Balancing Gameplay Elements and Interactive Digital Storytelling in Virtual Reality applications of War Heritage

S. Rizvic[1] [iD], D. Boskovic[1] [iD], and B. Mijatovic[2]

[1]University of Sarajevo - Faculty of Electrical Engineering, Bosnia and Herzegovina
[2]Sarajevo School of Science and Technology, Bosnia and Herzegovina

Abstract
War or Dark Heritage is challenging for digital presentation as it involves tragic events and the loss of human lives. Due to the same considerations, the importance of commemorating such a heritage is paramount. Virtual Reality offers tremendous possibilities for immersive experiences of war heritage. In the use case of the Battle on Kozara VR application, we will show how a combination of Interactive Digital Storytelling and gameplays can result in an educational and attractive immersive presentation of a battle from WWII, very important for the history of Bosnia and Herzegovina. User experience evaluation of museum visitors will show if we have obtained the right balance between heavy and tragic historical facts and challenging tasks for users to introduce them to the lives of Battle participants and enable them to relive the Battle themselves.
Index Terms - serious games, advanced interactive digital storytelling, war heritage, dark heritage, gameplays, gamification

1. Introduction

Dark heritage refers to "aspects of cultural heritage that are related to times of conflict, death, and suffering" [THSKK19]. We also call it "war heritage" if it originated from wars and armed conflicts. It includes both tangible (war monuments, remains, battlefields) and intangible elements (stories about battles, atrocities, genocide, and suffering). Its commemoration and interpretation have impact on national identity, reconciliation and reflection on human qualities and its stories, objects, and places help visitors to connect the past, present, and future. [PBU19]

War heritage digital presentation includes certain challenges. Undoubtedly the events and facts to be presented carry a tragic dimension due to the loss of lives and human suffering. Those elements certainly have to be included in the storytelling parts of digital applications. However, Virtual and Augmented reality quite often include gamification elements that actually attract users to these technologies. In the case of war heritage we need to find the right balance between the heavy and tragic historical facts and possible gameplays that should contribute to the edutainment of the applications, but by no means should turn the presentation into something not appropriate.

Battle on Kozara VR project is a case study through which we will describe our solution to obtaining that balance and presenting an important WWII battle in an educational and attractive way to the museum visitors. Created VR application completes the exhibition of the Memorial Museum in Mrakovica, (near Prijedor, Bosnia and Herzegovina), where the Battle took place, and enables the vis-

itors to experience this historical event. A similar methodology can be used for presenting different war heritage events and sites.

The paper is structured in the following way: Section 2 describes the related work on the importance of war heritage digitization projects, in Section 3 we offer historical info about the Battle and a detailed presentation of our VR application through the description of the application structure, 360 video recording, 3D modeling, interactive digital storytelling and gameplays development. Section 4 shows the feedback from users through a user experience evaluation study. In Conclusion, we summarize our contributions and lessons learned.

2. Related Work

War has been an integral part of human history, shaping civilizations, cultures, and societies in profound ways. However, the passage of time, natural decay, and the ravages of war itself often result in the loss or deterioration of precious artifacts and documents that form parts of our war heritage. In recent years, digitization has emerged as a powerful tool to safeguard and preserve war heritage, allowing us to document, conserve, and share these valuable resources for current and future generations.

Nevertheless, the digitization of war heritage also presents challenges and ethical considerations. The process of digitization requires careful handling of delicate artifacts, and proper standards and protocols must be followed to ensure accurate representation and preservation. To begin with, digitization workflows must be created and many authors are working on these topics [BTN13] [HLE15] [OMSRM19]. These sites not only stand the test of time

but also vandals, as pointed out in [RH20] : "There is no doubt that the built cultural heritage, as a shared history and culture, remains in danger because of the natural and human risks to which it is exposed on a daily basis." Examples can be found throughout the world [FA19] [BMM*20]. They all tackle this sensitive process, and war heritage is the most sensitive of them all. Many scars left from the wars are becoming important cultural heritage as suggested in [AD22]: "In the last twenty years, restoration/recovery/enhancement projects focused more on the permanent fortifications, leaving in the background the interest in the "care" of minor vestiges such as trenches, walkways, defensive posts, craters due to bombings, underground shelters." . Moreover, many contested lands have no laws regulating cultural heritage [HF20], and reconstruction of cultural heritage after the war can prove to be tedious work [Leg18] showing again the great potential of the digitization process.

However, it is not only the preservation of the cultural heritage that is important in war heritage but also its tourist potential. As stated in [FIB17]: "Tourism based on the valorization of places in which historical heritage is the main attraction is one of the fastest growing segments of cultural tourism." In that manner, war heritage sites are places of interest for many tourists as well as adventurers. The research in Northern Finland shows that "The activities of hobbyists using metal detectors can be regarded in some cases as an asset to archaeological research." [STH16]

Lastly, war heritage and its preservation and reconstruction can lead to reconciliation. In the devastating war in Bosnia, many heritage sites were completely destroyed and, as pointed in [Kud20], out to work of commissions that deemed necessary to reconstruct destroyed objects like Ferhadija Mosque in Banja Luka, Mostar Old Bridge, Aladza Mosque in Foca. They stated that: "This was not just for the purpose of restoring a city's splendor and architectural value; it was also the only possible way to regain trust and encourage peace." Other authors also pointed out similar findings: "The current projects seeking to reconstruct Bosnia's cultural heritage can contribute to a better understanding between groups and reestablish the collective memory of a people diminished by war." [Sup05]

Combining all of these aspects: digitization, war heritage, and tourism, we research the possibilities of preserving knowledge and disseminating it using new technologies. The projects like [OIKB*22] show great potential in using extended reality for these tasks. Our projects about Sarajevo survival tools [RSHK12] and Sarajevo War tunnel [JIK19] [RBO*19] showed promising results in user studies. Users enjoyed listening to the stories and the ability to experience the passage through the war tunnel inside a virtual environment. We believe that this innovative way of reliving some of the historical events through gamification is an important step in preserving the war heritage and our research continues in that direction.

3. Battle on Kozara VR application

After the successful development of the Battle on Neretva VR application and its installation in the Museum in Jablanica, Bosnia and Herzegovina [RMBIK22], we have been invited by the Memorial Museum in Mrakovica, to create a VR presentation of Battle on Kozara. This Battle had the same historical significance as the Battle on Neretva and it showed the courage of Yugoslav anti-fascist forces in fighting the much more powerful enemy of German, Italian, Croat and Serb collaborators forces at Kozara Mountain. Created application is installed on two VR set-ups and completes the physical exhibition of the Museum with the VR experience.

3.1. Historical info

In the spring of 1942, Yugoslav Partisans in Central and Western Bosnia liberated Bosanski Petrovac, Drvar, Glamoc and Prijedor. On 20th May the 1st Krajina Assault Brigade was founded, and the next day it obtained tanks and a modest air force. The free territory stretched from the river Sava south across the mountains Kozara and Grmec. During the winter, Partisans inflicted heavy casualties on the Germans. A great loss for the Partisans was the death of their capable and distinguished commander, Mladen Stojanovic, known as "Komandant Mladen".

In the summer of 1942, the West Bosnia fascist combat group surrounded Kozara with three rings of soldiers. The famous Battle of Kozara lasted from mid-June to mid-July 1942, when partisan forces tried to break through the enemy's encirclement and save the population of Kozara on several occasions. The biggest breakthrough took place in the night between July 3th and 4th. Following the offensive, 68,600 civilians, including 23,585 children, were taken from the towns and villages of Kozara to concentration camps.

It would be difficult to mark all the places and preserve the memory of all those who were a part of it. That is why in 1972, a memorial complex on Mrakovica was built, consisting of the Revolution Monument (Fig. 1), the Memorial Wall, and the Memorial Museum, in which now, with the help of the Virtual Reality application, the Kozara forest will tell the story of the Battle and its heroes. The Virtual Reality application allows visitors of the Memorial Museum in Mrakovica to take part in this famous battle and to solve the tasks that are set before them to build the imposing Monument to the Revolution.

Figure 1: *Monument to the Battle on Kozara, Mrakovica, Bosnia and Herzegovina*

3.2. Application structure

Battle on Kozara VR application consists of 360 videos of locations where the Battle took place inhabited by actors playing selected historical characters, a virtual environment of Kozara forest with trees-storytellers, a quiz with questions from stories, and a virtual environment with a 3D model of Kozara monument. Five gameplays are implemented in the application, each in a different 3D scene. In the beginning, after language selection, the user sees a 360 video of Kozara forest where the commander of partisan forces dr. Mladen Stojanovic and Mika Mandic, female heroes of Kozara history, tell their stories. After that, the user finds him/herself in the virtual forest where he/she should move from one storytelling tree to another. Next to each talking tree, a portal opens for entering a gameplay.

After the successful completion of all gameplays, the user is again in VR video, getting familiar with the tragic destiny of Mira Cikota, who was killed by enemies leaving her little daughter an orphan. Then the users are presented with questions from stories they heard. After each correct answer, a part of the Kozara monument is built.

At the end of the application, the user can browse around the monument and explore better all its parts. The application structure scheme is presented in Fig.2.

The application was built in Unity 3D with the help of their Interaction toolkit, a package that provides an interaction system to easily build VR games and experiences. It highly accelerates the development process since it already provides common components needed for VR development. The development process was mostly smooth and we encountered only a few issues. One of the issues we did encounter was the rendering of videos with alpha channels. Initially, the formats which we used would either not render at all, or would display the alpha channels that were supposed to be transparent, in black. After reading through the documentation we discovered that webm formats with VP8 codecs were supported, and were able to render alpha channels invisible. Unity also has a built-in transcoding functionality, which allows us to quickly transcode our videos into the needed codec. Since these videos appeared only in parts of the experience where it was known where the player was, we could make sure that they were only being viewed from the front. This way our 2D actors could appear in the 3D world as if they were there. Other than encountering the actors, the user could also listen to the trees telling stories. In order for them to be able to talk, we used Blender's facial mocap feature, and tracked our actor's facial motions onto 3D models of trees with faces. Finally, the gameplays and a quiz were created, which made the experience complete. Here, we utilized the interaction toolkit to create interactable, grabbable objects, make the player move and teleport around, as well as Unity's built-in components, such as their UI system to make the quiz and the general in-experience UI.

3.3. 360 video

The use of 360 videos in VR applications for cultural heritage contributes to the immersion of users, as they see a real appearance of the historical site around them. Based on that video, 3D models of cultural monuments' virtual reconstructions can be added using compositing. In our applications, we add actors-storytellers recorded against the green screen.

In the Battle on Kozara VR application, we recorded 360 videos of the monument area and several places in the forest around to provide backgrounds for the storytelling parts of the application. We also used 360 videos as a reference for adjusting the 3D model of the monument.

360 videos were recorded using Garmin VIRB 360 camera (Fig. 3). It has two lenses and can record up to 5,7K video quality. Recording in 360 has many challenges. One of them is that everything is inside the camera frame, so the crew needs to hide behind some physical barrier. Filming exteriors is easier due to the natural illumination of the scene, while interiors need to be illuminated with practical lights, as no film equipment should be visible in the shot. For this particular filming, the main challenge was the bright sunlight creating sharp shadows in the forest, so some parts of the shot tended to be overexposed. We performed some color correction postproduction to overcome this problem.

3.4. 3D modelling

For our application, we created 3D models of talking trees, a village house, and Kozara monument. Talking trees were modeled in 3ds max and animated upon the voiceover of the actor recorded before, using professional sound recording equipment. Trees models were created based on 360 videos and photographs of the forest around the monument and museum.

Kozara monument was created using drone photogrammetry. Some modeling has been added to the final mesh obtained from the photogrammetry software. All models needed to be optimized for real-time displaying purposes. The number of polygons was reduced as well as the size of textures.

The village house was created based on photographs from an ethnological museum in Prijedor. We recreated the original textures and materials, as well as the small objects from the interior (Fig. 4). Some of these objects were made interactive in the Unity scene, so the users could explore them and move them around. This model was used for the gameplay where users should pack the food for comrades. The bag where food was to be packed is modeled as a realistic replica of bags villagers from Kozara used in the past.

The rest of the assets, such as the forest environment, gameplay environments, headquarters house, shelter for wounded, herbs models, and smaller objects used in gameplays were either modeled or purchased online.

3.5. Storytelling

Interactive Digital Storytelling (IDS) has several definitions. Handler Miller defines digital storytelling as the use of digital media platforms and interactivity for narrative purposes, either for fictional or non-fiction stories [HM04]. In this kind of storytelling, the story is not linear, but the user has control over the storytelling. IDS is presently the main methodology for communicating information in modern internet-based media, Virtual and Augmented Reality applications, and computer games. The main challenge is

Figure 2: *Application structure scheme, Battle on Kozara VR*

how to overcome the "narrative paradox", the conflict between the interactor's freedom of choice (or agency) and the author's control over the story world [Sme19]. We faced this problem during the development of our digital heritage applications, as we usually offered the user historical information in form of several short stories. Considering that those stories were implemented to be watched on demand, it was possible that some of them will never be selected.

Therefore in our storytelling methodology called hyper-storytelling, we introduced a motivation factor for users to watch all stories [RDA*17]. Usually, we would finish the application with a quiz containing information presented in storytelling and, if the user replies correctly, he/she would be offered additional attractive activities (sailing the ancient boat, exploring historical monuments, interacting with museum exhibits). The same concept is implemented in the Battle on Kozara VR application, but it is being improved into the Advanced IDS, by adding the gameplays [RBM23].

Our storytelling follows a so-called "Aristotelian" theater approach, in which the audience is supposed to "empathize" (catharsis). We deliberately have not opted for the "epic theater" approach from Brecht and Piscator, although it is more modern and can better deal with dramatic and traumatizing memories. Our goal was not move the audience to change society for the better, but to motivate them to learn from tragic historical events and commemorate them using VR technology.

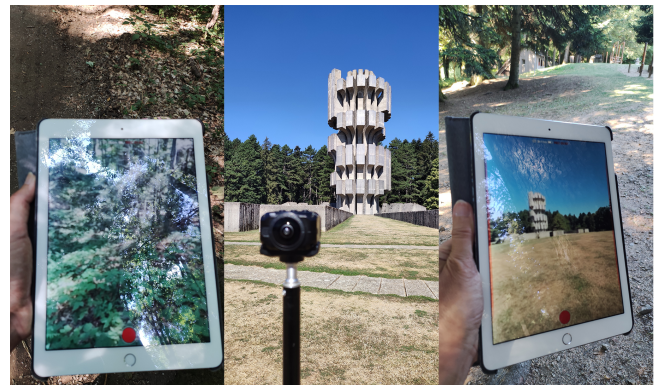We have four characters-storytellers in this application. They are

Figure 3: *Filming 360 videos*

historical personalities who have been selected to communicate the values related to national identity, historical facts, and reflection on human qualities. Dr. Mladen Stojanovic is the leader of Partisans in the Bosanska Krajina region, where mountain Kozara is located. An educated and prominent person, a medical doctor, he was very popular and respected in the region and his joining the resistance forces motivated many people to join as well. In our story, he is introducing the topic to the user inviting him to Kozara.

Mika Mandic was an old woman from a village in Kozara, famous for her resistance against Croat Fascist forces (ustase). When captured by them she has torn her blouse and said that her breasts have fed six sons, heroes, and at least one of them will avenge her. After that, she was brutally killed. In our story, Mika is showing the user the right path through the forest.

Mira Cikota was a member of the underground resistance to fascist forces. After expelling from Prijedor, she was captured by enemies, torn away from her little daughter, tortured, and executed by hanging. Her last letter to her parents was found and it is preserved in the Memorial Museum, as a testimony of the courage and dissent of the Kozara people. In our story, she is telling her emotional testimony. At the end of the application, she is inviting the users to build the monument through their answers to the quiz and commemorate Kozara.

The fourth character is a random partisan who tells us the story of Mira Cikota and her tragic destiny. Aside from these characters played by professional actors recorded on green screen, we introduced the talking trees telling short snippets of storytelling and recreating the timeline of the Battle. The main emphasis in our storytelling is on the suffering of the Kozara people, who had to hide from enemies in the forest and caves, without food or medicines. We described their support to the partisan fighters in spite of the horrible consequences they would suffer if discovered by fascists.

The storytelling we implemented serves as a teaser to the detailed information provided in the museum. It is supported by several computer animations showing the positions of Partisan fighters and the enemy in different stages of the Battle. It was not easy to select from a multitude of important historical facts presented by Museum curators. Our goal was to balance the storytelling with gameplays and keep the users attentive until the end of the application.

3.6. Gameplays

A combination of storytelling and gameplays has proved to be a good solution for increasing the edutainment factor of digital cultural heritage applications. Gameplays contribute to motivating users to explore the whole produced digital content thus overcoming the narrative paradox problem. They introduce gamification elements in cultural heritage presentations and offer challenges to the users.

The application is built as a PC executable file. This ensures that different models of Oculus devices can run it, and the computing is done on the computer rather than on the device. Additionally, the application is built for museum use and for the group visits it is good to have the option of showing the content on the LCD screen also. It is made as combination of 360 videos, five different gameplays and a forest scene which connect these five gameplays. Interaction in the application does not use teleport for movement but the locomotion through the joystick on the Oculus controller. This gives a more immersive feel and it helps with the mechanics for some gameplay, where the users have to physically duck to overcome obstacles. Trigger and grab buttons are used for the interaction with menus and items that the users find in the game. After viewing the first 360 video and listening to storytellers, the users

are transported to the forest which they have to navigate and solve each gameplay that they encounter.

In the first gameplay, the user can experience the feelings of horror and fear that Kozara people went through, being hunted by enemies in the forest and hiding in caves and shelters. The clock is ticking while the user navigates through the terrain to get to the destination marked by a red arrow (Figure 6.a). Sometimes there is a need to crawl under the branches or jump over obstacles.

Figure 4: *Village house 3D model*

Figure 5: *The storytellers: Dr. Mladen Stojanovic (up left), a partisan (up right), Mira Cikota (down left), Mika Mandic (down right)*

The second gameplay (Figure 6.c) recreates the bombing that happened so often during WWII in Kozara. Enemy planes are flying over the area spreading their dangerous cargo, while the user should hide in the holes in the terrain, crouching to avoid shrapnels and explosions. The goal is to reach the house where the partisan headquarters is located. The users have 3 lives to overcome this challenge.

In the third gameplay (Figure 6b) the user is tasked to mow the grass in a traditional way using a vintage cutter tool. This task introduces the users with the way how the grass was mowed before the invention of mowing machines. This skill now belongs to intangible cultural heritage. After mowing, the user should pick three

herbs that were used as medicines for wounded partisans during the Battle.

The fourth gameplay is located in a traditional village house from Kozara (Figure 6.d). The user should look for food items suitable for packing into a peasant bag and taking to the comrades at the battlefield. The mission is accomplished when all items are found and placed in the bag.

In the fifth gameplay, the task is to make a stretcher for carrying wounded soldiers from improvised material items found in the shelter (Figure 6.e). The user should discover which items around him/her are suitable and place them in a position to assemble the stretcher.

All gameplays present actions people in Kozara used to perform and events they experienced. This way the same experience can be transferred to the museum visitor, to complete the knowledge about the difficult times of the Battle learned through storytelling and physical exhibition. Considering that museum visitors can be people of any generation, computer literacy, and intellectual background, we tailored the gameplays to be challenging enough for young users and not too difficult for older or less experienced visitors.

4. User experience evaluation

Common user experience (UX) evaluation objectives are novel interaction approaches or success in exploitation of technology in use. For this research we focused on balance of gameplays and storytelling in War Heritage VR applications to obtain informative feedback for designers and developers.

The experiment was conducted at the University of Sarajevo (16 participants) and the Memorial Museum (6 participants). At both sites the participants were recruited by invitation. Evaluation sessions were conducted individually with average duration around 30 minutes, but with significant differences due to abilities of users to complete the gameplay. Since presentations of digital heritage are intended for a broad audience, we have invited different user types representatives, balancing their age, gender and professional background.

Prior to conducting the experiment, the participants were informed about the experiment procedure and their tasks. During the experiment, the users were expected to remain standing. Precautionary measures were taken to ensure participants' safety and well being. Participants were observed during the experiment and any significant interaction issues were noted and assistance provided if needed. Immediately after experiencing the VR application the users were asked to fill in the web-based questionnaire. They were advised to freely express their subjective experience when answering the questions.

The main part of the UX questionnaire was designed aiming towards user satisfaction with gameplays and narrative and their balance. This evaluation is conducted in addition to our standard instrument for measuring important constructs as Immersion and Edutainment not usually included in the common UX questionnaires used for business applications [BRO*17]. In further text we refer to that questionnaire as a second part of the UX evaluation.

The first part provided us with user subjective assessment of balance between gameplays and narrative. This balance is reflected also in the second part of our evaluation, since we were evaluating if our approach contributed to the common UX metrics we use for VR applications: Edutainment and Immersion; or this approach caused a decrease in these UX measurements.

The results of the main part of our evaluation are presented in Table 1. Questions are split by evaluation construct, with Gx directed towards Gameplays preference and Nx towards Narrative preference, both linked to Balancing Gameplays and Narrative. Responses were delivered on a 5-point Likert scale, with 1-strong disagreement and 5-strong agreement. Question N1 is presenting negative attitude towards Gameplays, hence the responses were linked to Narrative preference. Question B2 is linked to building the Kozara monument at the end, since the access to the activity in the VR application is granted to users who complete all Gameplays and answer all questions related to the Narrative.

Table 1: *Respective summary statistics per Question: Mean and Standard Deviation (SD).*

Item	Mean	SD
G1 The Gameplays in VR Battle on Kozara keep the attention and motivate users to complete the application	4.68	0.48
G2 The Gameplays are diverse and the change of scene retains the attention	4.50	0.51
G3 Gameplays facilitate immersion and focus on narrative of the Battle of Kozara	4.32	0.65
G4 Moving through the forest and hearing the sounds of war make the strongest impression	4.00	0.69
G5 The Gameplays are successful in illustrating the VR application topic	4.55	0.51
N1 The Gameplays are difficult and there are too many of them	2.41	0.96
N2 I liked the actors' narrations the most	3.73	0.83
N3 Narrative and stories should last longer	3.09	1.19
B1 All elements in the VR application are sufficiently represented and sufficient duration	4.00	0.76
B2 Building Kozara monument at the end is a significant part of the application	4.41	0.59

The summary statistics strongly indicate users' preference to Gameplays: with mean values in the range of 4.00 and 4.68 and standard deviation from 0.48 to 0.69 compared to Narrative preference mean values from 2.41 to 3.73 and standard deviation from 0.83 to 1.19. Users' grading for questions linked to Balance of these two VR application components are comparable to grading for the Gameplays.

The results of the second part of the evaluation are in line with

Figure 6: *Gameplays: a) hiding from enemies (up left), b) collecting herbs (up middle), c) hiding from bombs (up right), d) packing food (down left), e) making stretcher (down right)*

our prediction that the mixture of the Gameplays with the Narrative has a positive effect on Immersion and Edutainment. Mean values for the items measuring the Immersion are in the range of 4.00 and 4.59, and for the Edutainment items in the range of 4.27 and 4.59. Mean values for items reflecting ease of use are in the range of 2.32 and 4.32. The results for this part of the evaluation are presented graphically in Fig. 7 showing frequencies of answers per each item linked to the specific construct of interest.

The highest ratings for Edutainment were for the following items: ED4 - "I would love to see more VR stories about historical events"; ED2 - "I really liked learning more about what happened during the Battle of Kozara"; and for the ED5 - "I was touched by Mira Cikota story". The highest rated items for Immersion were: IM3 - "The Gameplays motivated me to move further through the VR application"; IM7 - "I liked the VR view of the hut" and IM8 "VR environment of the forest is realistic". The results are confirming the positive effects of introducing the Gameplays to promote Edutainment and retain Immersion for these challenging and difficult topics as War Heritage, even in presence of decreased satisfaction regarding the ease of use.

Figure 7: *Evaluation of Immersion, Edutainment and Easy of Use*

5. Conclusions

In this paper, we present the use of the Advanced Interactive Digital Storytelling for balancing gameplays and Interactive Digital Storytelling in War Heritage digital presentations. WWII Battle on Kozara was presented in a VR application through a combination of educational and entertainment elements. In the educational part, actors-narrators playing historical characters are storytelling about
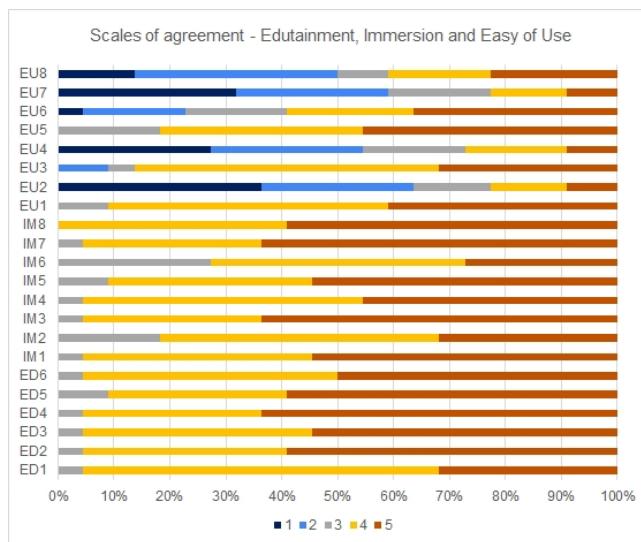
the Battle, through their personal stories. Trees from Kozara mountain tell stories about a horrific manhunt on civilians hidden in the forest and their killing or sending to concentration camps. This devastating information is balanced with gameplays where the users should learn how to avoid bombing, find shelters, collect plants as cures for illness, prepare food, and assist wounded comrades.

User experience evaluation showed the success of this methodology. The users have learned about this important historical event while experiencing the life of soldiers and civilians during the WWII. The statistical results are in line with answers to open question, proving that users were offered with unique experience of humanized and personalized account of the War Heritage events. Some important suggestions on user interaction expressed in the survey (movement causing motion sickness, length of gameplays, easy of use issues linked to instructions and hints) will be implemented in our future projects.

The described methodology can be used in any other war heritage presentation, contributing to the preservation and commemoration of difficult events from our history. Of course, the VR application should be a part of the physical exhibition, completing it by offering the experience aspect, stated as very valuable by museum visitors.

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