

Evaluation of Edutainment in VR Serious Games for Cultural Heritage

Hana Ibrić*
Supervisor Bojan Mijatović†

University Sarajevo School of Science and Technology
Faculty of Computer Science - Game Design and Development
Sarajevo, Bosnia and Herzegovina

Abstract

Games have great potential as teaching tools, due to their immersive narratives that make players engage with their worlds. In this research paper, we present an evaluation of a VR serious game that enables users to experience history. A valuable process to measure the quality of these applications is user experience evaluation. The SheLeadersVR educational game is installed in museums in five different Balkan countries, and it enables users to meet medieval queens of those countries, visit the places where they lived and find the artifacts that used to belong to them. We have determined the quality of this application by evaluating its edutainment level (educational entertainment) using qualitative user experience analysis. The conducted user study shows the achieved level of edutainment and confirms that SheLeadersVR effectively captures users' interest in medieval Balkan history and historical sites. Users appreciated the environments, storytelling, and narration, emphasizing how the app brought cultural heritage to life. This paper contributes to the research on VR-based educational experiences by demonstrating an effective methodology for assessing edutainment quality, therefore guiding the development of future VR learning applications.

Keywords: Virtual Reality, Edutainment, User Experience Evaluation, Serious Games, Immersive Learning

1 Introduction

The presentation of cultural heritage through digital technologies is becoming a part of modern museum experiences. Virtual Reality (VR) enables users to explore historical narratives in an engaging way, offering access to stories and artifacts that may not be available in physical exhibitions. By using VR, museums can connect the past with the present, and provide visitors with an interactive and educational journey through history.

The Laboratory for Computer Graphics – Sarajevo Graphics Group (SGG) [1] is a multidisciplinary research

group that specializes in the use of 3D technologies for cultural heritage presentation. The group consists of computer graphics experts who collaborate with archaeologists, historians, visual artists, writers, and film professionals to design and implement interactive digital storytelling experiences.

For over 15 years, SGG has been developing VR applications that preserve and present cultural heritage in innovative ways. These applications serve as digital reconstructions of historical sites, figures, and artifacts, allowing users to experience history in a more engaging way. An example is the SheLeadersVR educational game, which brings medieval queens from five Balkan countries to life. Through this application, users can visit the historical sites where these queens lived, explore artifacts associated with them, and gain knowledge about their legacy.

To ensure the effectiveness of such applications, user experience evaluation plays a big role. The quality of edutainment (educational entertainment) in VR heritage applications can be assessed using established methodologies, such as those proposed in previous research on user evaluation frameworks. Evaluating user engagement, interaction flow, and cognitive load is essential for designing effective digital experiences. As Muslić et al. [2] highlight, creating software that aligns with users' natural problem-solving approaches, movements, and perception is crucial, particularly in educational contexts. By carefully identifying the target audience, collecting relevant data, and applying a structured research methodology, developers can optimize usability and ensure that VR applications enhance learning rather than complicate it. These principles are crucial in the development of VR cultural heritage applications, where user-centered design and usability testing ensure strong engagement.

Building upon these foundations, this research evaluates the SheLeadersVR educational game, examining its edutainment value through a qualitative user experience analysis. By applying structured evaluation techniques, we aim to assess how well the application engages users, eases learning, and enhances cultural heritage appreciation.

After reviewing related work, we will present a case study of the SheLeadersVR educational game. This will

*hana.ibric@stu.ssst.edu.ba

†bojan.mijatovic@ssst.edu.ba

be followed by a user experience evaluation, evaluating its edutainment value. Finally, we will conclude with a discussion on our findings and their implications for the future development of VR-based cultural heritage applications.

2 Related work

Projects integrating virtual reality and gamification have demonstrated significant benefits in edutainment. Research shows that such environments enhance students' learning outcomes, motivation, engagement, and self-efficacy. Furthermore, studies indicate improvements in academic performance, active participation, and overall satisfaction. Gamified VR experiences also encourage curiosity, imagination, and focus while helping students develop essential skills and competencies. Ultimately, VR-based gamification has proven to be an effective educational tool adaptable across various subjects, educational levels, and learning contexts [3].

In addition to VR and gamification, interactive digital storytelling has turned out as an effective methodology for conveying information to audiences with short attention spans and limited time. By transforming historical content into engaging and immersive experiences, this approach enhances both retention and enjoyment [4]. This demonstrates how historical narratives can be presented in an appealing format that combines high levels of immersion and edutainment, making learning more accessible and captivating.

While the potential of gamification is evident, its success depends on several critical factors. Research by Hamari et al. [5] shows that while many studies report positive effects on motivation and learning, these effects don't always apply to every gamification element. Some studies also suggest that the impact of gamification depends on the context and the users themselves. This means that for gamification to work well, it needs to be designed carefully, considering both the learning environment and the people using it.

In the context of adult education, incorporating games has proven to enhance the learning experience beyond traditional methods. By integrating game elements, educators can create more dynamic and interactive training programs. This approach has been shown to increase both the efficiency and enjoyment of the learning process. However, the success of game-based learning depends on factors such as the design of the game and the characteristics of the learners. Properly incorporating games into adult education requires careful consideration of these elements to maximize their impact [6].

Virtual reality offers a unique opportunity to learn through simulated real-world experiences, allowing users to visualize and interact with the subject matter in an interesting way. When real experiences are not possible, VR becomes an invaluable tool. It enables simulations

of challenging or dangerous situations that are otherwise difficult or impossible to replicate in the real world. Additionally, VR allows educators to introduce complex topics that would be difficult to teach through traditional methods, making learning more entertaining [7].

Finally, the review by Theodoropoulos and Antoniou [8] highlight the role of VR games in the field of cultural heritage, emphasizing their potential to increase learning outcomes, visitor motivation, and engagement. Their analysis suggests that VR games will grow in popularity, supporting both onsite and offsite cultural experiences. This review provides insights into the current landscape of VR games in cultural heritage and offers guidance for future developments in this area.

This paper builds on the foundations laid by these previous works, aiming to connect cultural heritage education with interactive VR gameplay to create an interesting learning experience. By providing a platform for exploring historical figures and events through immersive technology, this research is hoping to engage users in a way that not only educates, but also nurtures a deeper connection with cultural heritage.

Incorporating Human Computer Interaction (HCI) principles is crucial when designing Virtual Reality (VR) edutainment experiences, as it ensures that usability and user needs are prioritized. The concept of User Centered Design (UCD) emphasizes placing the user at the center of the design process, involving methods such as user segmentation, profiling, task analysis, prototyping, and usability testing. This approach ensures that the design aligns with user expectations and enhances the overall experience. Furthermore, understanding mental models, individuals' internal representations of how systems function, is very important. Designers should consider these models to create intuitive interfaces that resonate with users' expectations, therefore improving usability and satisfaction. [9]

By integrating these HCI principles into VR edutainment projects, we can create more effective and engaging educational tools that serve diverse needs of learners.

3 Case study

This section explores the development of the SheLeadersVR educational game, describing its structure and key features. The application is designed to present medieval Balkan history through an interactive VR environment, allowing users to explore historically significant locations, discover artifacts, and learn about the lives of medieval queens.

The structure of SheLeadersVR consists of narrative-driven exploration, where users listen to historical stories, walk through virtual reconstructions of historical sites, and interact with objects and artifacts of that time. The interaction is designed to be engaging and educational, making sure that players not only absorb historical knowledge, but

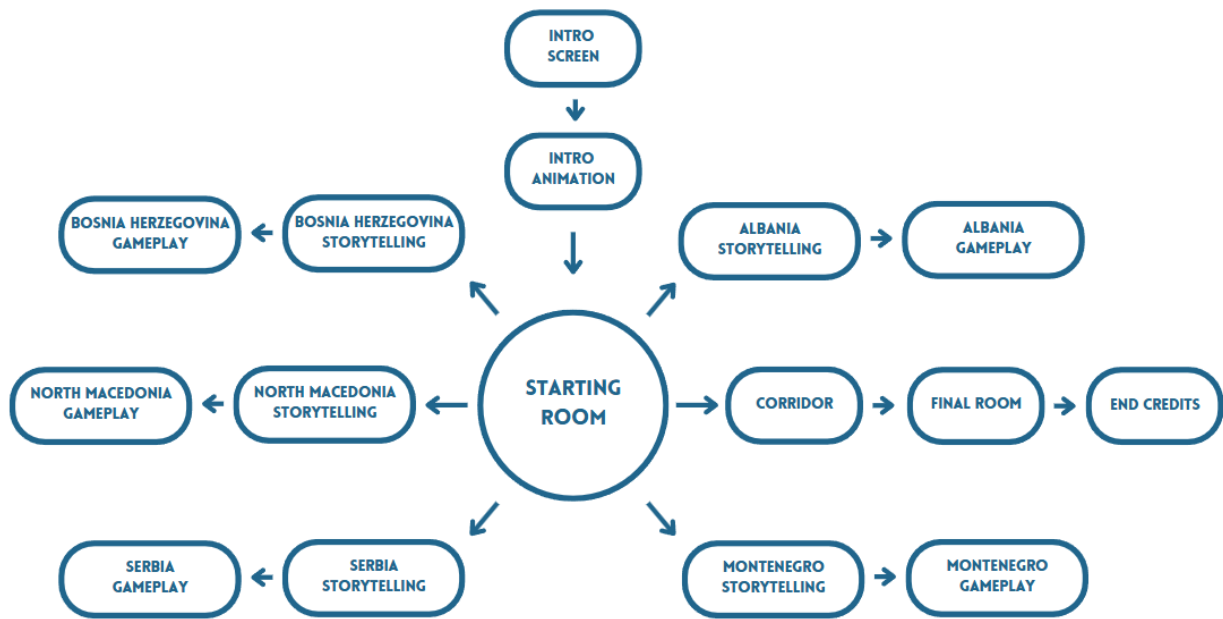


Figure 1: SheLeadersVR application tree

also feel connected to the cultural heritage of the region.

3.1 Application design and structure

The SheLeadersVR application is designed for Meta Quest headsets [10], combining 360-degree videos with interactive 3D environments to create an engaging educational experience. The application allows users to visit historically significant locations, listen to narrated stories about medieval Balkan queens, and participate in gameplay-driven learning activities.

The 360-degree videos feature an actress who presents stories of selected queens, introducing users to the historical context. In the 3D environments, users can move freely, explore reconstructed medieval sites, and interact with historical artifacts. The application also includes quests and knowledge-based challenges that require users to answer questions based on the narrated stories.

As users go through the experience, they collect an artifact for each completed level. Once all artifacts are collected, a final environment unlocks, allowing users to review all 3D models of artifacts and locations they have encountered throughout their journey.

3.2 Implementation

The project was developed in Unity [11], using a combination of 360-degree videos and custom-made 3D environments to take users back to medieval Balkan history. Similar approaches have shown to enhance engagement and immersion in educational VR experiences. Škola et al.

[12] explored the use of 360-degree storytelling in an interactive underwater archaeological VR application. Their study found that combining 360-degree video with VR led to high levels of immersion and engagement in users.

A key aspect of developing SheLeadersVR was structuring the application's flow (Figure 1). When launching the application, users are greeted with an intro screen featuring background music. Once they press the "Play" button, an introductory animation plays, setting the historical tone of the experience. From there, users arrive in a central starting room (Figure 2), from which they can choose which country's history they want to explore first. Each location represents a different country, and users can choose their exploration path freely.



Figure 2: Central starting room

Each country is presented in two parts. The first part is a

storytelling segment (Figure 3), where a 360-degree video plays. The video features an actress filmed on a green screen and integrated into a real world 360-degree environment, making it feel as though she is physically present in the historical setting [13]. After the storytelling part, the gameplay segment begins. Here, the user enters an interactive 3D environment, where they complete quests and answer questions related to the historical content.



Figure 3: Storytelling segment within a level

Once the user finishes the gameplay segment, they are brought back to the starting room, where they can select another country. After completing all five sections, a final corridor unlocks, leading to a congratulatory message that marks the completion of the experience. At this stage, the user can freely explore the final room before exiting through the “Return to the present” portal, which triggers the end credits and the final music loop.

From a technical perspective, the intro screen, intro animation, and end credits scene were programmed with interactive buttons that allow users to navigate through the application smoothly. The 360-degree videos were embedded as pre-rendered videos within Unity, while skip buttons were added to give users the option to move directly to the interactive portion. All 3D environments and assets used in the gameplay sections were custom-made, designed to reflect the historical themes of each location. The combination of these elements allows SheLeadersVR to provide an accurate educational experience that takes users back in time.

3.3 Interaction in the application

Movement within the SheLeadersVR application is handled through both teleportation and joystick movement. The left controller is primarily used for movement, featuring a custom 3D model that aligns with the theme of the experience, along with a device called the ‘Transdimensioner’, which allows users to teleport within the game. Teleportation (Figure 4) is activated using the ‘TRIGGER’ button, which enables users to quickly move to a new location. A graphical arrow indicates the teleport destination. For users who prefer continuous movement,

the ‘JOYSTICK’ on the left controller allows fluid movement.



Figure 4: Teleportation feature

The right controller is dedicated for interaction, also featuring a custom 3D model. The ‘TRIGGER’ button serves as the primary interaction mechanism, allowing users to press buttons and engage with elements in the environment. Additional functionality is provided through the ‘A’ and ‘B’ buttons, which open in-game menus. The ‘Y’ button enables a perspective shift, moving from the 3D environment to a real-life view using Oculus cameras. This mode allows users to locate hidden objects within their physical surroundings, adding a mixed-reality component to the experience.

Grabbing objects is available on both controllers via the ‘GRAB’ button. Unlike traditional VR mechanics that use automatic snapping, SheLeadersVR requires users to approach objects before picking them up, making sure users are using a more realistic sense of interaction. A guide for using the controllers is provided within the experience (see Figure 5).

Beyond controller-based interactions, the application incorporates a range of interactive environmental elements. Most objects within the scenes are interactable, meaning users can pick them up or use them to solve tasks. Apart from that, NPCs (non-playable characters) allow users to answer questions that test their knowledge of the narrated stories.

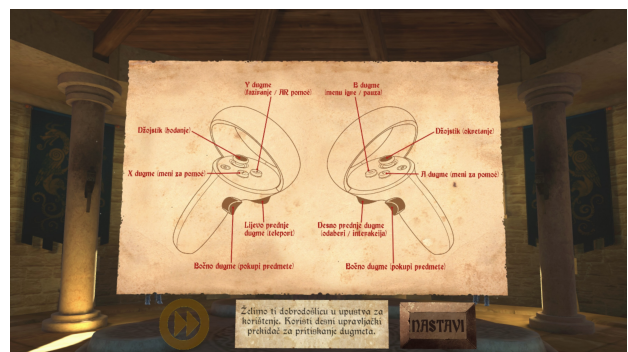


Figure 5: VR controller guide

The interaction design also incorporates subtle audio

and visual cues to guide the user. While there are no explicit audio hints directing users toward solutions, environmental sounds help enhance the realism of interactions, e.g. items produce distinct sounds when dropped, and unlocking a door is accompanied by the sound of a key turning. Certain levels incorporate visual cues to subtly indicate which objects can be used or interacted with, making sure that users explore and engage with the environment without the need for guidance.

4 Methodology

This paper presents a survey-based study evaluating the edutainment value of the SheLeadersVR application. The survey gathered user feedback through a combination of scaled and open-ended questions, capturing their experiences and interactions with the game.



Figure 6: User completing a level

Each participant navigated the virtual environment using both teleportation and joystick-based movement, interacted with NPCs, and explored various objects and puzzles within the historical setting (Figure 6). The average session lasted approximately 30 minutes per participant. Upon completing the VR experience, participants filled out a questionnaire assessing multiple aspects of their engagement, including ease of movement, interaction clarity, historical interest, and overall experience.

The study was conducted in the VR lab at SSST [14], ensuring controlled conditions for all participants. The setup included a VR system with a designated play area that provided enough space for movement. Environmental factors such as lighting and acoustics were optimized to reduce distractions, allowing participants to fully be present in the historical narrative.

Before beginning the session, participants were briefed on the controls and interaction mechanics. They were informed that they would be engaging individually to minimize external influences and ensure a focused assessment. Furthermore, all participants were given the option to dis-

continue their participation at any point if they experienced discomfort, dizziness, or any other effects, prioritizing their well-being throughout the study.

The aim of the structured approach of the user study is to evaluate the effectiveness of edutainment in VR serious games for cultural heritage by assessing how intuitive and engaging the interaction design was, as well as how successfully the experience brought historical narratives and educational value.

4.1 Participants

Participants in this study were a diverse group of individuals who evaluated the effectiveness of the SheLeadersVR application designed to explore cultural heritage. A total of 35 participants took part in the study, with 20% of participants being male, and 80% female, with ages ranging from 16 to 59 years. Of the total, 31.4% of participants were under the age of 20, 65.7% were between 20 and 50 and 2.9% were over 50, providing a varied age distribution for the evaluation. This pool of participants provided information into how people of varying ages engage with and perceive serious games for cultural heritage.

4.2 Survey design

The survey was designed to evaluate multiple aspects of the VR experience, including both entertainment and educational value, as well as user satisfaction. The survey consisted of both quantitative and qualitative questions, aimed to gather feedback on various components of the experience.

The quantitative section of the survey used a Likert scale, where participants were asked to rate statements related to their experience with the VR environment. Statements included topics such as ease of movement, control over object interaction, task navigation, and immersion in the historical content. Participants were asked to indicate their level of agreement with each statement on a 5-point scale, ranging from "Strongly Agree" to "Strongly Disagree."

In addition to the Likert-scale questions, the survey included open-ended questions to capture participants' subjective experiences and suggestions for improvement. These questions allowed participants to provide feedback on aspects of the VR experience that they found particularly interesting or challenging, as well as any suggestions for enhancing the educational value or overall user experience.

4.3 Data collection

The survey was distributed to participants via a Google Forms link, and they completed it on-site to ensure they could ask for assistance if any questions came up. This approach allowed for immediate responses, reducing potential misunderstandings. Additionally, conducting the sur-

vey in a controlled setting made sure that all participants had equal access to the necessary resources and support while filling out the form.

5 User experience evaluation

The user evaluation aimed to measure the effectiveness of the application in terms of historical education, interaction mechanics, and overall user experience. The study gathered participants from different backgrounds to analyze how they experienced movement, object interaction, and narrative-driven elements within the VR environment. In terms of previous VR experience, 17.1% of the participants strongly agreed and 34.3% agreed that they were familiar with VR, while 37.1% disagreed and 11.4% strongly disagreed, indicating a diverse range of familiarity levels among users.

Participants explored the interactive elements within the environment, including picking up objects, interacting with NPCs, and solving puzzles. The evaluation focused on how naturally users could manipulate objects, the clarity of in-game instructions, and whether the gameplay tasks were engaging.

Beyond interaction, the study also analyzed narrative elements within the VR space. Participants rated their enjoyment of the historical storytelling, their level of engagement with the environments, and whether they felt a sense of presence in the historical locations. The narrator's voice and the visual design of medieval settings were also evaluated to determine their impact.

Users also reflected on whether they had learned new information or felt motivated to explore more about the historical period of medieval Balkan. Furthermore, participants were asked if they would recommend the experience to others or visit historical sites in real life as a result of their engagement with the application.

By structuring the user evaluation in this way, the study ensured a comprehensive understanding of how intuitive and engaging the VR experience was while also assessing its potential as an educational tool. The following sections will present a detailed analysis of participant responses, highlighting key findings and areas for improvement.

5.1 Results

The user evaluation provided insights into the effectiveness of edutainment in VR serious games for cultural heritage. Participants' feedback showed a strong appreciation for the quality of the VR experience, with a majority expressing engagement with the historical narratives presented in the simulation.

5.1.1 Engagement and educational value

The majority of participants expressed a strong appreciation for the historical narratives presented in the VR envi-

ronment. Notably, 82.9% reported that the VR experience increased their interest in learning about medieval history, reinforcing the potential of VR as an engaging educational tool. Additionally, 85.7% of participants indicated a desire to explore more historical periods through similar interactive experiences, highlighting the demand to expand the content on medieval Balkan history (see Figure 7).

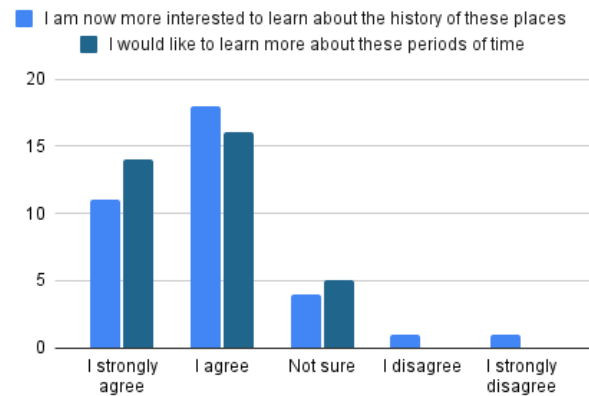


Figure 7: Engagement and educational value graph

5.1.2 Interaction and navigation

The evaluation of interaction methods revealed varied user preferences and experiences. Regarding movement within the VR environment, 88.6% of participants found navigation easy, while 11.4% reported some difficulty. When asked about task navigation, 25.7% of participants found it challenging, while 22.9% were uncertain. However, a significant 51.4% pointed out that they did not experience major difficulties (see Figure 8).

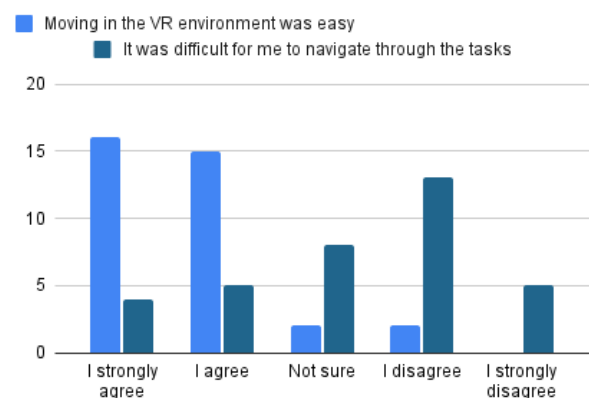


Figure 8: Interaction and navigation graph

5.1.3 Gameplay experience

Participants generally responded positively to the gameplay interaction methods. A total of 85.7% reported hav-

ing good control over holding and handling objects during gameplay, while 14.3% were unsure. In terms of interaction, 91.4% found the experience to be natural, with only 8.6% expressing uncertainty. Additionally, 94.3% of participants found interacting with ancient objects engaging, reinforcing the effectiveness of tangible interactions in enhancing the learning experience (see Figure 9).

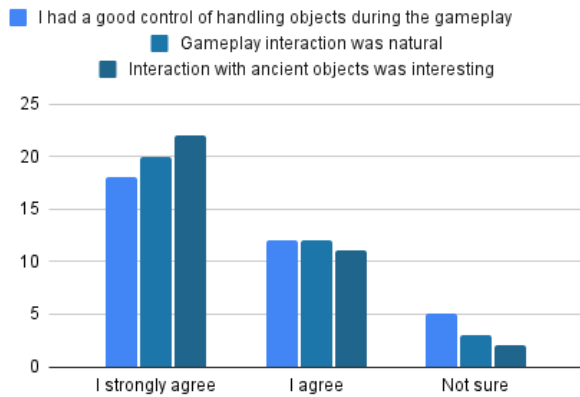


Figure 9: Gameplay experience graph

5.1.4 Role of visual and audio cues

Visual cues played a crucial role in guiding users through tasks, with 85.7% of participants finding them helpful for progressing through the experience. The absence of direct audio cues for gameplay hints was noted, though environmental sounds such as object drops and door unlocks contributed to the overall realism. Feedback suggests that incorporating additional audio guidance could further enhance accessibility and usability.

5.1.5 Immersion and presence

The survey also explored the sense of presence and immersion within the historical setting. Immersiveness is not only valuable for the longevity of a game, it also convinces the players to pay attention to – and care about – the messages within the game, which makes games useful from an educational standpoint [15]. A total of 88.6% of participants reported a strong feeling of immersion in the historical environment, with only 2.9% disagreeing. Similarly, 80% of participants felt a strong connection to the representation of past queens in the experience, while 14.3% were unsure, and 5.7% disagreed. Regarding the perception of time, 80% of participants stated that time passed quickly while in the VR simulation indicating high engagement levels (see Figure 10).

5.1.6 Suggestions for Improvement

Participants provided various suggestions to enhance the VR experience, particularly in terms of narrative pacing,

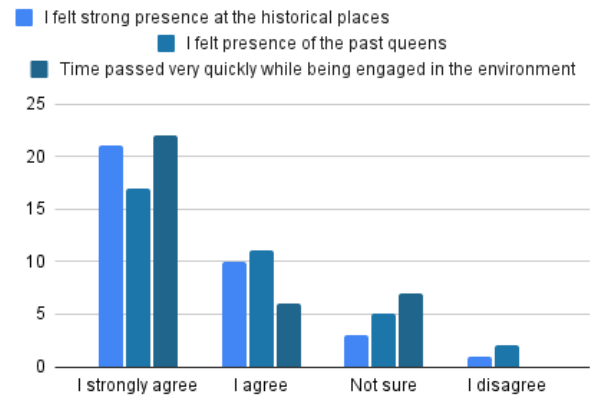


Figure 10: Immersion and presence graph

interaction mechanics, and overall engagement. Several participants expressed a preference for shorter video stories, as well as a reduction in the length of dialogue scenes, especially those involving the queens. Additionally, some suggested incorporating more interactive decision-making elements or extra historical scenarios to allow players to explore different perspectives.

Regarding gameplay and interactions, participants recommended increasing the number of tasks and challenges to improve engagement. Some felt that providing more walking space for exploration, along with additional interactions with NPCs who could share different parts of the story, would enrich the experience. Others suggested expanding the game with additional levels and progressively more difficult tasks to create a longer experience. The inclusion of more hints to guide players through tasks was another common suggestion. One participant also recommended adding a bell sound effect at appropriate moments to have auditory feedback while interacting with an artifact.

In terms of user experience and comfort, some participants suggested offering an option to choose which hand controls movement, as right-handed players often find it more natural to move with their dominant hand. Concerns about dizziness were also mentioned, with recommendations to refine movement mechanics to improve player comfort.

Overall, the findings suggest that the VR heritage application successfully blends education and entertainment, taking care of medieval history through an interactive experience. The feedback highlights key strengths, while also identifying areas for further improvement. These insights will inform future iterations of the VR experience to optimize edutainment value.

6 Conclusion and future work

This research provided valuable insights into the evaluation of SheLeadersVR, specifically examining its edu-

tainment value within the context of VR serious games for cultural heritage. By integrating interactive storytelling, exploration and gamified learning elements, the study showed how virtual reality can engage users while promoting historical education. Participants responded positively to the interactive elements, particularly those that allowed them to engage with historical objects and narratives. The strong sense of presence reported by users highlights the potential of VR as a medium for cultural heritage preservation and education.

Despite its success, the approach had some challenges. Some participants struggled with navigation and interaction precision, highlighting the need for improvements. While the VR environment effectively conveyed historical narratives, expanding interactive storytelling with personalized learning paths could enhance engagement.

One of the most common points of feedback related to navigation and interaction mechanics. While most participants found the tasks engaging and easy to accomplish, some experienced dizziness when walking too much. Additionally, a few users reported feeling lost at times while completing tasks, recommending the inclusion of more hints and clearer progress feedback. Addressing these concerns through visual markers or subtle cues, could improve the overall experience.

Some participants suggested shortening the length of video stories and dialogues for a smoother experience, while others wanted additional interactions with historical figures to further explore the narrative. Introducing more decision-making elements and varied scenarios could create a deeper learning journey. Expanding the number of levels and increasing task variety were also common suggestions, which suggests that adding more levels and tasks could keep players interested for longer.

Moving forward, future iterations of this project should focus on improving task guidance with contextual hints, and incorporating more interactive historical elements to increase engagement. Future work could also benefit from integrating additional quantitative methods, such as physiological metrics (e.g. heart rate monitoring or eye tracking) and pre- and post-intervention assessments, to strengthen the evidence for educational impact. By integrating these improvements, the project aims to enhance its edutainment aspects, which can strengthen the game's value as a way to attract people to explore cultural heritage.

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