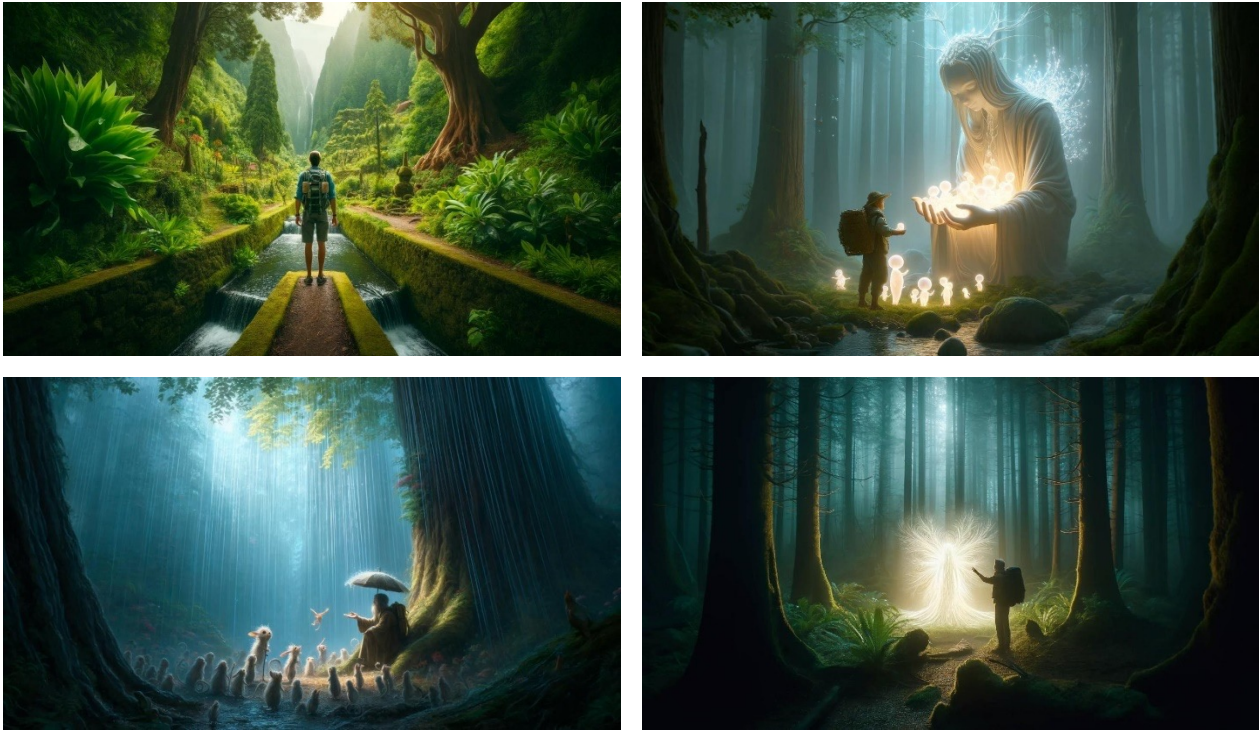
Figure 12 | Images created with the use of ChatGPT based on the created narrative.

3.1.2.2. Prototype Development and Implementation Challenges

The initial prototype was developed using Unity 2022.3.43f1 in a VR/3D setting, optimized for Oculus Quest 2 (Android SDK) to ensure portability without a direct connection to a computer. Key tools included XR Origin and custom scripts from the ergoUX Lab, which supported the creation of scene triggers.

Given the limitations of Android devices, especially concerning object complexity, a low-poly visual style was adopted. This choice balanced performance and visual quality, accommodating the device's constraints on polygon count while still creating an engaging environment. The first prototype aimed to recreate a Levada environment as the starting point for the user's journey. However, early development revealed some significant challenges. The linear nature of Levadas—narrow paths with limited exploration outside the designated route—posed mobility issues. Options such as teleportation disrupted immersion and narrative flow, while free movement risked inducing nausea and errors within the confined virtual space.

Further difficulties arose in accurately depicting the Laurissilva forest's unique flora, fauna, and terrain. The absence of assets that

could faithfully represent this specific ecosystem impacted the visual authenticity and undermined the forest's distinctiveness, compromising its ecological and cultural importance. This limitation marked a turning point, as it became evident that the lack of specific assets affected the environment's immersive potential and made the storyline harder to translate effectively into a VR experience.

3.1.3. Revised Narrative and Storyboard Development

3.1.3.1. Redefining the Narrative

After encountering challenges in adapting the initial narrative for VR, it became necessary to revisit and redefine the storyline to better suit the medium. Sketches (Appendix C) and storyboards (Figure 13) were co-designed with people from Madeira Island for a more authentic experience. These visual aids played an essential role in refining the narrative structure and helped visualize the new concept, which focused on the symbolic flow of water within the levadas—a central feature of Madeira's landscape.
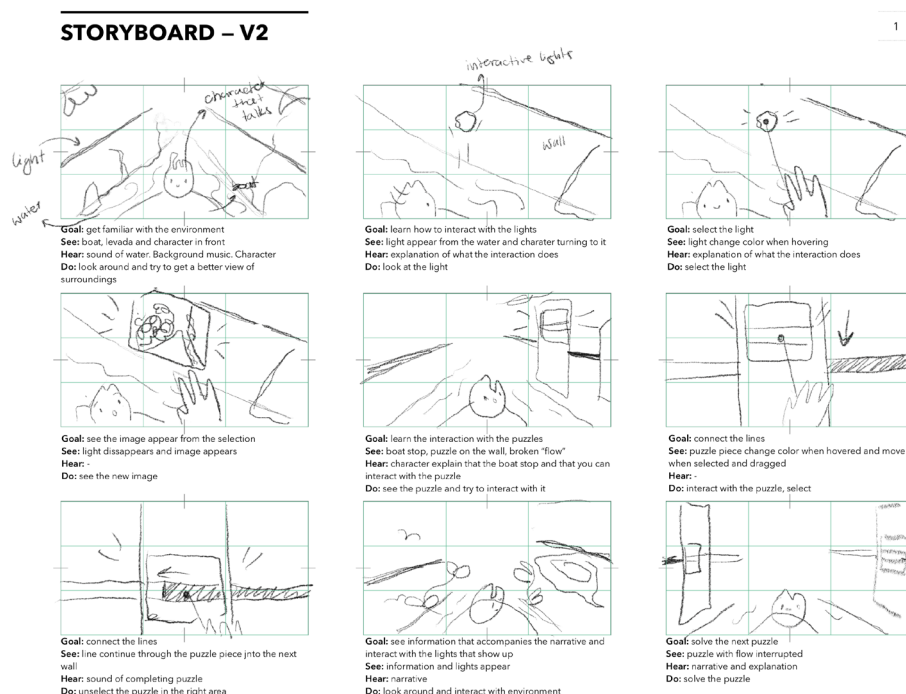
Figure 13 | Storyboard, Version 2

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This revised approach placed the user inside a levada on a small boat, allowing the narrative to center around the concept of "flow"—both the flow of water and the flow of knowledge. The boat's automatic movement along the levada created a smooth and controlled narrative progression, where the user could interact with their surroundings and absorb information in a structured manner. This setup allowed for a more straightforward VR experience and facilitated a more educational approach, where key facts about the Laurissilva forest could be shared in a guided, focused way, shifting slightly away from the emotional depth of the initial concept.

The narrative begins with the player awakening in a boat drifting down a levada channel, surrounded by the towering trees and tranquil landscape of the Laurissilva forest. Guided by an enigmatic character, the player embarks on a journey through the forest, solving a series of environmental puzzles to restore the water flow within the levada. Through these interactions, the user learns about the forest's biodiversity, its historical significance, and the modern-day threats it faces, such as invasive species and climate change.

The storyboard played a crucial role in shaping this symbolic journey, helping to illustrate how each narrative moment and interaction would deepen the player's understanding of the forest's role on Madeira Island. As the player restores each segment of the levada, they engage with visual elements that highlight the ecosystem's resilience, species diversity, and the impact of human actions on its health, ultimately encouraging a sense of responsibility for the forest's future.

3.1.3.2. Final Prototype Implementation

Using the same system and tools as the initial prototype, the final version was developed with careful consideration of the previous challenges. Restricting the environment to the levada path allowed for a more stylized representation, eliminating the need for highly accurate assets. The environment was scaled up, making the user appear smaller, which added a magical, immersive quality and lessened the demand for precise detailing.

While the environment design became less of a concern, the stationary position of the player in the boat introduced new complexities in creating meaningful interactions with the surroundings. This aspect, along with the strategies used to address it, will be explored in the following section.

3.1.4. Final Prototype

a) Functionalities, Interactions and Narrative Cues

To further enhance the simplicity and accessibility of the prototype, all interactions are managed using only the right controller. This design choice reduces potential confusion for users with limited VR experience, allowing them to focus on the experience rather than complex controls. Interactions are controlled with the "grip" button, which enables the selection and dragging of objects.

Two types of interactive elements are featured: puzzle pieces and glowing lights. Puzzle pieces can be selected and dragged along a predefined path (Figure 14), while glowing lights are activated with a simple press. A custom script was developed to enable smooth interaction with the puzzle pieces, allowing users to slide them vertically within a restricted area, ensuring that they do not move outside of the designated path. This script also includes multiple triggers that guide user interactions and progression, which will be detailed in the following section.
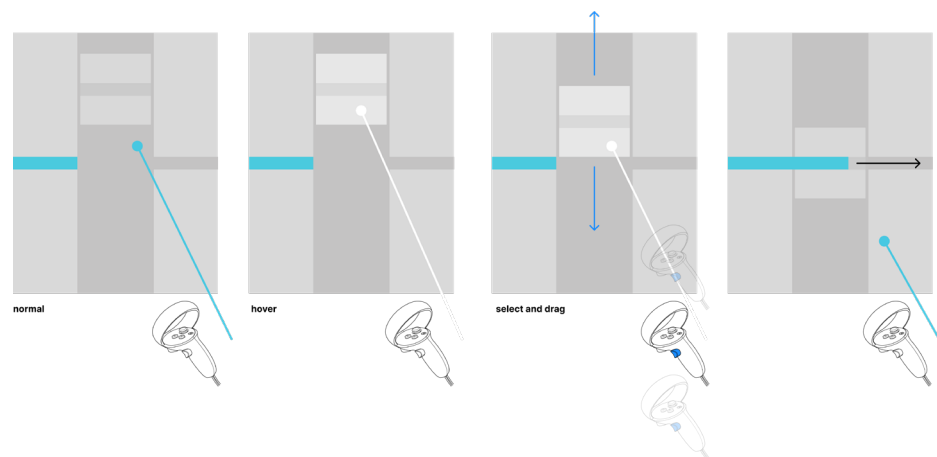
Figure 14 | Representation of the interaction with the puzzle pieces.

Interaction cues are further reinforced by visual changes: when a user points at an interactable object, the blue line representing the controller changes to white, signaling readiness for interaction. Both puzzle pieces and glowing lights also change color upon hover, further indicating their interactivity (Figure 15).
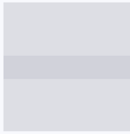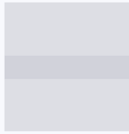
State		
Normal	Hover	Select

Figure 15 | Specification of the interaction states of different objects.

In addition to the color cues that signal interactable objects, the narrative itself provides further guidance to the user. The main character frequently directs the user's attention to key areas of the environment, helping them focus on important points in the journey. This is complemented by visual imagery displayed along the path, which aligns with the narrative, ensuring that the story is easy to follow and understand.

b) Triggers and Animations

Throughout the experience, users encounter a total of four puzzles, each with the same outputs but with increasing complexity as they progress (Figure 16).
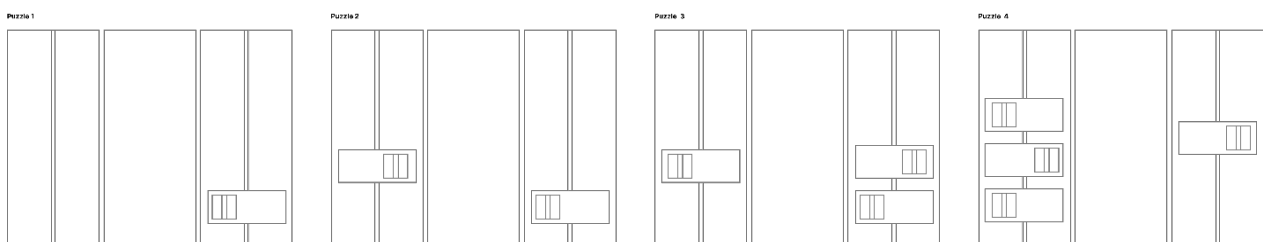
Figure 16 | Representation of the layout of the puzzles.

Taking the first puzzle functionality as an example: when a puzzle piece (represented by a square) is moved into its correct position, it triggers both a sound effect and an animation. This animation visually represents a line on the wall that progresses toward the next puzzle, with the line appearing to pass through the puzzle cube. Once the entire puzzle is solved, the boat automatically moves forward to the next location, where a new puzzle awaits. As puzzles increase in difficulty, the animations and sounds tied to the line's progression become more intricate, and puzzle pieces become interdependent—meaning that only when all squares are correctly positioned will the boat advance, and only when specific squares are correct the line animations and sounds are activated (Figure 17, 18, 19 and 20).
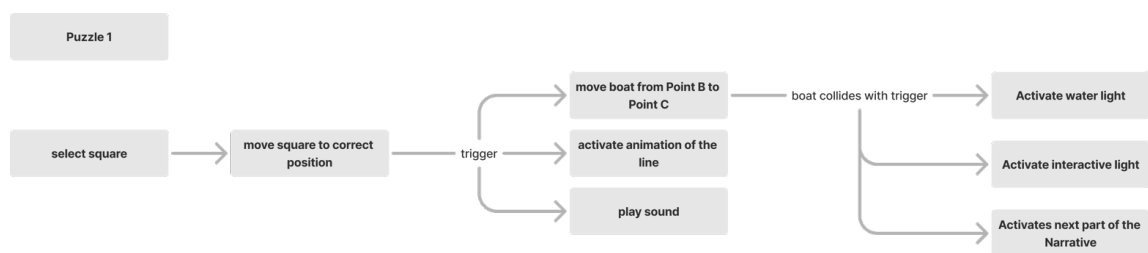
Figure 17 | Flowchart of Puzzle 1
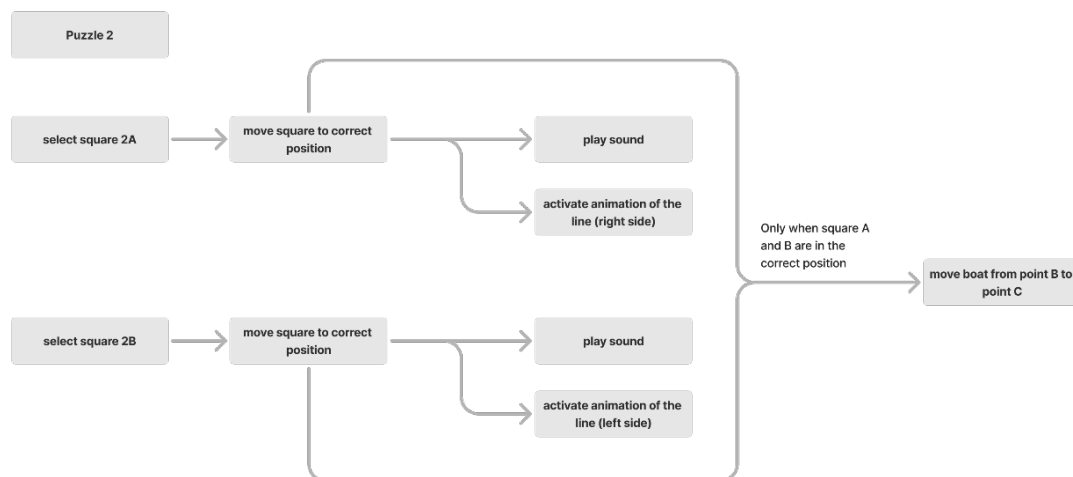
Figure 18 | Flowchart of Puzzle 2
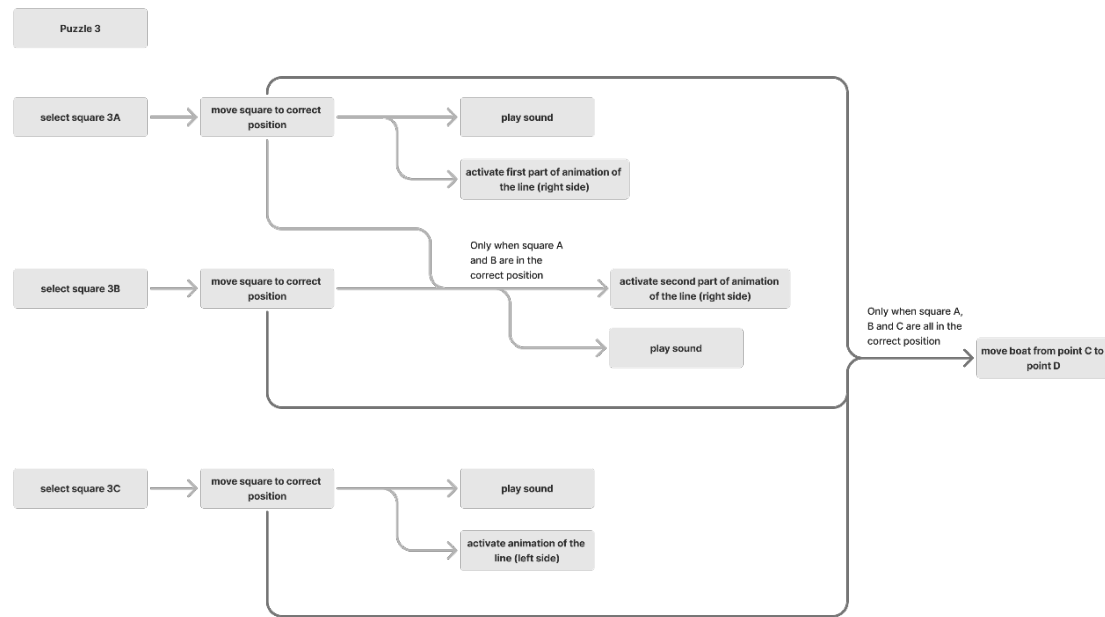
Figure 19 | Flowchart of Puzzle 3
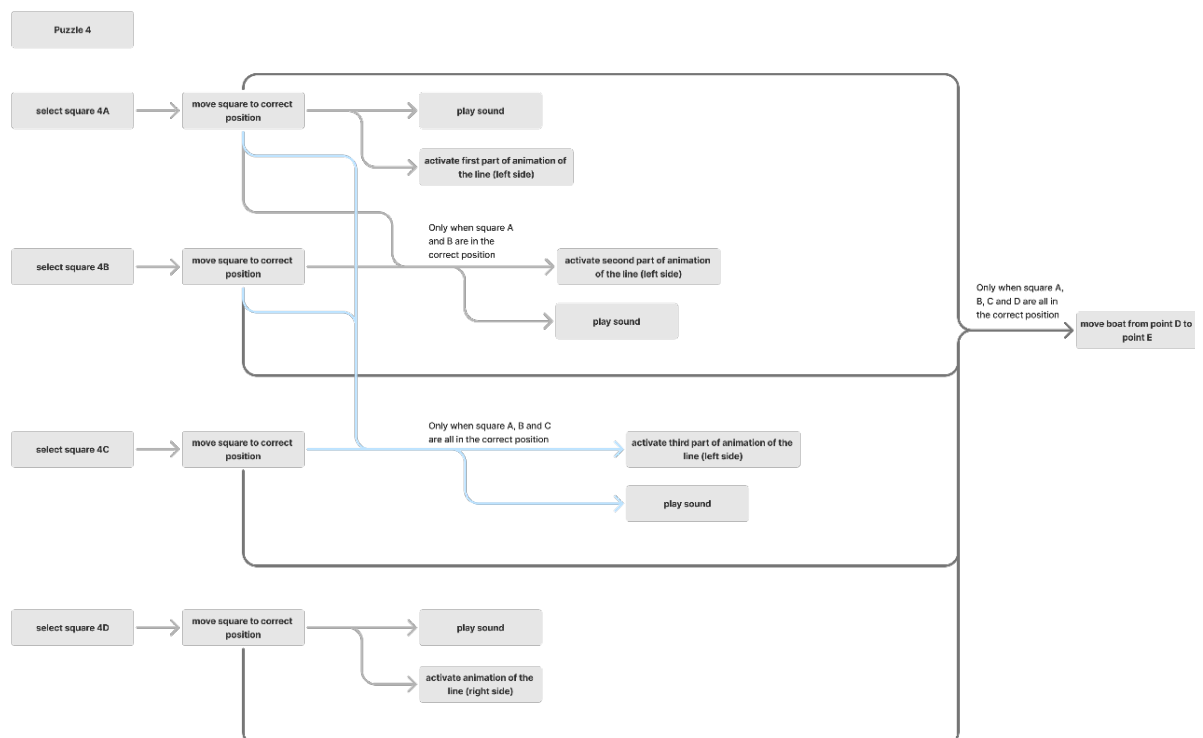
Figure 20 | Flowchart of Puzzle 4

Along the journey, specific triggers are activated by the boat's movement. These triggers initiate lights that represent flowing water, the next part of the narrative and interactive lights that emerge from underwater and remain near the wall, awaiting user interaction. When the user selects an interactive light, it disappears, revealing images that complement the narrative. These images animate as if emerging from the wall, enhancing the immersive storytelling and reinforcing key moments in the experience (Figure 21).
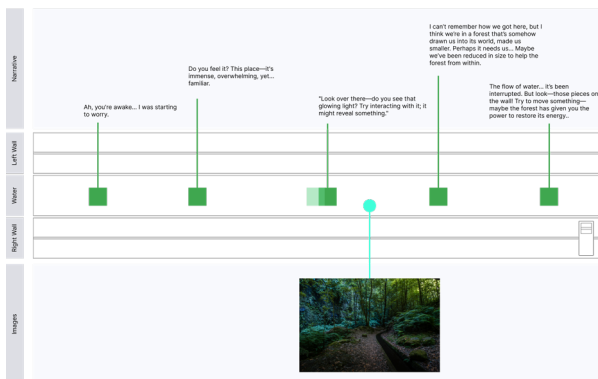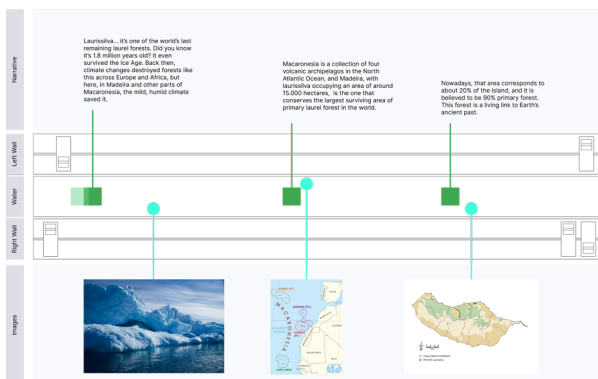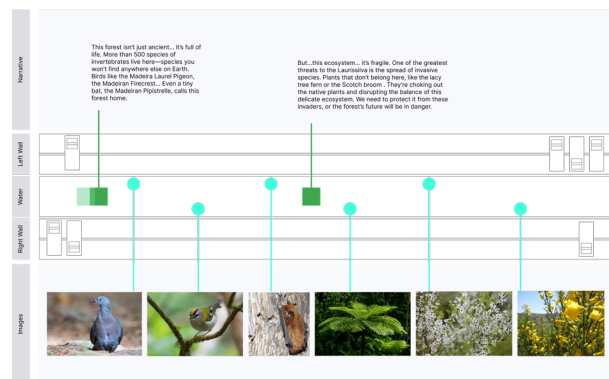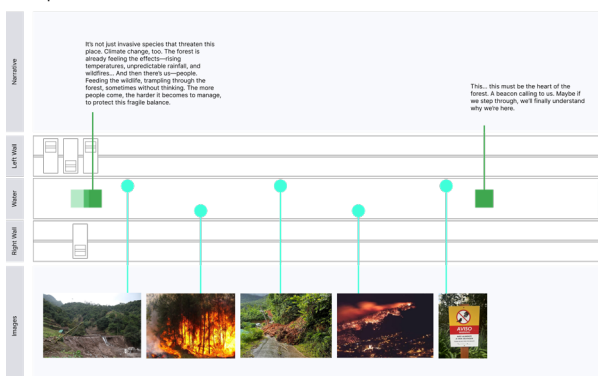
Figure 21 | Interactive Touchpoint Map

At the end of the journey, the user encounters a portal. This portal has a collider that, upon contact with the character, transitions the user to the next and final scene, initiating the conclusion of the narrative. The collider was designed to activate with the character rather than the user directly, avoiding the need for a fade-out effect that could not be implemented within the project timeline. This approach also prevents any abrupt collision with the portal, which might otherwise evoke feelings of stress or discomfort in the user.

c) Assets and Scenes

Due to time constraints, the project utilized pre-existing assets primarily sourced from the Unity Asset Store and Poly Pizza, with targeted modifications made to fit the experience.

The core environment was built around a single 3D asset, River by Poly by Google, which was customized in Blender to form the levada walls, water, and the portal at the end of the initial scene. To illustrate the water's flow and provide dedicated puzzle spaces, the wall asset was further edited to incorporate flow lines and puzzle areas. Although the experience includes four puzzles, some share common features, reducing the need to create more than three unique wall assets with puzzle slots. Puzzle cubes and blue lines were modeled in Blender, while the fog effect was achieved with Unity's particle system.

Additional environmental assets were chosen from several packs, and the sound design included both royalty-free music and sound effects. Visual elements along the narrative path were also supported by images, sourced primarily from Unsplash (unsplash.com), Pexels (pexels.com), and Pixabay (pixabay.com), all of which provide royalty-free images. These images were displayed when the user activated specific interactive lights, helping to reinforce the narrative content. Additional details about all of these assets can be found Appendix X. Narration lines for the character were generated using the text-to-speech tool ttsmp3.com, with the US English voice "Justin" selected for its natural tone, which suited the character.

The experience required two main scenes. The first, simulating the interior of a levada, integrated most of the assets mentioned above and had the movement of the boat synchronized with the characters audio to guide the narrative. Interactive lights were positioned along the levada path, triggering images relevant to the topics introduced by the character, enriching the user's engagement with the story. The second scene, characterized by its simplicity, places the user within a cube featuring dynamic projections of the Laurissilva forest. These projections were sourced from the same websites as the images used

previously and subsequently edited using CapCut. To ensure user comfort, a floor was added to the scene, minimizing any potential disorientation. Additionally, the character from the previous scene reappears in front of the user, creating a seamless transition and continuity between the two scenes. (Figure 22)
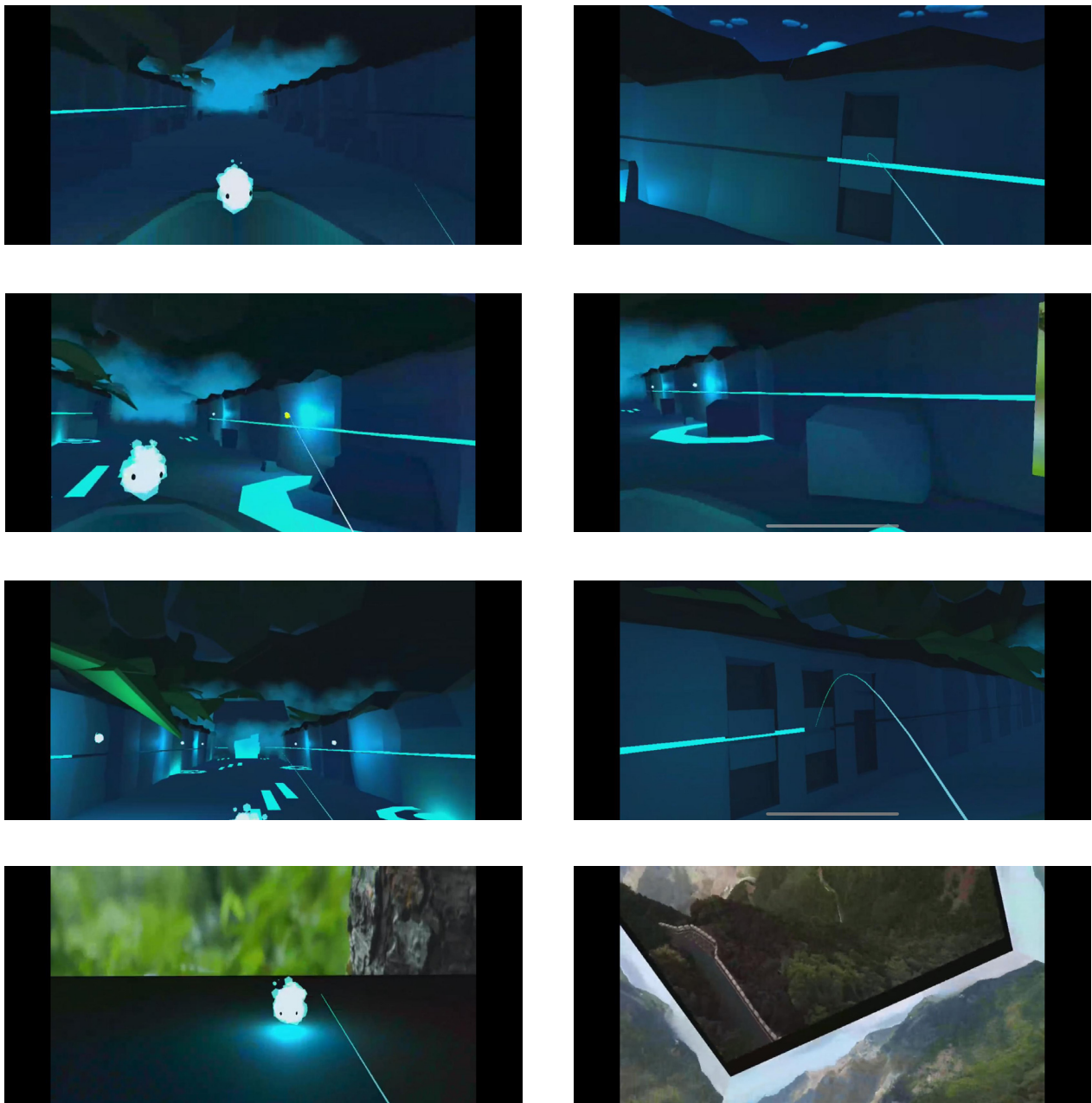
Figure 22 | Screenshots of the virtual experience

Chapter 4:
Evaluation

This chapter focuses on the evaluation phase, detailing the user testing process and assessing the overall usability of the system. It outlines the selected evaluation methods, the testing process, the protocol and guidelines followed, the target audience, the test sample, the purpose of the tests, and the research consent form (Appendix). Following the completion of user testing, the collected data was thoroughly analyzed to determine whether the project achieved its intended goals, addressed its key research questions, and identified areas for improvement to guide future iterations and research efforts.

4.1. Assessment Methods and Testing Objectives

This project aimed to evaluate a VR experience designed to foster empathy in participants in regards to the Laurissilva forest of Madeira Island. The evaluation relied on a combination of qualitative and quantitative methods to assess user engagement, system usability, and the effectiveness of the VR experience in conveying its intended messages. A controlled, laboratory environment was chosen for the testing phase, where participants interacted with the VR system under predefined conditions. Their actions were observed in real-time through screen-sharing software, enabling the identification of errors and challenges as they naturally occurred. This approach allowed for open-ended data collection, as no specific observables were predefined, encouraging participants to engage organically with the experience.

Four standardized questionnaires were employed to measure different dimensions of user experience and empathy. The Cognitive Absorption Scale (Venkatesh, 2000) was used to evaluate participants' levels of deep engagement, including their loss of time awareness, concentration, and enjoyment, as well as their perceived control and curiosity within the virtual environment. The Connectedness to Nature Scale (Mayer & Frantz, 2004) assessed how participants emotionally and cognitively related to the natural world, measuring aspects such as emotional attachment, ecological awareness, pro-environmental behaviors, and experiential immersion in nature. The Virtual Embodiment Questionnaire (Kilteni et al., 2012) provided insights into users' identification with their virtual avatars, examining their sense of ownership, control, spatial presence, and emotional connection to their virtual bodies and environments. The Virtual Reality System Usability Questionnaire (Kim & Rhiu, 2024) explored usability factors, including the intuitiveness of navigation, responsiveness, sensory realism, physical comfort, system stability, task support, and overall satisfaction with the VR system. Even though the authors of the VEQ used a 7-point scale, in order to guarantee uniformity between all questionnaires a five-point Likert scale (1 = strongly disagree; 5 = strongly agree) was adopted.

In addition to these standardized tools, the questionnaire also included sections on demographic information and participants' familiarity with VR technology and the Laurissilva forest. These sections provided valuable context for interpreting the results, offering

insights into how previous knowledge or exposure influenced user engagement and comprehension.

Post-experience simple question interviews were conducted to gather deeper insights into participants' recall of the VR narrative and to identify usability issues that might not have been evident during observation. These interviews focused on two areas: participants' comprehension and retention of key messages conveyed during the experience, and any challenges they faced while interacting with the system. A predefined list of narrative key points was used to structure the recall assessment. Responses were then organized into a table, highlighting which points were well recollected and which were less so, offering a clearer understanding of the communication strategy's effectiveness. This process not only assessed the clarity and impact of the experience but also identified areas for improvement in message delivery and usability.

4.2. Protocol and Participants

Before starting the official tests, two preliminary tests were made to determine if the prototype was showing any significant issues. The questionnaires were not applied, as the answers would not count for the overall results, but the recall was taken into consideration, as it could show some minor flaws that could still be corrected. The tests ended up being successful, so it was decided that it could be moved on to the official tests.

In the start of each test it was asked of the users to fill out a Research Consent Form, which showed the studies purpose, the data that would be collected and the users rights. After consenting, the user would then move on to the first part of the questionnaire. The decision to make one part of the questionnaire before and another one after was to be able to apply the Connectedness to Nature Scale before and after the experience. This would allow to determine if their empathy would show any change after the experience. After finishing the first part, we would then proceed to the experience, which started with a small explanation of the controls within it. With this the VR headset would be put on the user and the experience would be viewed for observation through the shared screen, being notes taken during. When finished, the users would then answer the rest of the questionnaire with the remaining scales and questions and at the end the interview would be had with the addition of voice recording in case the information would have to be consulted for further research. At the end the users were thanked for their participation. The signed declarations, protocol and guide can be found in Appendix D.

Participant selection for this study was guided by the criterion that individuals could not be residents of Madeira Island, as the target demographic consisted of potential future tourists. This requirement posed no challenge, as the testing was conducted in Lisbon. A total of thirteen participants took part in the study, including ten females and three males. All participants, except one who was 17 years old, fell within the 18-25 age range. All were of Portuguese nationality.

Among the participants, only one had visited Madeira Island (participant 2), and three had prior knowledge of the Laurissilva forest (participants P4, P6 and P9). In terms of familiarity with VR, eight participants had never used virtual reality before (P1, P3, P6, P8, P9, P10, P11 and P13), and nine had no prior experience with virtual avatars or embodiment in VR.

4.3. Evaluation and Analysis of Test Results

4.3.1. Performance and Observation

In general, the results were positive as most users did not show any difficulties with the commands and seven of the users went through the whole experience without any type of usability issues.

Five of the twelve testers did not notice the appearing light at the beginning of the journey, missing the "tutorial" that teaches how to interact with said objects (participants P2, P4, P5, P7 and P10). Most users that missed this step were overwhelmed with the immersive environment, choosing to look around and not paying attention to the first part of the narrative. When the character mentioned the possibility of interactivity with the light, some confusion was shown in regards to which light they were referring to, as the environment had various assets of bright nature.

Although some confusion was presented at the beginning, only one participant (P5) had difficulties understanding that the later lights could be interacted with, as most of them when hovering over the objects, with the visual feedback, were able to deduce that they were interactable.

It was observed that some users decided to select all of the lights as quickly as possible as they were appearing all at the same time in each section of the journey, causing them to feel overwhelmed with the amount of information appearing on the scene (P2, P4 and P8).

Only P5 had difficulties with the puzzle, not understanding what they were supposed to do, asking for external help. It was also noted two users solved all of the puzzles before reaching their assigned point, making the experience faster and creating some issues with the narrative timing.

The second test that was carried out, was the one that presented most problems, as the person was extremely distracted and enthusiastic, trying to do everything as quickly as possible, and interacting with everything around them. This created a problem, as they tried to interact with the portal at the end of the first scene, that had a grabbing script attached by mistake, preventing the user from finishing the experience as the piece was grabbed and teleported to the users hand, not activating the collider that allows to change scenes. This

was immediately fixed so that future tests would not have the same issue.

Some already known minor issues were also observed, as the system sometimes would still activate the animation of the lines of the wall even if the puzzle was not connected correctly. This was specially observed in P7, that did not seem to understand how the puzzle connected, trying to just drag the pieces in random directions until it worked. It was deduced that after a while they would understand the logistics behind the puzzles, but after the third one, it was mentioned to them how it was supposed to function.

The notes from the observation can be consulted in more detail in Appendix E.

4.3.2. Connectedness to Nature Scale

As mentioned previously, the Connected to Nature Scale was applied twice, once before the VR experience, and once after.

Here we can observe in Graph 1 that even though the level of empathy towards nature showed a pretty high result in the first questionnaire there still can be seen a small growth in regards to eleven of the thirteen affirmations. The only affirmation that showed a decrease in empathy was Affirmation A7 ("I feel as though I belong to the Earth as equally as it belongs to me."), and the one that did not show any changes was Affirmation A9 ("I often feel part of the web of life").

The fact that the initial scores were already high might indicate that the participants already had a strong connection to nature before the experience. This may be attributed to different factors such as their demographic profile, history of contact with nature or predisposition to environmental themes, as they were university students. In this context, when participants already show such connection there is less room for change. Future studies should consider a more broad target audience (e.g., environmental activists, residents of rural areas, urban residents).

The small increase in results after the interactive experience suggests that the intervention had an incremental, but not transformative, impact. In future studies it could be helpful to increase the intensity of the interactive experience and to extend its overall duration, as this would enhance immersion and foster the development of stronger emotional connections.

The individual scores can be found in Appendix F.

Connectedness to Nature Scale (average)
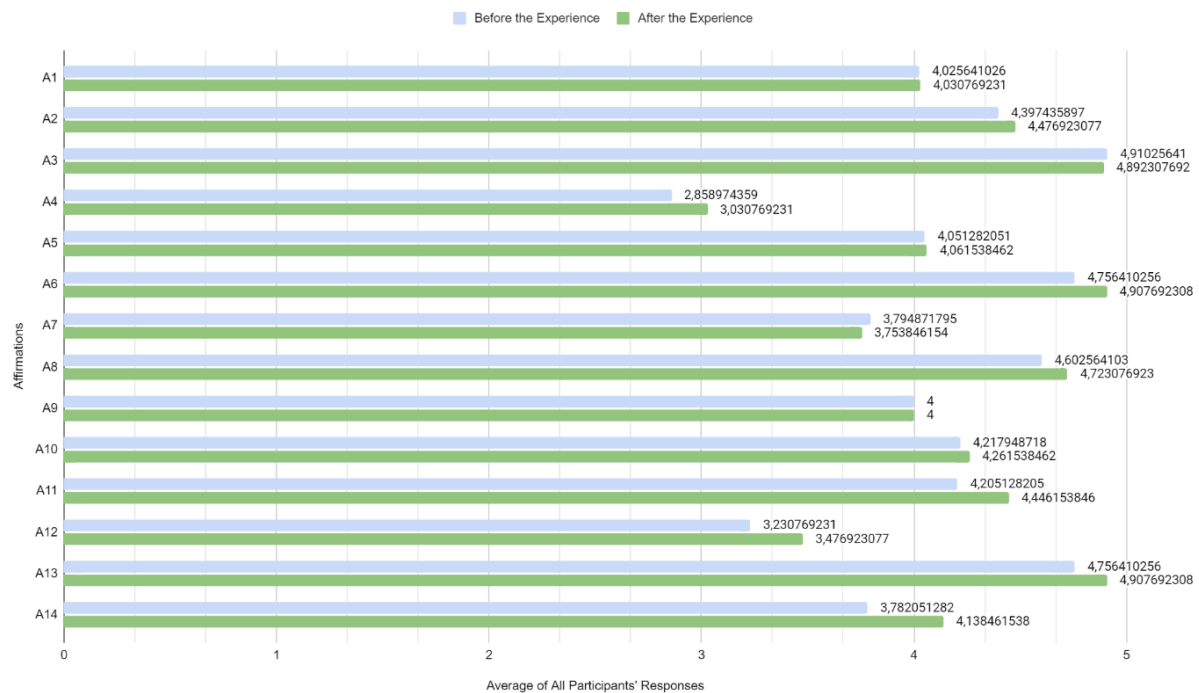
Graph 1 | Comparison of average results of both CNS questionnaires.
The graph illustrates the average scores for each item on the Connectedness to Nature Scale (CNS) before and after the interactive experience. The affirmations used in the questionnaire are as follows:

A1. I often feel a sense of oneness with the natural world around me.
A2. I think of the natural world as a community to which I belong.
A3. I recognize and appreciate the intelligence of other living organisms.
A4. (—) I often feel disconnected from nature.
A5. When I think of my life, I imagine myself to be part of a larger cyclical process of living.
A6. I often feel a kinship with animals and plants.
A7. I feel as though I belong to the Earth as equally as it belongs to me.
A8. I have a deep understanding of how my actions affect the natural world.
A9. I often feel part of the web of life.
A10. I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.
A11. Like a tree can be part of a forest, I feel embedded within the broader natural world.
A12. (—) When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.
A13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.
A14. (—) My personal welfare is independent of the welfare of the natural world.

Note. Items marked with (—) were reverse-coded before analysis.

4.3.3. Virtual Reality System Usability Questionnaire (VRSUQ)

Although the questionnaire has been created quite recently, not having enough data available to determine an average score, Kim and Rhiu (2024) defend that its high correlation coefficient with System Usability Scale (SUS) scores suggests that the VRSUQ reflects a similar level of usability. With this in mind, for example, according to Sauro (2018), the average SUS score is 68, determining that any score above this value is regarded as above average, while below it can be defined as below average.

Observing the Table 1 we can see that the attributed score to the system in terms of its usability is of 83.75 which is considered high, as scores above 80 show excellent results.

Participant	A1	A2	A3	A4	A5	A6	A7	A8	A9	VRSUQ Score
1	5	5	4	5	5	4	5	5	5	94,25
2	5	5	4	4	5	2	5	5	2	77,75
3	4	4	3	4	5	4	5	3	5	77,75
4	2	3	2	4	3	3	5	5	2	55,5
5	5	4	5	5	5	5	5	5	5	97
6	5	4	5	4	5	4	5	5	5	91,5
7	4	4	1	4	4	5	5	1	5	66,5
8	4	4	3	4	4	4	4	5	5	77,75
9	5	5	5	5	4	5	5	4	5	94,25
10	5	5	4	4	5	4	5	5	5	91,5
11	5	5	4	4	5	4	5	5	5	91,5
12	4	5	5	4	4	5	5	5	5	91,5
13	5	5	5	5	4	4	5	5	5	94,25
Average	4,46	4,46	3,85	4,31	4,46	4,08	4,92	4,46	4,54	83,75

Table 1 | Results of the VRSUQ of the experience.

This shows that the experience developed has good usability and that the participants encounters few obstacles or difficulties during the interaction. The learning curve was low and the experience was considered enjoyable and smooth, promoting immersion in VR.

The affirmations used can be found in Annex A.

4.3.4. Virtual Embodiment Questionnaire (VEQ)

In regards to the VEQ results observed in Table, we can identify that all of them are above the halfway mark, which shows that the experience had users feeling a moderate identification with their virtual avatars. One of the aspects that could be improved is the Emotional Engagement, as fostering empathy is one of the main focuses of the project in order to promote conservation.

Affirmations	Average
Sense of Ownership I felt a strong connection between my real body and the virtual body.	3,93
Sense of Agency I felt that the virtual body moved exactly as I wanted it to.	4,69
Self-Location I experienced the virtual world as if it were the place where I was really present.	3,92
Presence I had a strong sense of being in the virtual Laurissilva of Madeira Island.	4
Body Ownership Illusion I felt as if the movements I saw in the virtual environment were caused by my own movements.	4,38
Emotional Engagement I felt emotionally connected to the virtual environment.	3,77

Table 2 | Results of the VEQ of the experience.

The dimension based on the sense of ownership, which measures how much the participants felt that their virtual body was "their own body", scored 3.93, indicating that the participants moderately identified with the virtual body. This may be influenced by factors such as the graphical quality of the avatar and the synchronization between real movements and the ones of the avatar, which are not visible to the participant. Body identification is an essential part of embodiment in VR, and in this project, it is a key aspect to be improved , whether through the visualization of the body or the movements of the upper limbs.

The sense of agency dimension recorded the highest result (4.69), indicating that participants felt excellent control over their actions with the virtual body. A high sense of agency is generally associated with a responsive and natural interaction experience in the VR environment. This result is a strong point of the experience, however, to maximize embodiment, it is important to align this sensation with other dimensions, such as sense of ownership and body ownership illusion. The disparity between sense of agency (4.69) and sense of ownership (3.93) suggests that, although participants felt they controlled their actions, this connection to the avatar was not accompanied by a strong sense of "belonging" to the virtual body.

The self-location dimension had a result of 3.92, and it evaluates how much the participants felt "located" in the virtual body or in the virtual space. This value indicates that the interactive experience was able to create a moderate sense of self-location, but it was not convincing enough to create a complete perception of presence in the virtual body. It is suggested that for improving this dimension, more realistic visual elements of the avatar should be enhanced.

The sense of presence indicates how immersed the participants felt in the virtual environment, as if they were truly present in that space. A score of 4 reflects a positive presence, but one that can still be improved. The sense of presence is often influenced by factors such as the visual quality of the environment, smooth interaction, and sound design. Working with an application that runs without the aid of a computer with high graphic processing power compromises the graphic quality, although it makes it more usable in diverse contexts. This trade-off makes this project difficult and challenging. Probably, in the near future, we will have hardware easily capable of handling this problem.

The body ownership illusion dimension had the a value of 4.38, indicating that participants did feel strongly that the virtual body was an extension of their own physical body. This body ownership illusion is one of the most challenging aspects of embodiment, but it is crucial for creating deeply immersive experiences as it reflects the naturalistic design of the virtual environment and the overall quality of sensory feedback.

The emotional engagement dimension reflects the level of emotional connection participants had with the virtual avatar. The value close to 4 shows that participants were emotionally involved to some extent, but the experience did not manage to evoke a deep connection. The introduction of more engaging narratives or social interactions in the virtual environment could help intensify this dimension.

The individual scores related to each affirmation can be found in Appendix F.

4.3.5. Cognitive Absorption scale (CA)

Here we can observe in Table 3, that the overall results of the Cognitive Absorption scale were positive, highlighting the fifth affirmation that shows that the experience was able to spark the users curiosity about the forest and therefore that could lead to the development of more awareness of its risks and importance of its preservation.

Affirmations	Average
Temporal Immersion While immersed in the VR Laurissilva experience, I lost track of time.	2,77
Cognitive Absorption I was completely absorbed in the VR experience of Madeira's Laurissilva.	4,46
Pleasure I found the VR Laurissilva experience enjoyable.	4,92
Interactivity I could effectively interact with elements within the virtual environment.	4,23
Curiosity The VR experience sparked my curiosity about Madeira's Laurissilva.	4,77
Emotional Connection I felt emotionally connected to the virtual environment.	3,92

Table 3 | Results of the CA of the experience.

The sense of temporal immersion was assessed based on how much participants lost track of time while immersed in the interactive experience. A value slightly above the midpoint of the scale (2.5) was observed, indicating that temporal immersion was moderate. This suggests that, although the experience engaged participants, it did not reach a level of absorption that led to a complete loss of time perception. One possible explanation for this result is the short duration of the experience. Temporal immersion is often an indicator of flow — a state of deep engagement — which points to the need to increase the duration of the interactive experience.

Cognitive absorption was measured by how completely participants felt absorbed in the VR experience. With a score of 4.46, this dimension reflected a high level of mental engagement with the VR environment, indicating that participants experienced a high level of cognitive involvement. This suggests that the visual design and theme were effective in capturing the participants' attention. However, the fact that temporal immersion was not proportionally high suggests that this absorption may have been more superficial (due to the informational or visual content) rather than deeply integrated into an emotional flow state.

The pleasure dimension assessed how much participants enjoyed the experience, with a score of 4.92, the highest recorded, close to the maximum of the scale (5). This indicates that the experience was per-

ceived as highly enjoyable, which is a strong point, as pleasure is one of the key determinants for the acceptance of technologies like VR. However, it would be interesting to investigate whether the pleasure was more related to the use of the technology itself, the aesthetics of the environment or the theme being explored.

The effectiveness of interactions within the virtual environment was evaluated with a score of 4.23. This high value suggests that participants found the controls and mechanics to be functional and responsive. However, even higher levels could be achieved, for example, by making the interactions more challenging.

The experience's ability to spark curiosity about Madeira's Laurissilva scored 4.77, reflecting its success in generating participants' interest. Curiosity is a key dimension, particularly in educational and awareness experiences like exploring Laurissilva. This score shows that the content succeeded in sparking curiosity about the environment. Expanding with more information and adding interactive elements could further enhance this dimension and increase the impact of the experience.

The emotional connection participants felt to the virtual environment was evaluated with a moderately high score of 3.93, indicating that the experience was emotionally engaging for some, but not for everyone. The emotional connection could be strengthened by including richer narrative elements, immersive ambient sounds, or interactions that evoke empathy and personal engagement. Strong emotions are important as they tend to increase the memorability and impact of VR experiences.

The individual scores related to each affirmation can be found in Appendix F.

4.3.6. Interviews

After finishing the questionnaire the participants were asked to answer two questions. One that asked them to do a recall of the experience and another one to better understand if some issues in usability were missed during observation.

With the first question there was created a list of key narrative points that were taken into consideration to see if they were mentioned during the recall. Most of the key points were remembered, emphasis on the Historical and Biological Importance of the Laurissilva, as participant had a good memory of the old age of the forest. The impact of human actions and climate change was the other key point that was recalled by all participants. It can be assumed that this was easier to recall not only by the fact that it was one of the lasts moments of the

narrative that was accompanied by pictures but also by being a segment that is meant to create empathy with the testers with images that show destruction of the environment. The second participant is the only one that has no information in regards to two of the points because, as mentioned before, they were not able to conclude the experience.

Participant	Know where they are (Levada)	Feeling of smallness	Progressive Unveiling	Historical and Biological Importance	Unique ecosystem	Invasive Species and Ecosystem Fragility	Climate Change and Human Impact	Character Revelation	Guardian Role	Enduring connection
1	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
2	no	no	no	yes	no	yes	yes	N/A	N/A	yes
3	no	no	yes	yes	yes	yes	yes	yes	yes	yes
4	no	yes	yes	yes	yes	yes	yes	no	yes	yes
5	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
6	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
7	no	yes	yes	yes	yes	no	yes	no	yes	yes
8	yes	yes	yes	yes	yes	yes	yes	no	yes	yes
9	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
10	no	yes	yes	yes	yes	yes	yes	no	yes	yes
11	no	yes	yes	yes	yes	yes	yes	no	yes	yes
12	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
13	yes	yes	yes	yes	yes	yes	yes	no	yes	yes

Table 4 | Results of the recall of the narrative key points.

One of the biggest problems was that even though everyone knew they were in the Laurissilva forest, very few understood that they were in a Levada. Even after asking specifically if they realized they were in a levada, only four of them understood their whereabouts due to being focused on the narrative. It can also be observed that most participants missed the character revelation. This can be connected to the feeling of shock and surprise when switching scenes, as most participants were more focused on looking around and getting familiar with the new environment than listening to the character.

In terms of the second question, related to usability, only two participants mentioned some insecurities while using the VR. P7 mentioned that it would have helped the addition of a small tutorial as they were confused by the commands within the experience, and participant 4 admitted to not being able to follow the narrative, feeling overwhelmed with the amount of information, mentioning that it would have been nice if there was an option to access the information heard after it finished, showing it right before the solving of the next puzzle.

Overall, most participants remembered key narrative points, such as the historical and biological importance of Laurissilva and the impact of human actions and climate change. This suggests that the narrative was effective and capable of creating a lasting impression. The fact that they recalled the impact of climate change and environmen-

tal destruction, attributed to the presentation of powerful images, indicates that the use of visual elements to generate empathy was successful.

Although they recognized they were in the Laurissilva forest, most participants did not understand that they were in a Levada, indicating a failure to connect the narrative elements to the spatial context. This may have occurred because the participants were unfamiliar with what a Levada is. There will be a need to introduce this element at the beginning of the narrative in a future version of the application. Many participants did not grasp the final reveal, suggesting that this crucial narrative moment is poorly integrated into the flow of the experience. In the next version, it is recommended to use clearer affordances that guide the participant's attention to this moment in the narrative.

The key points tested can be found in Appendix F.

Chapter 5:
Conclusions

5. Conclusions

This project set out to explore the potential of virtual reality (VR) as a tool for fostering empathy and ecological awareness among tourists, focusing on the UNESCO World Heritage Laurissilva forest of Madeira Island. Using storytelling, gamification and interaction design the project created an immersive VR experience to provide educational engagement about the forest's biodiversity, its ecological significance, and the human impacts threatening its future.

Results demonstrate that the experience was successful in its primary purpose of fostering empathy, as indicated by a small but statistically significant increase in participants' connectedness to nature scores. The high usability scores in the VRSUQ also support the successful nature of the system providing an intuitive and interactive experience. The study also highlighted areas for improvement, namely on emotional engagement and better framing of a narrative to communicate key information points, such as identifying to the user their location in a Levada.

5.1. Limitations

The project faced several limitations, primarily due to a lack of prior experience with Unity for VR development. This restricted the complexity of the project, as implementing certain animations and controls required a deeper understanding of the programming language or simply more time.

Another significant limitation was the reliance on a system with low processing power. Although the use of the Oculus Quest 2 facilitated transportation and enabled the project to run independently of a computer, this choice compromised the graphical quality of the experience and, consequently, the overall immersion.

Additionally, the project would have greatly benefited from original assets specifically designed to represent the unique ecosystem of the Laurissilva forest. However, creating such assets would have required substantial time, advanced skills, and resources due to their complexity.

The use of premade images also presented challenges. While the initial plan included creating illustrations and animations to enhance immersion, this approach could have raised issues of legibility and comprehension for participants unfamiliar with the ecosystem. These challenges were further compounded by constraints in time and expertise.

5.2. Discussion of Results

The project showed promising results, showcasing its potential as an effective tool for fostering empathy and a deeper connection with nature. The raise of empathy in participants, although modest, provides positive indicators for the effectiveness of the interactive experience in fostering a greater connection with nature. These results could have significant implications, such as a higher likelihood of people adopting pro-environmental behaviors. However, it is important to note that this type of interactive experience might be particularly effective for audiences less sensitized to nature.

The usability evaluation, reflected in the high Virtual Reality System Usability Questionnaire (VRSUQ scores, underscores the system's ability to facilitate intuitive and meaningful interactions, which contributed to its overall success. Participants demonstrated strong control over their virtual avatars (sense of agency) and experienced immersion in the digital environment (sense of presence). However, revealed weaknesses in body identification (body ownership illusion) and emotional alignment, primarily due to the graphical limitations of the Oculus Quest headset. We believe that in the near future, this issue can be easily resolved with the advent of new equipment.

The interviews further emphasized the strengths of the VR experience, especially in regards to the retention of main narrative themes by the participants. Yet, the absence of introductory support negatively impacted the experience of some participants, detaching them from the overall engagement. It is suggested that future adjustments be made to the narrative flow and the clarity of visual cues in the virtual space to enhance the user experience and the impact of the project.

5.3. Recommendations for future studies

Building on the insights from this project, future studies should expand the target audience, testing with participants from diverse backgrounds, especially with those less exposed to environmental topics in order to be able to evaluate the impact of the project in the empathy of less sensitized groups. The narrative and the interactivity should also be enhanced through the introduction of more emotionally engaging and immersive storytelling elements, playing more with dynamic, multisensory feedback in order to strengthen the connection between the participants and the virtual environment.

One of the factors that could also create a bigger impact on the experience is the increase of its duration. This would allow for a richer engagement with the content, fostering a more profound sense of empathy.

As mentioned in the limitations, the developing of custom assets would also allow for an improvement in the projects depiction of the Laurissilva forest, improving authenticity and immersion.

Bibliographic References

A Agarwal, Ritu & Karahanna, Elena. (2000). Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage. MIS Quarterly. 24. 665-694. 10.2307/3250951. Agarwal,

B Bilynets, I., & Knezevic Cvelbar, L. (2022). Tourist pro-environmental behaviour: The role of environmental image of destination and daily behaviour. Annals of Tourism Research Empirical Insights, 3(2), 100070. https://doi.org/10.1016/j.annale.2022.100070

C Chen, J., Li, Z., Lv, Y.-F., Li, C.-L., Wang, Y., Wang, R.-R., Geng, K.-W., & He, T. (2015). Empathy for pain: A novel bio-psychosocial-behavioral laboratory animal model. Sheng Li Xue Bao : Acta Physiologica Sinica, 67(6), 561—570. http://europepmc.org/abstract/MED/26701631

Cheng, J. C. and Monroe, M. C. (2010). Connection to nature. Environment and Behavior, 44(1), 31-49. https://doi.org/10.1177/0013916510385082

Cruz, M. J., Santos, F. D., Aguiar, R., Oliveira, R. P., Correia, A., Tavares, T., & Pereira, J. S. (2008). Impactos das alterações climáticas nos ecossistemas terrestres da ilha da madeira. CLIMA 2008 - I Congresso Nacional Sobre Alterações Climáticas, July 2014.

D Dionisio, M., & Nisi, V. (2021). Leveraging Transmedia storytelling to engage tourists in the understanding of the destination's local heritage. Multimedia Tools and Applications, 80(26–27), 34813–34841. https://doi.org/10.1007/s11042-021-10949-2

Donly, C. (2017). Toward the Eco-Narrative: Rethinking the Role of Conflict in Storytelling. Humanities, 6(4), 17. https://doi.org/10.3390/h6020017

F Ferreira, N. (2024, August 20). Laurissilva na Madeira: "Corremos o risco de estar a fazer desaparecer espécies ainda não descritas." PÚBLICO. https://www.publico.pt/2024/08/20/azul/noticia/laurissilva-madeira-corremos-risco-estar-desaparecer-especies-nao-descritas-2101375

Forlano, L. (2017). Posthumanism and Design. She Ji: The Journal of Design, Economics, and Innovation, 3(1), 16–29. https://doi.org/https://doi.org/10.1016/j.sheji.2017.08.001

G

Gouveia, L. M., Menezes, D. M. G. G., Fontinha, S. M. G. e S. V., Oliveira, P. J. S. G., Domingues, M. M. C. S. A., Mateus, M. G. H., & Freitas, I. C. L. (2005). A Floresta Laurissilva da Madeira - Património Mundial. Serviço do Parque Natural da Madeira. https://ifcn.madeira.gov.pt/images/Doc_Artigos/Divulgacao/publicacoes/livros/FLORESTA%20LAURISSILVA.pdf

Graaff, J. V. d., Meeus, W., Wied, M. d., Boxtel, A. v., Lier, P. v., Koot, H. M., ... & Branje, S. (2015). Motor, affective and cognitive empathy in adolescence: interrelations between facial electromyography and self-reported trait and state measures. Cognition and Emotion, 30(4), 745-761. https://doi.org/10.1080/02699931.2015.1027665

Greitemeyer, T., & Osswald, S. (2010). Effects of prosocial video games on prosocial behavior. Journal of Personality and Social Psychology, 98(2), 211–221. https://doi.org/10.1037/a0016997

H

Hafner, M., & Jansz, J. (2018). The Players' Experience of Immersion in Persuasive Games. International Journal of Serious Games, 5, 63–79. https://doi.org/10.17083/ijsg.v5i4.263

Heller, N., & Zavaleta, E. (2009). Biodiversity management in the face of climate change: A review of 22 years of recommendations. Biological Conservation, 142, 14–32. https://doi.org/10.1016/j.biocon.2008.10.006

Hosseini, M. and Caragea, C. (2021). It takes two to empathize: one to seek and one to provide. Proceedings of the AAAI Conference on Artificial Intelligence, 35(14), 13018-13026. https://doi.org/10.1609/aaai.v35i14.17539

Humberstone, B. (2013). Adventurous activities, embodiment and nature: spiritual, sensual and sustainable? embodying environmental justice. Motriz: Revista De Educação Física, 19(3), 565-571. https://doi.org/10.1590/s1980-65742013000300006

K

Kilteni, K., Groten, R., & Slater, M. (2012). The Sense of Embodiment in Virtual Reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Kim, Y., & Ilsun, R. (2024). Development of a virtual reality system usability questionnaire (VRSUQ). Applied ergonomics. 119. 104319. 10.1016/j.apergo.2024.104319.

Kolbert, E. (2014). The sixth extinction: An unnatural history. Henry Holt and Company.

L

Laurisilva of Madeira. UNESCO World Heritage Centre. https://whc.unesco.org/en/list/934/

Lusa. (2018, August 8). Polícia Florestal detecta 11 queimadas ilegais na Madeira. PÚBLICO. https://www.publico.pt/2018/08/08/sociedade/noticia/policia-florestal-detecta-11-queimadas-ilegais-na-madeira-1840476

M

Manney, P. J. (2008). Empathy in the Time of Technology: How Storytelling is the Key to Empathy. Journal of Evolution and Technology, 19(1), 51–61. http://jetpress.org/v19/manney.htm

Martins, M. (2023). Ciência - Ilha da Madeira: A Preservação da Floresta Laurissilva em tempos de Ecoturismo de Massa. RFI. https://www.rfi.fr/pt/programas/ci%C3%AAncia/20230725-ilha-da-madeira-a-preserva%C3%A7%C3%A3o-da-floresta-laurissilva-em-tempos-de-ecoturismo-de-massa

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. Journal of Environmental Psychology, 24(4), 503-515.

N

Neves, H.C., Valente, A.V., Faria, B.F., Silva I.G., Marques, J.C., Gouveia, N.A., Silva, P.G., & Oliveira, P.J. (1997). Laurissilva da Madeira - Notícia Explicativa. Ministério do Ambiente. https://ifcn.madeira.gov.pt/images/Doc_Artigos/Divulgacao/publicacoes/livros/Atlas_do_Ambiente_-_Laurissilva_da_Madeira.pdf

Q

Quintal, R. (2023). Reportagem Ilha da Madeira. RFI. https://www.rfi.fr/pt/programas/ci%C3%AAncia/20230725-ilha-da-madeira-a-preserva%C3%A7%C3%A3o-da-floresta-laurissilva-em-tempos-de-ecoturismo-de-massa

R

Reddy, A., Kocaballi, A. B., Nicenboim, I., Søndergaard, M. L. J., Lupetti, M. L., Key, C., Speed, C., Lockton, D., Giaccardi, E., Grommé, F., Robbins, H., Primlani, N., Yurman, P., Sumartojo, S., Phan, T., Bedö, V., & Strengers, Y. (2021). Making Everyday Things Talk: Speculative Conversations into the Future of Voice Interfaces at Home. Conference on Human Factors in Computing Systems - Proceedings, May. https://doi.org/10.1145/3411763.3450390

S

Shin, D. (2018). Empathy and embodied experience in virtual environment: To what extent can virtual reality stimulate empathy and embodied experience? Computers in Human Behavior, 78, 64–73. https://doi.org/10.1016/j.chb.2017.09.012

Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. (2004). Implicit connections with nature. Journal of Environmental Psychology, 24(1), 31-42. https://doi.org/10.1016/s0272-4944(03)00022-7

Slater, M., Slater, M., Marcos, D. P., Ehrsson, H., Sanchez-Vives, M. V., & Sanchez-Vives, M. V. (2009). Inducing illusory ownership of a virtual body. Frontiers in Neuroscience, 3(2), 214–220. https://doi.org/10.3389/neuro.01.029.2009

Sobel, D. (1996). Beyond ecophobia: Reclaiming the heart in nature education. Great Barrington, MA: The Orion Society and the Myrin Institute.

Sousa, B. R. (2021). Floresta Laurissilva: Uma Relíquia da Ilha da Madeira. florestas. https://florestas.pt/conhecer/floresta-laurissilva-uma-reliquia-da-ilha-da-madeira/

T

Talgorn, E., & Ullerup, H. (2023). Invoking 'Empathy for the Planet' through Participatory Ecological Storytelling: From Human-Centered to Planet-Centered Design. Sustainability (Switzerland), 15(10). https://doi.org/10.3390/su15107794

V

Venkatesh, V. (2000). "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model." Information Systems Research, 11(4), 342–365.

Voigt, B. (2020). Making Connections: Empathy for Animals and Sustainable Behavior. February, 0–9. Whittaker, R. J.(1998) Island biogeography: Ecology, evolution and conservation. Journal of Ecology, 88(1), 179–180. https://doi.org/10.1046/j.1365-2745.2000.00425.x

W

Wang, L., Sheng, G., She, S., & Xu, J. (2022). Impact of empathy with nature on pro-environmental behaviour. International Journal of Consumer Studies, 47(2), 652-668. https://doi.org/10.1111/ijcs.12856

Wu, L. (2018). The relationships between environmental sensitivity, ecological worldview, personal norms and pro-environmental behaviors in chinese children: testing the value–belief–norm model with environmental sensitivity as an emotional basis. PsyCh Journal, 7(3), 111-121. https://doi.org/10.1002/pchj.217

Wulansari, O., Pirker, J., Kopf, J., & Guetl, C. (2020). Video Games and Their Correlation to Empathy: How to Teach and Experience Empathic Emotion (pp. 151–163). https://doi.org/10.1007/978-3-030-40274-7_16

Z   Zhao, Q., Neumann, D. L., Djekic, S., & Shum, D. (2021). Culture, sex, and group-bias in trait and state empathy. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.561930

Bibliography

Laurissilva

Almeida, A. R., Novais, A. T., Flávio, H., da Silva Oliveira, S., Pereira, R., & Talhadas dos Santos, P. (2016). Madeira morta, mas cheia de vida: uma proposta de educação ambiental. Chapter, 6(2), 44–55.

Capelo, J. (2004). A paisagem vegetal da Ilha da Madeira. Quercetea, 6(January), 3–200.

Cruz, M. J., Santos, F. D., Aguiar, R., Oliveira, R. P., Correia, A., Tavares, T., & Pereira, J. S. (2008). Impactos das alterações climáticas nos ecossistemas terrestres da ilha da madeira. CLIMA 2008 - I Congresso Nacional Sobre Alterações Climáticas, July 2014.

Fontinha, S. (2004). A Laurissilva da Madeira, Património da Humanidade: a investigação científica e a conservação.

Gouveia, L. M., Menezes, D. M. G. G., Fontinha, S. M. G. e S. V., Oliveira, P. J. S. G., Domingues, M. M. C. S. A., Mateus, M. G. H., & Freitas, I. C. L. (2005). A Floresta Laurissilva da Madeira - Património Mundial. Serviço do Parque Natural da Madeira. https://ifcn.madeira.gov.pt/images/Doc_Artigos/Divulgacao/publicacoes/livros/FLORESTA%20LAURISSILVA.pdf

Gutierres, F. R. S. (2007). Estudo da diversidade de briófitos epífiticos:abordagem fitogeográfica com ênfase na conservação de locais seleccionados na laurissilva da Madeira. Biologia. http://repositorio.ul.pt/handle/10451/1382

Laurisilva of Madeira. UNESCO World Heritage Centre. https://whc.unesco.org/en/list/934/

Martins, M. (2023). Ciência - Ilha da Madeira: A Preservação da Floresta Laurissilva em tempos de Ecoturismo de Massa. RFI. https://www.rfi.fr/pt/programas/ci%C3%AAncia/20230725-ilha-da-madeira-a-preserva%C3%A7%C3%A3o-da-floresta-laurissilva-em-tempos-de-ecoturismo-de-massa

Neves, H.C., Valente, A.V., Faria, B.F., Silva I.G., Marques, J.C., Gouveia, N.A., Silva, P.G., & Oliveira, P.J. (1997). Laurissilva da Madeira - Notícia Explicativa. Ministério do Ambiente. https://ifcn.madeira.gov.pt/images/Doc_Artigos/Divulgacao/publicacoes/livros/Atlas_do_Ambiente_-_Laurissilva_da_Madeira.pdf

Nunes, J., Camacho, O. & Silva, C. (2004). O contributo do Parque Ecológico do Funchal para a Literacia Científica. https://doi.org/10.34640/universidademadeira2021nunescamachosilva

Quintal, R. (2023). Reportagem Ilha da Madeira. RFI. https://www.rfi.fr/pt/programas/ci%C3%AAncia/20230725-ilha-da-madeira-a-preserva%C3%A7%C3%A3o-da-floresta-laurissilva-em-tempos-de-ecoturismo-de-massa

Santos, V. (2010). Biodiversidade: Guia Temático. https://ecoescolas.abae.pt/wp-content/uploads/sites/3/2020/05/GUIA-TEMÁTICO_BIODIVERSIDADE.pdf

Sousa, B. R. (2021). Floresta Laurissilva: Uma Relíquia da Ilha da Madeira. florestas. https://florestas.pt/conhecer/floresta-laurissilva-uma-reliquia-da-ilha-da-madeira/

Spínola, H. (2003). Estudo do ambiente: HélderSpínola. In Livro Branco do Património Cultural da R.A.M. (pp. 117–128). https://digituma.uma.pt/bitstream/10400.13/2130/1/Estudo do ambiente-HélderSpínola.pdf

Vasconcelos, F.R.E.V.(2015). Avaliação da Vulnerabilidade da Biodiversidade Terrestre às Alterações Climáticas e Proposta de Medidas de Adaptação para o Arquipélago da Madeira. [Masters' Dissertation in Ecology and Environmental Management , University of Lisbon]. Repositório da Universidade de Lisboa. http://hdl.handle.net/10451/22494

Empathy

Chen, J., Li, Z., Lv, Y.-F., Li, C.-L., Wang, Y., Wang, R.-R., Geng, K.-W., & He, T. (2015). Empathy for pain: A novel bio-psychosocial-behavioral laboratory animal model. Sheng Li Xue Bao : Acta Physiologica Sinica, 67(6), 561—570. http://europepmc.org/abstract/MED/26701631

Cheng, J. C. and Monroe, M. C. (2010). Connection to nature. Environment and Behavior, 44(1), 31-49. https://doi.org/10.1177/0013916510385082

Geng, L., Xu, J., Yang, L., Zhou, W., & Zhou, K. (2015). Connections with nature and environmental behaviors. Plos One, 10(5), e0127247. https://doi.org/10.1371/journal.pone.0127247

Graaff, J. V. d., Meeus, W., Wied, M. d., Boxtel, A. v., Lier, P. v., Koot, H. M., ... & Branje, S. (2015). Motor, affective and cognitive empathy in adolescence: interrelations between facial electromyography and self-reported trait and state measures. Cognition and Emotion, 30(4), 745-761. https://doi.org/10.1080/02699931.2015.1027665

Hosseini, M. and Caragea, C. (2021). It takes two to empathize: one to seek and one to provide. Proceedings of the AAAI Conference on Artificial Intelligence, 35(14), 13018-13026. https://doi.org/10.1609/aaai.v35i14.17539

Humberstone, B. (2013). Adventurous activities, embodiment and nature: spiritual, sensual and sustainable? embodying environmental justice. Motriz: Revista De Educação Física, 19(3), 565-571. https://doi.org/10.1590/s1980-65742013000300006

Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. (2004). Implicit connections with nature. Journal of Environmental Psychology, 24(1), 31-42. https://doi.org/10.1016/s0272-4944(03)00022-7 Sobel, D. (1996). Beyond ecophobia: Reclaiming the heart in nature education. Great Barrington, MA: The Orion Society and the Myrin Institute.

Tam, K. P. (2013). Dispositional empathy with nature. Journal of Environmental Psychology, 35(September 2013), 92–104. https://doi.org/10.1016/j.jenvp.2013.05.004

Voigt, B. (2020). Making Connections: Empathy for Animals and Sustainable Behavior. February, 0–9.

Wang, L., Sheng, G., She, S., & Xu, J. (2022). Impact of empathy with nature on pro-environmental behaviour. International Journal of Consumer Studies, 47(2), 652-668. https://doi.org/10.1111/ijcs.12856

Wu, L. (2018). The relationships between environmental sensitivity, ecological worldview, personal norms and pro-environmental behaviors in chinese children: testing the value–belief–norm model with environmental sensitivity as an emotional basis. PsyCh Journal, 7(3), 111-121. https://doi.org/10.1002/pchj.217

Zhao, Q., Neumann, D. L., Djekic, S., & Shum, D. (2021). Culture, sex, and group-bias in trait and state empathy. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.561930

Interactive Experiences

Anderson, C. A., Shibuya, A., Ihori, N., Swing, E. L., Bushman, B. J., Sakamoto, A., Rothstein, H. R., & Saleem, M. (2010). Violent Video Game Effects on Aggression, Empathy, and Prosocial Behavior in Eastern and Western Countries: A Meta-Analytic Review. Psychological Bulletin, 136(2), 151–173. https://doi.org/10.1037/a0018251

Anderson, E., McLoughlin, L., Liarokapis, F., Christopher, P., Panagiotis, P., & de Freitas, S. (2009). Serious Games in Cultural Heritage. Proceedings of International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST - State of the Art Reports (2009), January, 40.

Ballagas R, Kuntze A, Walz SP (2008) Gaming tourism: lessons from evaluating REXplorer, a pervasive game for tourists. In: Indulska J, Patterson DJ, Rodden T, Ott M (eds) Pervasive computing. Springer, Berlin Heidelberg, pp 244–261

DaCosta, B., & Kinsell, C. (2023). Serious Games in Cultural Heritage: A Review of Practices and Considerations in the Design of Location-Based Games. Education Sciences, 13(1). https://doi.org/10.3390/educsci13010047

Dionisio, M., & Nisi, V. (2021). Leveraging Transmedia storytelling to engage tourists in the understanding of the destination's local heritage. Multimedia Tools and Applications, 80(26–27), 34813–34841. https://doi.org/10.1007/s11042-021-10949-2

Dunn, M. E., Shah, G., & Veríssimo, D. (2021). Stepping into the Wildeverse: Evaluating the impact of augmented reality mobile gaming on pro-conservation behaviours. People and Nature, 3(6), 1205–1217. https://doi.org/10.1002/pan3.10273

Feltham, J. (2023, March 16). Free oculus quest/rift film the key packs a deceptive punch - quick review. UploadVR. https://www.uploadvr.com/the-key-review-free-quest/

Fragments of Laura. (2018). https://fragmentsoflaura.arditi.pt/
Greitemeyer, T., & Osswald, S. (2010). Effects of prosocial video games on prosocial behavior. Journal of Personality and Social Psychology, 98(2), 211–221. https://doi.org/10.1037/a0016997

Hafner, M., & Jansz, J. (2018). The Players' Experience of Immersion in Persuasive Games. International Journal of Serious Games, 5, 63–79. https://doi.org/10.17083/ijsg.v5i4.263

How virtual reality could help save the environment. Murdoch University. (2024, January 11). https://www.murdoch.edu.au/news/articles/how-virtual-reality-could-help-save-the-environment
Jerrett, A., Howell, P., & Dansey, N. (2021). Developing an Empathy Spectrum for Games. Games and Culture, 16(6), 635–659. https://doi.org/10.1177/1555412020954019

Lucid Dreams Productions, LLC. (n.d.). The key on Meta Rift. Meta. https://www.meta.com/experiences/pcvr/2470009999743363/
Our creations. Lucid Dreams Productions. (2019). https://www.luciddreamsprod.com/our-creations/

Nuryanti, N., Sanjaya, R., & Prasetya, H. (2019). Green Mission Game for the Forest Preservation Campaig. Sisforma, 5(2), 68–73. https://doi.org/10.24167/sisforma.v5i2.1027

Rattanarungrot, S., Kalarat, K., White, M., & Chaisriya, K. (2023). Preserving Southern Thai Traditional Manora Dance Through Mobile Role-Playing Game Technology. Journal on Computing and Cultural Heritage, 17(1), 1–22. https://doi.org/10.1145/3631122

Spangenberger, P., Geiger, S. M., & Freytag, S. C. (2022). Becoming nature: effects of embodying a tree in immersive virtual reality on nature relatedness. Scientific Reports, 12(1), 1–11. https://doi.org/10.1038/s41598-022-05184-0

Shin, D. (2018). Empathy and embodied experience in virtual environment: To what extent can virtual reality stimulate empathy and embodied experience? Computers in Human Behavior, 78, 64–73. https://doi.org/10.1016/j.chb.2017.09.012

Soliman, M., Peetz, J., & Davydenko, M. (2017). The impact of immersive technology on nature relatedness and pro-environmental behavior. Journal of Media Psychology, 29(1), 8–17. https://doi.org/10.1027/1864-1105/a000213

The Holy City VR (2019). https://www.holycityvr.com/

Wulansari, O., Pirker, J., Kopf, J., & Guetl, C. (2020). Video Games and Their Correlation to Empathy: How to Teach and Experience Empathic Emotion (pp. 151–163). https://doi.org/10.1007/978-3-030-40274-7_16

Storytelling

Dam, R. F. and Teo, Y. S. (2021, December 18). The Power of Stories in Building Empathy. Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/article/the-power-of-stories-in-building-empathy

Donly, C. (2017). Toward the Eco-Narrative: Rethinking the Role of Conflict in Storytelling. Humanities, 6(4), 17. https://doi.org/10.3390/h6020017

Forlano, L. (2017). Posthumanism and Design. She Ji: The Journal of Design, Economics, and Innovation, 3(1), 16–29. https://doi.org/https://doi.org/10.1016/j.sheji.2017.08.001

Jenkins H (2008) Convergence culture: where old and new media collide, updated and with a new afterword. New York Univ. Press, New York, NY

Manney, P. J. (2008). Empathy in the Time of Technology: How Storytelling is the Key to Empathy. Journal of Evolution and Technology, 19(1), 51–61. http://jetpress.org/v19/manney.htm

Nunes, N. J., Oakley, I., & Nisi, V. (2017). Proceedings of the 10th International Conference on Interactive Digital Storytelling ICIDS'2017 (Vol. 10690). https://doi.org/10.1007/978-3-319-71027-3

Reddy, A., Kocaballi, A. B., Nicenboim, I., Søndergaard, M. L. J., Lupetti, M. L., Key, C., Speed, C., Lockton, D., Giaccardi, E., Grommé, F., Robbins, H., Primlani, N., Yurman, P., Sumartojo, S., Phan, T., Bedö, V., & Strengers, Y. (2021). Making Everyday Things Talk: Speculative Conversations into the Future of Voice Interfaces at Home. Conference on Human Factors in Computing Systems - Proceedings, May. https://doi.org/10.1145/3411763.3450390

Talgorn, E., & Ullerup, H. (2023). Invoking 'Empathy for the Planet' through Participatory Ecological Storytelling: From Human-Centered to Planet-Centered Design. Sustainability (Switzerland), 15(10). https://doi.org/10.3390/su15107794

Tourism and Environmental behaviour

Bilynets, I., & Knezevic Cvelbar, L. (2022). Tourist pro-environmental behaviour: The role of environmental image of destination and daily behaviour. Annals of Tourism Research Empirical Insights, 3(2), 100070. https://doi.org/10.1016/j.annale.2022.100070

Ferreira, A. (2023, October 14). Duas queimadas ilegais detectadas em Santa Cruz. DNOTICIAS.PT. https://www.dnoticias.pt/2023/10/14/379097-duas-queimadas-ilegais-detectadas-em-santa-cruz/

Ferreira, N. (2024, August 20). Laurissilva na Madeira: "Corremos o risco de estar a fazer desaparecer espécies ainda não descritas." PÚBLICO. https://www.publico.pt/2024/08/20/azul/noticia/laurissilva-madeira-corremos-risco-estar-desaparecer-especies-nao-descritas-2101375

Heller, N., & Zavaleta, E. (2009). Biodiversity management in the face of climate change: A review of 22 years of recommendations. Biological Conservation, 142, 14–32. https://doi.org/10.1016/j.biocon.2008.10.006

Kolbert, E. (2014). The sixth extinction: An unnatural history. Henry Holt and Company.

Lusa. (2018, August 8). Polícia Florestal detecta 11 queimadas ilegais na Madeira. PÚBLICO. https://www.publico.pt/2018/08/08/sociedade/noticia/policia-florestal-detecta-11-queimadas-ilegais-na-madeira-1840476

Oliveira, N. N. P. (2023). Tourism Routes as a Tool for the Sustainable Development of Rural Areas [Politécnico de Leiria]. https://iconline.ipleiria.pt/bitstream/10400.8/9421/1/Tourism%20routes%20as%20a%20tool%20for%20the%20sustainable%20devolopment%20of%20rural%20areas_a%20case%20study%20in%20Madeira%20Island.pdf

UNESCO World Heritage Centre. (n.d.). World Heritage. https://whc.unesco.org/en/about/

Whittaker, R. J.(1998) Island biogeography: Ecology, evolution and conservation. Journal of Ecology, 88(1), 179–180. https://doi.org/10.1046/j.1365-2745.2000.00425.x

Methodology

Agarwal, Ritu & Karahanna, Elena. (2000). Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage. MIS Quarterly. 24. 665-694. 10.2307/3250951. Agarwal,

Dutcher, D. D., Finley, J. C., Luloff, A. E., & Johnson, J. B. (2007). Connectivity with nature as a measure of environmental values. Environment and Behavior, 39(4), 474-493

Hanington, B. M., & Martin, B. (2019). Universal Methods of Design: 125 ways to research complex problems, develop innovative ideas, and Design Effective Solutions. Rockport Publishers.

Kilteni, K., Groten, R., & Slater, M. (2012). The Sense of Embodiment in Virtual Reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Kim, Y., & Ilsun, R. (2024). Development of a virtual reality system usability questionnaire (VRSUQ). Applied ergonomics. 119. 104319. 10.1016/j.apergo.2024.104319.

Longo, M. R., Schüür, F., Kammers, M. P., Tsakiris, M., & Haggard, P. (2008). What is embodiment? A psychometric approach. Cognition, 107(3), 978-998.

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. Journal of Environmental Psychology, 24(4), 503-515.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549-3557.

Van Bijsterveldt, A. (2020). Cognitive Absorption: Analyzing and Comparing its Five Dimensions within Virtual Reality and Non-Virtual Reality Rhythm Games [BA Thesis, Tilburg University]. http://arno.uvt.nl/show.cgi?fid=156728

Venkatesh, V. (2000). "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model." Information Systems Research, 11(4), 342–365.

Appendix

Appendix A | Proto-Persona and User Journey Map

a) Proto-persona

AGE 32

EDUCATION Environmental Scientist

STATUS Single

LOCATION San Francisco, California

TECH LITERATE High

" Every step we take to protect and preserve our natural world is a step towards a brighter, more sustainable future for generations to come.

Personality

Passionate   Curious

Empathetic   Adventurous

Bio

Dedicated to conservation and sustainability, with a Master's Degree in Environmental Science, Emily works for a non-profit organization and enjoys hiking, bird watching, and volunteering for environmental causes. She seeks immersive educational experiences and authentic connections with nature during her travels.

Goals

- Explore new natural environments and learn about unique ecosystems.
- Engage in activities that allow her to connect with nature and local culture.
- Support destinations that prioritize sustainability and conservation.

Frustrations

- Overcrowded tourist spots.
- Lack of sustainable options.
- Limited Authentic Experiences.

Interests

- Passionate about nature and wildlife conservation.
- Enjoys learning about different ecosystems and cultures.
- Interested in sustainable travel and minimizing her environmental footprint.

b) User Journey Map

Emily Johnson

Dedicated to conservation and sustainability, she works for a non-profit organization and enjoys hiking, bird watching, and volunteering for environmental causes. Emily seeks immersive educational experiences and authentic connections with nature during her travels.

Expectations

- Immersive Learning
- Authentic Engagement with Nature
- Sustainable Practices

	Awareness and Interest	Planning and Arrival	Engagement with the VR Experience	Reflection and Feedback	Post-Experience Actions
Touchpoints	• Online travel research • Museum website • Social media • Travel guides	• Museum website • Travel itinerary • Museum entrance	• VR staff • Museum staff • VR headset and controllers	• VR experience exit • Museum feedback station • Personal journal/blog	• Social media • Personal blog • Museum follow-up email
Actions	• Emily researches sustainable travel options in Madeira. • She discovers the Laurissilva Forest and its importance. • Emily finds information about a VR experience at a local museum on social media and the museum's website.	• Emily includes the museum visit in her travel itinerary. • She checks the museum's hours. • Emily arrives at the museum and gets information about the VR experience.	• Emily receives instructions from the museum staff. • She puts on the VR headset and starts the experience. • Emily interacts with the VR environment, exploring the Laurissilva Forest, meeting virtual guides, and learning about the ecosystem.	• Emily completes the VR experience and removes the headset. • She provides feedback through a museum survey or feedback station. • Emily takes notes for her personal blog about her experience and reflections.	• Emily shares her experience on social media and her blog, highlighting the VR experience. • She stays connected with the museum through newsletters and social media. • Emily considers donating to or volunteering with conservation efforts in Madeira.
Thoughts	"I want to learn more about the Laurissilva Forest." "A VR experience sounds immersive and educational."	"I hope the VR experience lives up to my expectations."	"This is incredibly immersive! I'm learning so much about the forest's biodiversity and the importance of conservation."	"This was one of the best educational experiences I've had." "I feel more connected to the conservation efforts in Madeira."	"How can I stay involved and help from home?"
Emotions	• Excitement • Curiosity	• Anticipation • Hope	• Immersion • Awe • Satisfaction	• Fulfillment • Gratitude	• Inspiration • Motivation

Appendix B | Ideation Methods

a) Concept Mapping (Narrative)

b) Character Development

c) Sketches

d) Flow Diagram of the Initial Narrative

e) Definition of Interactions Within Each Scene

SCENE 1
Start of the experience

GOAL
Give information about where the player is

SEE
Hiking path

HEAR
Birds and leaves. Forest environment.

DO
Look around. Try to get a better view of their surroundings.

SCENE 2
Start the hike

GOAL
Get the player to move and start the hike.

SEE
Sign with information about the levada.

HEAR
Birds and leaves. Forest environment. Own footsteps.

DO
Get closer to the sign and read its instructions

SCENE 3
Pick leaves

GOAL
Walk and start picking up leaves.

SEE
Trees and plants. A specific branch gives information to the player that is interactive.

HEAR
Shiny sounds coming from the plant.

DO
Get closer to the plant and remove its leaves.

SCENE 4
Forest darkens and tourist gets distracted

GOAL
Notice the light.

SEE
Environment darkens. A small light in between the bushes.

HEAR
Small sound coming from bushes behind the player.

DO
Look at the area where the light and sound are coming from. Get closer to it.

SCENE 5
Touching the light

GOAL
Get transported to the fantasy forest.

SEE
Small light.
More brightness the closer they get to it.

HEAR
Sound of the forest in the background. Magical sound when getting closer to the light.

DO
Get closer to the light. Touch the light.

SCENE 6
Entry in new environment.

GOAL
Try to take a better look of the environment. Understand where they are.

SEE
Fantasy environment. Magical forest. The small light crearture.

HEAR
Magical forest sounds.

DO
Look around the area.

SCENE 7
Follow the light. Start journey.

GOAL
Follow the light. Move in the environment.

SEE
Light moving away, but looking back to see if they are following.

HEAR
Magical forest sounds. Light.

DO
Follow the light.

SCENE 8
First challenge.

GOAL
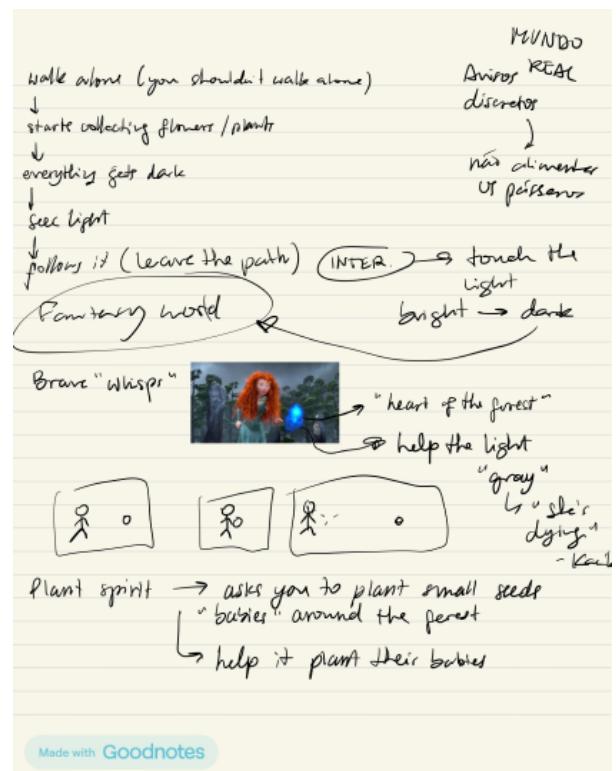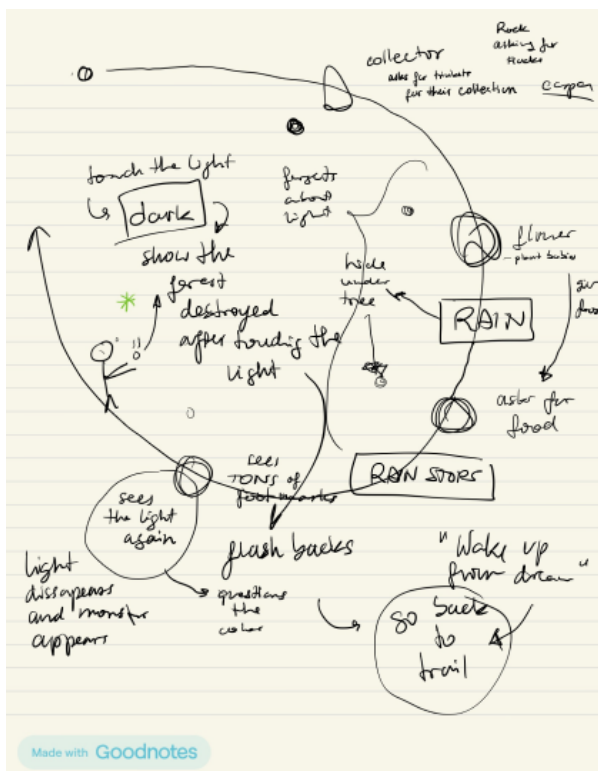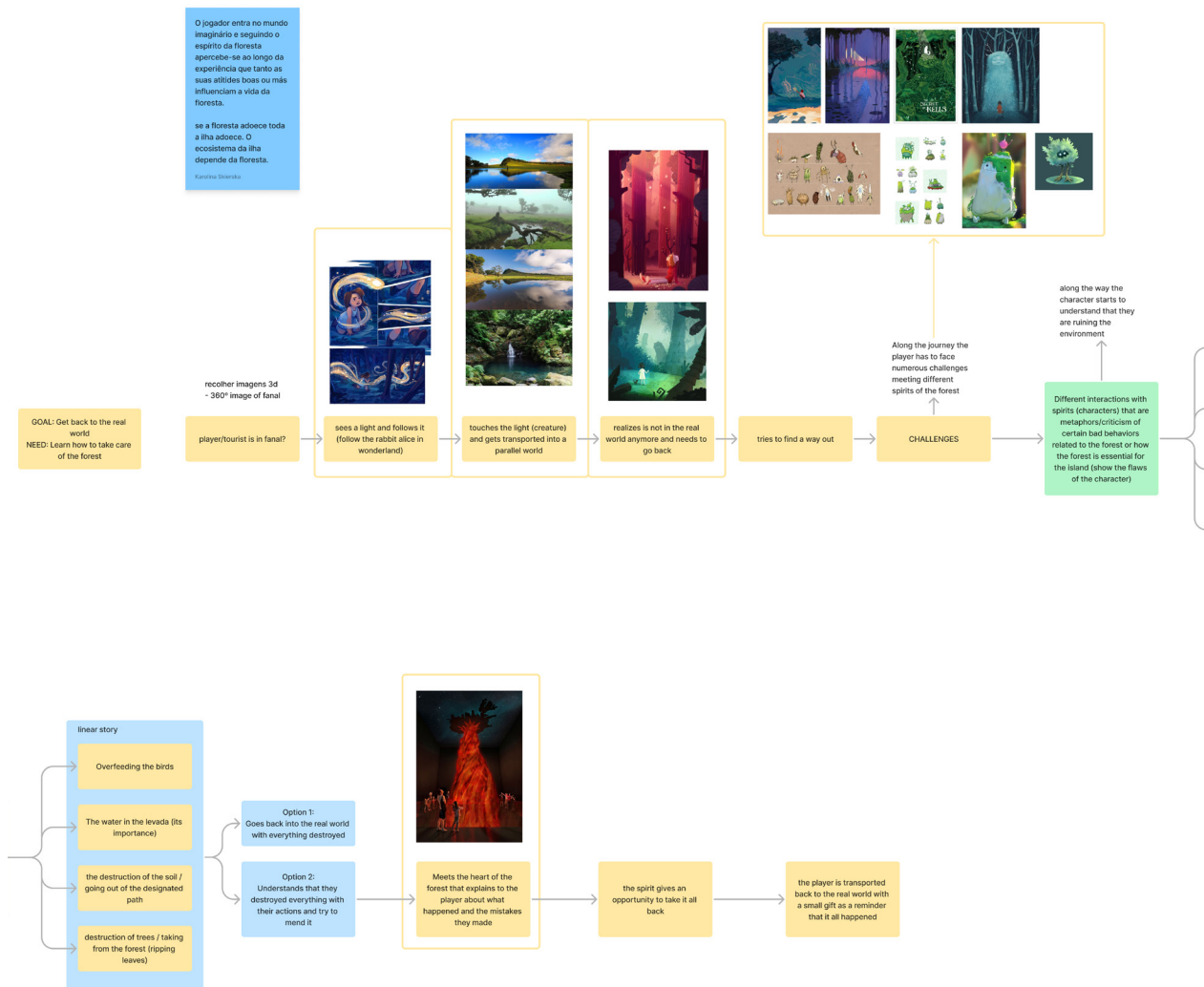Meet the new creature (Collector). Understand what is the first challenge

SEE
Big rock-like creature in the middle of the path.

HEAR
Creatures speech.

DO
Get closer to the creature and hear them out.

SCENE 9
First challenge.

GOAL
Collect rocks

SEE
Area of the forest, with certain parts with brightness.

HEAR
Forest sounds.

DO
Move around the designated area and try to find the rocks that the creature asked for.

SCENE 10
First challenge.

GOAL
Give the rocks to the creature.

SEE
Creature waiting.

HEAR
Forest sounds. Creature speech.

DO
Get closer to the creature. Extend arms. Give the rocks to the creature.

SCENE 11
Follow the light

GOAL
Move to the next quest.

SEE
Light in the middle of the path. More dull.

HEAR
Light. Forest.

DO
Follow the light.

SCENE 12
Challenge 2

GOAL
Start the 2nd challenge.

SEE
Small creature with something in its arms.

HEAR
Creature speech.

DO
Hear the creature. Extend arms to grab the small beings.

SCENE 13
Plant the seeds

GOAL
Plant the seeds

SEE
Area of the forest, with certain parts with brightness (areas to plant).

HEAR
Forest. Magical sounds coming from the areas to plant.

DO
Get closer to the area where to plant the seeds. Move your hands.

SCENE 14
Talk to the creature. Receive gift.

GOAL
Talk to the creature. Receive gift.

SEE
Creature happy giving you something in return.

HEAR
Forest. Creature thanks.

DO
Accept the gift. Extend hand to the creature and grab the gift.

SCENE 15
Talk to the creature. Receive gift.

GOAL
Talk to the creature. Receive gift.

SEE
Creature happy giving you something in return.

HEAR
Forest. Creature thanks.

DO
Accept the gift. Extend hand to the creature and grab the gift.

f) First Narrative

You arrive in Madeira as a curious tourist, eager to explore its famed hiking trails. Your journey begins at the entrance of a Levada, a quaint irrigation channel adorning the island's landscape with its lush surroundings. As you set foot on the trail, a symphony of chirping birds and rustling leaves serenades you, and beams of sunlight filter through the dense canopy overhead, painting the scene with a verdant glow.

Enthralled by the forest's natural beauty, you venture forth, marveling at the myriad flora and fauna adorning your path. The solitude of the trail is comforting, fostering a sense of belonging amidst nature's embrace. Along the way, you encounter familiar species from your guidebook, like the aromatic laurel leaves that beckon you to gather a few as keepsakes.

Lost in your picking, you feel a subtle shift in the forest's ambiance. The verdant canopy seems to darken imperceptibly, and a faint, unfamiliar sound tickles your curiosity from the depths of a nearby thicket.

Drawn by a sense of wonder, you tread softly toward the source of the mysterious sound. Amidst the foliage, an inexplicable glow dances, casting bewilderment upon your senses. With cautious steps, you breach the leafy veil, only to be greeted by a fantastical sight—a diminutive creature, radiant and ethereal, hovering before you.

Silent but not fearful, the creature's presence intrigues you further. Its shy demeanor beckons you to approach with gentle reassurance, bridging the gap between uncertainty and curiosity. As you draw nearer, the luminosity of the creature intensifies, hinting at a profound connection between your touch and its radiance.

With trembling fingers, you extend your hand, tentatively reaching out to this wondrous being. At the brush of your skin against its luminous form, a blinding brilliance ensues, enveloping you in a kaleidoscope of light.

Blinking against the residual brightness that envelops your vision, you slowly adjust to the new reality that surrounds you. Gone is the familiar forest you knew, replaced by an otherworldly realm that seems plucked from the pages of a fairytale.

As you tentatively explore this enchanted landscape, every step whispers secrets of magic and wonder. The flora and fauna wear hues unseen in the mortal realm, each species a living testament to

the fantastical nature of your surroundings.

Amidst your bewilderment, a familiar glow catches your eye. There, amidst the surreal beauty, hovers the small light that led you into this mystical realm. Questions flood your mind like a torrential river—how did you end up here? What secrets does this place hold?

A subtle urgency tugs at your heartstrings as the light beckons you forward, a silent guide in this fantastical odyssey. With no clear path or destination, you trust in the whims of fate and follow the dancing light through the ethereal wilderness, ready to embrace the unknown and discover the mysteries that await in this magical realm.

As the light dances with increasing speed, slipping from your grasp, a sudden obstacle emerges from the mystical ether—a colossal, rock-like creature materializes before you. To your astonishment, the creature speaks, revealing itself as a collector of rare stones. Despite its imposing appearance, its voice carries a gentle tone, tinged with age-old wisdom.

"Hello there, traveler," the rock-like creature rumbles in a deep yet friendly voice, "I am a collector of stones, but alas, my eyesight isn't what it used to be. Would you be so kind as to help me find some unique rocks for my collection?"

Baffled by the creature's unexpected request and still searching for the elusive light, you hesitate for a moment. However, sensing the sincerity in its tone, you nod. "Of course, I'll be glad to help," you replied.

With a sense of determination, you comb through hidden nooks and crannies, unearthing stones that fit the collector's descriptions. Returning to the creature with your findings, a sense of camaraderie blossoms.

"Ah, these are splendid specimens indeed," the creature exclaims, its rocky features softening in appreciation. "Thank you, kind traveler, for your act of kindness."

As quickly as it appeared, the rock-like collector begins to fade away, leaving you momentarily adrift. Panic creeps in, but before despair can take hold, the familiar glow of the light reappears in the collector's place, a beacon of reassurance in the unknown.

The light's cheerful dance welcomes you as you follow its whimsical movements once more. With each playful swirl, it leads you deeper into the forest's mysterious embrace. A subtle shift in its hue catches your attention, but you dismiss it as a trick of the shifting daylight. As you venture further, the light draws near to another creature,

its radiance casting a mesmerizing glow around the being. Without warning, the light vanishes, leaving you face-to-face with a creature cradling small beings in its arms. Intrigued, you approach.

"These are my babies," the creature murmurs, its voice gentle yet filled with concern. "I seek a home for them, a place where they can flourish and bring beauty to this forest."

Moved by the mother's plea, you take the small beings and begin to carefully plant them in various places in your surroundings, envisioning their future growth and the beauty they will bring. With each placement, a sense of fulfillment blossoms within you.

Grateful tears glisten in the creature's eyes as she thanks you, offering a small object in return. "This may aid you in your journey ahead," she whispers before fading away.

Pleased with your good deed, you scan the surroundings for the light, only to find it dimmer than before. Before you can ponder the change, raindrops begin to fall, urging you to seek shelter beneath a nearby tree.

As you huddle beneath the tree's protective canopy, a curious creature approaches. Soon, more follow, their eyes fixed on the object you still hold—the gift from the mother. With a gentle gesture, you offer it to them, watching as they dart away in excitement.

As the rain subsides and you resume your search for the light, you notice the ground marked with countless footprints, a silent testament to the many who have passed this way before you. Amidst this evidence of previous travelers, you traverse the shadowy expanse of the forest, a faint glimmer catching your eye in the distance. It's the familiar flickering light, your steadfast companion through this mysterious journey. However, something feels amiss—the light appears dimmer, its glow waning since your initial encounter.

Curiosity mingled with concern, you approach the light, sensing its unease. With gentle reassurance, you extend your hands towards it, inviting its trust. Hesitant at first, the light eventually settles in your palms, surrendering its dwindling brightness until darkness envelops you both.

When your eyes adjust to the obscurity, you find yourself in a starkly different landscape. The once vibrant forest now stands ravaged, devoid of its lush foliage, teeming creatures, and life-giving waters. Amidst this desolation, the only familiar sight is the subdued light resting in your hands, resilient despite the chaos surrounding it. Through the solemn voice of the light, you come to understand the

delicate balance of nature disrupted by human whims. The once-bright companion, now dimmed by your unwitting deeds, imparts a sobering lesson on the far-reaching impact of seemingly trivial choices.

In a soft, ethereal voice, the small light illuminates a profound truth. "Dear traveler," it begins, "the steps you've taken, though seemingly innocent, cast ripples far beyond what meets the eye. The creatures you've encountered are not mere inhabitants of this forest, as they are echoes, reflections of choices and actions taken by humanity that disrupt the harmony with nature."

As the light's glow shimmers with each word, painting a picture of a once-thriving ecosystem now marred by the weight of human folly. "Once, this forest was a tapestry of life," it continues, "with towering trees and vibrant plants that sang of abundance. But alas, the seeds of neglect and ignorance were sown."

The light's radiance dimms slightly as it speaks of invasive species, the silent invaders that had usurped the natural order. "These intruders," it laments, "have displaced the native flora, strangling the very lifeblood of this land."
With each passing moment, the gravity of the situation becomes clearer. The bustling footsteps of humanity had left scars upon the soil, disrupting the delicate balance that sustained life. Bugs, once nestled in their homes, now wander aimlessly amidst the wreckage of their habitats.

"The levadas," the light continues, "once the veins that nourished this island, now stand as parched reminders of a bygone era. The creatures, once in harmony with humans, have grown reliant, only to face extinction as their homes wither away."

Gently floating before you, the light paints a picture of collective consequence. "Imagine," it whispers, "if every soul took such small, seemingly harmless steps as you have. The combined effect, multiplied by thousands, would shape a world vastly different from what we now know."

Then, in a solemn tone tinged with ancient wisdom, the light reveals its identity. "I am the spirit of this forest," it declares, "and every choice, every action, echoes within my essence." With a melancholic flicker, it speaks of the repercussions, the fading vibrancy, and the dimming life force of the once-thriving woods.

In that moment, you understand the weight of your journey's impact, a reminder that even the gentlest breeze can stir the mightiest storm, and every seemingly insignificant decision holds the power to shape the world around us.

Even though you are not at fault for the small actions you took, you realize what a huge impact they can have in such an environment. As you're transported back to where your journey began, you're granted a moment of introspection—a chance to reconsider your path and tread more mindfully, aware of the intricate web of life your footsteps affect.

g) Screenshots of first prototype
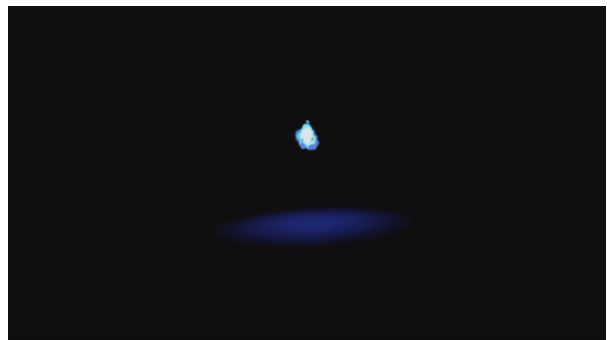
Appendix C | Revised narrative

a) Character development sketches

Development of possible character designs based on typical outfits from Madeira Island.

b) Sketches for the puzzles
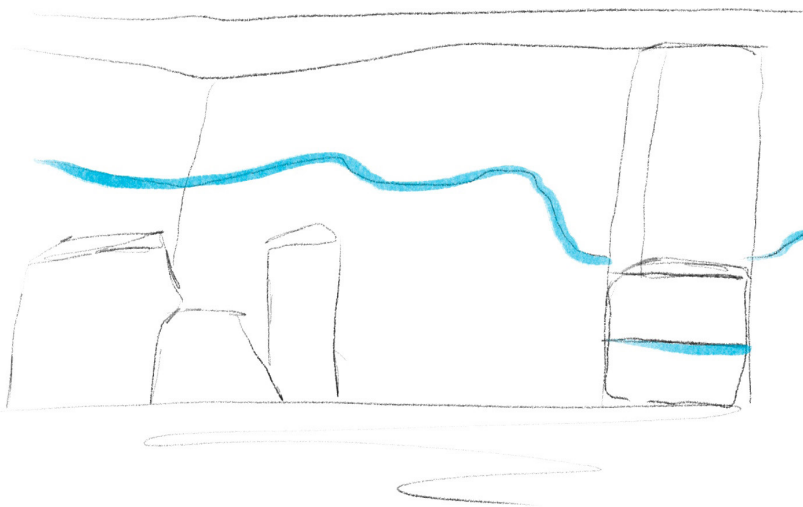
c) Moodboards
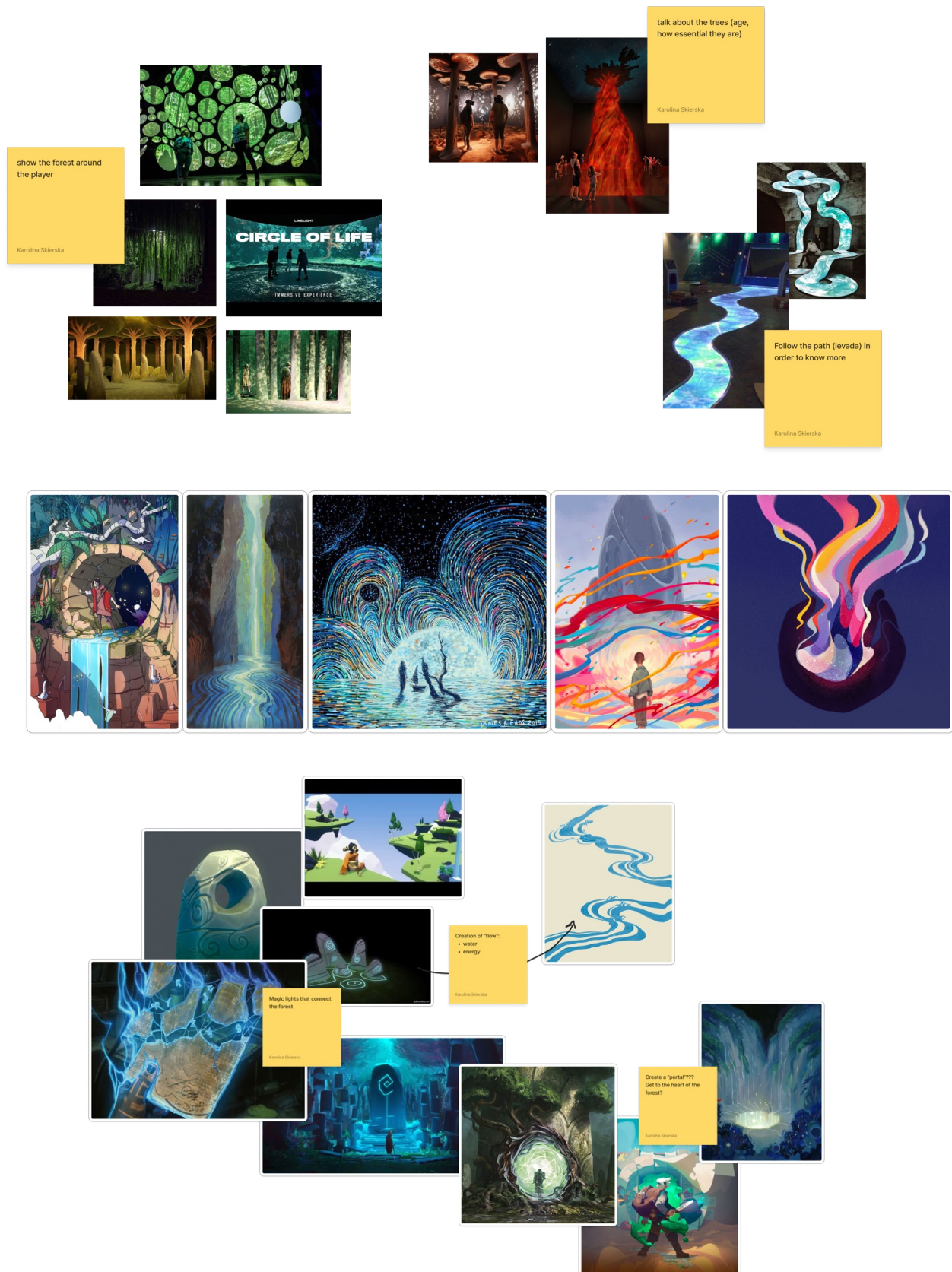
d) New narrative

INT. LEVADA CANAL - MAGIC HOUR

The player wakes up in a small boat, floating in a narrow canal (levada). The surroundings are majestic—the towering trees and mountains of the Laurissilva forest seem to reach endlessly into the sky, making the player feel tiny in comparison. Ethereal light glimmers on the water, and in front of them, an enigmatic character is gazing thoughtfully at the forest.

The character turns toward the player, relief visible in their eyes.

CHARACTER
Ah, you're awake... I was starting to worry. Do you feel it? This place—it's immense, overwhelming, yet... familiar.
"Look over there—do you see that glowing light? Try interacting with it; it might reveal something."
I can't remember how we got here, but I think we're in a forest that's somehow drawn us into its world, made us smaller. Perhaps it needs us... Maybe we've been reduced in size to help the forest from within.

The boat comes to an abrupt stop. The character looks confused.

CHARACTER
Why did we stop?

They scan their surroundings, eyes lingering on faint glowing lines running along the canal walls, pulsing dimly as if waiting for something to awaken them.

CHARACTER
The flow of water... it's been interrupted. But look—those pieces on the wall! Try to move something—maybe the forest has given you the power to restore its energy..

GAMEPLAY: TUTORIAL ON COMMANDS AND INTERACTIONS
A tutorial appears. The player learns to manipulate the environment, aligning glowing lines along the canal walls. As the lines connect, the forest begins to stir—the walls light up, the water starts to flow again, and the boat moves forward. With this, a carved image on the walls lights up, depicting the Laurissilva forest and its vast levadas.

CHARACTER
Incredible! You're bringing the forest back to life. I can feel memories returning... This is a levada, one of the ancient irrigation chan-

nels that carries water through the Laurissilva forest. These channels were built centuries ago to transport water from the wet, green mountains to the drier parts of Madeira Island. Without them, the island wouldn't thrive.

Currently, it occupies an area of around 15.000 hectares in Madeira, which corresponds to 20% of the island.

A glowing carving emerges on the walls—a depiction of the levadas winding through the forest, carrying life and water. The imagery invites the player to grasp the scale and importance of these channels.

The boat slows once again as another puzzle presents itself. The character's eyes flicker with recognition.

CHARACTER
Another puzzle... It looks like you'll have to connect both sides to keep the water flowing.

GAMEPLAY: SECOND PUZZLE
The player solves the second puzzle, connecting glowing lines on either side of the canal. The boat moves forward, and the forest around them becomes more vibrant. A new series of carvings light up, showing the forest's evolution through time.

CHARACTER
Laurissilva... it's one of the world's last remaining laurel forests. Did you know it's 1.8 million years old? It even survived the Ice Age. Back then, climate changes destroyed forests like this across Europe and Africa, but here, in Madeira and other parts of Macaronesia, the mild, humid climate saved it.

Macaronesia is a collection of four volcanic archipelagos in the North Atlantic Ocean, and Madeira, with laurissilva occupying an area of around 15.000 hectares, is the one that conserves the largest surviving area of primary laurel forest in the world.

Nowadays, that area corresponds to about 20% of the island, and it is believed to be 90% primary forest.
This forest is a living link to Earth's ancient past.

As the character speaks, images of the Macaronesian islands light up on the walls, illustrating the vastness of the forest and its age-old connection to the world's climate.

The boat approaches another puzzle. As the player works on connecting the glowing lines, the character begins to remember more.

CHARACTER
This forest isn't just ancient... it's full of life. More than 500 species of invertebrates live here—species you won't find anywhere else on Earth. Birds like the Madeira Laurel Pigeon, the Madeiran Firecrest... Even a tiny bat, the Madeiran Pipistrelle, calls this forest home.

A glowing depiction of the unique wildlife appears on the walls, with vibrant representations of the animals and insects that rely on the Laurissilva forest for survival.

CHARACTER
But...this ecosystem... it's fragile. One of the greatest threats to the Laurissilva is the spread of invasive species. Plants that don't belong here, like the lacy tree fern, the manuka or the Scotch broom . They're choking out the native plants and disrupting the balance of this delicate ecosystem. We need to protect it from these invaders, or the forest's future will be in danger.

As the player completes the puzzle, the environment around them becomes richer and more alive, with vibrant colors returning to the trees and the sound of birds growing louder. The walls light up with images of invasive species, portraying their threat to the forest.

The journey continues as the boat reaches the fourth puzzle, the character looking more contemplative as the player works to solve it.

CHARACTER
It's not just invasive species that threaten this place. Climate change, too. The forest is already feeling the effects—rising temperatures, unpredictable rainfall, and wildfires... And then there's us—people. Feeding the wildlife, trampling through the forest, sometimes without thinking. The more people come, the harder it becomes to manage, to protect this fragile balance.

As the puzzle is solved, the forest around them seems to exhale—a sense of life and balance returns. Images light up on the walls, showing the destructive force of fires, and the pressures of tourism.

CHARACTER
That's why it's so important to protect this ecosystem... It's so delicate, yet vital for the island.

INT. PORTAL CHAMBER - MAGIC HOUR

The boat slows as it approaches a large, intricate portal adorned with ancient carvings, faintly glowing with latent energy. The character looks at it with a sense of awe.

CHARACTER
This... this must be the final puzzle. The heart of the forest. If we can solve it, maybe we'll understand why we're here.

This... this must be the heart of the forest. A beacon calling to us. Maybe if we step through, we'll finally understand why we're here.

GAMEPLAY: FINAL PUZZLE

The player solves the complex puzzle, lighting up the portal, which then opens into a glowing space filled with visions of the Laurissilva thriving. Trees stand tall, animals flourish, and the channels of the levadas flow freely, all bathed in radiant light.

The character stands still, as if overwhelmed by a sudden understanding.

CHARACTER
I remember now... I am the spirit of this forest. The Laurissilva. And you... you've helped restore its soul, its balance. You've healed a part of the world that needed your care. Thank you, truly.

The glowing visions surrounding the player shift, showing the beauty of the untouched forest, the life it nurtures, and its ancient connection to the Earth.

CHARACTER
This place... it's more than just trees and water. It's a living memory of our planet, a precious world that needs protection. And now, you are a guardian of this forest. Take what you've learned, and help others understand its importance. The Laurissilva will live on... through you.

As the character speaks, their form begins to dissolve into the radiant light of the forest, merging with the trees and the water, leaving behind a sense of calm, balance, and purpose.

Appendix D | Test Requirements

a) Protocol / Guide

Introduction

Hello! Thank you for participating in this test. My name is (first and last name of the facilitator) and this test is intended for the realization of a final master's project in Interaction Design, where an interactive experience in virtual reality will be tested.

The test will take about 15-20 min and will consist of three distinct parts, two questionnaires and a phase in which you will have to put on a virtual reality headset.

Consent and questionnaire

In this first phase I will ask you to sign the consent form and fill out the first part of the questionnaire. If you have any questions just let me know

(Give the consent form)
(Fill out the questionnaire with the CNS)

Now we can start testing the experience in virtual reality.

Explanation + VR Experience

(Explain the controls)

The game's controls are quite simple, there is only 1 button that serves to press which is the "grab", and there are two types of interaction within the experience: just press the button or press and hold the button by dragging pieces up or down.

Any questions?

Okay, the experience is to be carried out seated for greater comfort, so I will ask you to use this chair.

(Check if the experience is being transmitted to the computer or mobile phone)
(Sit the participant down and put on the headset)

Now I ask you to select the black icon in the right corner to start the experience.

(Observation of the experiment)

Okay, the experience came to an end.

Questionnaire (phase 2)

Now I'm going to ask you to fill out the rest of the questionnaire, this will consist of some scales that will help measure certain aspects such as usability and the existence of empathy with the laurel forest. If in doubt, don't hesitate to ask.

(Completion of the questionnaire/scales)

Interview

Okay, now at this stage I just wanted to confirm again if I can record the sound so that I can then access the data in order to analyze it more carefully.

(prepare the audio recording)

So, at this stage, I wanted to ask you to recount the experience, what happened in each phase, what you learned, basically to explain to me what you remember from the story. There are no right or wrong answers, this is only for the evaluation of the experience and whether it had the intended effect.

(audio recording and taking notes - narrative key points)

In regards to the experience, is there anything you had difficulties with or did not understand?

Final

Okay, we have reached the end of the test, thank you very much for participating!

b) Research Consent Form

FACULDADE DE ARQUITETURA
UNIVERSIDADE DE LISBOA

RESEARCH CONSENT FORM

Title of the study

Foster Empathy to Promote the Conservation of the Laurissilva Forest: An Interactive Experience

Study Purpose

By focusing on fostering empathy and conveying the ecological significance of the Laurissilva forest of Madeira, the project aims to contribute to the conservation of this vital ecosystem and teach more about its preservation and role within the island through an interactive experience in Virtual Reality.

Data Collected

The experience is going to have a duration of around 15 minutes and it will be tested through the use of two questionnaires, one before and another one after the test in Virtual Reality. In the end there will be a small interview to better understand your personal experience. The session will be recorded and notes will be taken in order to gain more insight into the usability within the virtual environment.

How the data will be used

Any data, recording or other personal information collected about you will be treated confidentially. The recordings and notes will be used exclusively for research purposes.

Your rights

Your participation in this study is voluntary. You can take a break or discontinue participation at any time without giving a reason. If you have any questions or concerns about this study do not hesitate to ask.

Your Consent

I declare that:

- I agree to participate in this study knowing that the information collected (data, images, sound and videos) will be used exclusively for academic purposes and will not be shared without my consent.

- I consent to the recording and collection of images and sound in order to facilitate data analysis.

- I am aware that my participation is voluntary and that I can withdraw at any time, without penalties.

- I undertake to maintain the confidentiality of any information to which I have access as part of this study.

By signing below, you acknowledge that you are 18 years of age or older and have read and understood the information in this Research Consent Form.

Date: ____/____/2024

Participant's printed name (legible): _____

Participant's signature: _____

Appendix E | Observation Notes

Teste 1
- não teve problemas com o sistema e comandos
- não percebeu que estava na levada
- mostrou-se "overwhelmed"
- não percebeu o que era uma levada

Teste 2
- não viu a luz/bolinha no início ("tutorial") e quando apercebeu-se disso começou a entrar em pânico
- resolveu todos os puzzles muito mais cedo do que o pretendido muito entusiasmo
- carregou em todas as bolinhas logo que apareciam, não percebendo que eram elas que ativaram as imagens, sentindo-se assim "overwhelmed" com a quantidade de informação que apareceu toda de uma vez
- falha no puzzle final (erro do sistema - funcionalidade grab tem de ser removida do objeto do portal)
- devido à falha não chegou à cena final da experiência

Teste 3
- nível de conhecimento de inglês baixo
- demorou a perceber que tinha de resolver os puzzles de ambos os lados no Puzzle 2 (mas acabou por conseguir chegar lá)
- notou se um problema no puzzle da esquerda do Puzzle 4 (erro de sistema - animação do P4D funciona sem os 3 estarem todos feitos)
- não percebeu o que era uma levada e onde é que estava

Teste 4
- não viu a luz/bolinha no início ("tutorial"), nem a animação da luz a aparecer, tentando então interagir com a personagem e com as luzes no chão
- teve que ser dito que as luzes/bolinhas ativaram imagens nas partes seguintes
- carregou nas bolinhas logo que podia (demasiado cedo)
- falha na entrada no portal (erro de sistema - o trigger de passagem para a próxima cena funcionou com atraso, levando o tester a avançar mais para a frente do que o pretendido)
- pensava que estava numas ruínas
- sentiu dificuldade em acompanhar a narrativa

Teste 5
- não viu a luz/bolinha no início ("tutorial"), nem a animação da luz a aparecer
- não percebeu o primeiro puzzle (pediu ajuda)
- teve de ser explicado que pode carregar nas bolinhas
- não selecionou todas as bolinhas por olhar em seu redor/ apreciar o ambiente

Teste 6
- sem problemas de interação
- fez tudo como pretendido

Teste 7
- não viu a luz/bolinha no início ("tutorial"), nem a animação da luz a aparecer (não interagiu)
- estava distraída a olhar em seu redor
- não percebeu que tinha de conectar as linhas (estava só a puxar as peças à toa)

Teste 8
- sem problemas de interação
- queria carregar em todas as bolinhas ao mesmo tempo

Teste 9
- sem problemas de interação
- fez tudo como pretendido

Teste 10
- nível de conhecimento de inglês baixo
- não carregou na primeira bolinha mas carregou nas próximas sem ser preciso dizer
- não olhou para as imagens

Teste 11
- sem problemas de interação
- fez tudo como pretendido

Teste 12
- fez os puzzles mais cedo do que o pretendido
- queria selecionar todas as bolinhas de uma vez

Teste 13
- sem problemas de interação
- fez tudo como pretendido

Appendix F | Individual Scores

a) CNS results before experience

Participant	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
1	3	5	5	4	4	4	3	5	4	4	4	3	4	4
2	2	5	5	1	4	5	3	5	5	4	5	5	5	5
3	4	5	5	4	2	5	4	5	5	4	5	4	4	5
4	4	3	3	2	4	3	3	5	4	3	4	3	3	2
5	4	4	5	2	5	5	4	5	4	5	5	3	5	5
6	4	4	5	4	4	5	2	4	3	5	2	3	5	4
7	4	5	5	3	5	5	3	4	4	5	4	5	5	5
8	3	5	4	4	4	4	4	4	4	4	3	3	4	2
9	5	5	5	5	4	5	3	4	3	5	4	3	5	3
10	4	3	4	3	3	5	3	4	2	4	5	1	4	4
11	4	4	4	3	3	4	4	3	3	3	3	3	4	2
12	2	1	3	2	4	3	4	4	3	4	3	2	5	3
13	3	2	5	3	4	4	4	4	4	5	4	5	5	5
Average	3,54	3,92	4,46	3,077	3,85	4,38	3,38	4,31	3,69	4,23	3,92	3,30	4,46	3,77

b) CNS results after experience

Participant	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
1	4	5	5	5	4	5	3	5	5	4	5	2	4	4
2	5	5	5	1	5	5	1	4	4	4	2	5	5	5
3	4	5	4	5	4	4	5	5	4	5	5	5	5	4
4	4	4	5	2	4	4	4	4	4	4	3	2	4	2
5	5	5	5	1	5	5	5	5	5	5	5	2	5	5
6	4	4	5	4	4	5	3	5	2	4	4	4	5	5
7	4	5	5	3	5	4	3	4	4	5	3	5	5	5
8	4	5	5	4	5	4	3	5	4	5	5	4	5	3
9	5	5	5	5	5	5	4	5	5	4	5	3	5	4
10	4	3	2	5	3	5	5	4	3	2	4	3	3	2
11	4	4	4	1	4	5	5	5	4	5	5	2	4	2
12	3	3	3	2	4	3	4	4	4	4	5	2	4	2
13	4	4	5	3	4	5	4	5	4	5	4	5	5	5
Average	4,15	4,38	4,46	3,15	4,31	4,54	3,77	4,61	4	4,31	4,23	3,38	4,54	3,69

c) VEQ individual results

Participant	Sense of Ownership	Sense of Agency	Self-Location	Presence	Body Ownership Illusion	Emotional Engagement
1	4	5	4	4	5	4
2	4	5	4	4	4	5
3	4	5	5	4	5	2
4	4	4	3	4	4	4
5	5	5	2	3	4	2
6	5	5	4	4	5	4
7	4	5	3	3	4	3
8	3	4	4	4	4	4
9	4	4	5	5	5	5
10	4	4	5	5	4	5
11	4	5	5	5	4	5
12	5	5	5	4	5	5
13	1	5	2	3	4	1
Average	3,93	4,69	3,92	4	4,38	3,77

d) CA individual results

Participant	A1	A2	A3	A4	A5	A6
1	3	5	5	4	5	4
2	2	5	5	5	5	5
3	2	5	5	4	5	3
4	1	3	4	3	4	2
5	1	4	5	5	5	5
6	4	3	5	5	4	4
7	4	4	5	3	5	3
8	1	5	5	3	5	4
9	4	5	5	4	5	5
10	3	5	5	4	5	5
11	5	5	5	5	4	5
12	5	5	5	5	5	5
13	1	4	5	5	5	1
Average	2,76	4,46	4,92	4,23	4,77	3,92

e) Key points tested in the interview

1. Immersion and localization
     a) Know where they are
     b) Feeling of smallness

2. Interactivity and engagement
     a)Progressive Unveiling (solving puzzles restores water flow)

3. Educational highlights of forest significance
     a) Historical and Biological Importance (age and rarity)
     b) Unique ecosystem (biodiversity and endemic species)

4. Conservation challenges and threats
     a)Invasive Species and Ecosystem Fragility
     b) Climate Change and Human Impact

5. Emotional connection through the character as forest spirit
     a)Character Revelation (The forest spirit's gradual return
to memory reflects the idea that the forest "remembers" through
human care)
     b) Guardian Role (When the player is named a "guardian" of
the forest at the narrative's climax, it reinforces the idea of steward-
ship. They aren't just visitors—they have an enduring duty to protect
this place.)

6. Final message and responsibility and legacy
     a)Enduring connection

Appendix G | Video of Gameplay

Title:
Foster Empathy with the Laurissilva Forest: An Interactive Experience

https://youtu.be/vO5_frGKd0g

Annex

Annex A | Affirmations VRSUQ

1. The system responded well to my manipulations as expected with no delays.
2. I think the virtual reality system provides clear feedback on my manipulations.
3. (—) I kept making errors/mistakes while using the virtual reality system.
4. I could clearly understand the information presented within the virtual environment.
5. I think this system is user-friendly, straightforward to learn, and designed in such a way that most people will find it easy to adapt to.
6. I think it is easy to correct errors made during virtual reality experiences.
7. I enjoyed the virtual reality experience.
8. (—) I felt dizzy, motion sickness, or a headache while experiencing virtual reality.
9. (—) While experiencing virtual reality, I felt mental burdens such as tension, frustration, and time pressure.

Note. Items marked with (—) were reverse-coded before analysis.

Annex B | Assets Credits

Environmental assets (objects):

Low Poly Woods (Version 1.1.0) by NebulaLabs, available on the Unity Asset Store. https://assetstore.unity.com/packages/3d/environments/landscapes/low-poly-woods-232818?srslti-d=AfmBOopWnV2ypEzyxqrhtTtmIBboP4tFKfOQ31y7KVNGGhPt48e8TwAC#description

Fantasy Skybox FREE (Version 1.6.5), available on the Unity Asset Store. https://assetstore.unity.com/packages/2d/textures-materials/sky/fantasy-skybox-free-18353
Low-Poly Simple Nature Pack (Version 1.24) by JustCreate, available on the Unity Asset Store. https://assetstore.unity.com/packages/3d/environments/landscapes/low-poly-simple-nature-pack-162153
Simple Low Poly Nature Pack (Version 1.2) by NeutronCat, available on the Unity Asset Store. https://assetstore.unity.com/packages/3d/environments/landscapes/simple-low-poly-nature-pack-157552
Boat by Pixel, available on Poly Pizza. https://poly.pizza/m/YwdXrwbN3o

River by Poly by Google, available on Poly Pizza. https://poly.pizza/m/1k7vlBS5CLB

Music and Sound Effects:

Magic by Universfield, available on Pixabay. https://pixabay.com/sound-effects/magic-142974/
Elder Land from 50 Tracks RPG Game Music Pack Loops (No Copyright) by AlkaKrab, available on Itch.io. https://alkakrab.itch.io/50-tracks-rpg-game-music-pack

Images used in the project:

Alarie, Y. (2021). Brown dirt road between green trees during daytime. Available in Unsplash. https://unsplash.com/photos/brown-dirt-road-between-green-trees-during-daytime-Dbx-FLb_fvng

Clode, D. (2019) Sphaeropteris cooperi. Available in Unsplash. https://unsplash.com/photos/photo-of-green-fern-plant-uSUwDijDGbY

Dederichs, T. (2023). A group of icebergs floating on top of a body of water. Available in Unsplash. https://unsplash.com/photos/a-group-of-icebergs-floating-on-top-of-a-body-of-water-Fn-IlgDbw5w

De Water, D. V. (Unknown). Levada trail Madeira. https://www.dreamstime.com/beautiful-landscape-view-hiking-path-nature-green-island-madeira-hike-trail-along-famous-levada-image145840601

Government of Madeira (2020). Floods and landslide damages in Madeira, Portugal, after a storm on 25 December 2020. https://floodlist.com/wp-content/uploads/2020/12/flood-and-landslide-damage-mdaeira-portugal-26-december-2020-Gov-of-Madeira-1024x678.jpg
Jones, J. (2018). Madeira Firecrest, Regulus madeirensis. https://www.birdguides.com/gallery/birds/regulus-madeirensis/981805/

Reinaldo. (2022). Caminho de Rei. Available in Unsplash. https://unsplash.com/photos/a-dirt-path-in-a-forest-_ADgB5Xm6hQ

Richardson, G. (unknown) Cytisus scoparius Scotch Broom. Available in Unsplash

Rocha, R. (2015) Adult Madeira pipistrelle Pipistrellus maderensis. Porto Moniz, Madeira. Available in Rocha, Ricardo. (2015). Look what the cat dragged in: Felis silvestris catus as predators of insular bats and instance of predation on the endangered Pipistrellus maderensis. Barbastella 8: 8-11.

Unknown. (2014) Madeira Laurel Pigeon (Columba Trocaz). https://worldofpigeons.blogspot.com/2014/11/madeira-laurel-pigeon-columba-trocaz.html

Unknown. (2016). Incêndio na Madeira: trêm mortos confirmados, um desaparecimento e mil deslocados. https://www.movenoticias.com/2016/08/incendio-na-madeira-tres-mortos-confirmados-um-desaparecido-e-mil-deslocados/

Yung, J. (2023). A bunch of white flowers that are in the grass. Available in Unsplash. https://unsplash.com/photos/a-bunch-of-white-flowers-that-are-in-the-grass-Fv9ioalFxPk

Videos used in project:

Groeneveld, M. (2022). Forest tree path woods madeira. Available in Pixabay. https://pixabay.com/videos/forest-trees-path-woods-madeira-127454/

Groeneveld, M. (2022). Mountains fog Madeira. Available on Pixabay. https://pixabay.com/videos/mountains-fog-madeira-127441/

Groeneveld, M. (2022). Trees forest madeira island. Available in Pixabay. https://pixabay.com/videos/trees-forest-madeira-madeira-island-127462/

Groeneveld, M. (2022). Trees forest woods path madeira. Available in Pixabay. https://pixabay.com/videos/trees-forest-woods-path-madeira-127452/

Nilov, M. (2021). Drone Shot a Mountainside. Available in Pexels. https://www.pexels.com/video/drone-shot-a-mountainside-8358623/