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Corresponding Author	Family Name	**Michael**
	Particle	
	Given Name	**Louis**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	University of Madeira
	Address	Funchal, Portugal
	Division	
	Organization	ITI-LARSyS
	Address	Funchal, Portugal
	Email	2038415@student.uma.pt
Author	Family Name	**Freitas**
	Particle	
	Given Name	**João**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	University of Madeira
	Address	Funchal, Portugal
	Email	2051816@student.uma.pt
Author	Family Name	**Dionísio**
	Particle	
	Given Name	**Mara**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	University of Madeira
	Address	Funchal, Portugal
	Division	
	Organization	ITI-LARSyS
	Address	Funchal, Portugal

	Email	mara.dionisio@staff.uma.pt
	ORCID	http://orcid.org/0000-0003-0684-7512
Author	Family Name	**Bermudez i Badia**
	Particle	
	Given Name	**Sergi**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	University of Madeira
	Address	Funchal, Portugal
	Division	Madeira N-LINCS
	Organization	Universidade da Madeira
	Address	Funchal, Portugal
	Email	sergi.bermudez@staff.uma.pt

Abstract	In this paper, we explore the potential of using 3D scenarios to visually reconstruct part of the rich cultural heritage of Madeira Island. Through an adventure game called: Lucky Hero's Legacy, we aim to engage teenagers in embracing and getting to know their cultural heritage. The game was designed to provide freedom for teenagers to explore the 3D scenarios of Madeira Island, thus dynamically and engagingly discovering its legends, folktales, and heritage. In this paper, we will describe the entire process, techniques used in the process of recreating the heritage in the digital world, as well as in the creation of cinematics for the transmission of educational content. Furthermore, the paper will describe a preliminary evaluation with 15 teenagers showing the game's potential in engaging the target audience with cultural heritage.

Keywords (separated by '-')	Cultural heritage - 3D modeling - Cinematics - Video game - Blender - Photogrammetry - Madeira Island - Videogame - Education

Lucky Hero's Legacy: An Interactive Game that Explores the Potential of 3D Scenarios to Engage Teenagers in Cultural Heritage

Louis Michael[1,2(✉)], João Freitas[1], Mara Dionísio[1,2], and Sergi Bermudez i Badia[1,3]

[1] University of Madeira, Funchal, Portugal
{2038415,2051816}@student.uma.pt,
{mara.dionisio,sergi.bermudez}@staff.uma.pt
[2] ITI-LARSyS, Funchal, Portugal
[3] Madeira N-LINCS, Universidade da Madeira, Funchal, Portugal

Abstract. In this paper, we explore the potential of using 3D scenarios to visually reconstruct part of the rich cultural heritage of Madeira Island. Through an adventure game called: Lucky Hero's Legacy, we aim to engage teenagers in embracing and getting to know their cultural heritage. The game was designed to provide freedom for teenagers to explore the 3D scenarios of Madeira Island, thus dynamically and engagingly discovering its legends, folktales, and heritage. In this paper, we will describe the entire process, techniques used in the process of recreating the heritage in the digital world, as well as in the creation of cinematics for the transmission of educational content. Furthermore, the paper will describe a preliminary evaluation with 15 teenagers showing the game's potential in engaging the target audience with cultural heritage.

AQ1 AQ2

Keywords: Cultural heritage · 3D modeling · Cinematics · Video game · Blender · Photogrammetry · Madeira Island · Videogame · Education

1 Introduction

Within the United Nations Agenda 2030, the Sustainable Development Goal (SDG) 11 is dedicated to cities and human settlements. In target 11.4, it is specifically called upon to "strengthen efforts to protect and safeguard the world's cultural and natural heritage" [23]. Ethnographic museums are the infrastructures responsible for conserving, displaying, and contextualizing items relevant to the field of ethnography, the systematic study of people and cultures, but a recent report regarding the current state of museums in Portugal revealed that these sorts of museums are the least attended [7]. Furthermore, there seems to be a general lack of interest from Portuguese citizens in their cultural heritage when

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compared to other countries in the EU [7]. Looking at the context where this research develops, Madeira Island, the local Ethnographic Museum has revealed that they are facing many challenges to capture the attention of the general population. However, a specific target group is even harder to engage with cultural and natural heritage: the teenagers. Cultural heritage is a legacy left to us by previous generations, and those of us living in present times have the responsibility to cherish and transmit it to the generations to come. Teenager plays an essential role in this process, and it is crucial to empower them to increase their awareness and involvement in protecting their heritage [22].

Video games are enormously popular; if, in the past, video games were considered a supplement to such media mainstays as television and the movies, this is no longer the case [20]. Not only are games popular, but they are often deeply engaging and, as a result, may well influence a wide range of attitudes and behaviors [18]. Hence, we want to take advantage of the significance of this medium in young people's lives [13] so that we can understand how to leverage games to promote cultural heritage engagement among a young audience.

Hence, the main objective of this research is to design a video game, with accurate 3D representations of Madeiran Cultural Heritage, from structures, legends, and folklore, with the intention of not only preserving Madeiran Culture in a virtual world but also to engage teenagers in getting to know more about their heritage.

2 Related Work

The preservation of cultural heritage for the digital world brings benefits in many ways; thanks to this digitization, it is possible to share the heritage for studies and the public offering. Not only this approach allows for the preservation of artifacts without being affected by corrosion or degradation with time, but it also allows for better disclosure of the culture among the society and future generations [9]. This section delves into the different approaches to represent cultural heritage in 3D format, and then it highlights current efforts and the potential of digital games to raise awareness towards cultural heritage and its preservation.

2.1 3D Techniques for Cultural Heritage Representation

For this type of process, there are two ways of gathering data by photogrammetry, which is the science and technology of making measurements through photographs. The process involves taking overlapping photographs of an object or structure and converting it into a 3D digital model [5]. The second method is the technology of using lasers to measure the object. This process results in using a beam of light to calculate the depth or measures of the object converting it to a 3D digital model [21]. In the case of photogrammetry, we can find several challenges; the most relevant is to select only what is intended. In this scenario, it is common to have a group of images and merge them to achieve a 3D object.

The second method collects depth data using a tracking device like a Kinect with infrared lights. This data is processed in a program called KinectFusion [12] that allows the 3D reconstruction of the object. This method is the most accurate in data gathering, although it is the most expensive [1]. When using one method or the other the final presentation of the 3D object is dependent on the textures used to achieve the desired result.

The Digital Michelangelo, [15] is one of the most important models and the oldest in the digitization field related to heritage. Thus, this method utilizes various tools to achieve the final result. The reconstruction of the Great Buddha of Bamiyan, in Afghanistan, used only one tool. The model ended up being reconstructed in 3D as a statue for a local museum by using static images to reconstruct this 53 m Buddha [10].

Despite photogrammetry being used for other purposes, not only for 3D reconstruction [6,24]. Some studies, present an incredible evolution of this method. For example, in the work of Covas [6], this method was used images to reconstruct two castles in Portugal that were of difficult access. The principal limitations of this method are how much it relies on the ambient involving the structure or object being photographed and the intensive process of generating precise replicas of this reconstruction. For example, it is difficult to split the background from the main object; this can be overcome by resourcing to a scanner which allows tweaking on the information gathering of the process, resulting in a more clean final product (Fig. 1). AQ3

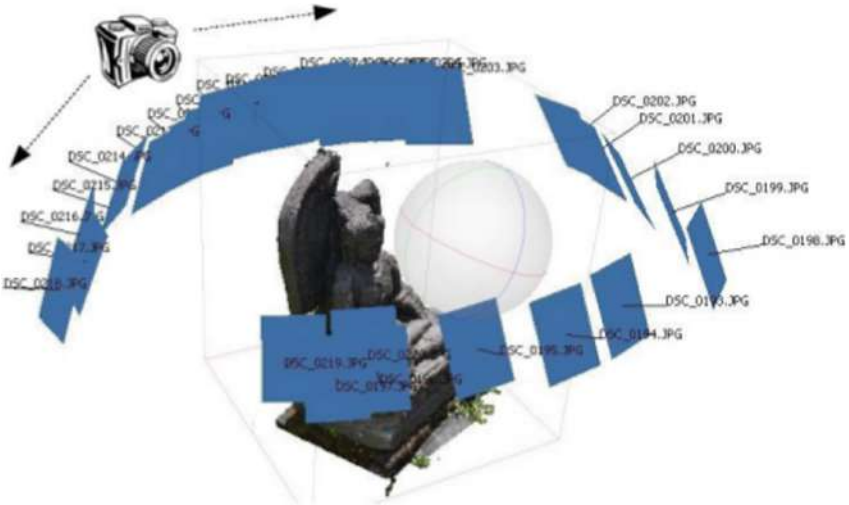

Fig. 1. Image acquisition process [24]

2.2 Cultural Heritage Representation in Video Games

Cultural Heritage (CH) dissemination and preservation have been the focus of several research projects, and initiatives [9]. The body of works spam from Games, Augmented Reality, and Virtual Reality applications [3]. One popular example where we can see CH dissemination and preservation is the game series created by Ubisoft "Assassin's Creed" [8]. The storyline is purely fictional, but the surrounding world is filled with real monuments, characters and it recreates historical events in detail from the war between the Crusaders and Saracens in the year 1191. In these types of games created for pure entertainment, the cultural heritage is used to give realism and shape the world around the game, but these games have the potential to be used for educational purposes [16].

Research shows that playing Serious Games (SG) [2] has proven benefits to acquiring greater problem-solving skills; this, combined with their strong visual components and their interactive nature, indicate that games are a powerful tool for the dissemination and preservation of cultural heritage [3]. One of the challenges that some SG faced was the lack of freedom in the player's decisions, actions, and creativity. This issue can be tackled by introducing a Sandbox aspect in the educational matter of the game. In this way, all the knowledge delivered in the game is spatially organized and should be simple activities for the user to embody the knowledge that can be discovered. Thus, this type of approach opened a new world on how we could immortalize the cultural heritage of a given area and a new way to induce knowledge to every user of this type of game [11]. Moreover, the knowledge distributed in the game is as important as the environment design surrounding that game. A virtual representation of Cultural Heritage can create adventures and reconstruct places where the player can have a contextualized experience through gaming. Another thing to consider regarding serious games is to specify the video game genre. An SG can be specifically focused on, for example: Cultural Awareness, Historical Reconstruction, Artistic/Archaeological Heritage Awareness, Architectural/Natural Heritage Awareness [17]. However, entertainment-focused video games can bring improvements on enhancing SG experience. For example, adventure-type games combined with quizzes and puzzles can improve the learning process because their 3D realistic environment allows users to interact with the world. Furthermore, video games can be suited to deliver knowledge by creating a game character and a plot, in which we can create empathy between the player and character, also in which the plot can help a better understanding of historical events and different cultures.

Despite all this potential, we can not overlook the fact that the usage of new technologies for educational purposes is often depreciated, as there is still the idea of video games being a bad influence on teenagers. This is due to the fact that the majority of games known to the general audience are focused on pure entertainment [11]. In summary, as we see the serious games industry is growing, the development of a serious game for CH needs to be well planned. Balancing the visuals (3D style) with accurate data for the educational purpose and the entertainment levels is essential to ensure that teenagers embrace the

game, allowing it to spread among the younger community and eventually lead to the intended outcome: the dissemination and preservation of CH (Fig. 2).

Fig. 2. Serious games for cultural awareness [17]

3 Lucky Hero's Legacy

The general concept was to create an adventure game on Madeira Island at the time of the discoveries. The game portrays the adventures of Lucky an endemic Lizard, in the search for the Wisdom pearl that was scattered into fragments spread around Madeira Island. To collect them, the player has to learn about Madeira's cultural heritage to gain leverage and overcome all the enemies and the challenges posed by Madeira Island terrain. To deliver knowledge about Madeira's cultural heritage, the information present in the video game is mostly based on legends and their respective locations or buildings, which are still preserved today.

3.1 Narrative

The Lucky hero Legacy fictional story was designed according to Campbell's Hero Journey [4], where the protagonist undergoes a series of adventures and challenges culminating in a significant event and transformation of the character. The events are set in the XV century, presenting the players with information regarding the history and legends of the island. After an extensive research phase, three popular legends were selected to be featured in the game narrative. As

Fig. 3. Gameplay of Lucky Hero's Legacy

the narrative was developed, several characters and maps were introduced to complement the story, thus giving meaning and fluidity (Fig. 3).

The narrative invites the audience to enter a virtual quest to follow the hero, Lucky. A Lizard that was stranded on the coast of Madeira Island, aided by an old man who saw in this lizard a potential hero. The old man tells a tale to Lucky about what is tormenting the island calling for his help to recover the pearl fragments spread across the island. Both go on an adventure through some historical locations in Madeira, presenting the audience with some information regarding the legends and history of Madeira. As the hero grows stronger in power and knowledge, facing many challenges from the evil forces of Wilson II that come across his path to replenish peace on the island.

The main narrative plot points that guides the game are:

- Lucky starts his adventure in search of the Pearl of knowledge fragments guided by the help of Sebastião. This plot point is linked with the "Legend of Machim", which is one of the first legends since it dates back t to the island's discovery(which happened by accident).[1]
- Lucky grows in power after finding a mythical sword. Thus, it is related to the "Legend of Arguim" in which the sword reassembles the one that D. Sebastião speared on the cape of Garajau.[2]

[1] This legend remounts to the first village of Madeira, Machico named after Machim, which is the protagonist in this legend. https://www.visitmadeira.pt/en-gb/madeira/legends/legend-of-machim.

[2] Legends say that D. Sebastião did not perish in battle but fled to an island called Arguim, on his way to the island speared his sword on Cape Garajau Madeira Island. https://www.visitmadeira.pt/en-gb/madeira/legends/legend-of-arguim.

- Wilson II captures the Old Man leaving Lucky hopeless. The fortress of Pico is used as a cultural reference and is one of the villain's lair.
- A crow helps Lucky to complete his adventure and become much stronger by defeating Ladislau in Câmara de Lobos.[3]
- Lucky defeats Wilson II and unshackles the Old Man. Allowing Lucky to place all the pearl fragments on the Chapel of São Vicente near the sea.[4]

3.2 Game Development

In this section, we delve into the aspects of the game development, focusing on describing the details behind the creation of the 3D environments and assets that portray the CH of the island. The game was developed in the Unity game engine and compiled for Windows.

Cultural Heritage 3D Creation
The recreation of immovable cultural heritage in the game is one of the main focus of this game, hence we recreate some of the heritage sites in the digital world, in this way preserving them for posterity. The first step was to select the cultural heritage sites according to the locations mentioned in the game's narrative. After the selection, a mood board is made based on paintings and photographs for each of the heritage sites. This process is vital for the creation of 3D models, serving as a method of comparison between the real and the virtual. Then based on the research carried out at the beginning of this process, we decided to focus on two types of recreation techniques: through photography observation and analysis, as well as through photogrammetry [24].

Photogrammetry
This method was applied only to represent the chapel of São Vicente because it has a very natural and organic shape. The first step of this process is to capture the images, and it is crucial to have a clear image without any noise or blur. To have as little noise as possible in the image it is necessary to reduce the aperture (f) and the sensitivity to light (ISO) of the camera to minimum values. For the reconstruction of the chapel, 45 photos were taken to obtain 360°C information about the object. The photo taken was loaded in the MeshRoom software[5] and with the help of the nodes defining the parameters desired. Parameters should be adjusted until the desired mesh is achieved. Then a filter is applied to smooth it out, reducing the number of vertices and increasing the simplification factor, turning it into a simplified model. In the nodes panel, the texture output is defined for this new mesh. After this phase is completed, the textured model with a good topology is ready to be imported in Blender[6] (Fig. 4).

[3] Ladislau was king of Poland and Hungary, he was defeated in battle, but he was never found. Legends say that he was the mysterious knight named Henrique Alemão that appeared in Madeira ten years after the battle. https://www.visitmadeira.pt/en-gb/madeira/legends/legend-of-ladislaus.
[4] http://www.somosmadeira.com/2015/05/capela-de-sao-vicente.html.
[5] https://alicevision.org/#meshroom.
[6] https://www.blender.org/.

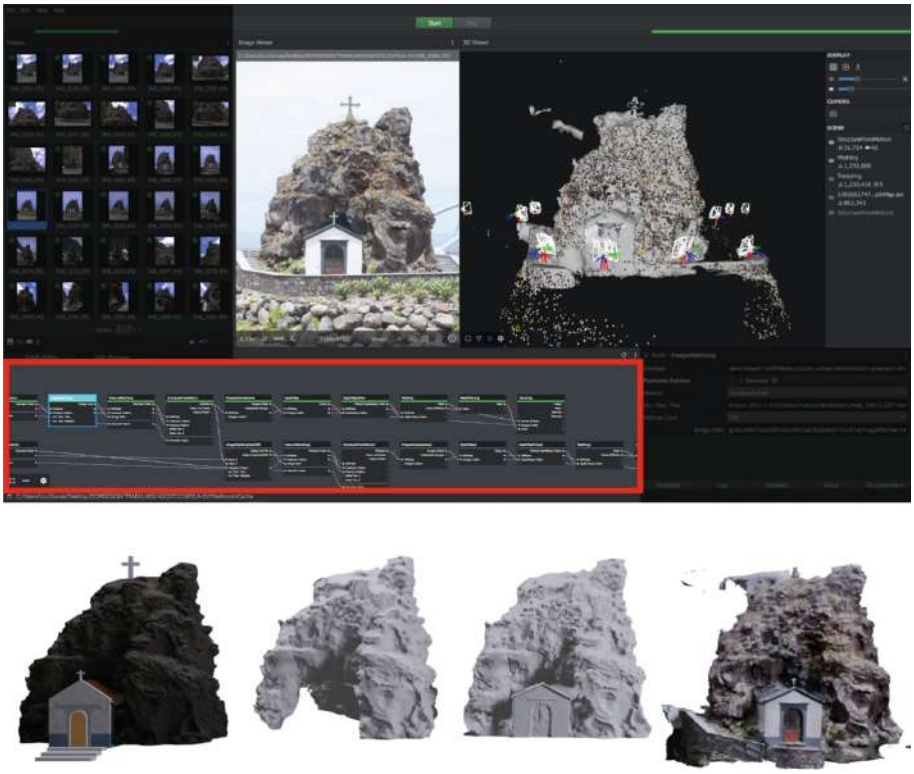

Fig. 4. Creation of the 3D model of the Capela de São Vicente in MeshRoom

3D Modeling

The chapel was placed on a plane so that its base was flat, and through the sculpting method, unnecessary mesh points were removed. At the end of this process, the mesh is more realistic, and its original texture can be removed for a better view of the base mesh itself. After reconstructing the mesh, the "Unwrap" is performed in order to be able to apply custom textures to it. The process is done using Quixel Mixer[7], applying rock textures as the base color of the mesh, made with the help of Photoshop[8], to achieve the same graphic style as the rest of the game. With the help of masks, by selecting only the deepest areas and applying a darker color to convey the notion of depth. Regarding the chapel, a painted wall texture was applied. The same process was applied to the rock.

Observation of Images

Modeling through the observation of images was the most used method because of two factors. First, due to the pandemic, it was not possible to visit the selected heritages, which interfered with the photo gathering. Thus, it was decided to

[7] https://quixel.com/mixer.
[8] https://www.adobe.com/pt/products/photoshop.html.

create a mood board with various photos and paintings related to each heritage to create an exact digital representation from that era. The second factor was related to the need to reduce the level of detail in these buildings, allowing for a simplified version. The following patrimony: Traditional Madeiran Housing, Chapel of "Nossa Senhora dos Milagres", Fort of São João Batista do Pico, and Typical Madeiran fishing boat "Xavelha" was modeled using this method. In this example, it all started by modeling the base structure of the fort by addressing image references of the structure, adding a cube and manipulating it, moving vertices, and extruding faces until the desired base shape is achieved. After having the shape of the walls, a Boolean modifier was added to remove the excess points of the structure, thus forming the grooves. This stage was completed by adding the floor and some details. In the second phase of this reconstruction, all possible details are added, such as: doors; gates; windows; roofs; stairs and rocks at the ends of the wall. All these objects are modeled following the same process, previously described. With the modeling phase concluded, the Texture phase begins. By Unwrapping the model to apply textures with ease.

CH Cinematics

The game was enriched with cinematics in key points of the gameplay. They exhibit the created 3D models in detail and add crucial information about legends or cultural facts. Five heritage cinematics were created to capture the CH value of several of the game locations. For example, in the first cinematic: Traditional Madeiran Housing, we can learn about the construction of one of the oldest shelters in Madeira Island. In the second cinematic: Chapel of Senhor dos Milagres, we can learn about the Legend of Machim and the origin of the chapel's construction. In the third cinematic: Fort of São João Batista do Pico, we learn in which era it was built and what purpose it served. In the fourth cinematic: we learn why the boat "Xavelha", is painted in different colors and the purpose of each color. In the fifth cinematic: Chapel of São Vicente, we learn a local legend about its patron saint and why this chapel was built on a rock by the sea. The Fig. 6 showcases screenshots of each of the cinematics. For each cinematic, it was necessary to develop a storyboard of where it aided to visualize where to place cameras and what information they would contain. With the help of Photoshop[9], the video interface was created, as well as the title of each and a background. Within Unity[10], a canvas was built for displaying the information adjusting the canvas to the desired positions and sizes. In this phase, the Unity Cinemachine plugin was used, which allows to control cameras by defining a focus point in which, regardless of the movement performed by the camera, it will always keep the focus in the same place, giving thus the freedom and ease of animating the scenario. It was necessary to create an animation and define the keyframes that store the coordinates at that exact moment. This process was carried out for the various desired positions and at different times. After this phase was completed, a timeline was developed in order to link all the intended elements from information, camera movement, and the narrator's voice (Fig. 5).

[9] https://www.adobe.com/pt/products/photoshop.html.
[10] https://unity.com/.

Fig. 5. 1 - 3D modeling using reference images; 2 - 3D model with textures implemented;

Fig. 6. 1 - Traditional Madeiran Housing; 2 - Chapel of "Senhor dos Milagres"; 3 - Fort of São João Batista do Pico; 4 - Typical Madeiran fishing boat "Xavelha"; 5 - Chapel of São Vicente;

4 Evaluation

4.1 Protocol

Participants were recruited for this study using a convenience sample; they needed a computer, mouse, keyboard, audio output, and internet connection. Each participant was given a link to a Discord server created for this evaluation and had access to a link to download the game. The evaluation protocol was the following:

- (1) Consent form: where the user accepts to volunteer to be part of this study evaluation.
- (2) A pre-questionnaire probing: Age, Gender, Video games experience, and a set of four questions to measure cultural knowledge about Madeira Island, about legends and some cultural heritage.
- (3) Gameplay: each user was asked to share their screen to allow the observation of their behavior during gameplay. At the end of the game, each user was put through an in-game test of five questions about cultural facts and legends present in the game that needed to be answered to be able to complete the experience. Each response was collected by the observers and placed in a private questionnaire.
- (4) A post-questionnaire consisting: of four questions to measure cultural knowledge about Madeira Island (same as in the pre-questionnaire), a reduced version of Game User Experience Satisfaction Scale (GUESS scale) [14], and an open section for general feedback of the game experience.

4.2 Measures

To evaluate the overall game experience, we used a reduced version of the GUESS scale [19] called: GUESS-18 [14]. It consists of eighteen questions with a total of eight parameters related to experience satisfaction: Usability, Narrative, Play Engrossment, Satisfaction, Creativity, Sound, Visuals and Self Gratification, Communication. This last parameter was not used in our questionnaire as our game does not support multiplayer or co-op features. GUESS-18 uses an evaluation from one to seven points, being one point equal to "completely disagree" and seven "completely agree". Once the data is all collected, the mean is calculated of each parameter, giving a result for each criterion. In the end, each result would be added, forming a composite score that is later measured on a scale from nine to sixty-three points.

To evaluate if the game had produced any awareness and knowledge regarding CH, we applied one questionnaire with items designed by us about the local CH. Applying this before and after the gameplay experience allowed us to compare the influence of the game on the participants' knowledge.

4.3 Results

Demography
Testing was done with fifteen male users with an average age of fifteen years old. The majority played video games frequently, with a high count of hours in game.

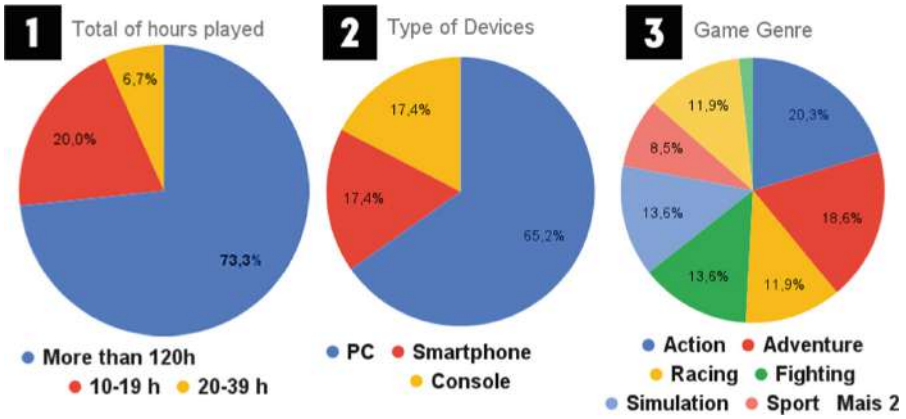

Fig. 7. 1 - Total of hours played of users tested; 2 - Type of devices most used by the users; 3 - Game Genre played by the users;

Hence, most of the users resource the use of the computer as the main source of entertainment. Leading to an increase of capabilities and knowledge of different video game genres (Fig. 7).

In-Game Questionnaire
As we mentioned, five multiple-choice questions about the cultural heritage and legends were included within the game-play. These appeared at the end of the video game. Once the results from the in-game questionnaire were evaluated, it was possible to realize that the majority of our users had chosen the right answer (85.3%) and only (14.7%) were incorrect answers, see Fig. 8.

Madeira's Cultural Heritage Knowledge
When comparing the results obtained in the pre-questionnaire versus the results obtained in the post-questionnaire, we can see a clear positive outcome. Thus, it shows that the experience successfully delivered knowledge to our participants about Madeira's Cultural Heritage. Since more users got the correct answers after the game experience.

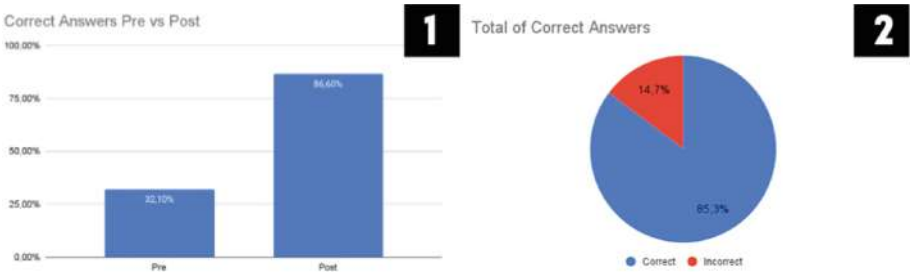

Fig. 8. 1 - Comparison of correct answers pre vs post questionnaire; 2 - Total of correct answers related to the in-game questionnaire;

Game Experience

In the last parameter of evaluation, we used the GUESS-18 scale to evaluate our game in general. The graphic demonstrates the mean scores for the GUESS-18 parameters were between 5.4 and 6.5 (on a scale from 1 (completely disagree) to 7 (completely agree). The parameters with higher scores were: Enjoyment, Personal Gratification, and Visual Aesthetics. This indicates that the 3D visuals and the representation of Madeiran Culture in the game were successfully portrayed, which allowed for enjoyment of the game and enabled some degree of learning (Fig. 9).

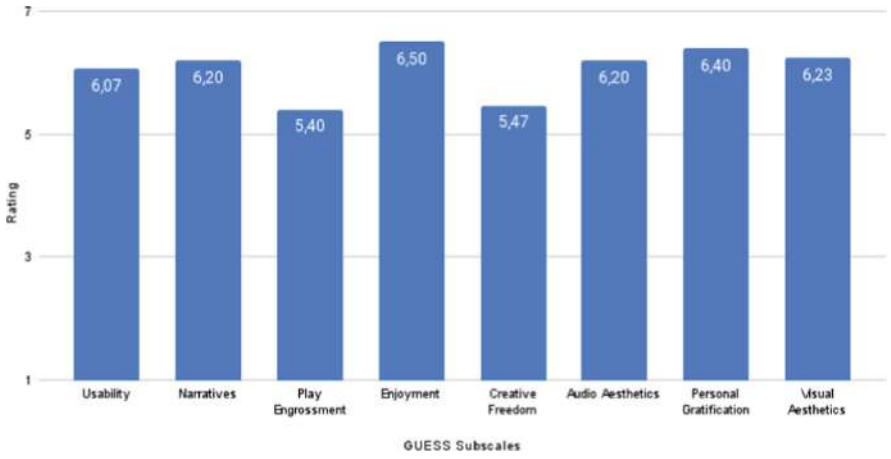

Fig. 9. Results of the Guess 18 sub-scales, related to the overall aspects of the game.

5 Discussion

An adventure game enriched with the cultural heritage of Madeira Island was created. The game incorporates in its narrative several legends of Madeira Island

and part of its cultural heritage is portrayed in a total of five heritage cinematics. The information described in these cinematics was conceived in order to convey the cultural value in the best possible way. Since our target audience is teenagers, we tried to describe this information in a more intuitive way for those ages. The use of a narrator was successful in bring out some of the most relevant details and information but the camera animations used gave more details and dynamism to the showcasing of the heritage sites. Results show that these cinematics were a successful approach to deliver the information that we intend to pass on to the teenagers. In the pre-questionnaire it was possible to verify that 32.1% of the users answered correctly, and after viewing the cinematics this percentage increased to 86.6%, thus demonstrating that there was an increase in cultural knowledge. In the game Lucky Hero's Legacy, we faced the same situation, where I highlight the comment of a user: "I enjoyed seeing the chapel of São Vicente that looks just like the real one and I also learned new things like the legends of Wilson II and also about the island I live on", thus demonstrating that the learning factor was present in this experience.

It is important to highlight that during the development of the game we had some unexpected situations related the pandemic situation. The vast majority of the 3D models had to be build based on reference images since we were not able to visit some of the heritage sites in question. Thanks to this game, we developed a more detailed and accurate workflow with regard to 3D modeling. Defining the steps in a more practical and faster way. We also developed skills in photogrammetry, achieving a good final result. To improve this process, it would be an idea to visit the heritage sites themselves as well as talk to historians, to be able to add more important details regarding certain periods. This information could influence the way in which the cinematics are carried out, thus portraying these details in animations that help the user to retain more information about a particular heritage and its time.

6 Future Work

The CH content present in the game is limited, as we only approach three legends and five heritage sites. Hence, the game could be expanded by adding more legends and heritage throughout Madeira Island, increasing the CH content present in the game. Looking at the results, it is possible to say that this game has the potential to be a learning tool for young people. In the future, it would be interesting to present the game to schools in partnership with the Local Department of Education to evaluate it on a larger scale and verify whether an expansion of the game would be viable. Furthermore, a partnership could be established with several museums island to showcase artifacts belonging to their collections in the game. By including these artifacts in game-play we could increase the awareness about them eventually creating a curiosity to visit the museums and see the artifacts live. Regarding the game design, it would be valuable to increase player interaction, and new Non-Playable Characters could be introduced with different traditional costumes from each of the local villages, where the daily

life of the villagers in the time of the discoveries could be presented, thus creating secondary missions. It could be interesting to increase the gamification by allowing players to collect, buy and sell heritage items.

7 Conclusion

This research effort showcases the potential that an adventure game enhanced with cultural characteristics can have as an effective method in raising awareness towards CH among young people. Part of Lucky Hero's Legacy game process was presented, highlighting the critical role of 3D models, visuals and cinematics in portraying cultural heritage scenarios and stories. The 3D models, together with the scenery, played an essential role in motivating and creating enthusiasm among the participants to know a little about our past and our culture.

To summarize, our main contribution is the design of this artifact: Lucky Hero's Legacy game. The game incorporates different methods: creating scenarios through heights maps, creating 3D models using the photogrammetry method, and by observation. This work also shows that it is possible to learn about culture by portraying cultural heritage in a game and that 3D artifacts play an essential role. Furthermore, thanks to this game, it was possible to transfer part of our heritage to a digital world, thus preserving it for future generations and maintaining proximity between the past and the future.

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