Συνέδρια της Ελληνικής Επιστημονικής Ένωσης Τεχνολογιών Πληροφορίας & Επικοινωνιών στην Εκπαίδευση

Τόμ. 1 (2023)

13ο Πανελλήνιο και Διεθνές Συνέδριο «Οι ΤΠΕ στην Εκπαίδευση»

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Βιβλιογραφική αναφορά:

Anastasiou, K., Kapakis, C., Kazanidis, I., & Goubili, C. (2024). Virtual reality educational game for the marine ecosystem: The case of Blue Life VR. *Συνέδρια της Ελληνικής Επιστημονικής Ένωσης Τεχνολογιών Πληροφορίας & Επικοινωνιών στην Εκπαίδευση*, *1*, 212–220. ανακτήθηκε από https://eproceedings.epublishing.ekt.gr/index.php/cetpe/article/view/7270

Virtual reality educational game for the marine ecosystem: The case of Blue Life VR

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Abstract

In recent years, the traditional models employed in the educational system have faced increasing scrutiny, leading to a paradigm shift driven by the emergence of immersive technologies. Extensive research has revealed the transformative potential of immersive technologies in enhancing the learning experience for students. This study aims to contribute to this evolving landscape by introducing an educational application that utilizes Virtual Reality (VR) technology. Specifically focused on educating users about the marine ecosystem, the application engages users through their interaction with a virtual environment. A meticulously designed script guided the creation of various scenes within the app, and all functionalities were implemented with careful consideration of available resources. The proposed VR application was evaluated for its effectiveness and impact with positive results. This research seeks to expand the understanding of immersive educational tools and their application, emphasizing the significance of leveraging VR technology to create engaging and effective learning experiences.

Keywords: Virtual Reality, Marine ecosystem, Modern education, Game based learning, marine environment

Introduction

Education is one of the few fields that has not substantially changed in the 21st century (Wesley, 2018). However, this is about to change with the advent of virtual reality (VR) and augmented reality (AR). Teachers also believe that new technologies can modify and enhance the learning experience as we know it today. The latest studies show that the global market size of AR and VR is projected to reach $296.9 billion by 2024 (Statista, 2021). The growing market size only shows how popular the technology is expected to become in the coming years (Lin, 2022). VR is a cutting-edge technology that has revolutionized education. It lets the user explore and interact with a virtual 3D world created by a computer. This helps the user to imagine and understand things that are hard to experience in classrooms. VR can enhance teaching and learning by making educational content more immersive and interactive. Moreover, VR supports student learning by visualizing information and engaging them in ways that other media cannot reach (Lee and Wong 2008). VR also aligns with the constructivist theory of learning, which supports that people learn from their own experiences. Also, VR can be used in education, in ways such as enriching core curricula, creating virtual museums and edutainment, demonstrating concepts and phenomena, and training skills and abilities (Oyelere, et al., 2020).

I. Kazanidis, A. Tsinakos (Eds.), Proceedings of the 13th Pan-Hellenic and International Conference "ICT in Education", International Hellenic University, Kavala. Greece, 29 September – 1 October 2023. ISSN: 2529-0916, ISBN: 978-618-83186-8-7

The originality of the VR technology lies on the fact that the users can enter either an imaginary or a realistic world, while in fact they are provided with the possibility of interaction between these two (Zheng, Chang & Gibson, 1998). Another distinguishing feature of VR in the technological field is the freedom of movement and navigation in a virtual reality. VR usually consists of a headset, which is placed on the user's head and contains two screens (one for each eye) or two lenses, depending on the platform on which the headset is used (Hu. X, Su. R & He, L , 2016). Usually, VR is used for video games so that the player can fully experience the digital and imaginary world that the game provides. In addition, the use of VR is also intended for educational purposes, giving a more entertaining touch to the educational process. Pellas et al., (2021) provide a list of various educational domains where VR technology is successfully used with positive results.

Related work

Effective teaching of science requires a combination of knowledge and the stimulation of students to learn. Immersive Virtual Reality can become a novel instructional method in marine biology, ecology and biodiversity education. However, the connection between immersive VR and environmental education is underdeveloped, as there are challenges associated with using virtual technology and the complexity of the marine environment. Despite international attempts to include environmental issues in new educational strategies (Markowitz et al., 2018; Fauville et al., 2020), such approaches remain unexplored in Greece.

Few applications have been developed for the environmental education that use game-based learning; “Ice Flows” (http://www.iceflowsgame.com) is an educational game made by scientists and programmers to inform players about climate change and its effect on Antarctic ice. Additionally, “Ecosystem” (https://ecosystem-game.com) is a simulation game in a 3D environment offering a realistic depiction of the creation and evolution of life at the bottom of the sea . NASA has also developed its own application called “NeMO-Net” (http://nemonet.info/) which started originally as a scientific approach to track and record the world's reefs and study the deterioration caused by climate change.

Blue Life VR

Most of the previously mentioned applications focus on specific subject and are presented in the form of an educational game. Therefore, the purpose of the application should be a combination of features from many other applications to achieve its goal. The application should use the full capabilities of VR technology and inform the player about the marine ecosystem. Through the virtual world that has been created, the player should acquire some knowledge about the underwater world and more generally about ecology.

Blue Life VR is an educational game designed to provide immersive learning experiences for children aged 10 to 12 years old. Leveraging virtual reality technology, the application creates an immersive educational environment that authentically represents the user's interaction with the virtual world. To access the VR environment, users can utilize various settings such as smartphones coupled with a Bluetooth remote control and a VR mobile headset, or they can opt for a dedicated VR headset like the Pico G2 or Oculus Quest. For this reason the game is available on various platforms and operating systems. The game's content encompasses multiple rooms, each serving a specific role within the virtual environment. It is divided into two main thematic sections: the exploration of the marine environment and the cultivation of ecological awareness in today's era. Throughout the game, players are tasked

with solving problems as they progress through stages, reinforcing learning through information retention and application.

The proposed game introduces a unique innovation by offering compatibility in both PC and VR formats. This dual accessibility caters to users with diverse setups, allowing PC users to engage with the game using traditional methods while providing VR users with an immersive environment. This combination enhances the efficiency of training compared to conventional methods and surpasses previous PC game experiences. By enabling direct interaction with the virtual environment and facilitating easy access to information, the game promotes a more engaging and effective learning experience.

To ensure the educational content's quality, the game's learning objectives and educational material were developed in collaboration with the Hellenic Agricultural Organisation, Fisheries Research Institute (INALE). Leveraging their extensive expertise in the field, the game benefits from a deeper research background, in contrast to other standalone applications. This collaborative effort ensures that the information provided in the game is rooted in sound scientific research and offers a higher level of credibility and accuracy.

he design of Blue Life VR incorporates three distinct layers, each serving a crucial role in delivering an effective educational experience. The first layer, known as the "learning" layer, involves the preparation of educational material and pedagogical elements to establish a solid foundation for the educational process. INALE, in collaboration with the developers, provided guidance and a diverse range of multimedia resources such as videos and photos to enhance the learning experience.

The second layer, referred to as the "showing" layer, encompasses the various methods employed to effectively transfer knowledge to users. This layer employs multimedia elements such as videos, photos, and dialogues to effectively convey information. Additionally, the design of different areas within the application contributes to the immersion of users, enhancing the overall educational experience.

The final layer, the "gameplay" layer, plays a pivotal role in facilitating user interaction with the virtual environment. This layer focuses on creating engaging and interactive experiences, promoting active participation and exploration within the educational context of the application. By combining these three layers, Blue Life VR aims to provide a comprehensive and immersive learning experience for users.

The following design criteria were followed in order to achieve the best possible result:

- The tools and models were compatible with different platforms (Android, Oculus Quest, Pico G2, WebGL, Windows OS) and different versions of Unity Engine
- The sense of immersion was rendered in the most realistic way possible
- Free movement in the environment, where the user can explore the virtual environment
- The ability to select any scene and visit it many times by the user
- The user should have fun and be educated at the same time

The app consists of nine different scenes as presented at Fig.1, most of which will appear sequentially as the player plays the game.

Scene 1 sets the initial tone of the game by immersing the player in a black, dark environment with the prominent display of the app's title. In this scene, the player is introduced to the game's atmosphere, allowing them to look around and get familiar with the surroundings, although their movement may be limited initially.

In Scene 2, the player's first interactive experience within the application unfolds. They encounter two human avatars, one male and one female, alongside instructive prompts to guide their actions. The player is asked of choosing their preferred guide, either the male or

female character, who will serve as their assistant throughout the entirety of the game. This choice personalizes the player's experience, enabling them to establish a connection with their chosen guide for the remainder of their journey.

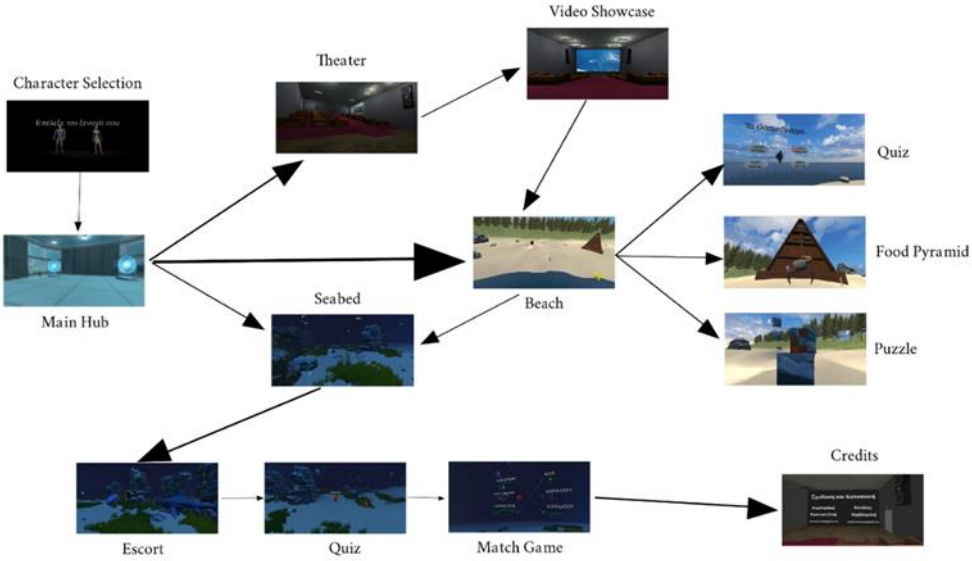

Figure 1. Flow chart of the player's progress

Scene 3 introduces the first realistically constructed environment, which portrays the entrance of a building submerged in the depths of the sea. In this scene, the player gains the ability to navigate and move freely within the virtual space. A brief introduction will provide instructions on how to interact using the remote control buttons or other input devices. Inside the building, the tour guide will accompany the user and provide an explanation of the upcoming activities and objectives within the application. As the player progresses through the building, they will reach a spacious chamber with three gates leading to different scenes of the game. While the player is encouraged to explore the scenes freely, the tour guide will suggest beginning the journey from the theater scene, setting the initial direction for the player's adventure.

Stage 4 unveils the captivating theater environment, featuring an array of elements that contribute to its immersive atmosphere. The room showcases a large screen, accompanied by rows of empty armchairs, inviting the player to take a seat. A staircase offers access to the elevated area where the screen is located, providing an elevated viewpoint. Additionally, a control panel is available, enabling the player to change videos and control the lighting within the theater hall. At the bottom of the room, an additional door serves as an entry point to the next scene, offering a sense of progression. As the player begins in the highest area of the room, the tour guide provides instructions on the various activities and interactions available within the theater. A control panel, equipped with buttons to adjust the lighting, enhances the player's control over the ambiance. Moreover, a door leading back to the third stage allows for seamless navigation between scenes. The primary objective of this room revolves around

watching educational videos on the large screen, granting the player complete control over the playback and enhancing their engagement with the learning content

Scene 5 takes place on a virtual beach, capturing the essence of a Mediterranean coast. It serves as the backdrop for three educational games located solely on the shore. Firstly, the player engages in completing a food pyramid (Fig.2) using various marine species. Seven model species found on the shore must be correctly placed on the pyramid. The next game, a question-based challenge, resides a few meters away from the pyramid near the sea. Upon pressing a button, a question and four answer options appear in the sky, requiring the player to select the correct answer. The third game offers a puzzle experience, with the player choosing between two images and utilizing a wooden board. Puzzle pieces appear scattered near the board, and the objective is to correctly assemble the pieces to complete the puzzle.

Figure 2. Completing a food pyramid

Scene 6 transports the participant into the sea, providing a realistic swimming experience with freedom of movement in all axes. Starting from a designated point, the player navigates through easily identifiable areas marked by a stone pathway resembling a corridor. Three games must be successfully completed to progress further. In the first game, a virtual great white shark follows a predetermined path, pausing at intervals where garbage models emerge. The player's task is to remove the garbage, allowing the shark to continue its course. The second game presents three marine species models, challenging the player to determine which animal the shark would select as its prey. Lastly, the stage concludes with a matching game, where the player matches predators to their corresponding prey by selecting and placing orbs from the left side onto the correct spots on the right side.

Scene 7 is visually similar to the theater scene (Scene 4), and an informative video provides credits to all contributors involved in the development of the application.

Scene 8 maintains the visual appearance of Scene 3, restricting the player's access solely to the gates leading to other scenes. The player can freely transition to this scene at any point and opt to be transported to a different scene of their choice.

Methodology

The purpose of the educational application is to act as an auxiliary tool for the education of young children. There are three main types of skills; life, learning and literacy skills. (Stauffer, 2022). Here, we will focus on the part of literacy skills where through the use of the application, the students will learn various useful information about marine ecosystems, and a basic use of Virtual Reality (VR) immersion technology. The final goal of this research is to prove that the application has a positive impact on the students/users in order to realize that new technologies can contribute to modern education.

As part of the research, the application was presented to primary school children, during their visit to INALE. Students were asked to complete a knowledge questionnaire (10 minutes) before the teaching intervention. Subsequently, they watched two educational videos lasting 3:20 on the subject that was being examined. Each student tested the app for 10 minutes using the Pico G2 virtual reality glasses, trying to solve various problems in the virtual world. In the last 15 minutes of the activity, the students answered the second questionnaire with questions of knowledge but also questions of attitudes and perceptions.

The aim of this research is to investigate the impact of the VR educational application on young children's literacy skills, specifically focusing on marine ecosystems. The study aims to demonstrate the positive effects of the application in enhancing students' learning experiences and highlighting the potential of immersive technologies in modern education. To achieve this goal, primary school children were selected as participants and were introduced to the application during their visit to INALE. Prior to the teaching intervention, students completed a pre-intervention knowledge questionnaire, which lasted approximately 10 minutes. Subsequently, they watched two educational videos, each lasting about three minutes, providing relevant information on the topic. Each student then had the opportunity to engage with the application for 10 minutes using Pico G2 VR glasses. During this time, they were presented with various problems to solve in the virtual world. Finally, in the last 15 minutes of the activity, students completed a post-questionnaire that included questions on their knowledge along with 5-point Likert scale type questions to retrieve their attitudes and perceptions.

Results

The research was conducted in May 2023, involving a sample of 10 fifth-grade primary school students. These students were introduced to the VR application following the proposed methodology (Fig. 3), and upon completion of the experiment, they responded to the intervention questionnaire.


Figure 3. Students playing the game during the intervention

In terms of demographics, initial questions were asked to gather information about the students' background. When asked about smartphone ownership, 60% of the participants responded positively, indicating that they own a smartphone. Regarding previous exposure to VR applications, only 30% of the students answered positively, suggesting that the majority had not encountered VR technology before. However, all students indicated that they have experience using the internet from a mobile phone or tablet.

The students provided positive feedback regarding the app and its usability. 80% of the students agreed that the app was easy to use, indicating its user-friendly nature, while 20% remained neutral. Additionally, a majority of 90% expressed their preference for learning through this VR application, demonstrating their enthusiasm for this immersive learning approach. Furthermore, the majority of students (80%) expressed their interest in using VR technology for other educational fields as well, with only 10% remaining neutral and a small percentage (10%) expressing disagreement.

The students' enthusiasm extended beyond the classroom, as 90% of them expressed a desire to use VR technology in their homes. It is noteworthy that all students reported having fun using the VR application and feeling fully immersed in the virtual world it created. 80% of the students agreed that they felt immersed, while 10% remained neutral, and a minority of 10% disagreed.

In terms of learning outcomes, the students acknowledged that they gained knowledge about sea creatures through the app. 80% of the students agreed that they learned something from the game, with 20% remaining neutral. However, it is important to note that some students experienced dizziness after prolonged use of VR. 70% of the students did not report feeling dizzy, while 30% reported experiencing dizziness. Despite this, the majority of students (80%) expressed their willingness to use VR again, with 20% remaining neutral.

Discussion and conclusion

Our findings indicate that although all students were familiar with using the Internet, the majority of them had little to no prior experience with VR technology. Despite this, the students' initial interaction with the technology was overwhelmingly positive, as they expressed enjoyment and interest in using it both at home and at school. This highlights their

openness to embracing new educational tools and suggests a potential for wider adoption of virtual reality in the educational setting. Furthermore, our research demonstrated a noticeable improvement in the students' performance on the questionnaire after engaging with the VR app and watching the training videos. This indicates that the application effectively fulfilled its intended purpose as a supplementary educational tool for young children. The positive impact on the students' learning outcomes suggests that the app successfully facilitated knowledge acquisition and retention, supporting their educational development.

These findings underscore the potential of virtual reality technology as a valuable asset in the education of young learners. The positive initial experience and the demonstrated improvement in knowledge acquisition support the use of VR as a tool to enhance the learning process and engage students in a more immersive and interactive educational environment. Further exploration and development of VR applications in education can open new avenues for optimizing learning outcomes and fostering a more engaging educational experience for young learners.

This research presented an innovative approach to teaching about the marine ecosystem through the utilization of VR technology. The proposed game serves as a supplementary educational tool for primary school students, offering an engaging and interactive learning experience supported by the INALE Institute. By leveraging virtual reality, students can enhance their understanding of the educational material while enjoying interactive activities that foster a sense of amusement. The marine realm, particularly sharks, rays, and skates, has always captivated the imagination of children. Our findings from the knowledge and attitude questionnaires demonstrate that children exhibit a keen interest in both the new technology and the marine environment, even if they have had no prior exposure to it. Through the immersive nature of virtual reality, primary school pupils have gained valuable insights into the importance and ecological role of these apex predators within the marine ecosystem.

However, it is important to acknowledge the limitations of our research, notably the small sample size of 10 children. While our results provide valuable insights, future investigations should involve a larger and more diverse sample to ensure broader generalizability. Such research will form a pivotal part of the ongoing development and refinement of Blue Life VR.

In conclusion, the use of virtual reality technology in teaching about the marine ecosystem has showcased its potential to enhance students' understanding and engagement. As we continue to explore and refine the educational application, we envision a future where immersive technologies and educational games like Blue Life VR can play a crucial role in transforming the educational landscape, enabling students to explore and appreciate the wonders of the natural world in captivating and interactive ways.

Acknowledgments

Game design and development was supported by the Save Our Seas Foundation (SOSF: 2019-86213).

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