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# Virtual Journeys, Real Engagement: Analyzing User Experience on a Virtual Travel Social Platform

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**Abstract:** A sustainable smart tourism ecosystem relies on building digital networks that link tourists to destinations. This study explores the potential of web and immersive technologies, specifically the Virtual Romania (VRRO) platform, in enhancing sustainable tourism by redirecting tourist traffic to lesser-known destinations and boosting user engagement through interactive experiences. Our research examines how virtual tourism platforms (VTPs), which include web-based and immersive technologies, support sustainable tourism, complement physical visits, influence user engagement, and foster community building through social features and user-generated content (UGC). An empirical analysis of the VRRO platform reveals high user engagement levels, attributed to its intuitive design and interactive features, regardless of the users' technological familiarity. Our findings also highlight the necessity for ongoing enhancements to maintain user satisfaction. In conclusion, VRRO demonstrates how accessible and innovative technologies in tourism can modernize travel experiences and contribute to the evolution of the broader tourism ecosystem by supporting sustainable practices and fostering community engagement.

**Keywords:** virtual tourism; sustainable tourism; cultural heritage digitization; user engagement; VRRO platform; case study; empirical analysis

## 1. Introduction

A pivotal paradigm in the modern travel industry, sustainable tourism encompasses environmental, economic, and social dimensions, seeking to strike a balance between the needs of the visitors, the tourism industry, local environments, and hosting communities [1]. This approach encourages cities to exchange best practices, integrating advanced tele-tourism into urban planning to guide travelers towards informed choices, thereby driving sustainable economic development in tourist destinations [2].

Virtual tourism, powered by advancements in immersive technologies, has the potential to be a significant component of sustainable tourism. The COVID-19 pandemic underscored the fragility of the traditional tourism model, when the travel, tourism, and cultural sectors faced unprecedented challenges. Although reluctant to digitalization, due to fears of diminishing of the actual experience and losing potential visitors, cultural landmarks' administrations realized the potential of a tech-driven solution [3,4].

Virtual tours (VTs) can be pivotal in ensuring that tourism activities continue, even during challenging times [1,5]. Such opportunities not only allow travelers to explore and gain knowledge about various locations during travel constraints from the safety of their homes, but also enable cultural institutions to maintain their connection with audiences. Additionally, they can offer employment avenues, such as virtual tour guides, ensuring job continuity for professionals in the field [3].

Web social platforms are powerful tools in expanding the traditional tourist experience into the virtual domain. These platforms, evolving through both public and private initiatives, have become integral in shaping users' interactions and documentation of

their travel experiences. Web social platforms not only facilitate the dissemination of virtual content but also encourage tourists to share their experiences, thereby creating a rich repository of user-generated content (UGC). This content can serve as electronic word-of-mouth (eWOM), significantly influencing potential travelers' perceptions and decisions [6]. Tourists are increasingly relying on the experiences and reviews shared by others on social media platforms to make informed travel decisions [7,8]. Moreover, the use of UGC on social media has shown to be a cost-effective and enduring marketing strategy, as it generates organic content that resonates more authentically with potential tourists [9]. Despite raising privacy and security concerns, users adapt and navigate these challenges, sharing their experiences as "postcards, not ticket stubs" [10], thus prioritizing narrative over mere location logging [11]. This organic promotion helps to build trust and credibility, essential for lesser-known destinations striving to gain recognition.

The combination of virtual reality (VR) and social platforms thus offers a comprehensive marketing approach, leveraging the immersive appeal of VR and the expansive reach of social media to promote less-explored destinations effectively [12]. With the aid of immersive web technologies, distances for tourists are condensed to a mere click, morphing cultural sites into readily accessible digital destinations. This shift is redefining traditional tourism, paving the way for "digital tourists" [13]. For instance, VR platforms combined with gamification and social media interactions have proven to be effective in creating an engaging and interactive promotional strategy for tourism destinations during the COVID-19 pandemic [14].

Despite the increasing interest in mixed reality (XR) applications within tourism [15], there remains a significant gap in understanding how these technologies specifically enhance user engagement and contribute to sustainable tourism. While previous research has broadly explored VR applications in tourism, the potential benefits of VR as a tourism marketing tool, particularly in terms of presence and emotional response, are still not fully understood. The concept of presence, well-studied in information and communication technologies (ICT) and cyberpsychology research, remains nascent in the tourism literature, suggesting the need for more context-specific studies to explore VR's effectiveness in tourism marketing [16]. A hybrid integrative review emphasizes the emotional and immersive attributes of XR that sustain tourist engagement, while also pointing out the gaps in the exploration of cultural theories and user engagement intentions and perceptions in specific contexts, such as VR tourism mobile applications. It notes that most VR tourism research centers on visitor and emotional engagement, suggesting a need for future research to consider "social engagement" and "sustainability" concepts [17].

As previous research has identified, there is a need for more empirical research on the relationship between mobile technology and sustainability, network environments, and consumer costs [15]. Furthermore, there is a lack of research on frameworks for multi-stakeholder involvement in implementing regional digital destination marketing projects. The effective promotion of neglected landmarks requires the collaboration of various stakeholders, including local businesses, tourism boards, and technology providers. A multi-stakeholder involvement management framework can ensure that all parties are aligned in promoting these destinations through VR platforms, thereby maximizing the impact and reach of digital marketing efforts [15].

This paper assesses the role of VR web social platforms in shaping a new dimension of tourism that complements the physical experience with a virtual counterpart, accessible through panoramic imagery and interactive features. Previous studies have highlighted the potential of VR in tourism but often lack empirical data on user engagement and sustainability. The originality of this study lies in its focus on the Virtual Romania (VRRO) platform, a virtual tourism web application designed to complement physical visits and enhance user engagement through immersive experiences [18]. In this study, "virtual tourism platforms" (VTPs) refer to digital technologies that provide virtual experiences of tourist destinations, including web-based and immersive technologies. By integrating theoretical insights with practical applications, this research aims to fill the identified gaps

and provide a comprehensive understanding of these technologies' role and impact in modern tourism.

To guide our research, we posed several key questions:

- RQ1. How do VTPs contribute to sustainable tourism practices and the promotion of lesser-known destinations?
- RQ2. How can VTPs complement physical visits to tourist destinations, and what is their impact on user engagement and decision-making processes?
- RQ3. What are the primary challenges and factors influencing user engagement with VTPs, particularly in terms of technological familiarity and design principles?
- RQ4. How do the social, interactive, and UGC features of VTPs enhance user satisfaction, foster community building, and build trust among users?

To address these research questions, the following section of this paper provides an extensive review of the significant literature on VTPs and their impact on the tourism industry. We then present the VRRO platform as a relevant practical example, illustrating its design, features, and capabilities as a model of a self-sustainable virtual tourism platform. This model aims to meet the evolving needs of digital tourists by offering immersive, interactive, and user-generated content. Furthermore, we conduct an empirical analysis of user adoption and engagement with the VRRO platform, evaluating its potential for long-term use and its effectiveness in complementing physical tourism experiences. By integrating theoretical insights with practical application, this paper aims to provide a holistic understanding of the role and impact of VTPs in modern tourism.

## 2. Background and Literature Review

Given the intangibility of the tourism product, XR technologies, including VR, augmented reality (AR), and augmented virtuality (AV), hold the capacity to unlock significant opportunities in the tourism sector by revealing rich sensorial information to travelers before they reach their destination. These technologies have broad applications across various tourism sub-domains, including planning and management, marketing, education, heritage preservation, and accessibility [19]. XR technologies have revolutionized tourism planning and management by providing immersive experiences that assist in strategic decision-making and resource allocation [20–23]. In marketing, immersive experiences have proven to be valuable tools in destination promotion, leading to increased engagement and higher visit intentions [24–27]. Moreover, they provide innovative ways of presenting historical and cultural information in engaging and accessible manners. Integrating non-invasive tools such as VR and AR in heritage management can generate new experiences and promote sustainable tourism without compromising the integrity of monuments [28–30]. XR technologies also play a significant role in enhancing accessibility in tourism. For example, immersive technologies can be used to create inclusive environments for tourists with disabilities, ensuring that heritage sites are accessible and inclusive. Research has shown that XR applications can significantly improve the accessibility of tourism services, making them more user-friendly and engaging for people with disabilities [31].

In addition to XR, social media platforms have become vital in shaping modern tourism experiences through eWOM and UGC. Social media serves as an important tool for destination marketing and engagement, facilitating the dissemination of traveler experiences and reviews that influence others' travel decisions. Studies indicate that eWOM on social media can significantly enhance the destination image and tourists' intentions to visit or revisit destinations [32]. The impact of UGC on tourism is substantial, as travelers increasingly rely on peer reviews and shared experiences to inform their travel choices [33]. Moreover, the integration of social media with XR technologies enhances these experiences, creating more immersive and interactive platforms that engage users more deeply and contribute to a more comprehensive understanding of destinations [34]. As a result, the convergence of XR technologies with social media platforms offers a powerful approach to promoting neglected destinations and supporting sustainable tourism practices by leveraging the expansive reach and authenticity of UGC.

### 2.1. Virtual Touring as a Sustainable Practice

Sustainability in tourism is crucial for managing its multifaceted impacts. A 2021 critical review identified key sustainability indicators, emphasizing the role of virtual tourism in promoting eco-friendly practices by reducing physical travel and promoting lesser-known destinations [35]. This aligns with the goals of VRRO, which foster sustainable tourism through immersive virtual experiences. The indicators highlighted by this review cover environmental conservation (carbon footprint reduction, biodiversity protection, and resource efficiency), economic benefits (job creation, income generation, and equitable distribution of tourism revenue), social equity (inclusive practices and improving the residents' quality of life), and cultural preservation (protecting and promoting local heritage, traditions, and culture) [35].

Uncontrolled overtourism can have significant negative impacts. Economically, it can inflate prices and disrupt the development of industrial structures, weakening the resilience of local economies. Socially, it can commercialize local culture, change residents' attitudes from hospitality to hostility, and create a false sense of authenticity. Environmentally, the consequences are severe, including higher carbon emissions that contribute to global warming, damage to water and soil resources, destruction of flora and fauna, and harm to cultural heritage sites [36].

Digital technologies intersect with tourism sustainability on various fronts. By dematerializing practices such as booking, accessing informational materials, and using maps via downloadable apps, environmental impacts are reduced. Additionally, the use of immersive technologies offers further potential to mitigate the negative effects of tourism [37].

As a powerful tool for promoting sustainable tourism, VR platforms provide immersive virtual environments that can meet travel needs without the necessity of physical travel. VR tourism platforms offer a safe alternative to real-life tourism, particularly beneficial during mobility constraints similar to those experienced during the COVID-19 pandemic [30,38]. VR tourism is therefore a sustainable solution, significantly reducing eco-guilt and travel anxiety, thus fostering positive attitudes towards tourism practices [39].

Furthermore, VR tourism platforms can reduce the environmental footprint by minimizing physical travel, protecting cultural heritage sites from overtourism and supporting local economies through alternative income streams [30]. VTs can have a profound impact on sustainable tourism practices, both by increasing awareness and reducing physical visitation pressures on fragile sites [30,40]. Peštek and Savan explored the potential of VR as a marketing tool that supports conscious tourism by enabling tourists to virtually explore destinations before visiting them physically. This approach not only reduces the need for physical travel but also enhances the tourism experience by providing detailed and engaging previews of destinations [41]. VR's vividness and interactivity significantly impact tourists' attitudes and visiting intentions, thereby promoting sustainable tourism by engaging potential visitors through VTs [22].

Promoting lesser-known destinations is integral to achieving well-balanced tourism, as it helps to distribute tourist traffic more evenly, reducing the environmental and social pressures on popular sites. For instance, Idris et al. demonstrated that incorporating VR technology into Indonesia's smart tourism information system efficiently promoted less popular touristic attractions by offering easy and quick access to detailed information [27]. By redirecting tourists to less-visited areas, destinations can benefit from a more balanced economic distribution and preserve their cultural and natural heritage. Successful sustainable tourism destinations generate income for local communities, preserve local identities, and promote the sustainable use of ecosystems [42].

However, the disparity in data availability between popular and less popular destinations poses a significant challenge. The Travel and Tourism Development Index (TDDI) report aims to assess the role of regional policy in building a sustainable and resilient tourism economy. The report also highlights the critical role of regional policy in correcting territorial imbalances, spreading the benefits of tourism, and supporting long-term sustainable tourism practices. It suggests that regional policy should focus on mainstreaming

sustainability, supporting vulnerable territories, improving infrastructure and connectivity, promoting green tourism, and facilitating digital transitions [43]. The EoRPA report also discusses the significant contributions of regional policies and emphasizes the importance of building resilience, diversifying destinations, and promoting local value chains. Specific regional examples include the promotion of rural tourism in Portugal, nature-based tourism in Norway, and cultural tourism in Italy, all aimed at leveraging unique territorial assets and fostering sustainable tourism practices [44].

The key determinants of international tourist flow include a range of economic, personal, and supply-side factors. Economic considerations such as income levels and transportation costs, along with promotional efforts and special events, significantly influence travel decisions. Personal preferences and consumer expectations also play a crucial role. On the supply side, accessibility, attractions, service quality, and destination image enhance a location's appeal. Socio-cultural elements such as cultural ties, language, and hospitality, as well as geographical factors such as distance, climate, and location, further shape travel patterns. By understanding and addressing these factors, destinations can effectively attract more international tourists and increase tourism revenue [45].

A paper delving into the influence of online information on international travelers' destination choices underlined a glaring gap: the scarcity of regional tourism data, particularly in lesser-known areas such as certain regions of South Korea [46]. This deficiency often skews tourism funds towards well-known destinations. Digital platforms, utilizing Global Positioning System (GPS) and mobile technology, provide a dynamic and comprehensive view of travel options, promoting the discovery of less popular destinations towards a more balanced and sustainable tourism landscape. A study proposing and analyzing a recommendation system for less-frequented attractions in Thailand further emphasizes the need for UGC and eWOM [47]. In Australia, online search engine data reflect the popularity distribution among tourism destinations, with popular sites receiving more searches and reviews compared to lesser-known areas [48].

There are significant disparities in tourism competitiveness across European and Eurasian nations, with Western European countries generally outperforming their Eastern counterparts in key indicators [49]. Romania is seen as a competitive tourist destination, due to its historical, cultural, and geographical attractions, but also the diversity of protected areas. In comparison with neighboring destinations, specifically Bulgaria and Hungary, Romania performs well in terms of travel and tourism policies, environmental permissiveness, and cultural and natural resources. At the same time, key challenges that need to be addressed include improving infrastructure, ensuring competitive pricing, enhancing safety and security measures for tourists, and investing in training and developing the tourism workforce. Focusing on digital advancements, Romania can enhance its tourism competitiveness by improving digital marketing strategies, enhancing online booking systems, optimizing mobile platforms, ensuring digital connectivity, offering virtual experiences, utilizing data analytics, and managing its online reputation. [50].

Building on these strategies, an indicator-based framework to measure sustainable tourism in Romania highlights the importance of promoting tourism in regions with high sustainability potential [51]. A study analyzing the impact of Facebook communication on user engagement with Romanian ecotourism destinations, such as the Eco Maramureș, the Land of the Bisons, and the Tușnad Baths and the surrounding area, found that posts related to culture and nature received higher user interactions. The findings suggests that destination management organizations should increase the frequency of posts and tailor content to audience preferences to effectively engage users and promote lesser-visited sites [52]. Additionally, a case study on the development and use of VTs of wooden churches demonstrates how VR can raise awareness and interest in these cultural sites [30]. Furthermore, an investigation into the image of the Bihor tourist destination reveals significant differences between secondary (indirect) and global images, which include personal experiences, indicating a gap between promoted perceptions and actual visitor impressions. The study also found that the current promotional strategies are less effective for the younger

demographic, suggesting a need for improved marketing approaches to better engage this age group [53].

*2.2. Complementing Physical Tourism and Decision-Making Processes*

The examination of various studies on the application of virtual reality (VR) in cultural heritage tourism reveals a consensus that VR serves as a complement to traditional tourism rather than a replacement. A comprehensive review of VR applications in cultural heritage, assessing their educational potential and usability, noted their limitations in replicating the sensory richness of actual site interactions [54]. Bekele and Champion compared different immersive reality technologies and interaction methods, finding that, while these technologies enhance cultural learning, they do not replace the authenticity of real-world experiences [55]. Another study, using a user-centered design approach to develop a VR system for cultural heritage, demonstrated that VR enhances digital tourism through immersive, multi-user experiences but cannot fully replicate the physical and emotional impact of real visits [56]. In a different study, Kersten et al. detailed a methodological workflow from data acquisition to VR visualization, emphasizing realistic visualizations and interactivity, reinforcing the idea that VR enhances but does not substitute physical exploration [57]. Finally, Park et al. employed an experimental design to evaluate the effectiveness of video-based VTs in promoting cultural heritage sites, concluding that VR significantly boosts engagement and interest, serving primarily as a promotional tool to complement actual visits [58]. These studies collectively advocate for using VR to enhance traditional tourism, improving accessibility and engagement while preserving the unique value of real-world experiences.

The concept of destination image—how potential tourists perceive a destination based on information and impressions—is crucial in travel decision-making processes. VR web platforms significantly influence the destination image by providing immersive and engaging previews that shape tourists' perceptions. A positive and vivid destination image created through VR experiences can enhance tourists' intentions to visit and recommend the destination to others. A well-crafted VR experience can effectively convey the unique attributes and appeal of a destination, thereby enhancing its overall image [59].

VTPs offer immersive experiences that allow users to virtually tour destinations, attractions, and accommodations. These platforms serve as powerful tools to complement physical tourism by providing potential visitors with realistic previews of destinations. This capability significantly influences their travel planning and decision-making processes [16,60]. Such enhanced pre-visit experiences lead to better-informed decisions and a greater satisfaction with the travel experience [16].

By offering detailed previews of destinations and facilities, VR builds confidence in travel decisions by addressing potential travelers' uncertainties, such as concerns about safety, accessibility, and comfort. Higher levels of self-presence in VR experiences have been proven to lead to greater tourist engagement and a stronger intention to visit the physical destination [25]. This reduction in perceived risk is crucial for encouraging travel to less familiar or less popular destinations [25,61].

*2.3. Factors Influencing User Engagement*

The spread of VTs in the tourism sector has been significantly influenced by user motivations and technological preferences. A primary driver for individuals participating in virtual tours is the pursuit of relaxation, followed by interests in novelty and education. Interestingly, the digital experience itself was not a dominant motivation, suggesting that users still value the authenticity of physical travel [62].

The web component plays a critical role in enhancing VR tourism experiences by making them easily accessible to a broader audience. Interactive VR experiences available on web platforms allow tourists to actively engage with the content, making the information more memorable and influential in their decision-making processes. Features such as guided tours, interactive maps, and personalized content that adapts to the user's

preferences enhance engagement and provide a more comprehensive understanding of the destination [26].

A bibliometric review with a timeline from 2004 to 2020 [63] charted the progression of e-tourism trends, from the initial focus on web-based technologies to the more recent emphasis on augmented and virtual reality. The period between 2017 and 2020 was marked by advancements such as netnography, big data, and tourism 4.0. The COVID-19 pandemic accentuated the importance of e-tourism, emphasizing a shift towards internet technology over traditional modes of communication [3,14,38,63].

According to a study on tourism flow in Southern Europe [64], digital adoption—the incorporation of digital technologies within the tourism industry—has a less significant effect on drawing tourists than virtual proximity, which is defined as the perceived ease of digital interaction with a destination. This emphasizes the crucial role of a strong online presence and an engaging online experience in increasing tourism. It also implies that the perception of accessibility and closeness enabled by digital tools may have a greater impact on traveler behavior than the simple existence of cutting-edge digital infrastructure and services.

Demographically, a trend emerged where VT attendees, predominantly young and well-educated, accessed these tours mainly through mobile devices. This preference underscores the importance of optimizing VTs for handheld device compatibility [65]. Understanding tourists' preferences for fixed versus mobile internet can significantly influence the design of virtual tourism platforms. Preferences may vary based on factors such as the type of trip and the requirements of the decision-making process. For instance, tourists often use mobile internet during outdoor activities or while traveling, suggesting a need for VTPs that offer seamless mobile access to interactive content and real-time updates. Conversely, for more immersive experiences or detailed planning, tourists may prefer fixed internet access, implying that platforms should be optimized for desktop or laptop use, providing high-quality visuals and comprehensive information. By catering to these connectivity preferences, VTPs can enhance user engagement and offer personalized, interactive experience [15].

Interactivity is a critical factor in enhancing user satisfaction on VR tourism platforms. Interactive features, such as VTs, interactive maps, and real-time information, engage users more deeply than static content. Higher levels of interactivity in VR experiences lead to increased user engagement and satisfaction [66]. Interactive elements allow users to explore destinations at their own pace, providing a sense of control and personalization that enhances the overall experience [26].

The integration of smart technologies in the tourism sector has a significant impact on user engagement and satisfaction. A recent study conducted in Romania found that technologies such as artificial intelligence (AI), the Internet of Things (IoT), VR, and AR enhance the tourist experience by offering personalized services, improving operational efficiency and supporting sustainable practices. Tourists familiar with these technologies reported higher satisfaction and a greater intention to revisit, valuing the convenience and real-time information provided [67]. This is supported by other research, which states that tourists with greater technological skills and knowledge of smart tourism technologies proved to have more memorable experiences [68].

Technological familiarity plays a crucial role in user engagement with VR tourism platforms. Users who are more familiar with VR technology are more likely to have positive experiences and engage deeply with the content, while those who lack familiarity may feel intimidated or frustrated, creating a barrier to engagement [69]. Therefore, providing intuitive and user-friendly interfaces and comprehensive tutorials can help to mitigate these challenges and enhance user engagement.

Designing effective virtual tourism platforms requires a focus on usability, interactivity, and content quality and relevance to ensure high user engagement. With a user-centric approach, platforms should be intuitive and easy to navigate, including strategies such as

educational tutorials to overcome technological barriers and enhance the perceived value of VTs [16,69].

*2.4. Community Building and UGC*

Social media platforms and UGC have become pivotal in shaping modern tourism experiences. The integration of VR with social media platforms extends the reach and impact of these experiences, providing users with interactive and immersive environments, encouraging engagement and content creation. This synergy fosters a sense of community among users, enhancing satisfaction and trust [32]. Online sources, particularly social media, significantly influence users' motivation to co-create, which in turn impacts the destination image. Notably, the most influential motivators for co-creation were social media recommendations, especially from family and friends, and the promotion of lesser-known destinations [70].

Before embarking on their journey, tourists typically draft a rough itinerary based on extensive online research, using both social media and official channels. Upon reaching their destination, they further refine their plans by consulting online forums and review platforms, especially to discover attractions in proximity to their primary points of interest [71]. This dual-phase reliance on social media underscores its pivotal role as a travel companion and guide. Furthermore, social media platforms serve as a validation tool, helping travelers decide which sites to visit [11]. This process highlights the traveler's dual role as both a consumer and a contributor in the digital travel ecosystem.

Reviews, photos, and videos contributed by tourists significantly enhance the engagement of users on VR tourism platforms. While UGC plays a role in community building, its primary impact on user engagement comes from providing authentic, diverse perspectives that enrich the user experience. UGC can influence potential tourists by offering realistic and relatable information, making the virtual experience more engaging and credible [72].

Moreover, the use of geotagged social media content can inform modern travelers by providing real-time, location-based information that enhances their travel planning and on-site experiences. This dynamic interaction between social media and VR platforms not only supports the discovery of less popular touristic attractions but also fosters a sense of community among travelers who share their experiences and insights [10].

Despite the potential of VR and AR technologies in tourism, there remains a significant gap in understanding their full impact on user engagement and satisfaction. Most research has focused on the emotional and immersive attributes of these technologies, suggesting a need for more studies that explore their social engagement and sustainability aspects [17]. This gap highlights the importance of designing VTPs that not only provide immersive experiences but also facilitate social interactions and community-building, thereby enhancing user satisfaction and trust.

In conclusion, the integration of social, interactive, and UGC features on VTPs plays a crucial role in enhancing user satisfaction, community building, and trust. By leveraging the expansive reach and authenticity of UGC, these platforms can effectively promote lesser-known destinations and support sustainable tourism practices. This comprehensive approach to virtual tourism fosters a more engaged and informed travel community, ultimately contributing to the growth and resilience of the tourism industry.

**3. The VRRO Platform**

The VRRO platform (Virtual Romania) [18] is a multi-user web platform, serving both as an informational and promotional tool for a Romanian network of virtual heritage tours, as well as a social hub. It acts as a foundation for the creation of the virtual tour network and fosters a community that remains active and engaged within the platform.

*3.1. Functionalities*

In the initial launch of VRRO, the primary objectives were to quickly provide users with a rich and interactive experience and to gather user feedback for future enhancements.

The platform's core modules, including the interactive map, social module, virtual tour gallery, and blog module, have been comprehensively implemented. These features offer users a complete experience, emphasizing ease of use and immediate access to Romania's cultural and natural beauty.

While the main modules of VRRO are operational and provide a comprehensive user experience, specific areas have been identified for future development. The platform currently lacks automated content moderation for user-uploaded content, advanced image compression, and request queuing processes. Additionally, the implementation of a custom-built ID verification system using computer vision technology is planned but not yet achieved. Future enhancements will also include the development of animated virtual tours, incorporating video uploads, frame capture, and a corresponding viewer.

The initial version of VRRO stands as a comprehensive yet evolving foundation, designed to be adapted and expanded based on user feedback and technological advancements. The aim is to continually refine and enhance the virtual tourism experience, making VRRO a dynamic and responsive platform in the virtual tourism landscape.

### 3.1.1. Virtual Tour Gallery

One of VRRO's primary features is the VT gallery, which allows users to filter and search tours automatically ordered by popularity (Figure 1a). Additionally, an alternative viewing mode is provided through an interactive map, granting users a geographical perspective of the showcased locations (Figure 1b). These virtual tours are available as non-immersive VR, mobile AV with gyroscope sensor input, and fully immersive mobile VR with the help of smartphone VR mounts. The mobile VR functionality offers a highly immersive [73] yet low-interaction experience, allowing users to delve into static 360° VTs of diverse Romanian tourist attractions (Figure 1c).
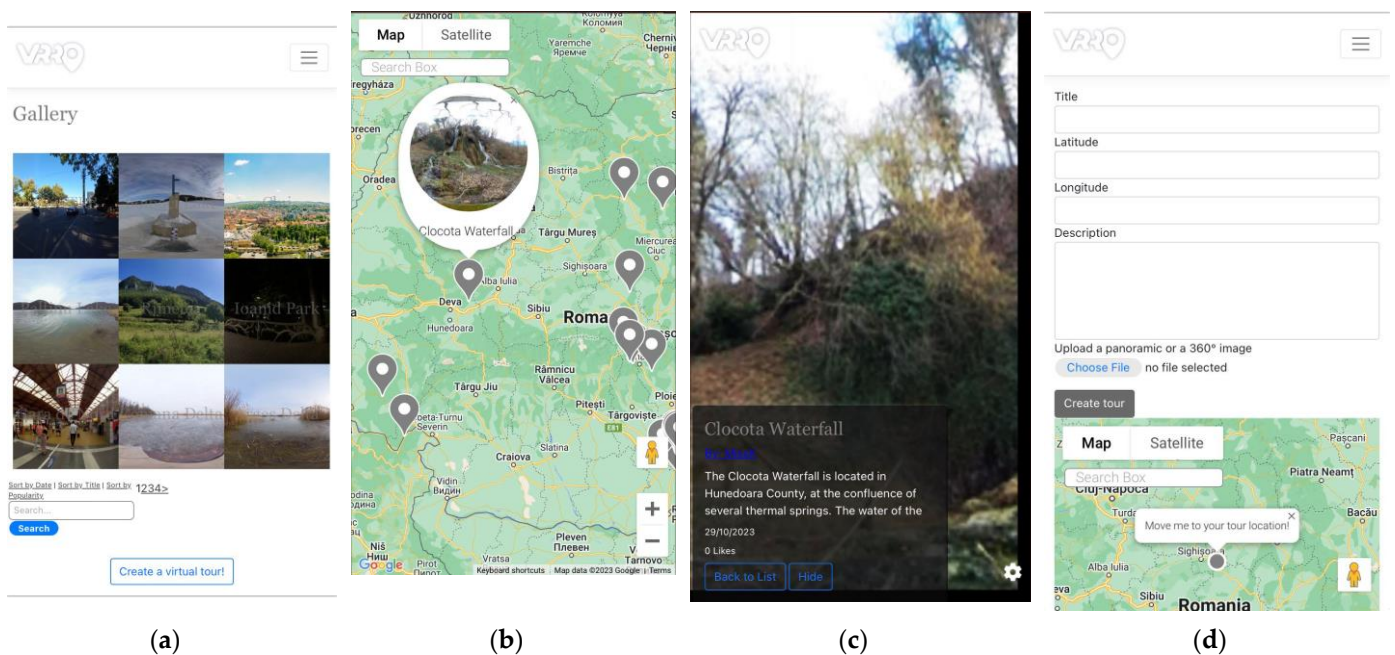


(**a**)  (**b**)  (**c**)  (**d**)

**Figure 1.** Four major pages of the VT module: the map (**a**), the gallery (**b**), the single tour view (**c**), and the tour creation form (**d**).

Another pivotal feature is the VT creation toolset. Beyond just viewing, registered users are endowed with the ability to upload and design their own virtual tours. In the creation process, the challenge of finding and entering the tour location is solved with the use of a map submodule with a single pin serving as input. The pin's position can be adjusted via direct drag on the map or through location search using the name or address (Figure 1d).

The VRRO platform is designed for accessibility across various devices, using the Panolens.js [74] library to ensure cross-compatibility and optimal performance. This library, complemented by custom CSS rules, guarantees that the virtual tour views are correctly displayed on desktop interfaces, mobile devices, and mobile VR equipment. The platform's multi-platform approach is integral to providing users with a flexible and immersive virtual tourism experience, catering to diverse preferences and ensuring accessibility through traditional desktops, portable smartphones and tablets, or immersive mobile VR devices.

The settings menu allows users to change their tour viewing experience by selecting their preferred control and view mode. The control options include sensor-based navigation using a gyroscope for a more immersive experience, particularly on mobile devices, or traditional mouse and touch inputs for desktop and standard mobile use. For the view mode, users can choose between normal, cardboard, or stereoscopic views. The fully immersive mode is accessible on mobile devices by combining sensor data as the control setting with either the cardboard or stereoscopic view modes. These customizable settings ensure that users can enjoy a seamless VT experience on the VRRO platform, regardless of their device or preferred mode of interaction (Figure 2).



**Figure 2.** The mobile VR view is accessible through the selected settings.

### 3.1.2. Social Module

The platform's commitment to fostering community engagement is evident in its social component. Users are empowered to create personal profiles, facilitating interactions such as comments, likes, and direct messaging. To ensure user trust, all interactions are meticulously stored in compliance with the General Data Protection Regulation (GDPR) [75].

The social module of the VRRO platform encapsulates a real-time chat feature. By integrating SignalR [76], a powerful real-time web functionality library for ASP.NET, the platform delivers instant messaging capabilities through a persistent, bidirectional connection between the server and connected clients.

The social module is accessible to registered users; however, interactions are limited to befriended users. Only those who made a public presence through posts or comments have accessible profiles and can receive friend requests (Figure 3).

### 3.1.3. Blog

Complementing its virtual tour offerings, the VRRO platform also serves as a hub for tourism-related content through its Blog section (Figure 4a). Both individual enthusiasts and institutional partners can contribute articles centered on tourism themes. To encourage reader engagement, functionalities such as commenting and liking articles have been integrated (Figure 4b,c).
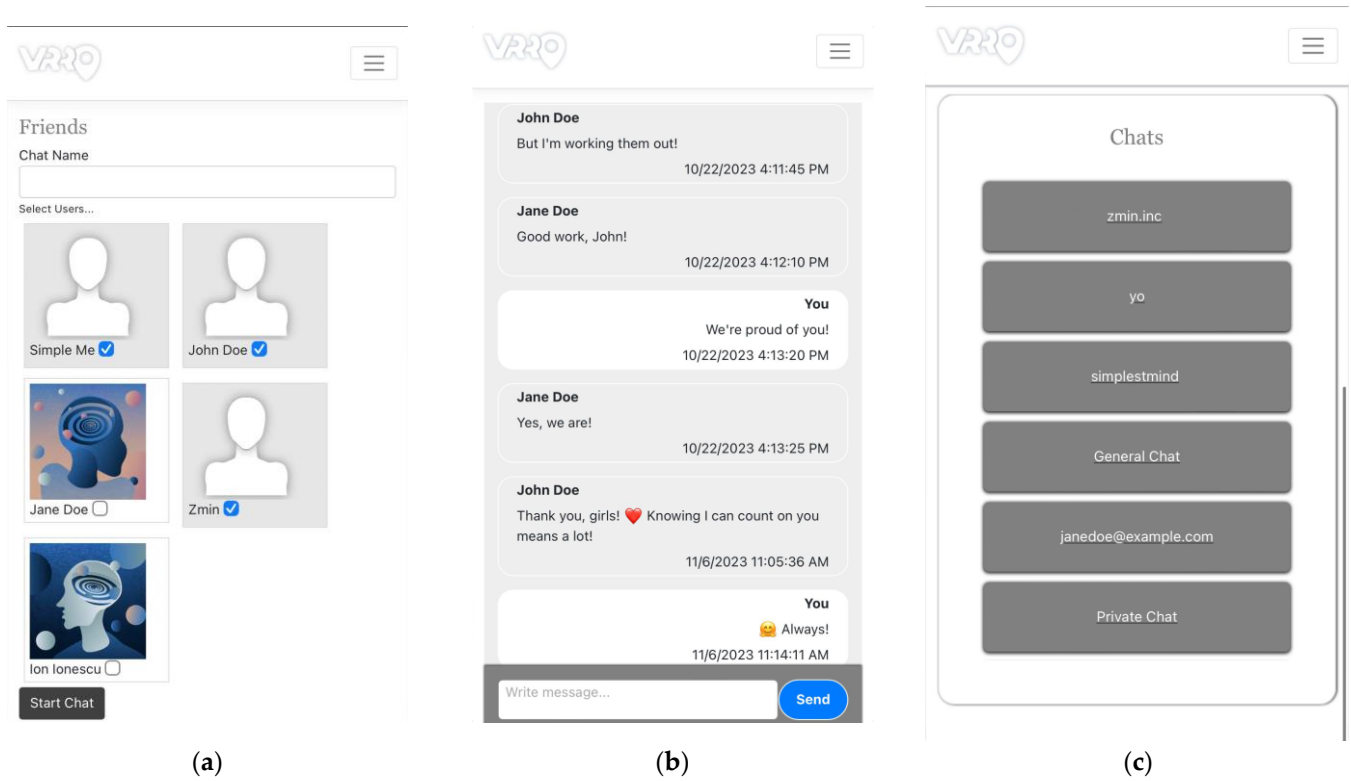
(**a**)  (**b**)  (**c**)

**Figure 3.** The social module's main pages: friend list (**a**), chat (**b**), and chat list (**c**).



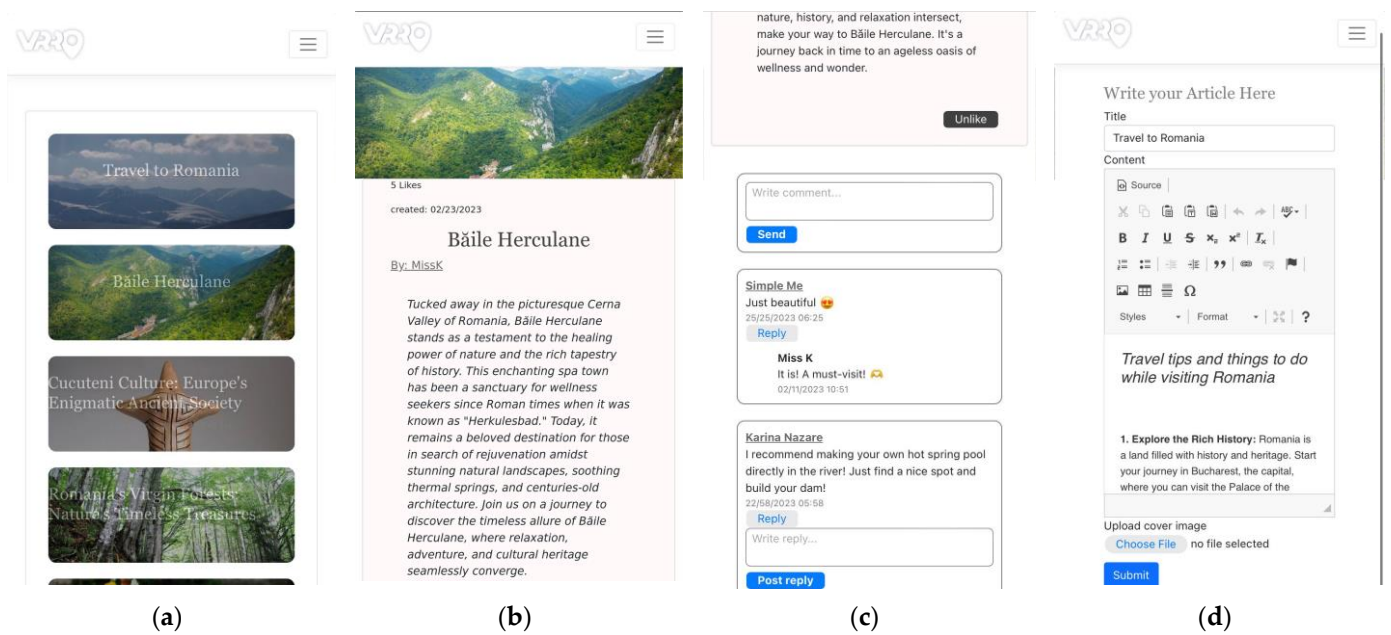(**a**)  (**b**)  (**c**)  (**d**)

**Figure 4.** The informational blog also plays a major role in user engagement and interaction. The figure presents the article list (**a**), a single-article view (**b**), associated comments, (**c**) and the article creation form (**d**).

The integration of the CKEditor [77] library in the blog's text editor allows for rich content creation. Users can easily style text and incorporate images, facilitating the production of visually appealing and well-formatted articles (Figure 4d).

### 3.1.4. User Engagement

To encourage user activity and reward engagement, the gamification module introduces elements such as badges for active users. It also promotes popular articles or tours, ensuring that quality content receives the recognition it deserves.

Visitors are encouraged to become a part of the community through the welcoming messages on the site's landing page and encouraging messages on buttons that lead to account creation actions or VT creation actions if logged in (Figure 5a,b).
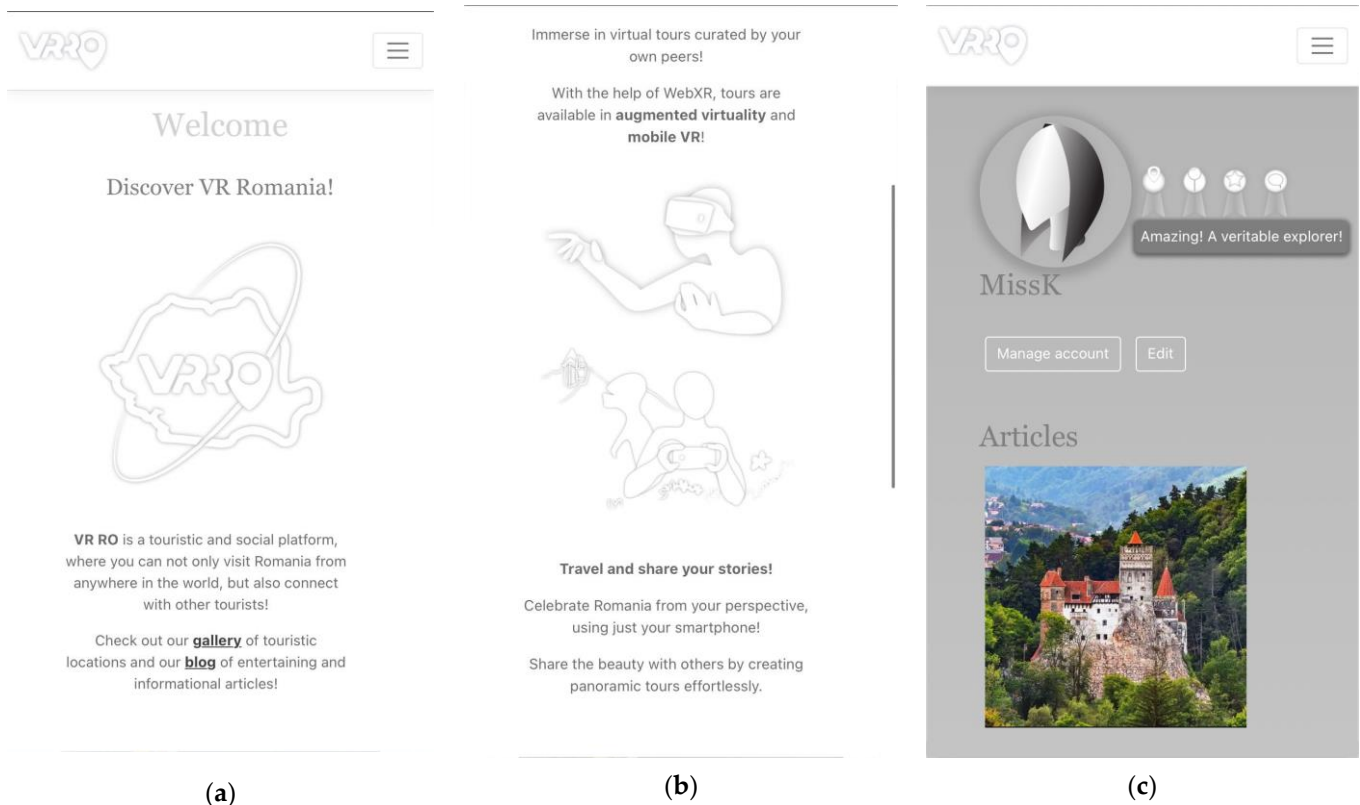


| (**a**) | (**b**) | (**c**) |

**Figure 5.** Users are encouraged to take an active part in the community (**a**,**b**) and are rewarded (**c**).

VRRO employs a gamification strategy that rewards users with badges for various levels of engagement. These badges include the Community Badge, awarded for engaging in multiple posts or chats; the Explorer and the Informer Badges, for users who actively create gallery or blog posts, respectively; and the VIP Badge, for those whose posts exceed in popularity. This system not only incentivizes user interaction but also acknowledges and celebrates the contributions of active members within the VRRO community (Figure 5c).

### 3.2. Architecture

VRRO is designed with a combination of distributed, three-tier, and Model-View-Controller (MVC) architectures. This integration ensures scalability, maintainability, and efficient data processing, with a focus on distributed functionalities across various services and components.

The Three-Tier architecture provides a structured approach by dividing the application into three distinct layers: the presentation layer, the business logic layer, and the data layer (Figure 6). Within this structure, the platform's architecture is built on a robust and scalable NET Core framework [78], integrating a Model-View-Controller (MVC) design pattern that divides the application into logical units to enable efficient development, testing, and maintenance. Each functional module (Social, VT Gallery, Blog, and Map) consists of models, views, and controllers, using specific services or libraries that facilitate their functionality. The Entity Framework Core [79] is used in the backend for object-

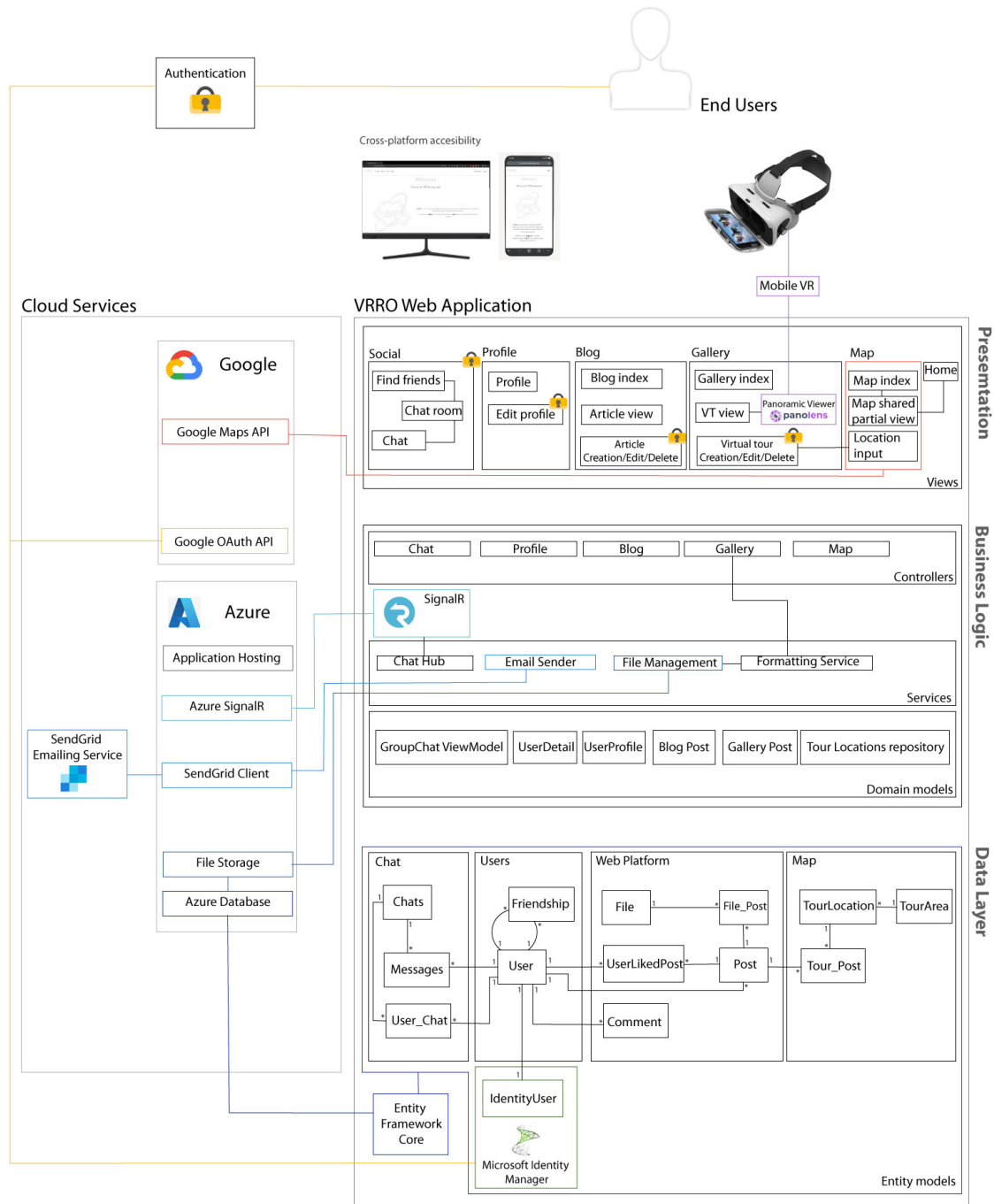relational mapping, ensuring smooth data transactions with our Azure-hosted distributed database [80].



**Figure 6.** Architecture and component diagram: a structured overview of the VRRO web application, detailing its interactions with external cloud services and between different modules within the application. In the Data Layer representation, * denotes a many-to-one relationship, while 1 represents a one-to-one relationship, indicating the cardinality of database entities.

### 3.2.1. Presentation Layer

The presentation layer primarily consists of views from the MVC architecture, focusing on user interface and interaction. These views are dynamically rendered based on the data and logic provided by models and controllers located in the business logic layer. This layer is fundamental in defining the user's initial and ongoing interaction with the platform.

The design is minimalist and elegant, providing a user interface that is visually appealing, with a straightforward and intuitive interface. This design choice helps new users to quickly learn how to use the platform, improving their overall experience.

Additionally, the presentation layer features a responsive design, ensuring compatibility across a variety of devices, from desktop computers to mobile phones and tablets. It is robust and user-friendly, with content that is easy to read and provides helpful input assistance. Designed to be inclusive, the platform offers text alternatives for non-text content and enabling its transformation into various accessible forms. While adaptable to many different scenarios, it is especially effective with basic input methods such as mouse, keyboard, and touch gestures.

Overall, the presentation layer of VRRO delivers an accessible, user-friendly, and aesthetically pleasing experience, reflecting the platform's commitment to making Romania's cultural and natural heritage globally accessible and adhering to various accessibility standards [81].

### 3.2.2. Business Logic Layer

The core of VRRO's functionality lies in its business logic layer. This layer is primarily composed of controllers, the functional components of the MVC architecture that manages the flow of data within the application. They interact with models to process business logic, handle user requests, and determine the data presented in the views. Central to this layer are the entity models, responsible for more than just data handling; they enforce business rules, including access protocols, formatting rules, and error message management. Complementing these are the domain-specific models, which define the data structure, outline relationships, and establish business rules (e.g., GalleryPost and BlogPost, which extend the Post entity model).

The layer is further enhanced by specialized services that manage specific processes or business rules, such as authentication, content management, and the logic behind user interactions. An integral part of this layer are also the client-side scripts, which include integrations with client-side APIs and support for synchronized real-time services, ensuring a smooth and responsive user experience.

### 3.2.3. Data Layer

In the data layer, the VRRO platform utilizes Entity Framework Core [79] as its Object-Relational Mapping (ORM) system. This layer consists of database tables that correspond to entity models. Although these entity models are part of the business logic layer, they are crucial for the data layer as they directly map to the database, facilitating seamless data management and interaction between the application's business logic and its data storage.

The platform utilizes a relational database model, which organizes data into tables corresponding to entities or relationships between them. This model is particularly advantageous for its ability to efficiently handle large volumes of data while maintaining strong data integrity and consistency. Compared to other database models, relational databases offer superior flexibility in querying and data manipulation, making them ideal for complex applications like VRRO that require robust data management and sophisticated query capabilities.

### 3.2.4. Cross-Layer Accessibility of Cloud Services

The VRRO platform is characterized by a distributed architecture, a design that spreads its functionalities across multiple computer networks to enhance efficiency and reliability with the use of Azure cloud hosting [82]. Additionally, VRRO integrates a range of external cloud services, each contributing unique functionalities to the platform. The following paragraphs present the specific cloud services and functionalities integrated within each of the three-tier layers, illustrating how they collectively contribute to the robust and flexible nature of the platform.

In the presentation and business logic layers, the platform utilizes the Google Maps API [83] for dynamic map displays, enriching the user's navigational experience with geographical context. Additionally, the Panolens.js [74] library plays a crucial role in providing immersive VT views, ensuring a seamless and engaging user experience across different devices.

Within the business layer, the platform's core functionalities are supported by a suite of services. Microsoft's Identity Service ensures secure user authentication and management, while Google OAuth [84] integration offers a streamlined sign-in process. Real-time communication is facilitated by Azure SignalR [76], essential for the platform's chat feature. Furthermore, the SendGrid Emailing Service [85], integrated within the Azure framework, handles email communications.

Within the data layer, which includes hosting and infrastructure, Azure Files storage [80] is employed for efficient file management. The Azure Database [80] is used for data management, offering scalability and robust performance. The Microsoft Identity Management platform [86], beyond authentication, also contributes to the management of user data tables.

## 4. Empirical Study

An empirical study was conducted to evaluate the platform's ease of adoption by users. This assessment is crucial to gauge the platform's potential for integration into potential tourists' practices and to cater to their distinct needs. By analyzing received feedback and collected data, the aim is to pinpoint the platform's strengths and areas that might require enhancements to optimize its adoption among the target audience.

### 4.1. Methodology

To gain a comprehensive understanding of the user experience on the VRRO platform, a mixed-methods approach was chosen. This methodology allows for both quantitative assessments of user experience metrics and qualitative insights into user behaviors, motivations, and feedback.

A convenience sampling method was employed, leveraging peers, friends, and acquaintances primarily through social media outreach and direct contact. We opted for this technique due to its feasibility and the potential to gather diverse feedback quickly. While the study did not set strict demographic controls, the participant pool inherently consisted of tech-accustomed users, ensuring a basic level of technological comfort. This demographic is particularly relevant as the study aims to understand the attitude of users who are already curious or prone to adopt such technologies.

Participants were provided with access to the VRRO platform and were encouraged to explore it at their convenience over a period of several days. This approach allowed participants to interact with the platform in a manner that suited their schedules and preferences. However, it resulted in varying interaction durations, with some users spending more than 30 min and others only 5–10 min. While this variability provides a realistic picture of user engagement, it may introduce inconsistencies in the feedback collected. Due to the study design and the anonymous nature of the responses, precise interaction durations were not recorded. Participants' engagement levels were inferred from their responses and the depth of their feedback.

The data collection instruments that were used are:

- Quantitative: The short form of the User Engagement Scale (UES) [31] was employed to gather numerical data on user engagement. Additionally, participant ratings of platform modules, self-assessed digital familiarity, and evaluations of future engagement intentions were included, offering a comprehensive view of user interaction and platform impact.
- Qualitative: Open-ended questions were used to collect qualitative data, providing deeper insights into users' experiences and perceptions. This approach captured feedback on specific platform modules, suggestions for improvements, and challenges

encountered during interaction. It also included aspects related to technology usage and participants' self-evaluation of their activity on the platform.

Post-interaction, participants completed the feedback questionnaire [87] consisting of the demographic questions (age, gender, prior engagement with such technologies, and interest), the short form of the UES (Table 1), module-specific rating of platform functionalities, self-rating of users' activity (including platform of use), and impressions (open-ended questions).

**Table 1.** The short form of the user engagement scale.

| Factor | Description | Affirmations |
| --- | --- | --- |
| FA | Focused attention feeling absorbed in the interaction and losing track of time. | I lost myself in this experience.<br>The time I spent using VRRO just slipped away.<br>I was absorbed in this experience. |
| PU | Perceived usability, negative affect experienced in the interaction, and the degree of control and effort expended. | I felt frustrated while using VRRO.<br>I found VRRO confusing to use.<br>Using VRRO was taxing. |
| AE | Aesthetic appeal, the attractiveness and visual appeal of the interface. | VRRO was attractive.<br>VRRO was aesthetically appealing.<br>VRRO appealed to my senses. |
| RF | Reward factor, curiosity, interest, felt involvement, and the overall success of the interaction. | Using VRRO was worthwhile.<br>My experience was rewarding.<br>I felt interested in this experience. |

The rating or self-scoring questions' answers were in the form of 5-point Likert scales, with values corresponding to the context. For example, "How often did you upload virtual tours?" had the answers "Never", "Once", "Twice or thrice", "Multiple times", or "Often". Their feedback was recorded [88] and analyzed to draw insights.

Open-ended questions were designed to be clear, relevant, neutral, specific, and encourage detailed responses, following best practices that emphasize these qualities to ensure high-quality responses [89]. Each question was intentionally formulated to avoid ambiguity and to encourage users to provide thoughtful and comprehensive answers. Such open-ended questions are crucial for capturing the depth and breadth of user experiences, as they do not constrain the respondents' answers, thus providing richer and more detailed feedback. Furthermore, detailed responses from open-ended questions can provide deeper insights into user engagement and satisfaction, which are essential for improving the platform [90].

The questions used in this study aimed to capture detailed feedback on specific platform modules, suggestions for improvements, and challenges encountered during interaction:

- What kind of friends would you recommend this platform to?
  This question aims to identify the target audience for the VRRO platform based on user perceptions. It helps understand the platform's appeal and potential user base from the perspective of current users.
- What did you feel this platform was missing?
  This question seeks to uncover gaps in the platform's features and functionality, providing insights into areas for improvement and innovation.
- What was the most enjoyable part of the platform?
  Positive feedback helps to pinpoint the platform's successful elements that can be emphasized and further developed. Understanding what users enjoy most can guide marketing strategies and the enhancement of key features that drive user engagement and satisfaction.
- What was the most annoying part of the platform?
  Identifying the negative aspects of the platform provides critical insights into user dissatisfaction and potential barriers to engagement.

- Please add any other observations you might want to share.
  This open-ended question allows users to provide additional feedback that may not have been covered by the other questions, ensuring that all relevant user experiences and insights are captured.

The inclusion of the final open-ended question ensures that any feedback not covered by the previous questions can still be captured, reflecting a comprehensive approach to user feedback collection [89]. These methodological choices not only enhance the quality of the data collected but also support a thorough analysis of user engagement and satisfaction, contributing valuable insights for the platform's ongoing development and refinement.

Quantitative data from the UES and module-specific ratings were analyzed to assess overall user engagement and satisfaction. Qualitative data from the open-ended questions were analyzed thematically to identify common themes and insights regarding user experiences, preferences, and areas for improvement. By combining quantitative and qualitative data, this study aimed to provide a holistic understanding of user engagement with the VRRO platform, identifying both its strengths and areas for improvement. The variability in interaction durations is acknowledged as a limitation but also reflects real-world usage patterns, providing valuable insights into user behavior.

*4.2. Results*

The results include answers from 31 users, 9 female (29%) and 22 male (71%), aged between 22 and 42 years, all past or present visitors of Romania, with the intention of traveling within Romania in the future. While this sample size provides valuable insights, it is relatively small and may not fully represent the broader population of potential users. This limitation should be considered when interpreting the findings.

Users rated their familiarity with web technologies highly, with a mean score of 4.5 out of 5, while familiarity with immersive technologies had a mean score of 3.7 out of 5 (Figure 7).
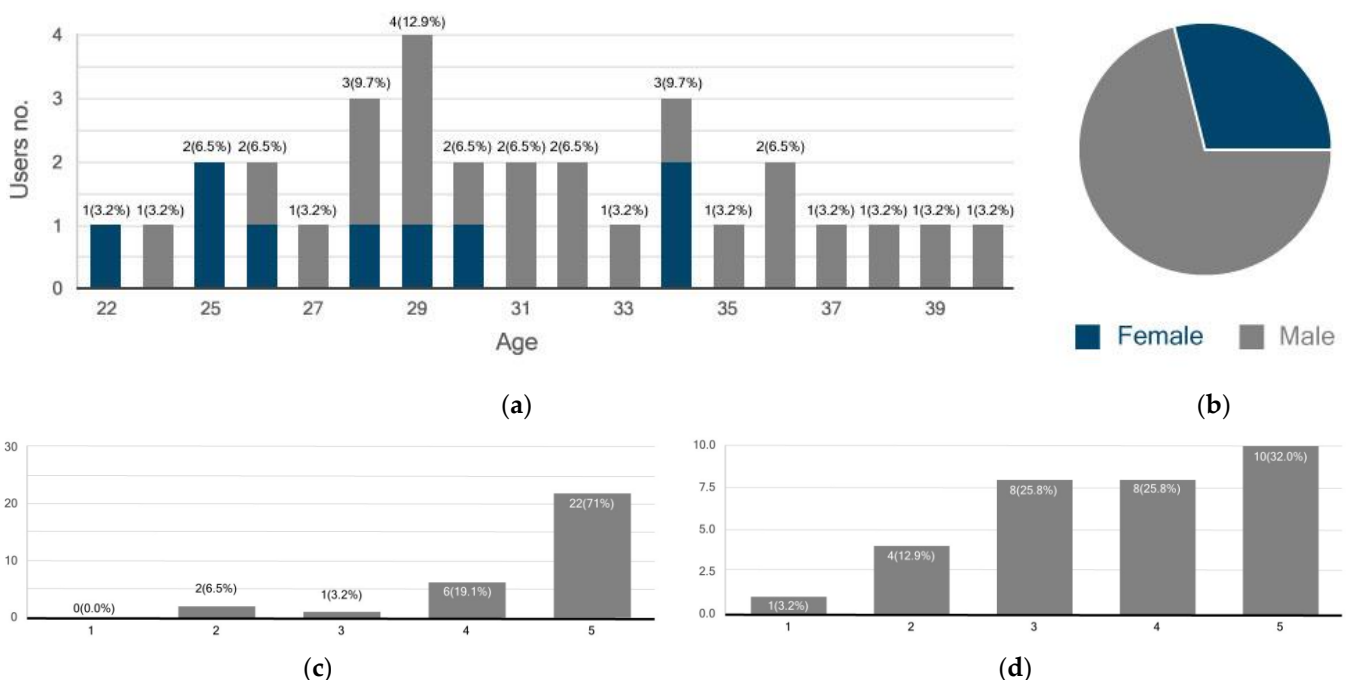
(a)

(b)

(c)

(d)

**Figure 7.** User demographics: age (**a**), gender (**b**), and reported familiarity with web (**c**) and immersive (**d**) technologies.

The devices used for accessing the platform were predominantly mobile (21), with the most used operating system being iOS. Four participants used both mobile and desktop devices in their experience, and nine used only desktop devices (Figure 8).
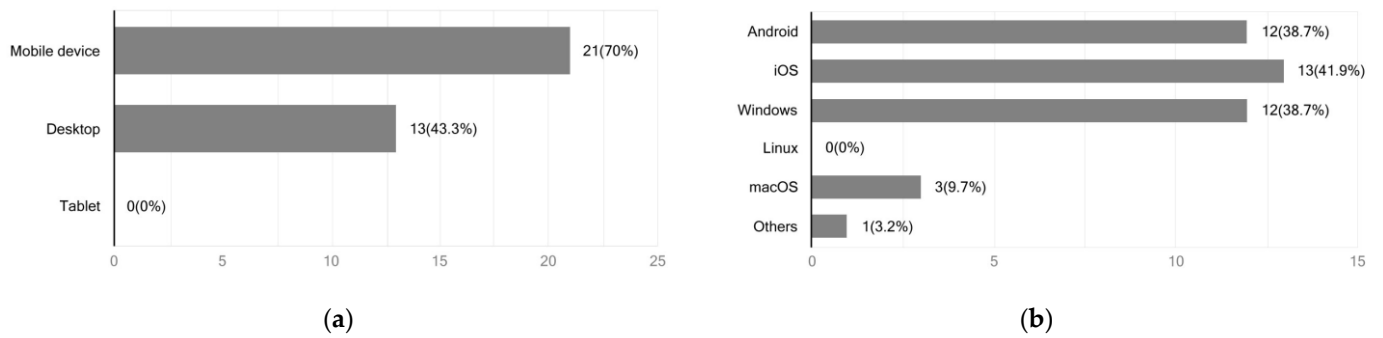
(**a**)



(**b**)

**Figure 8.** Preferred platform access. (**a**) A total of 70% of the surveyed users preferred access by mobile devices; (**b**) the preferred operating system was iOS (41.9%).

4.2.1. Activity

We categorized our users based on their level of interaction with the platform from a pool of 31 participants. A total of 10 users, representing 32.3% of the sample, were identified as "active creators". Within this group, 60% (six users) created tours, 20% (two users) wrote articles, and another 20% (two users) contributed to both the gallery and blog posts. These individuals were not only frequent visitors but also actively engaged with the platform's features.

A smaller segment, consisting of four users (12.9%), showed "low interaction", participating minimally and preferring to engage through voting or commenting on posts rather than creating content.

Among the 14 active users, 14.3% (2 users) never voted, 71.4% (10 users) voted multiple times, and 14.3% (2 users) voted once. For commenting, 21.4% (three users) did so once, 28.6% (four users) commented more than once, and 50% (seven users) never commented at all. Additionally, 28.6% (four users) befriended other users, and only 14.3% (two users) of the active users received badges, a reward for high levels of activity.

The "visitors", who primarily used the platform to view content, constituted the majority, with 17 users making up 54.8% of the total participants. This group's interaction was characterized by significantly less content creation and interaction compared to the other groups (Figure 9).
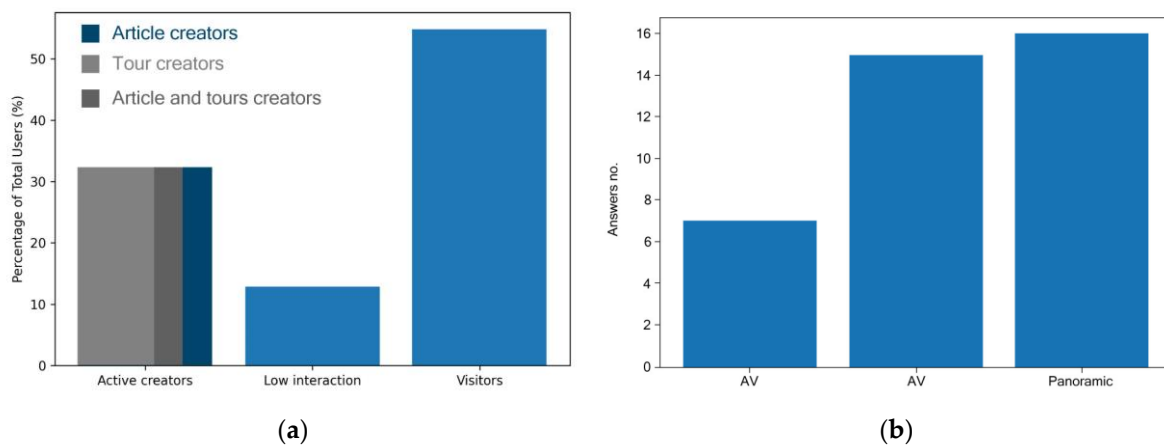


(**a**)



(**b**)

**Figure 9.** User classification by activity (**a**) and user preferences of viewing virtual tours (**b**).

Twenty-nine percent of the participants favored a traditional approach to VT viewing, engaging exclusively with basic panoramic views on desktop interfaces, aligning with the nine users who exclusively used desktop devices.

A significant majority, approximately 68%, utilized mobile devices to access the tours, indicating a preference for more immersive experiences. Within this mobile user segment,

a small proportion, roughly 10%, experimented with AV, which integrates the physical environment with digital overlays through device sensors. A larger portion, 48%, opted for a VR format, suggesting a preference for a fully immersive digital experience.

Notably, 23% of participants were inclined towards a hybrid approach, engaging with both basic panoramas and VR formats. This indicates a non-exclusive, exploratory interaction with the available technological modalities.

### 4.2.2. Engagement

The platform's commitment to delivering a seamless and engaging user experience is reflected in the ratings provided by our diverse user base. To capture the essence of this experience, we analyzed the UES scores alongside the ratings for open-access modules and specialized features accessible to active users. This analysis not only sheds light on the overall satisfaction but also allows us to discern patterns across various user segments (Table 2).

**Table 2.** Summary of user engagement scale scores.

| Factor | Focused Attention | FA 1 | FA 2 | FA 3 | Perceived Usability | Aesthetic Appeal | Reward Factor | UES (Overall) |
|--------|-------------------|------|------|------|---------------------|------------------|---------------|---------------|
| Score | 2.97 | 2.29 | 3.23 | 3.39 | 4.56 | 3.70 | 3.97 | 3.81 |

The lower scores in the Focused Attention (FA) factor of the UES for the VRRO platform align its primary function as an informational and educational tool. The platform's minimalist aesthetic, characterized by a simple color scheme and a straightforward interface, facilitates easy navigation and efficient information retrieval. However, this design approach, while effective for its intended purpose, does not inherently promote deep immersion or a sense of escapism, which are typical contributors to higher FA scores.

The content and interaction style on VRRO, including article viewing, virtual tour exploration, and chatting, are primarily structured for information exchange rather than immersive engagement. The VR mode, offering static image views, provides a basic level of virtual experience but lacks interactive or dynamic elements that could lead to higher levels of user absorption. This focus on information delivery over immersive interaction is reflected in the FA scores, particularly in the lower ratings for the first statement, "I lost myself in this experience".

Future enhancements to VRRO could aim to increase user immersion and engagement by incorporating engaging narratives, interactive tutorials, and enhanced VR experiences. However, any such enhancements should be carefully balanced with VRRO's core informational and educational objectives to ensure the platform remains true to its primary purpose while enriching user experience.

The survey questions also assessed the users' intent to use the platform for travel-related activities and their likelihood to recommend it to others. These responses were used to create an endurability index, mirroring the concept from the long-form UES, which reflects users' long-term engagement and potential for recommendation (Table 3).

The Drive Index, with a calculated value of 3.98, serves as a quantitative measure of the users' immediate motivation to engage with the VRRO platform. This index is derived by averaging responses to four key questions that assess users' intentions to use the platform for specific activities: commemorating travels, connecting with travelers, gathering pre-travel information, and informing other travelers. This high score suggests that the platform successfully meets user needs and interests.

The Endurability Index, with a value of 4.05, reflects the long-term potential of user involvement and the likelihood of users recommending the platform to others. It is calculated by averaging the Drive Index and responses to the next two questions, regarding future platform use and the propensity to recommend the platform to friends. The score underscores the platform's capability to not only attract users initially but also retain

them over time, indicating a strong potential for building a loyal user base and fostering community growth.

**Table 3.** Engagement endurability scores.

| Question Categories | Average Score |
|---|---|
| Commemorate Travels | 4.10 |
| Connect with Travelers | 3.65 |
| Pre-travel Information | 4.06 |
| Inform Other Travelers | 4.10 |
| Future Platform Use | 3.94 |
| Recommend to Friends | 4.23 |
| **Drive Index** | 3.98 |
| **Endurability Index** | 4.05 |

Another section of the user feedback questionnaire focused on user satisfaction with specific modules of the platform (the Map, the Blog, and the VT Gallery). Overall ratings for the open-access components—Map, VT Viewer, and Article Viewer—indicate a consistently positive experience, with scores exceeding 4 out of 5 (Table 4). This suggests a high level of satisfaction with the platform's core functionalities, which are available to all users.

**Table 4.** Platform module ratings.

| Module | Map | VT Viewer | VT Creator | Article Viewer | Article Creator | Chat |
|---|---|---|---|---|---|---|
| Rating | 4.03 | 4.03 | 4.00 | 4.13 | 4.14 | 3.14 |

The specialized features, such as Article Creation, VT Creation, and Chat, evaluated only by our 14 active users, also received favorable ratings, with the Article Creation module standing out with the highest scores. This reflects the platform's ability to cater to content creators with tools that are both functional and user-friendly.

When segmenting the data, nuanced variations in ratings based on users' expertise with web and immersive technologies were observed. Notably, participants who reported having a high technological familiarity tended to rate the modules slightly higher than the other participants, pointing to a correlation between technological familiarity and user satisfaction (Table 5).

**Table 5.** Overall experience ratings.

| Module | UES | Open Access Modules | Advanced Features | Endurability |
|---|---|---|---|---|
| Rating | 3.81 | 4.06 | 3.76 | 4.05 |

### 4.2.3. The Influence of Digital Literacy on Experience

In the initial stage of our analysis, we focused on the distribution of user engagement scores (measured through the UES), technology familiarity assessments, and ratings of the open-access modules (accessible for both visitors and authenticated users). These datasets encompass information from all 31 participants. The selection of these datasets for normality testing was driven by our aim to understand the underlying patterns of user interaction with the platform.

Before presenting the normality of these distributions, we present an overview of overall ratings by user engagement factors and technology familiarity. This summary (Table 6) offers a baseline understanding of how users with different levels of digital literacy perceive various aspects of the platform, setting the stage for a deeper analysis of distributional characteristics.

**Table 6.** Summary of overall ratings by user engagement factors and technology familiarity.

| Factor | All Participants | High Web Familiarity | High XR Familiarity | Low Web Familiarity | Low XR Familiarity |
|---|---|---|---|---|---|
| UES | 3.81 | 3.81 | 3.93 | 3.81 | 3.71 |
| VT Viewer | 4.03 | 4.00 | 4.11 | 4.11 | 3.92 |
| Article Viewer | 4.13 | 4.05 | 4.11 | 4.33 | 4.15 |
| Map | 4.03 | 3.95 | 4.11 | 4.22 | 3.92 |

The preliminary analysis of the overall ratings suggests a pattern where participants with a higher familiarity with web and immersive technologies tend to report slightly higher engagement scores across the individual factors of the UES, as well as the overall UES. Similarly, the ratings for the VT Viewer, Article Viewer, and Map functionalities also appear marginally higher among these users.

By assessing the normality of these distributions, we aim to validate the appropriateness of the statistical methods used for further comparative analysis. The Table 7 encapsulates the results of the Shapiro–Wilk test and key descriptive statistics, providing a snapshot of the data's distribution.

**Table 7.** Data normality and descriptive statistics for key study variables.

| Variable | Shapiro–Wilk W | *p*-Value | Average ($\bar{x}$) | Std. Deviation (S) |
|---|---|---|---|---|
| UES | 0.9749 | 0.6616 | 3.8118 | 0.5137 |
| VT Viewer | 0.8253 | <0.001 | 4.0323 | 1.016 |
| Article Viewer | 0.7897 | <0.001 | 4.129 | 1.0565 |
| Map | 0.8174 | <0.001 | 4.0323 | 1.0796 |
| Web Familiarity | 0.5904 | <0.001 | 4.5484 | 0.85 |
| XR Familiarity | 0.875 | 0.0018 | 3.7097 | 1.1603 |

The comparative analysis of user engagement and module ratings across different levels of technology familiarity revealed no statistically significant differences (Table 8). The UES scores, which reflect user engagement, showed a slight tendency for higher engagement among users familiar with immersive technologies, but this did not reach statistical significance. Similarly, the ratings for the open-access modules did not differ significantly between users with a high or low familiarity with web and immersive technologies. The effect sizes were generally small, indicating minimal practical differences in perceptions between the groups. This suggests that familiarity with the technology did not significantly influence the users' engagement or their perception of the platform's modules. This may also imply that these factors may not have a substantial impact on the user experience within the sample studied.

**Table 8.** Summary of Mann–Whitney U test and effect size measures.

| Variable | Technology Familiarity | Mann–Whitney U | *p*-Value | Cohen's d | Glass's Delta | Hedges' g |
|---|---|---|---|---|---|---|
| UES | Web | 91 | 0.7414 | 0.008 | 0.007 | 0.008 |
| | Immersive | 102.5 | 0.3843 | 0.380 | 0.362 | 0.377 |
| VT Viewer | Web | 95.5 | 0.89656 | 0.121 | 0.096 | 0.108 |
| | Immersive | 110 | 0.79486 | 0.111 | 0.106 | 0.110 |
| Article Viewer | Web | 91.5 | 0.76418 | 0.297 | 0.245 | 0.270 |
| | Immersive | 107.5 | 0.71884 | 0.098 | 0.094 | 0.097 |
| Map | Web | 94.5 | 0.86502 | 0.273 | 0.220 | 0.245 |
| | Immersive | 106 | 0.67448 | 0.031 | 0.028 | 0.030 |

### 4.2.4. Qualitative Insights

To draw qualitative insights into users' experiences, four open-ended questions were posed to assess their candid opinions on the platform's usability and features. Users expressed a strong affinity for the platform's core functionalities, particularly the ease of creating and viewing VTs, and the informative content provided by the map feature and blog posts. The platform is seen as a valuable tool for travel enthusiasts, especially those interested in VR and photography, with many users indicating they would recommend it to close friends and family who share a passion for travel.

However, users also highlighted areas for improvement, suggesting a need for a more engaging user interface and additional functionalities such as video uploads and social media integration. Technical issues such as slow loading times and navigation difficulties were noted as annoyances that detracted from the overall experience. Despite these challenges, the concept of "pre-visiting" destinations resonated well with users, pointing to the platform's potential as a planning tool for explorers and adventurers. These insights suggest that, while the platform's concept is well-received, focusing on design elegance, technical refinement, and community-building features could significantly enhance user satisfaction and engagement.

### 4.3. Discussion

The empirical study conducted on the VRRO platform offers valuable insights into user engagement and the platform's potential for widespread adoption. The mixed-methods approach, combining the UES with qualitative feedback, has provided a comprehensive picture of the user experience, highlighting the platform's strengths and areas for improvement.

The study sample consisted of 31 participants, predominantly young adults aged between 22 and 42 years, with a notable 71% being male. This demographic skew is important, as young adults are generally more adept at using new technologies, which could influence their engagement levels with VR platforms. Studies indicate that younger users are more likely to adopt and engage with advanced technologies, including VR, due to their higher familiarity and comfort with digital interfaces [22].

The participants rated their familiarity with web technologies highly (mean score of 4.5 out of 5), while their familiarity with immersive technologies was slightly lower (mean score of 3.7 out of 5). This disparity suggests that, while users are comfortable with traditional digital platforms, there is still a learning curve associated with fully immersive experiences.

The data revealed that 70% of users preferred accessing the platform via mobile devices, primarily using iOS. This aligns with broader trends in digital consumption, where mobile internet usage surpasses desktop usage, especially among younger demographics. Mobile access facilitates on-the-go engagement, which is crucial for integrating virtual experiences with physical tourism [91].

A significant observation was the categorization of users into "active creators", "low interaction" users, and "visitors". The majority (54.8%) were "visitors", primarily using the platform to view content without actively contributing. This behavior is consistent with the general online user engagement pattern, where a small percentage of users generate content while the majority consume it. Active creators, representing 32.3% of the sample, engaged deeply by creating tours, writing articles, and contributing to galleries and blogs. This segment is crucial for content richness and community engagement on the platform.

Engagement endurability is a critical measure, with users indicating varying levels of interaction. While many initially engaged, their sustained engagement depended heavily on the platform's usability, interactivity, and content quality.

Quantitatively, the platform demonstrates strong engagement, with the Endurability Index suggesting a high likelihood of sustained use and recommendations to others. This is indicative of a successful user interface and experience design that resonates with the target audience. The high ratings for the platform's core functionalities, such as the Map and VT Viewer, underscore the effectiveness of these features in meeting user needs and expectations.

Qualitatively, the feedback points to a user base that values the platform's utility for travel planning and connection with other travelers. The enthusiasm for creating and viewing VTs suggests that VRRO has tapped into a niche that is both relevant and exciting for users. However, the call for a more engaging user interface and additional features like video uploads indicates room for enhancement. Addressing technical issues and improving navigation could further refine the user experience. Studies corroborate that user-friendly interfaces and engaging content are paramount for maintaining high levels of user engagement over time [26,92].

The study also reveals that, while technological familiarity does influence user satisfaction to some extent, it is not a significant barrier to engagement. This suggests that the platform has managed to create an accessible environment that can cater to both tech-oriented users and those less familiar with immersive technologies.

Our findings align with previous research, which also found that technological familiarity enhances user satisfaction with VR platforms [15,21,22,59,60,69,92]. For instance, Lee et al. highlighted that user satisfaction with VR tourism platforms increases with technological familiarity and intuitive interface design [21]. Additionally, the role of mobile devices in providing flexible and accessible virtual experiences is supported by research from Buhalis and Amaranggana, which underscores the significance of mobile accessibility in modern tourism [92]. However, our study uniquely highlights the importance of social and interactive features in fostering community building and trust. These results suggest that future virtual tourism platforms should prioritize these elements to enhance user experience.

In summary, the empirical study reveals critical insights into user demographics, technological preferences, and engagement patterns on the VRRO platform. The findings underscore the importance of addressing technological familiarity, optimizing mobile access, and enhancing user interface design to foster sustained user engagement and satisfaction. These insights contribute to an in-depth understanding of how VR platforms can complement physical tourism and enhance decision-making processes, aligning with the broader trends and challenges identified in existing research.

It is important to note that the study's small sample size may limit the generalizability of these results. A larger sample size would enable a more comprehensive analysis and increase the generalizability of the findings. Future research should aim to involve a more extensive and diverse participant pool to validate these results and explore additional aspects of user engagement with virtual reality tourism platforms. Additionally, longitudinal studies could provide in-depth insights into long-term user engagement and the sustained impact of virtual reality experiences on tourism behavior.

## 5. Conclusions and Broader Implications

### 5.1. Conclusions

The current landscape of virtual tourism is increasingly dependent on digital platforms that facilitate connections among travelers, hosts, and destinations. Our findings indicate that virtual tourism platforms (VTPs) can effectively promote sustainable tourism by redirecting tourist traffic to less-traveled venues, thus promoting economic balance [48–50]. This supports the notion that VTs can provide an immersive preview of destinations, encouraging tourists to explore diverse locations.

Our research revealed that VTPs enhance user engagement by offering interactive and immersive experiences that complement physical visits [27,54–56]. Technological familiarity and preferences were found to be significant factors influencing user engagement. Users who were more familiar with digital technologies show higher engagement levels. Our study also identified the need for user-friendly interfaces and comprehensive tutorials to mitigate the challenges faced by less tech-savvy users [21,69,92]. Social media and user-generated content (UGC) have also been proven to play a crucial role in enhancing user satisfaction, community building, and trust. The integration of social features and the

ability to share experiences online were found to significantly impact user engagement and the promotion of lesser-known destinations [47].

The VRRO platform, blending web-based social interaction with low-immersive virtual experiences, is designed to cater to a diverse range of user needs. Our platform's empirical evaluation indicates strong user engagement and satisfaction, attributed to its intuitive design and interactive features. The study also underscores the necessity for ongoing interface and functionality enhancements. Overall, VRRO demonstrates the potential of digital platforms to enrich travel experiences, emphasizing the ongoing need for adaptation and improvement based on user feedback and technological progress.

### *5.2. Implications*

#### 5.2.1. Theoretical Implications

Our research contributes to the literature on virtual tourism by highlighting the significant role of technological familiarity and user-friendly design in enhancing user engagement. It extends previous studies by emphasizing the importance of integrating social and interactive features to build community and trust among users. Our study also underscores the potential of VTPs to promote sustainable tourism practices by redirecting tourist traffic to less traveled venues, thus preserving popular sites and promoting economic balance. This aligns with previous findings, noting the benefits of VR in conscious tourism marketing [17,27].

#### 5.2.2. Practical Implications

For practitioners, this study provides actionable insights into the design and implementation of VTPs. Enhancing user interfaces, incorporating interactive elements, and providing comprehensive tutorials can significantly boost user engagement and satisfaction [60,67].

Policymakers can leverage these insights to develop strategies that promote underrepresented destinations through VTPs, contributing to a more balanced and sustainable tourism landscape [35]. This can be particularly beneficial in regions with underdeveloped tourism infrastructure, as highlighted in the TDDI report [43].

### *5.3. Limitations and Future Research Directions*

This study is not without limitations. The relatively small sample size may limit the broader applicability of the findings. Future research should involve a larger and more diverse participant pool to validate these results. Additionally, the cross-sectional nature of the study does not capture long-term user engagement patterns.

Another limitation is the absence of precise data on the duration of interaction with the VRRO platform, which may have introduced inconsistencies in the feedback collected. Future research should aim to record precise interaction durations to better understand the relationship between time spent on the platform and user engagement and satisfaction levels.

Future research should explore the long-term impacts of VTPs on user engagement and satisfaction. Longitudinal studies could provide in-depth insights into how the sustained use of VTPs influences travel behavior and destination choices [1,3,22].

Further investigation into the integration of advanced features such as AR or AI-driven personalization could also enhance the effectiveness of virtual tourism platforms. This direction is suggested by previous research [4,15], with practical applications demonstrated by Balakrishnan et al. [29].

Additionally, incorporating sentiment analysis can provide valuable data on user satisfaction and emotional responses. Yung [16] and Adachi et al. [25] recommend this approach as a future research direction to enhance the understanding of user engagement with VR platforms. Morrison et al. also support this recommendation, providing initial insights into its applicability in virtual tourism [23].

In summary, our research provides a valuable foundation by offering an initial user engagement analysis and a detailed framework for a VTP. Future studies building on

these insights can further advance the field by addressing long-term user engagement, integrating advanced technologies, and utilizing sentiment analysis. These efforts will not only enhance theoretical understanding but also lead to practical improvements in VTPs, making tourism more accessible, engaging, and sustainable for a diverse range of users.

**Author Contributions:** Conceptualization, A.M. and A.-K.N.; methodology: A.M. and A.-K.N.; software, A.-K.N.; formal analysis, A.-K.N.; validation, A.M. and F.M.; investigation, A.-K.N.; resources, A.M. and A.-K.N.; data curation, A.-K.N.; writing—original draft preparation, A.-K.N.; writing—review and editing: all authors; visualization, A.-K.N.; supervision, A.M. and F.M.; project administration: A.M.; funding acquisition, A.M. All authors have read and agreed to the published version of the manuscript.

**Institutional Review Board Statement:** Ethical review and approval were waived for this study due to the anonymous nature of the data collection and the focus on platform engagement rather than personal or sensitive information.

**Informed Consent Statement:** Informed consent was obtained from all participants involved in the study.

**Data Availability Statement:** The raw data supporting the findings of this study are openly available in Mendeley Data, under the dataset titled "VRRO User Engagement Survey Data", at doi: 10.17632/j39dx362p3.1. The VRRO User Experience Survey can be accessed at https://forms.gle/8MnQoBPv3Le4vNuk6, accessed on 6 May 2024. The VRRO platform can be visited at https://vrro.azurewebsites.net/, accessed on 6 May 2024. The code used for this study contains sensitive data and is therefore available upon request. Researchers interested in accessing the code can contact the corresponding author at nazare.ana.karina@gmail.com.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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