

Article

Virtual and Augmented Experience in Virtual Learning Tours [†]

Fotios Bosmos ¹, Alexandros T. Tzallas ¹, Markos G. Tsipouras ², Evripidis Glavas ¹
and Nikolaos Giannakeas ^{1,*}

¹ Department of Informatics and Telecommunications, University of Ioannina, GR47150 Arta, Greece

² Department of Electrical and Computer Engineering, University of Western Macedonia, GR50100 Kozani, Greece

* Correspondence: giannakeas@uoi.gr

[†] This article is a revised and expanded version of a paper entitled "Virtual and augmented experience in cultural places: The perspective of integration in the learning progress", which was presented at 7th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference, 7th SEEDA-CECNSM CONFERENCE 2022, Ioannina, Greece, 23–25 September 2022.

Abstract: The aim of this work is to highlight the possibilities of using VR applications in the informal learning process. This is attempted through the development of virtual reality cultural applications for historical monuments. For this purpose, the theoretical framework of virtual and augmented reality techniques is presented, developing as a showcase of the virtual environment of the historical bridge of Arta, in Greece. The bridge model is created through 3D software, which is then imported into virtual world environment by employing the Unity engine. The main objective of the research is the technical and empirical evaluation of the VR application by specialists, in comparison with the real environment of the monument. Accordingly, the use of the application in the learning process is evaluated by high school students. Using the conclusions of the evaluation, the environment will be enriched with multimedia elements and the application will be evaluated by secondary school students as a learning experience and process, using electroencephalography (EEG). The recording and analysis of research results can be generalized and lead to safe conclusions for the use of similar applications in the field of culture and learning.

Keywords: cultural technology; digital destination; virtual learning tours



Citation: Bosmos, F.; Tzallas, A.T.; Tsipouras, M.G.; Glavas, E.; Giannakeas, N. Virtual and Augmented Experience in Virtual Learning Tours. *Information* **2023**, *14*, 294. <https://doi.org/10.3390/info14050294>

Academic Editor: Andrea Sanna

Received: 28 March 2023

Revised: 5 May 2023

Accepted: 10 May 2023

Published: 16 May 2023



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1. Introduction

The development of mobile applications keeps pace with the development of new technologies and the universalization of interactive learning experiences. Our era, which is rightly called the digital era, among other things, provides the possibility of digital tours that complement traditional ones, in terms of ways of transmitting information and knowledge. Any hesitant attitude towards this development is gradually giving way to the acceptance and establishment of new touring techniques, as they have a greater degree of involvement, and easier access to information and interaction possibilities.

Within this environment, the cultural and archaeological sites are not left unvisited. On the contrary, the entities that manage these areas take advantage of the possibilities provided by digital touring technologies to keep up with technological developments, to save and disseminate their content, and to improve the experience of their visitors through the use of appropriate multimedia elements [1]. The combination of the real and the digital world establishes a new reality called mixed reality. A new, revised reality is being documented, which includes elements of both worlds, while the space between the real and virtual is where augmented reality is applied [2].

Nowadays, with the help of virtual reality, for tourists, distances are shortened to the click of a button, while cultural objects are within a breath's distance. Traditional tourism is being redefined and evolved as additional digital destinations are created, and new

audiences that can visit them digitally, as so-called digital tourists. At the same time, it is very likely that these virtual visitors will visit the corresponding physical destinations in the future, as their remote experience may entice them [3]. As a consequence, new national tourism strategies are being developed, in which cultural technology is now at the center [4].

Visitors like to become one with the archaeological objects they visit. For this reason, they travel to countries, cities, and regions of particular archaeological and historical interest, expecting to make a corresponding journey through time and become part of that older era [5]. To do this in the context of interdisciplinarity, a number of sciences collaborate and exchange know-how. Sciences such as anthropology, history, philosophy, literature, music, arts, and multimedia work together to produce digital cultural content [6].

Especially for the creation of a virtual 3D model, which is based on an authentic monument of antiquity, it is attempted through 3D software to create a faithful copy, based on the geometry and morphology of the original [7]. The degree to which the 3D visualization is close to the real thing is particularly important. In this case, the project is reborn. Accordingly, visitors enjoy their tour as they see the work as it was on the day it was completed. In this way, it is as if they were there the day the original work was released to the general public. Through the computer, the decay of time disappears and a journey through time begins [8]. The effective design and visualization of the monuments of the past is what determines the success of a produced virtual world, as well as the degree of full or partial immersion of users. If the above project succeeds, it will lead to the further dissemination of the monument and the effective teaching and interpretation of the cultural heritage [9].

In a well-designed virtual world, simulation provides an ideal learning environment, in which students update their pre-existing knowledge and effectively acquire new knowledge [10].

While searching for related papers, various works related to this work were found. Attempting a categorization:

1. Several papers present VR and AR technologies as applied to the digital upgrade of guided tours in archaeological sites;
2. Some others analyze issues related to risk management for the integrity of certain archaeological and cultural sites;
3. In the technological part, some works highlight photogrammetry techniques;
4. In terms of their design, surveys incorporating gaming elements are recorded;
5. Finally, research focusing on educational use are presented.

More specifically, in regards to the first category, Blanco-Pons et. al. [11] present the AR application developed in the Cova dels Cavalls rock complex. The purpose of the work is to offer users an improved browsing experience by recreating some of the damaged spots, such as the murals. Another paper, using a video of a 3D model of Fishbourne Roman Palace in West Sussex, England, examines people's readiness to embrace virtual reality technologies while touring [12]. Another work describes the construction of a computerized model of the Roman Theater of Byblos. At its center are the historical sources [13]. Another study aims to quantify economic and performance indicators, in order to compare the capabilities offered by different types of devices (portables, single-board SBCs, tablets, smartphones) for MixAr [14]. The study [15] investigates and presents the use of augmented reality and GPS-guided mobile applications for cultural heritage updating, with a focus on Cisneros Square in Medellín of Colombia. To evaluate the application, the experiences of two groups were recorded, one using an application and the other group not using the application. The results showed that the first group had better learning outcomes and a greater degree of understanding of the subject. A method called "Walkable MxR Map", as presented in [16], allows users to interact with virtual objects and multimedia using immersive and interactive maps. The Microsoft HoloLens was used as the HMD, allowing users, through the maps, to interact in an immersive and exciting way with the application. An augmented reality (AR) approach to cultural heritage, using drones, is presented in [17]. The aim of

the study is to augment the material collected by the drones with 3D models of cultural heritage sites. In this particular case, the Roman Baths in Turkey are represented. The system significantly increased the interest of the participants, as well as their enjoyment of the tour.

In the second category, related to risk management, the sites indicative of Kyriakou and Ermon [18], using augmented reality, attempt to provide the possibility of digital contact with the exhibits, in order to deal with the impossibility of physical interaction in some museum exhibits (e.g., those that are fragile). The research in [19], using Historic Building Information Modeling (HBIM) and Virtual Reality (VR), proposes a data structure related to recording risk management information in our cultural heritage.

Regarding the investigations that are included in the third category, highlighting photogrammetry techniques, this research suggests a methodology similar to that applied to the Ancient Theater located in the village of Behramkale, Canakkale, Turkey. Unmanned aerial photogrammetry systems are used. These systems incorporate multiple sensors to collect visible, thermal, and infrared radiation of the electromagnetic spectrum to infer the geometry, location, and materials of archaeological sites [20]. AgnanoRiVive, in [21], is a virtual reality application for the Museum of Preclassical Civilizations of Southern Murgia in Ostuni, Italy. The app allows users to explore a settlement and interact with ancient artifacts. Three-dimensional modeling, laser scanning, photogrammetry, and Unity were used to develop the application. Users noted the high level of immersion, as well as the educational value of the application.

In the fourth category of investigations that embed elements of gamification, several research groups presented related work, such as ArkaeVision. The model is applied to the exploration of the Hour II Temple of Paestum with virtual reality (VR) technology, and the exploration of the gravestone of the swimmer with augmented reality (AR). It is a mode of navigation where the viewer is guided by their choices, following the patterns of virtual world exploration games. It also includes features of digital imagination and storytelling [8]. Another study, in [22], presents a method for training users to use of digital twins through a gamified and virtual environment. The process evolves between four main parties: a game expert, a digital teaching expert, a virtual reality expert, and the end users. The proposed method offers solutions to address the challenges of training users to use digital twins. The FabricVR project is presented in [23] as a digital platform that allows visitors to virtually experience the Wieng Yong House Museum. The 3D application incorporated gamification elements to provide an immersive experience for visitors. The FabricVR project is considered useful for preserving cultural heritage and educating its users, especially during times when physical access to the museum may be limited, e.g., due to COVID-19.

The fifth category includes research that presents the use of corresponding technologies in the educational process; in [24], a system is introduced that uses two imaging units and gives the user a better sense of space-time. It is a multi-touch augmented reality (MARS) application to present digital cultural heritage objects for educational use. This research proposes to evaluate works of art through an AR application, while controlling for learning outcomes [25]. The study in [26] utilizes a multi-case qualitative approach, including document analysis, field and online research, and interviews with staff members, to assess the use of VR/AR and AI in three cathedrals. Technologies can be used to educate, as well as entertain, visitors. These digital copies can contribute to the “preservation” of cathedrals. The research in [27] presents the development of a VR application for a castle in Corsano, Italy. The application is created using the Unity engine and the Open XR plugin. Open XR enables the creation of VR experiences that can be transferred between different devices. The VR application was designed for both educational and informative use, with the aim of increasing visitors and contact with cultural heritage. In [28], the virtual model of a bridge is created in order to integrate it into a virtual reality application to evaluate its use in the educational process. At [29], VISAS is an innovation that aims to improve the educational experiences of underwater cultural heritage sites by leveraging modern digital technology.

The VISAS project focused on the creation of the underwater site of Cala Minnola, on the island of Levanzo, in Italy. The system received positive feedback, with users noting the convenience of readily available multimedia information. Finally, in [30], the CTDGP (Cultural Tourism Digital Guiding Platform) provides 3D virtual tourist attractions, and allows tourists to make personalized tourist itineraries anywhere and anytime. Two tests were used, one before and one after the tour, to record the learning outcomes, as well as an online questionnaire to record perceptions of the use of the CTDGP. A positive effect was found in both of the above areas.

The present work innovates as it creates the virtual model of the historical bridge of Arta. Beyond that, it innovates by creating the virtual world that surrounds the key point of interest, as well as creating a VR app that runs on mobile devices and provides navigation at the users' fingertips. It is important to contribute an application to an iconic monument where students can have the real experience as well, so that they can compare the virtual tour with the real tour. In the place where the research is carried out, there is such a monument, the famous bridge of Arta. The monument is the most famous monument of the city and is known throughout the country, and also in other countries, for its unparalleled beauty, for its special architecture, and for its legend. In particular, the myth of the bridge of Arta is an invaluable literary text that is analyzed in schools and universities around the world. In this work, through the marriage of history and modern digital technology, an application is created that aesthetically approximates the construction by the master craftsman and his students, which was an architectural wonder of the era. This application is called upon to integrate harmoniously into the course process and bring the monument into the classroom. A key element of innovation is the technical and empirical evaluation of the VR application by a group of experts and its evaluation in learning by a group of high school students. Equally important is the fact that the above conclusions, after investigating their degree of confirmation with the use of EEG on the students during the learning process, highlights the possibilities of learning through corresponding applications, belonging to the category of informal learning, and provides opportunities for active involvement, self-regulation, and playful learning.

2. Materials and Methods

The study flow consists of three main stages as it is shown in Figure 1: (a) the design stage, (b) the implementation stage, and, finally, (c) the evaluation of the virtual reality environment.

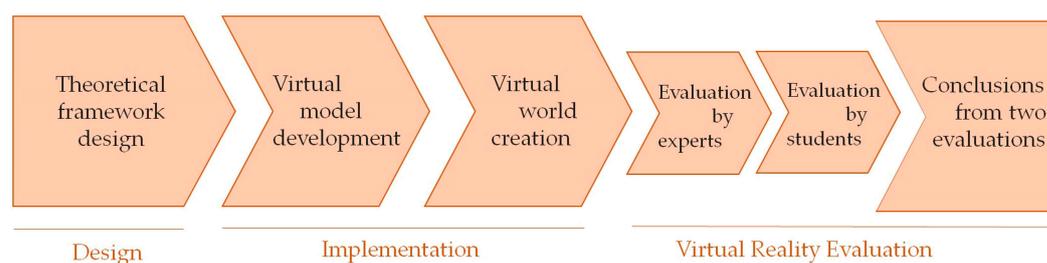


Figure 1. The flowchart of the study.

Initially, through state-of-the-art techniques presented in the literature, a theoretical framework of virtual and augmented reality techniques is designed. The model created in the current work is the key element to create an effective virtual reality application for the successful virtual tour of the users in the archaeological site. The virtual world includes, among other things, the cultural object in question in three-dimensional form. Then, additional 3D digital objects are incorporated through the Unity engine, such as the folklore museum building, located at the west entrance of the bridge, running water, trees, benches, lamps, etc. Using a first-person character, each user uses their mobile device and fingers to navigate the adjacent space digitally, as if they were there, and evaluates

according to its capacity the technical or learning application. The application, finally, is used and evaluated by a group of experts and a group of secondary school students.

2.1. The Development of the Virtual Model of the Bridge of Arta

Regarding stage 2, Figure 2 presents the flowchart with the steps followed to create the bridge model.

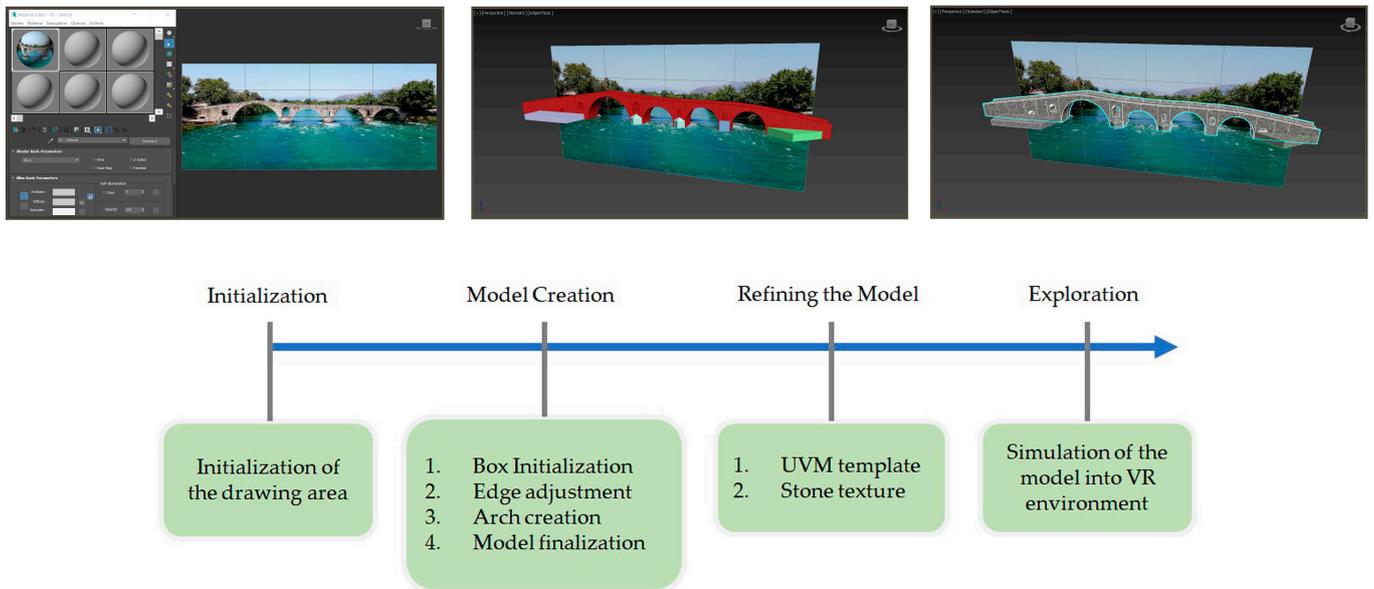


Figure 2. The flow chart of creating the virtual model.

2.1.1. Creating the Model

The bridge model is built using 3D-modeling software. First, in the Material Editor, a material is created with a front photo of the bridge, which is inserted into a Plane Object Type. Then, a Box Object is created, which gradually transforms into a bridge. As shown in Figure 3a, the depth and width of the bridge can be defined.

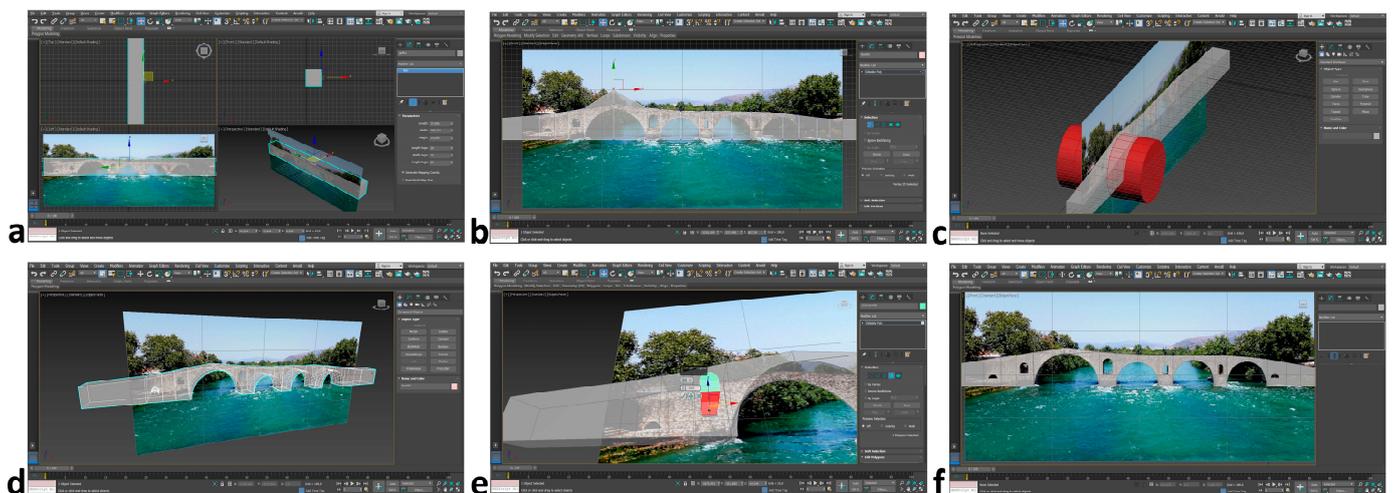


Figure 3. The process of creating the virtual model: (a) Box creating; (b) Adjusting the edges; (c) Arch creating; (d) The bridge with the big arches; (e) Half cylinder expansion; (f) Completed model without textures.

To achieve the transformation of the box into a bridge, several vertical cuts are made. Then, the appropriate vertices are selected, which are transformed in the three dimensions.

Figure 3b shows the vertices of the model. Then, the larger arch, and, similarly, the smaller ones, need to be designed. The Cylinders Object Type is used for this purpose (Figure 3c). The part of the bridge intersected by the cylinder is removed, following a series, as it is shown in Figure 3d. For narrower arches, the cylinder must be cut in half (Figure 3e). Finally, the bridge is created, as seen in Figure 3f.

2.1.2. Giving Texture to the Bridge

To give the bridge a better resolution, a textured map is used first (Figure 4a). Then, the unwrap process begins (Figure 4b). The smaller the boxes, the more resolution is achieved. That is why the individual pieces are placed in the available space, covering the maximum possible surface (Figure 4c).

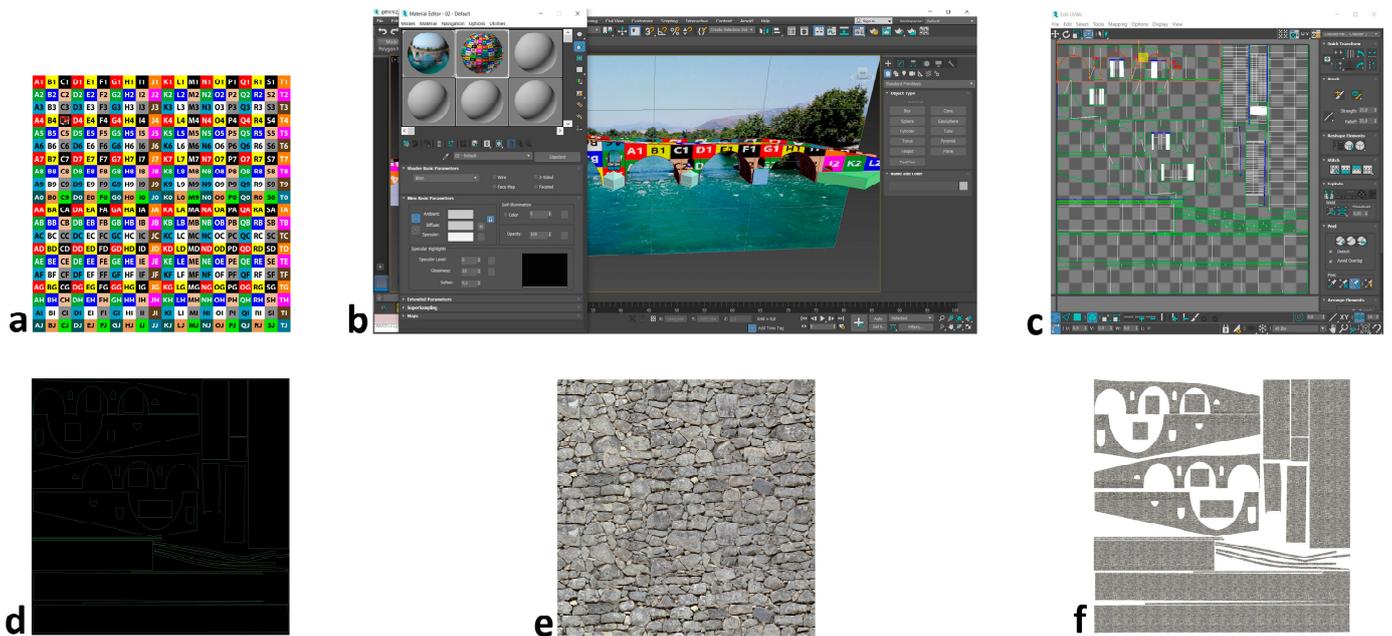


Figure 4. Texturing the model: (a) Texture map; (b) Texture map material; (c) Stitch, Explode, and Break; (d) UVW Template; (e) Seamless Rock Wall; (f) Template with stone texture.

The model is then rendered into a high-quality image (Figure 4d). To give a stone texture to the bridge, an image depicting a wall similar to that of the real bridge is used (Figure 4e). The surfaces of Figure 3d are replaced with the image representing the stone wall (Figure 4f). The generated image is imported into 3D-modeling software and completes the creation of the bridge model. The final model, which can be exported for use in the Unity engine, is shown in Figure 5.



Figure 5. The model of the bridge of Arta.

The current work leads to a virtual reality experience for the Arta bridge that will be used to explore these technologies in the learning process.

2.2. Virtual World Creation

2.2.1. Main Point of Interest and Nearby Objects

Starting the creation of the virtual world based on the corresponding real one, where the bridge is built, as well as adjacent objects, the model of the bridge created earlier is imported into Unity. With the use of the tools provided by Unity, the scale of the model is changed, and the bridge is placed in an appropriate position (Figure 6a).

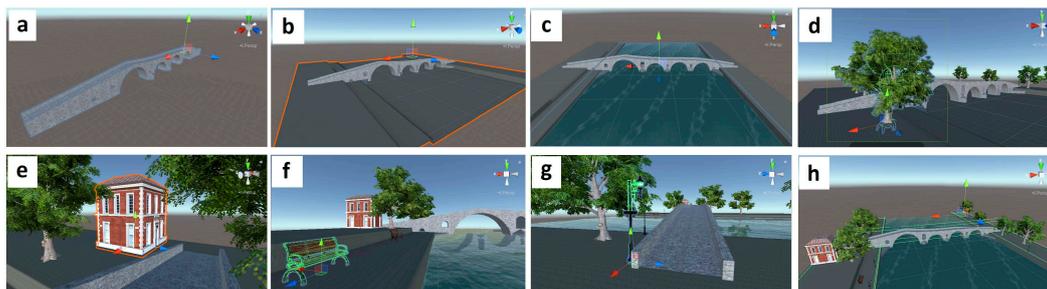


Figure 6. Virtual world creation: (a) Import the model in the scene; (b) Import terrain; (c) Import water; (d) Import trees; (e) Import building; (f) Import benches; (g) Import traffic lights; (h) Colliders setup.

A terrain is imported into the scene, representing the ground on which the bridge is built, as well as adjacent sights and objects. This is a RAW-type image, which has different shades of black and gray to form suitable depressions and elevations in the surrounding space. The terrain is given a texture that resembles the corresponding real terrain, which is, to some extent, stony in places where grass grows (Figure 6b).

Water is introduced into the central depression. Water, as well as other imported items, were obtained for free from Unity’s asset store. When choosing the water, the one that most resembles a riverbed was chosen. The river that passes through the bridge is the Arachthos river. Its sources are located in the mountains of Tzoumerka, from the regional unit of Arta, and from the regional unit of Ioannina. The mouth of the river is located in the Amvrakikos Gulf, south of Arta (Figure 6c).

In a similar way, trees are imported into the virtual world. On the Arachthos riverbanks, there are century-old Platanus trees with rich foliage and large trunks. Platanus trees thrive in places that have plenty of water, so it’s clear that the environment next to the bridge is an ideal place for them to grow. The trees used were placed in similar positions to the real ones, while their size was configured in a similar way (Figure 6d).

At the western entrance of the bridge, and among the trees, the folklore museum of the city of Arta is built. Its proximity to the famous bridge links it inextricably to it. The purpose of the folklore museum is to present to the visitors the local tradition on a spiritual and material level (Figure 6e).

During the surrounding area layout, new constructions that surround the archaeological site are imported, intended to provide the best and most pleasant experience for the visitors. So, benches are placed on the west riverbank, and lighting is imported in places on both banks (Figure 6f) and (Figure 6g).

During the digital navigation of the visitors in the virtual space, the goal is to define their route, to a certain extent. This is achieved by creating box colliders (Figure 5h). With their use, it is impossible for the visitor to fall into the river. It is also impossible for them to jump over the railings of the bridge as they cross it. By extension, the whole virtual world is delimited in a corresponding way, which “keeps” the visitor within its boundaries and, thus, avoids the possibility of falling into chaos.

2.2.2. Performance Motion and Lighting

In Figure 7a is presented the arrangement of some of the objects of the virtual world in the Unity Hierarchy. Their properties were parameterized in the unity inspector to harmoniously frame the main point of interest. The game object, named Borders, contains the box colliders that delimit the scene.

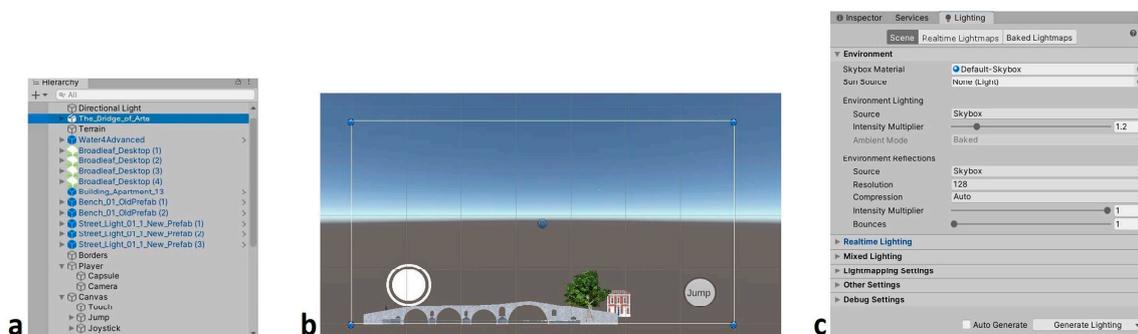


Figure 7. Details of the application: (a) Objects' arrangement in the Hierarchy; (b) FPS Control Mobile Creation; (c) Light rendering.

Then, a player is created. It consists of a capsule, as well as a camera. The capsule could be said to represent the visitor/user body, while the camera represents their eyes. Essentially, they are an FPS Controller, which helps the user to move, look anywhere, and make jumps. Afterward, a Canvas component is created. There, additional components are created, related to the user navigation in the virtual world, using their fingers on their mobile device.

A joystick is created to help the user move around the space, as well as a jump button, so that they can make jumps when needed. The manipulation function is completed by the creation of the touch area, which is placed inside the Canvas component and enables the user, by touching the screen with his fingers, to rotate his "head" in the scene and focus on the space, according to his will (Figure 7b). Within Canvas, there is the possibility to add buttons that will host multimedia material related to the archaeological site, thus enhancing the possibility of using the application in learning processes.

For a more realistic rendering of the entire world, the scene is lit by applying appropriate brightness and shading settings (Generate Lightning), so that each object acquires a realistic form, shading, and, finally, aesthetic harmony with the rest (Figure 7c).

3. Evaluation and Results

3.1. A Virtual Tour Can Be Converted into an Informal Learning Tour

Arta's bridge is the most important point of interest of the city, and is famous throughout the world. Its special architecture, as well as the particularities of the natural environment in the place where it was built, make it a pole of attraction for thousands of visitors. The difficulty faced by its builders were the ones that led to the creation of the myth around it that has spread to today.

In addition to its museum and cultural value, the said archaeological site also has special learning value in fields such as literature, history, archaeology, music, architecture, construction, and, recently, in the field of IT and digital technology, etc.

So, visiting archaeological sites, apart from its usual role when integrated into travel programs of tourist offices, or as an important activity for travelers with historical, archaeological, and cultural concerns, can well be turned into a learning process. This particular form of learning is not part of formal education, but is more of an informal form of education.

The term informal education refers to the possibility of those involved in the learning process, whether they are teachers or students, to transmit and acquire knowledge in alternative ways outside of the traditional models that are usually found in institutions

such as schools and universities. It is noteworthy that, through informal learning, teachers and students are freed, to a certain extent, from the narrow framework of detailed curricula.

Learning is redefined through the visit to an archaeological site, as well as through the interaction of learners, with adjacent sites and exhibits (Figure 8).

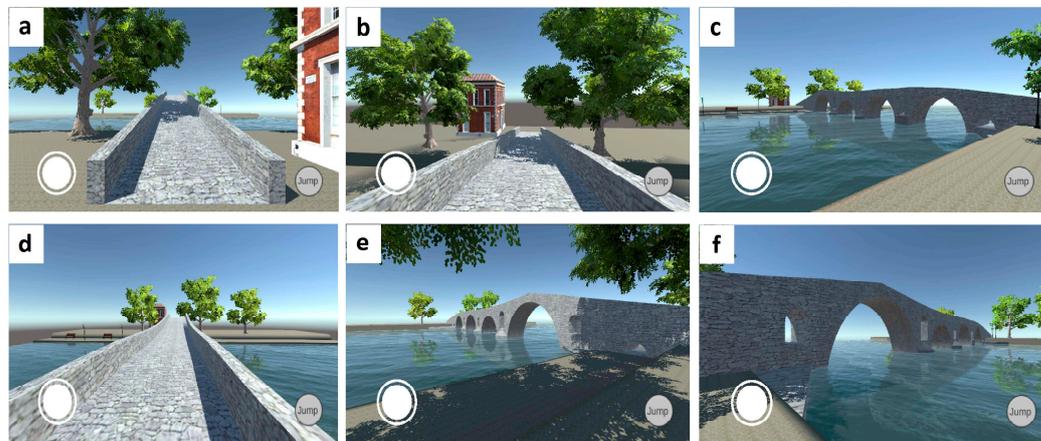


Figure 8. Virtual world tour: (a) West entrance of the bridge; (b) View of the folklore museum crossing the bridge; (c) Front east view of the bridge; (d) Crossing the bridge; (e) Back west view of the bridge; (f) Front west view of the bridge.

Unlike more traditional models, which take place, almost exclusively, in closed spaces, informal learning involves more elements of improvisation and spontaneity. It is important to emphasize that the learner has more freedom of movement in the space, and, to a certain extent, he learns on demand and not by necessity. Learning is less passive as learners learn using all their senses.

Within this environment, new technologies come to complement and expand the possibilities mentioned above. Virtual reality is one of the most basic areas of modern technology that could be used in the informal learning process. For example, in cases where a physical visit is impossible, a virtual world simulates the corresponding real one. Students step out of the physical confines of an educational institution without even having to move. Organizing a study visit is often an activity that takes a lot of time and organization to carry out. At the same time, to a certain extent, it disorganizes the students from their daily student life, while it also has a fairly significant cost. With the help of VR, the above problems are eliminated. The contact with a cultural space takes place with just a few clicks on the laboratory computer, or on the smart mobile devices that the students usually carry with them, after downloading the corresponding VR application.

The above converges in the creation of a digital learning environment in which the acquisition of new knowledge is done in a smarter and, clearly, more pleasant way for the students. After all, the possibility of integrating additional multimedia information (e.g., images, sounds, video animation, texts, etc.) during virtual touring expands the possibilities of learning through VR. The media in question, until now, would have had to be sought out on one's own, or perhaps never watched. In addition, a virtual reality application can include elements of gamification (e.g., treasure hunt, collection of reward points, encouraging messages, etc.), thus transforming the learning process from something cold and introverted into a pleasant process with elements of teamwork and extroversion.

In any case, when designing a VR application, it is taken into account that when someone visits an archaeological site virtually or physically, they are in a more relaxed mood, they are not as focused as they would be in a class, and the whole process is more like a game than a lesson. Thus, it becomes clear that the environment of each application must be adapted to the user, and must be functional and "easy".

3.2. Virtual Reality Evaluation by a Team of Experts

Before the use and evaluation of the application by a group of high school students, the application was evaluated by Human Computer Interaction experts. Initially, the members of the workshop were informed about the software and the methods used for the implementation of the bridge and the virtual world. Then, there was a demonstration of the application. Finally, 52 members of the workshop were asked to fill out a questionnaire with questions regarding technical issues surrounding the creation of the application, but also issues related to the use of the application in the learning process, its functionality, and its comparison with corresponding traditional experiences. Possible responses were on a scale of 1 to 5, where 1 = Not at all, 2 = A little, 3 = Quite a bit, 4 = Much, and 5 = Very much. The measure of dispersion of the sample values relative to the mean value (arithmetic mean) was 9.6.

Analyzing the results of the research in terms of the design and aesthetics of the application, the members of the laboratory, in a percentage of 84.6%, consider that the visualization of the bridge of Arta through the 3D software has been achieved Much and Very Much, while the rest find the display successful enough. To the question whether the creation of the virtual world of the bridge gives the user of the VR application the feeling of visiting the corresponding real one, the answers are divided as follows: a fairly large percentage of 38.5% answered Quite a bit, while 51.9% answered Much and Very much (Figure 9a).

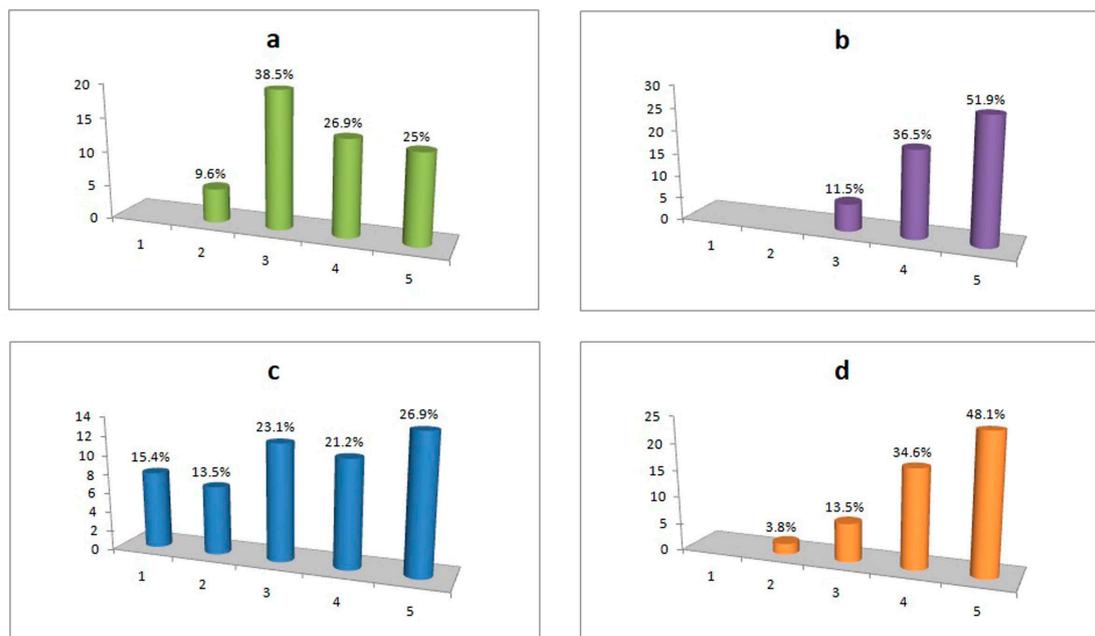


Figure 9. Specialists research statistics: (a) Sense of visit in relation to the corresponding real world; (b) Necessity of multimedia elements for the learning use of the application; (c) Influence of the degree of familiarity of educational staff with VR applications; (d) Push for a corresponding physical tour.

Regarding the technologies used to create the application, the majority of respondents consider that modern and appropriate state-of-the-art technologies were used Much (51.9%) and Very much (32.7%).

Regarding the use of the application in the learning process, 94.3% answered that an excellently designed virtual environment can play a Much and Very much decisive role in the learning tour of a site of archaeological interest, with the majority of them considering to a Very (36.5%) and to a Very large extent (51.9%) that it is necessary to integrate multimedia information in such an application to achieve learning objectives (Figure 9b). It is noteworthy that a similar percentage believe that the use of a large amount of historical and other educational information can contribute to a successful learning tour.

In the area of the application's functionality and ease of use, respondents consider basic IT knowledge to be sufficient for the effective use of the application, while opinions are more divided as to whether teachers' possible low familiarity with such applications can act as a barrier to an effective learning process (Figure 9c).

When comparing the said virtual tour with the corresponding physical tour, a percentage of the order of 96.2% considers that it can tempt a user to visit the corresponding real area of the bridge to a satisfactory (13.5%), a very (34.6%), and a very large degree (48.1%) (Figure 9d), while the vast majority (92.3%) consider that a VR experience cannot completely replace the corresponding traditional tour.

The findings of this research are utilized in the further development of the application. The fact that the design and aesthetics of the virtual world is considered positive serves a key objective of our work, which is to create for users a similar feeling as visiting the corresponding real space. In the field of the learning process, the application is enriched with historical, and other, multimedia information, suitable to support learning in a non-linear way, and with a high degree of interaction with users. In the field of functionality, as well as for the ease of use of the application by users with basic IT knowledge, the application is considered satisfactory, a fact that is positively evaluated, while the dispersion of the answers to whether the possible low familiarity of teachers with such applications can limit the effectiveness of the learning process leads us to the conclusion that an external or in-school training of teachers in the use of VR applications and how they integrate into the lesson would be useful. At the same time, it is a very positive finding that such an application can tempt a user to visit the corresponding real archaeological site, though it, in no case, completely replaces the physical tour. VR does not replace traditional tour models, on the contrary, it complements them and has the potential to regenerate, advertise, and highlight sites of archaeological interest that may not be as well-known to the general public.

Finally, the response of the application is considered positive, while, based on the above evaluation, the degree of its acceptance by a group of secondary school students is investigated. In the future, the experience of the users and the degree of its acceptance and use in the learning process will be recorded, with the use of an encephalogram. The recording and analysis of research results can be generalized and lead to safe conclusions for the use of similar applications in the field of culture and learning.

3.3. Virtual Reality Evaluation by High School Students

The application was used as a supplement during the teaching of a lesson in high school. The experience of a total of 54 students was recorded by completing an appropriately designed questionnaire after the end of the lesson. The questions were related to the pedagogical value of the application, to its functionality, to its further development, and to its comparison with corresponding traditional experiences. Possible responses were on a scale of 1 to 5, where 1 = Not at all, 2 = A little, 3 = Quite a bit, 4 = Much, 5 = Very much. The measure of dispersion of the sample values relative to the mean value (arithmetic mean) was 7.1.

Analyzing the results of the research in terms of the aesthetics of the application, 81.5% consider the visualization of the bridge of Arta through the 3D software as Quite, Much, and Very much successful, in descending order.

On the question of whether the virtual world of the bridge gives students a similar feeling as if they were visiting the corresponding real space, 68% answered positively. Specifically, a percentage of (30.2%) answered satisfactory, 32.1% answered Much, while 5.7% answered Very much.

Regarding the use of the application in the learning process, a large percentage of 90.6% answered that it worked positively during their lesson, with 32.1% answering that it worked quite positively, and 58.5% answering that it worked Much and Very much positively (Figure 10a). The majority considers that the integration of multimedia information in the application (e.g., videos about the bridge, songs about the legend of the bridge, historical

texts, animated tour guide, etc.) to make the course more interesting is considered Much and Very much (75.5%) necessary (Figure 10b). It is worth noting that 62.9% believe that the use of a large amount of multimedia information can contribute to making the lesson even more interesting.

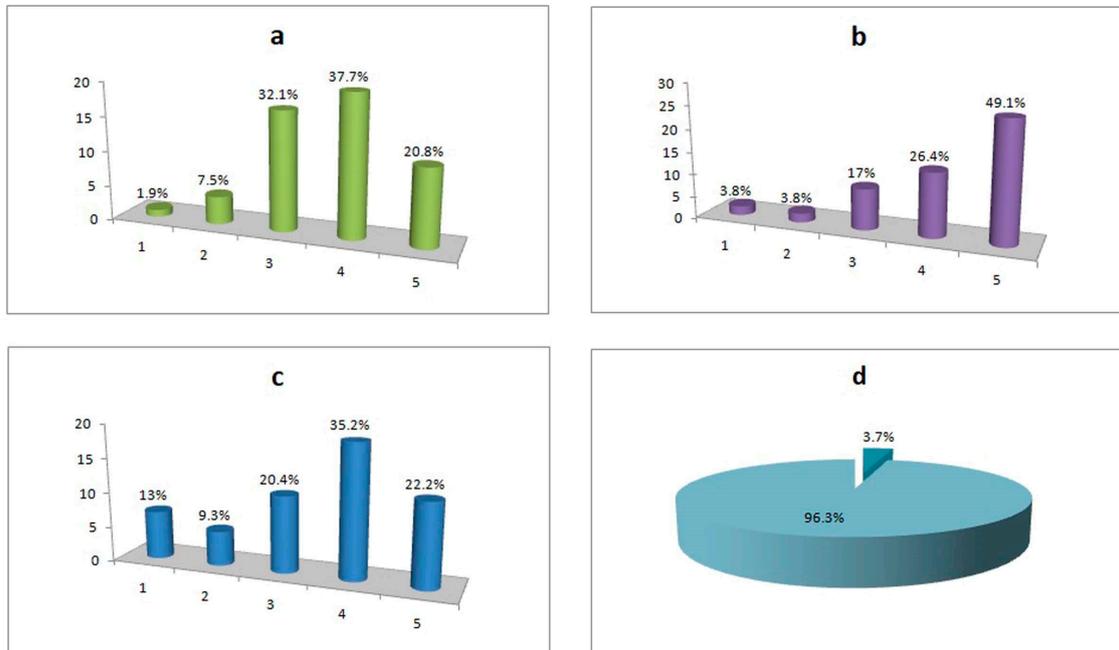


Figure 10. Students research statistics: (a) Positive impact of the application in the course; (b) Integration of multimedia elements into the application; (c) Push for a corresponding physical tour; (d) Utilization of corresponding applications in other lessons as well.

In the field of functionality, respondents consider the application Much and Very much easy to use, at a rate of 73.6%. In fact, the majority (55.8%) consider that even a possible low familiarity of their teachers with such applications can make the course process a little (21.2%) and not at all (34.6%) difficult.

When comparing the said virtual tour with the corresponding physical tour, a percentage of 77.8% consider that it can entice a user to visit the corresponding real area of the bridge Quite a lot (20.4%), Much (35.2%), and Very much (22.2%) (Figure 10c), while a similar percentage (72.2%) considers that a VR experience cannot fully replace the corresponding traditional tour. At the same time, it is recorded that the vast majority of students, at a rate of 96.3% (Figure 10d), would like to use corresponding virtual reality applications in their other courses as well.

The findings of this research are used for the additional upgrade and use of the application, as well as corresponding applications, in the teaching of courses. The students, being the core of the new digital society that is evolving day by day more and more, and having previous experience in virtual environments, for example, through games, consider the application aesthetically successful, as it creates, to a satisfactory degree, a similar feeling to visiting the corresponding real space.

Summarizing, in the area of the learning process, the application complements the traditional course in a positive way, and this is particularly encouraging. Regarding the further development of the application, the integration of multimedia information (even in a very large amount) is judged to make the lesson even more interesting for the students, as it will provide them with additional information about the main point of interest, while simultaneously increasing the degree of interaction with the application during touring. The ease of use of the app does not seem to bother the students. Accordingly, it seems that it will not trouble the majority of their teachers. It is concluded, however, that a more

complex application can create confusion for the above with what this means for the need to train teachers around the use of such applications.

The application prompts students to want to make a corresponding visit to the physical space of the bridge as well. This fact can give ideas to students, who will be more informed when choosing the next destination of an educational trip. The students, however, despite the pleasure and familiarity they have anyway with the use of technology, with the use of smart mobile devices and their applications, consider that a virtual tour cannot completely replace the corresponding physical tour. Once again, the complementary role of virtual reality (in education, tourism, and advertising of new destinations) is noted here, as it cannot replace the physical experience. Despite this, almost everyone seeks the generalized use of such applications in their courses.

3.4. Conclusions from the Comparison of Expert and Student Responses

The responses of the students, in terms of the aesthetics of the application, are positive, but, compared to the experts, they focus more on the satisfactory, while their answers are close to the question whether they felt a similar sensation as if they were visiting the real space. Identification also exists in the need to integrate multimedia elements into the application, in order to acquire more dimensions of interaction. The application in both questionnaires is characterized as functional and easy, while there is a significant identification of opinions on whether a more complex application would also mean a need for teacher training. The answers to the question of whether the application also encourages a physical visit to the bridge area are quite close. The scales tip the same way on the question of whether a VR experience can completely replace the corresponding traditional tour.

The above, to a fairly high degree, in concurrence with expert and student responses, reveals that application designers and developers have common sensibilities and criteria for what a virtual reality application should be and what it should avoid. Also, both groups understand the complementary role of VR applications. This fact means that the essential contribution and cooperation of those who plan the curricula of the courses with VR experts is needed, in order to make educational-use VR applications.

4. Discussion

With the help of the possibilities provided by the comparison of technological and anthropological factors within a defined scientific framework, data (scientific and empirical) are exploited in an integrated and systematic way. The above basic principle can be used to compare virtual and augmented reality technologies, in areas such as the ways in which they produce content, the way they are applied in various areas of everyday life, the degree of interaction they offer, their limitations, and the way in which they complement each other.

These technologies, within the modern technological environment, shaped by next-generation web capabilities and high data transfer speeds, enable their users, in conjunction with the use of their mobile devices, to enjoy partial or full touring experiences. More and more citizens are turning from physical to digital travelers, visiting their respective virtual or augmented “new” destinations, creating a new, dynamic group capable of redefining the methods that the actors involved will use in the future.

For example, the application described in this document can be used in the learning process by institutions such as schools and universities. The simulation can be used as experiments are used in practical courses, with the difference being that VR applications can also be extended to more theoretical courses, such as literature, history, etc. After all, with the addition of appropriate multimedia material, the expected learning outcomes can be achieved in higher degree, because students navigate in a playful way and, at the same time, have real-time visual information available to them.

Especially in the field of cultural tours, visitors can get in touch with cultural heritage through educational structures, thus establishing next-to-remote work, remote governance,

remote health etc., and remote tourism, expanding through it and through the possibilities of distance education. The “new” cultural destinations that are created are free from extraordinary restrictions, such as a pandemic, but also from stereotypes, such as social, religious, and geographical restrictions. It goes to show that, with the right equipment, anyone can be in the most remote part of the planet and have a realistic cultural experience, be entertained, and learn something they might never have the opportunity to do in reality.

It does not mean that a virtual tour cancels out or renders unnecessary the possibility of a corresponding physical visit to a cultural space. On the contrary, it can often tempt the virtual visitor to make the journey in reality and observe with his own eyes, visit physical points of archaeological interest and adjacent exhibits, and interact with other people who work or visit these sites. Very important is the possibility of promoting these applications through social networks, which leads to additional dissemination and advertising of the specific points. In other words, anyone can learn about a great destination or an event that might get them out of their office or home and lead them to make the trip. In other words, we conclude that sectors closely related to tourism, such as catering, hotels, and businesses in a region may eventually be stimulated, instead of suffering losses, through the above possibility. In the learning part, it is worth noting that, in the case of making such a trip, visitors come to the archaeological site prepared and, to a significant extent, educated.

On the other hand, there are certain elements which can negatively affect a virtual cultural experience. Such elements can be an insufficient modeling of an archaeological object, an application with a degraded design, an insufficient selection of multimedia material, the possibility of incompatibility of certain devices with the specific applications, or the impossibility of internet access by a part of the population. At the same time, the inability to access adjacent exhibits, the lack of contact with other visitors, but also with the workers at the archaeological sites and museums, the lack of intellectual background that exists during the physical visit, and the general reticence of a portion of the population to anything new are just some challenge points for the future of virtual reality applications.

5. Conclusions

This paper presents the possibilities provided by the use of VR technologies in cultural tourism and, by extension, in the informal learning virtual process provided by physical cultural visits. Through the marriage of the museological narrative, with a more modern technological narrative, the way of approaching historical sites is redefined, always with respect to their tradition and spirituality, with the aim of creating a digital way of participatory and interactive learning, which has the acceptance of the educational community.

Author Contributions: Conceptualization, F.B. and N.G.; methodology, F.B., A.T.T. and M.G.T.; software, F.B.; validation, M.G.T., A.T.T. and E.G.; resources, F.B. and E.G.; writing—original draft preparation, F.B. and N.G.; writing—review and editing, A.T.T. and M.G.T.; visualization, N.G.; supervision, N.G. and E.G.; funding acquisition, E.G. All authors have read and agreed to the published version of the manuscript.

Funding: This work is partly funded by the project “Immersive Virtual, Augmented and Mixed Reality Center of Epirus” (MIS 5047221) which is implemented under the Action “Reinforcement of the Research and Innovation Infrastructure”, funded by the Operational Programme “Competitiveness, Entrepreneurship and Innovation” (NSRF 2014–2020) and co-financed by Greece and the European Union (European Regional Development Fund).

Data Availability Statement: All data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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