Metaverse Education: Immersive VR Exploration of Mountain Heritage and Culture

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METAVERSE EDUCATION: IMMERSIVE VR EXPLORATION OF MOUNTAIN HERITAGE AND CULTURE

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Abstract

The rapid technological progress has led to a profound digital overhaul across sectors, notably in education. VR technologies and the metaverse offer novel avenues for disseminating knowledge, promising immersive, flexible, scalable, diverse, and interactive learning environments (Baynat & Lopez, 2020; López-Belmonte et al., 2022). Incorporating gamification within the metaverse enriches learning experiences, providing engaging content delivery methods (Khan et al., 2022). This study assesses the metaverse's potential in VR applications to enhance learning outcomes and user engagement, emphasizing content accessibility and immersive educational experiences through gamification. Authors created an open virtual platform within the metaverse, inviting users to explore a mountain area blending historical, cultural, and environmental elements. The experience unfolds within an interactive three-dimensional reconstruction of the valley, featuring a virtual mountain trail walk and a tour of a historic mountain village. Application development involved data acquisition for modeling and interaction design using Unity3D, with online deployment facilitated by the Spatial Creator Toolkit. For project evaluation, users complete a post-experience survey, providing quantitative data on engagement, motivation, content understanding, and interaction quality (López-Belmonte et al., 2022). Survey results indicate high engagement and positive feedback, implying enhanced accessibility via the metaverse. The project fosters real-time interaction, dialogue, and collaboration on educational topics, promoting community involvement. This dynamic virtual environment transcends traditional limits, allowing diverse users to actively interact, share knowledge, and engage.

Keywords: *Metaverse, gamification, Virtual Reality (VR), engagement, learning environments.*

1. Introduction

Metaverse is a combination of “meta" (meaning beyond) and the stem “verse" from "universe", denoting the next-generation Internet in which the users, as avatars, can interact with each other and software applications in a three-dimensional virtual space (Duan et al., 2021). The term comes from author Neal Stephenson's dystopian sci-fi novel Snow Crash, which imagined a gigantic 3D playground where people escaped the struggles of the real world (Jaung, 2022). Rather than considering the metaverse a mere escape into a videogame-like virtual reality, we believe it is worth exploring its potential as an innovative tool for communicating, interacting and learning.

Metaverse education offers several advantages over traditional teaching methods, for instance it provides the possibility of incorporating gamification techniques into the learning experience, introducing gaming strategies and elements into non-gaming settings. It is an effective tool for overcoming difficulties related to students' lack of interest or capturing visitors' attention (Khan et al., 2022) as it creates a richer and more engaging experience. A further advantage of metaverse education is the potential to create immersive experiences through VR technologies, which enables learners to access distant or difficult-to-reach places at any given moment. Users can gain a comprehensive understanding of the subject matter and engage with the learning content with the autonomy to explore the virtual world at their own pace (Marougkas et al., 2023).

The capacity of the metaverse to engage users in immersive and memorable learning experiences extends its potential for utilisation beyond school education, for example in the context of museums, exhibitions and virtual tourism. Such virtual reality experiences could facilitate the sharing of cultural heritage and, in the case of fragile environments, prove useful in raising awareness of sustainable visitation or living, encouraging pro-environmental attitudes (Jaung, 2022).

This article presents an innovative approach to education about mountain heritage and environment through immersive VR exploration in a mountain valley metaverse.

2. Methodology

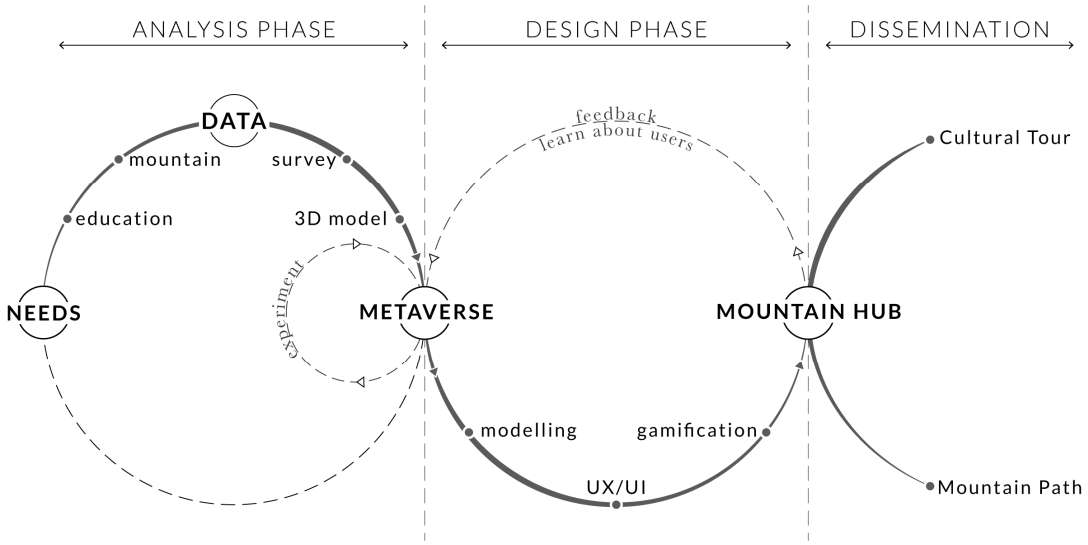
This project employs a methodological approach based on Design Thinking (Lewrick et al., 2018), a structured method for solving complex problems. The focus of the project is the mountain context, in line with the NODES (Northwest Digital and Sustainable) project initiative, which aims to improve the performance and sustainability of enterprises in mountain areas through the use of digital technologies. The metaverse was designed as an open virtual platform, creating the Collaborative Innovative Mountain Areas Living Lab (CIMAL2). This environment provides a space for developing and sharing knowledge of mountain areas.

2.1. Workflow

The initial phase of the workflow involved identifying current needs and challenges in the field of education and in the mountain context, outlining user requirements and the content to be disseminated. Subsequently, the focus shifted to the development of the metaverse, starting with virtual modelling and extensive study of the user experience (UX). The development of the user interface (UI) was guided by gamification techniques. The experience was then tested to assess the value and potential of the project. The feedback from these tests was essential in optimising the workflow and further improving the user experience. Finally, the project was completed and revised through new experiments, ensuring continuous improvement to meet emerging needs.

The chosen case study is the Cervo Valley in Piedmont, Italy. The first experience explores Rosazza village, known for its history and unique architecture. The second focuses on a mountain path to Piane di Piedicavallo, profuse in flora and fauna at 1320 meters above sea level. The region's rich cultural heritage renders these settings optimal for educating on sustainability and involving the local community (Scarzella, 1983). Given their sparse population, innovative projects like these are crucial for rural area conservation and development, potentially driving social and economic regeneration in the region.

Figure 1. Workflow.



2.1.1. Rosazza Tour Virtual Experience. Rosazza, a small village in the Biella mountains, boasts a rich historical and cultural legacy, characterized by unique architecture predominantly crafted from local stone.

The main aim of the proposed experience is to immerse visitors in the beauty of Rosazza through an interactive journey, exploring virtual platforms suspended above the valley, allowing for complete exploration of its iconic buildings.

The initial phase involved data acquisition from historical archives and surveys, capturing photographs, 360-degree panoramas, and measurements. Furthermore, the utilisation of laser scans for the buildings and drone-based scans for the valley model contributed to the comprehensive documentation of architectural elements and the physical landscape, respectively. This data was used to create a virtual representation of the valley and its structures with InfraWorks and Blender software, emphasizing architectural details of key landmarks such as the church, castle, and town hall.

The next stage of the project involved the design of a virtual space that would provide an immersive experience for users. This was achieved by introducing virtual platforms placed on top of the

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buildings, which offered an innovative perspective of Rosazza. Graphics were designed to emphasize key buildings, aiding environmental comprehension rather than detailed replication. Standard data formats facilitated easy navigation and accessibility across web platforms.

Finally, the design of the interactions has been optimized to enhance the user experience during the virtual tour. This is achieved using images, 3D models, an audio guide, and 360-degree panoramic photographs, which offer a realistic and immersive view of the most interesting features.

The experience comprises a series of interactions developed with the Unity3D game engine software. (i) orbiting and zooming in on space models and images; (ii) realistic immersion in spherical photos; (iii) audio guidance that accompanies the user along the way; (iv) teleportation for moving between platforms; (v) photographs and text on historical monuments; (vi) a full-scale 3D model of the valley and buildings; and (vii) social connection between avatars through the use of the online platform Spatial.

Figure 2. User experience tests for Rosazza Tour Virtual Experience.

2.1.2. Mountain Path Virtual Experience. This virtual reality experience has been developed in the context of an evocative mountain path aiming to educate through engaging activities. Focused on the route from Piedicavallo village to the scenic Piane area by the Cervo stream, the project aims to teach sustainability in mountain environments while offering recreational fun. Data collection involved archival research and field surveys, capturing photos, panoramas, and laser scans via drone for a detailed route representation. The virtual space includes two activities: mushroom picking and animal searching. In the mushroom-picking activity, the user is introduced to the main types of mushrooms present, learning how to distinguish poisonous from edible ones. The game takes place inside the forest, and to increase immersion, VR visors and joysticks are used, allowing users to carry a virtual basket and a mushroom collection card in order to collect 12 edible specimens. The animal spotting activity aims to familiarize users with the valley's fauna and promote awareness of proper behaviour when encountering wildlife. Along the route, users encounter flora and fauna specimens, encouraged to photograph animals without disturbing them.

The trail was modelled using scan data and Blender modelling software, instead interaction design focused on user spatial perception, employing simplified graphics to mitigate navigation issues. The development of interactions was conducted using Unity3D software, combined with Spatial's Creator Toolkit plug-in, which enabled the following functionalities to be implemented. (i) The manipulation of objects in the hands, such as the basket, mushroom board and camera; (ii) The collection of mushrooms and the updating of the number on the board; (iii) The display of information on flora and fauna; (iv) The taking of photographs and the collection of images; (v) The provision of audio guidance along the way; (vi) The feedback on actions taken in the game; and (vii) The connection with other users in the experience.

Figure 3. User experience tests for Mountain Path Virtual Experience.

3. Results

Combining the metaverse and virtual reality with the mountain environment is a challenge, but it can be an aid to tourism and mountain repopulation as well as being an excellent means of knowledge and education accessible to all. Furthermore, combining education with gamification applications is a challenge that will enrich the user's awareness of sustainability issues, an extremely topical subject.

The project was tested on many people during the 'Virtual Reality and the Digital Mountain Metaverse' event, held during the 2024 Technology Bienniale at Politecnico di Torino. On April 18, the doors of Drawing to the Future Lab, in the Department of Structural, Construction and Geotechnical Engineering (DISEG) were opened to the public.

The project was tested at the 'Virtual Reality and the Digital Mountain Metaverse' event during the 2024 Technology Bienniale at Politecnico di Torino. The event, held at the Drawing to the Future Lab in the Department of Structural, Construction, and Geotechnical Engineering (DISEG) on April 18, featured presentations on the project and its technologies, followed by practical experiences with web and VR platforms. Participants explored one or both experiences and provided feedback via questionnaires, evaluating the metaverse's educational efficacy in such contexts.

Figure 4. Feedback on the user experience.

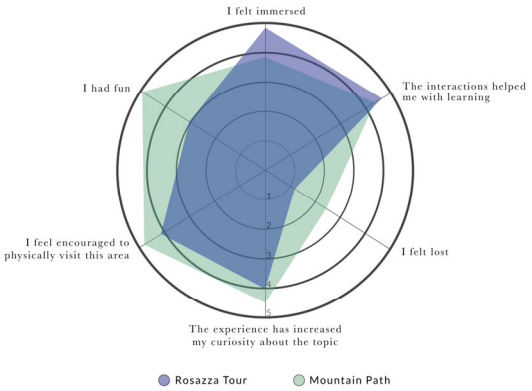
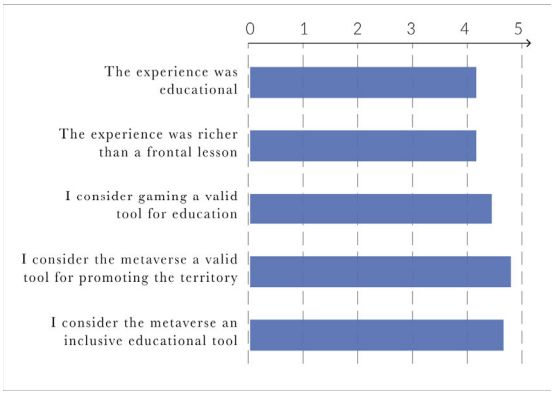


Figure 5. Feedback on the educational method.



The questionnaire was compiled by a heterogeneous sample of 87 participants, distributed equally between the two activities. The majority of users are in the age group of 13 to 30 years, characterised mainly by high school diploma and master's degree level education. The questionnaire required users to assess their perception of the experience in terms of immersion in the virtual space and the educational content, as well as the use of gamification and the metaverse as educational tools.

The results presented in Fig. 4. demonstrate that, in the Rosazza experience, the integration of audio guides and 360-degree panoramic images has significantly enhanced the immersion of the experience and stimulated interest in virtual space interactions, making the route and proposed content clear. With regard to the mountain path experience, the graph serves to illustrate the enjoyment and fun that users derived from this experience. Furthermore, it indicates a subsequent increase in curiosity and intention to further investigate the topic at hand.

Finally, the analysis of the data illustrated in Fig. 5. indicates a positive assessment of the use of the metaverse in the field of education, highlighting a preference for the gaming experience over traditional frontal learning. Moreover, the graph depicts the potential of the metaverse as a communication tool for the promotion the territory, due to its inclusivity and the possibility of wider spatial and temporal access.

4. Conclusion

The widespread use of the metaverse and VR technologies can lead to some interesting developments in the field of education and culture, increasing users' interest and active involvement.

The success achieved in this initial experiment with the mountain metaverse paves the way for the future use of this technology in scenarios related to cultural and natural education, as well as for the dissemination of information about the region linked to the NODES project.

The feedback obtained from the questionnaires enables the enhancement of the virtual experiences, leading for example to increasing the gamification-related interactions which have been particularly successful in engaging and entertaining the public.

These tests are just the first phase of a journey to better understand the potential of the metaverse for sharing knowledge in a captivating and immersive way, researching new learning techniques.

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