

Exploring the potential of immersive technologies in university education worldwide

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Abstract

This paper explores the potential of immersive technologies in university education worldwide. We analyze the advantages and disadvantages of using immersive technologies and highlight their use in professional training for archaeologists, architects, engineers, pilots, rescuers, and physicians. We also emphasize the use of immersive technologies in creating inclusive learning environments for students with special educational needs. Our analysis of global experiences with immersive technologies in university education reveals their use in distance learning, empathy training for social issues such as homelessness, and environmental education on topics such as ocean oxidation and coral reefs. We conclude that immersive technologies are used not only for professional training but also for gaining social and emotional experiences and raising awareness of environmental issues.

Keywords

immersive technologies, university education, professional training, inclusive learning, distance learning, empathy training, environmental education

1. Introduction

In today's digital age, there is increasing pressure on educational systems worldwide to integrate new information and communication technologies into their curricula to equip students with the knowledge and skills required for the 21st century. This necessitates the transformation of the educational process and the adoption of new learning technologies [1]. In our view, the use of immersive teaching methods represents a natural progression in the evolution of education.

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Previous research has examined the use of immersive learning technologies, including AR and VR, as teaching methods and tools, as well as their application in education [2, 3, 4, 5, 6]. Other studies [7, 8, 9, 10, 11, 12] have focused on defining key concepts, exploring aspects of VR technology theory and methodology, and investigating the use of immersive technologies as a factor in educational development.

The questions of peculiarities of the use of immersive technologies have been studied by Khvilon and Patru [1] in order to study information and communication technologies in teacher training, by Bockholt [13] to determine the essence and features of virtual reality (VR), augmented reality (AR), mixed reality (MR). Biggs [14] focuses on using the potential of VR technology to help memorize learning material. Calvert and Abadia [15] investigated the influence of immersion of university students and high school students in educational narratives using virtual reality technologies.

Our analysis reveals that some research (e.g., Kamal et al. [16]) has investigated the use of immersive technologies at specific universities, including the University of British Columbia, Central Pacific Institute in Hawaii, Punahou International University, and Malaysian universities. However, these studies have not yet comprehensively examined the global experience of using immersive learning technologies in university education.

The aim of this paper is to analyze the theoretical aspects and practical implementation of immersive technologies in universities worldwide. To achieve this goal, we will examine the forms, methods, and means of using immersive technologies in leading countries, as well as analyze positive and negative experiences in their implementation at leading universities.

2. Methods

Interrelated and complementary research methods have been used to achieve the aim of the scientific intelligence. Thus, to collect scientific material in the article the method of studying scientific sources, analysis of the results of surveys conducted by international companies has been used. In particular, a survey conducted by the global law firm Perkins Coie LLP and XR Association in 2019, which identified specific areas of use of immersive learning technologies in the training of professionals in the world's leading universities [17]. The results of the survey conducted by the company Sony in July 2019 on the use of video in higher education institutions were studied [18]. The results of this survey give us the idea of how video is currently used in the educational space of universities, and what the use of video in the educational process may look like in the future; questionnaires and surveys conducted among researchers and students of Lviv Ivan Franko University, Volodymyr Hnatiuk Ternopil National Pedagogical University and Khmelnytskyi Humanitarian-Pedagogical Academy allowed to determine that respondents are familiar with virtual and augmented reality technologies in the context of their use for entertainment, games, but a clear definition of what is immersive learning technology could give only research and teaching staff, students answered that they do not know how to define such a concept, or difficult to answer; special linguistic methods allowed to make correct editing and translation of information from English.

3. Results

The introduction of new innovative technologies in the educational process of universities is an integral part of improving the quality of education around the world. In connection with the global pandemic [19, 20], although distance learning has been introduced in universities [21, 22], teaching is carried out mainly by traditional methods, which include providing material in the form of text documents, its processing by students and testing of knowledge [23, p. 159]. Therefore, in this research we will summarize the world experience of using immersive learning technologies in the educational space of universities.

Let's consider the problem of development of immersive technologies. The idea of creating a virtual world originated in the 1930s and belongs to Stanley Grauman Weinbaum, who described a similar world in the story "Pygmalion's Spectacles" [24]. It was then that VR technologies began to develop, but due to technical limitations and high costs of ample opportunities, they were not actively introduced [7, p. 17].

With the development of immersive technologies, educational processes become more complex and a grainy picture of reality emerges. There is a whole spectrum where the digital and real worlds are mixed and mixed reality is used, which is becoming increasingly important [25, p. 2].

A new impetus for the development of immersive technologies occurred in 2014, when Facebook acquired the startup Oculus VR - a pioneer of digital technology. An updated model of the virtual reality helmet was released, which caused a real sensation in the technology market. Nowadays, VR is gaining momentum and refers to the so-called immersive technologies - the generalized name of all technologies that include human interaction with space, information, content. They blur the boundaries between real and fictional worlds, allow to interact and immerse oneself in information and information product [26].

According to a survey conducted by the global law firm Perkins Coie LLP and the XR Association in 2019, by 2025, immersive technologies, including augmented reality, will be as necessary as mobile phones. This is the opinion of almost 9 out of 10 respondents who took part in the survey [17, p. 2].

The use of immersive learning technologies in the educational space of higher education institutions provide the effect of full or partial presence in the alternative space and thus change the user experience in different fields and in different specialties.

The components of immersive learning technologies are virtual and augmented reality technologies, as well as 360 video [27, 28, 29]. In our research it is necessary to clarify the meaning of immersive technologies and to show the difference between virtual and augmented reality technologies.

We are going to consider in more detail what lies behind the basic concepts of our research. Virtual reality is often used to denote an experience that completely immerses the user in the environment created by the computer, and largely "disables" his or her physical environment. Augmented reality, contrary, imposes digital elements on real objects and backgrounds.

Virtual reality is an ideal educational environment. Perception of the virtual model with a high degree of reliability allows to qualitatively and quickly train professionals in various specialties: aviation, process control, medicine, remote control of technical means and more. Over the last decade, virtual reality has become a leading technological trend in the development

PYGMALION'S SPECTACLES

By **STANLEY G. WEINBAUM**

Author of "The Black Flame," "A Martian Odyssey," etc.

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Unbelieving, still gripping the arms of that unseen chair, Don was staring at a forest

Pygmalion's Spectacles

By **STANLEY G. WEINBAUM**

He put on the glasses, and fell in love with a dream. . . .

BUT what is reality?" asked the gnomelike man. He gestured at the tall banks of buildings that loomed around Central Park, with their countless windows glowing like the cave fires of a city of Cro-Magnon people. "All is dream, all is illusion; I am your vision, as you are mine."



Figure 1: "Pygmalion's Spectacles" by Stanley G. Weinbaum (illustrated by Virgil Finlay).

of educational technologies. This is due to the powerful investments of technology companies that improve VR systems, while increasing consumer access and interest in these technologies [30]. Professional reality training allows to visually conduct lectures and seminars, workshops, demonstrate to learners all aspects of the real object or process, which in general gives a huge effect, improves the quality and speed of educational processes and reduces their cost [31, p. 313].

This is, first of all, visual and sound content, sound in this case of key importance – it complements the virtuality and creates the effect of presence in an unreal location by simulating the reflection and directions of sound waves. One can get into alternative, virtual reality, for example, wearing special glasses, dividing the picture in front of the eyes into two parts, they create a stereoscopic effect. In the presence of tracking for body positions, the virtual space will also take into account the movements of the head and torso.

There are other ways to get into virtual reality: a smartphone with a special VR application, tracking systems, special gloves, mobile VR helmets and more [8, 13]. We are going to consider them in more detail.

Smartphone with a special VR application, which is inserted into the case with lenses – Google Cardboard.

Tracking systems allow moving the user into the virtual space, and the costumes that convey feelings from virtual reality are also being worked out.

Special gloves instead of the usual joystick, so that human hands naturally interact with the virtual world.

Mobile VR helmets with built-in monitors (HTC Vive, Oculus Go and others), optimized devices with high-quality graphics, integrated sound and joystick for control.

Standalone VR helmets (like Oculus Rift), graphics to which are transmitted via wires from a gaming computer with a powerful video card, communication with a PC creates restrictions on use, but VR helmets have better graphics and more potential purposes for users.

Trekking cameras capture the position of the joystick and the position of the person, immersing him or her in virtual reality more realistically, complete with helmets are controllers.

Augmented reality is the result of entering into the field of perception of any sensory data in order to supplement them about the environment and improve the perception of information.

The term “augmented reality” was proposed by company Boeing researchers (Tom Caudell) in 1990 [32]. The concept of 1994 by Milgram and Kishino [33] defines augmented reality as part of a mixed reality, also called a hybrid reality. But since 2016, Microsoft has been actively using the term “mixed reality” to market its HoloLens product. And now some experts (and equipment suppliers) define the terms as follows:

Augmented Reality – projecting any digital information (images, videos, text, graphics, etc.) on top of the screen of any device. As a result, the real world is supplemented by artificial elements and new information. It can be implemented using applications for ordinary smartphones and tablets, augmented reality glasses, stationary screens, projection devices and other technologies [34].

Augmented Reality technologies can create digital information (images, videos, text, graphics) on device screens and combine virtual objects with the real environment. For example, the game Pokemon GO is a prime example of AR technology [35].

Panoramic and 360° photos or videos. These are sequential sets of pictures sewn by means of algorithms, it is possible to make them both by one camera, and special 360° cameras. Cameras which take pictures of surrounding space then the received videos are sewn up in special programs. There are also seamless solutions, but they are more expensive, sometimes additional graphics are added to the finished video. Nowadays, “panoramic” online broadcasts are also common, when you have several points with a panoramic view, which give the viewer the opportunity to “be present in the moment” [8].

Virtual reality, using a 360-degree image, carries a person into the artificial world, where the environment is completely changed. We can get acquainted with augmented reality only with the help of a smartphone, but to dive into the virtual space you need to have a special helmet or goggles.

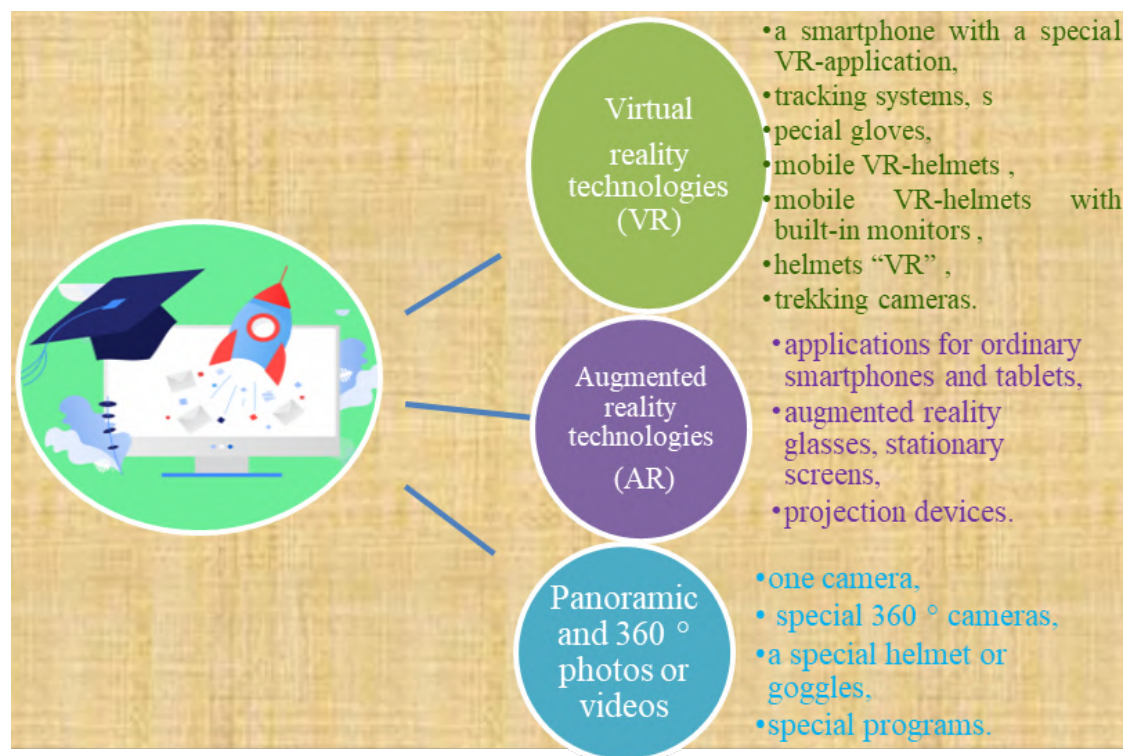


Figure 2: Components of immersive learning technologies.

Thus, the use of immersive learning technologies today can become an effective tool in learning and revolutionize the training of the future professionals [36].

The use of immersive learning technologies in higher education involves taking into account a number of key points on which the principle of visualization in education is implemented. Thus, this principle does not deny, but on the contrary expands and complements the acquired knowledge, taking into account current trends in the development of modern information and communication educational technologies and scientific-technological progress. Immersive technologies in education enhance the importance of visualization in the process of learning due

to deep immersion in the virtual environment, the role of which is very important – enriching students with complex sensory cognitive experience necessary to master abstract concepts. The human sensory system as the first degree of cognition must be strengthened through deeper immersion, the impact on the senses, which contributes to the acquisition of knowledge in the form of concepts, rules, laws, which are laid down at the next stage. Providing knowledge with objectively existing reality should continuously accompany the learning process based on feelings. To increase the effectiveness of learning, the principle of immersion requires, above all, the use of immersion tools, based on visual modality. The principle of complexity in the immersive approach involves the impact on all human senses to the perception of educational material.

The effectiveness of the principle of visualization in the use of immersive technologies is confirmed by the fact that of the five organs of human perception today it is possible to use three – sight, hearing, touch.

Let us consider the experience of using immersive learning technologies in the world's leading universities. Interesting for our research is a survey conducted by the company Sony in July 2019 on the use of video in higher education institutions [18]. In total, the survey was conducted in 13 European countries, in which 123 educators took part. The study showed that the demand for virtual reality is growing today, and several respondents stressed on the benefits of using VR in education: with AR/VR, the potential is further enhanced by the ability to create more interactive and autonomous learning systems. VR allows teachers to create interesting life and interesting learning experiences when students can interact with 3D objects and environments. Students can take virtual tours of artists' exhibitions, explore space or explore the internal organs of a human [18].

Today, VR is actively used in the health care training system to provide medical students with an overview of surgical procedures with their own eyes without being in the operating room. Teachers can simulate the situation and ask students to perform exercises that they could not safely perform in reality, or interact with artifacts that would not otherwise be available [37, 38].

The researches have shown that in a socio-constructivist approach to learning, the most effective educational activity is the experience gained, which involves the acquisition of authentic knowledge in the context of a personally realistic situation. Therefore, the use of immersive technologies is particularly suitable for providing practical experience. Modeling allows students not only to reproduce and practice routine situations, but also to have access to experiences that would be unattainable – due to difficulties, costs, dangers or simply the impossibility of obtaining it in the real educational process. However, their effectiveness depends on the ability to create an environment where the learner feels truly immersed in the environment and the story, going through the real experience.

The positive side of using immersive learning technologies in the process of training the future professionals at the university is to make the learning process exciting and more efficient.

The use of immersive learning technologies provides a deep understanding of the material by the student with the possibility of its further application in real life [39].

Immersive learning technologies should be used to attract the intellectual abilities of students to a more effective learning process. They provide a safe and realistic environment for involving students in learning and practice, where they learn these methods and use them effectively in

the training of the future professionals in various fields. For example, in the training of the future archaeologists to perform work on archaeological excavations; in the training of the future pilots, to guide the landing of aircraft on the aircraft carrier or in the training of the future doctors for surgery. The advantage of using these methods is that the computer system can track the progress of student learning and report any errors [39].

Researchers at the University of Maryland have found that people remember information better when it is presented in VR than a two-dimensional personal computer. It means that VR education is more effective than learning with the use of tablets or computers. Researchers at the university conducted a study in which they asked two groups of people to remember the location of certain images. During the experiment, one of the groups used virtual reality helmets, the other – ordinary computers. The group that studied the image with VR helmets showed a result 10 % higher than the participants of the other group [14].

Universities and colleges have always been at the forefront of introducing new technologies, driving progress and training the next generation of scientists, developers and entrepreneurs [40]. Therefore, let's consider the experience of using immersive learning technologies on specific examples.

During the global pandemic, immersive learning technologies are actively used in distance learning in the world's leading universities, which allows, in particular during video conferencing to improve the effectiveness of learning. For example, professors at the University of British Columbia are already lecturing using immersive teaching methods [40].

For example, at the Central Pacific Institute in Hawaii, students who spent a few minutes using immersive technology for social education regarding the prospects of a homeless person noticed how they realized how easily they could find themselves in the same situation. "Becoming Homeless" is a project developed by Stanford University's Virtual Human Interaction Laboratory (VHIL) to determine the level of empathy for the problem of homelessness, but despite the feelings of discomfort and inconvenience received by students' own practical experience. Students and teachers usually report the consequences of the project implementation as "positive" [25, p. 7].

Another VHIL project that demonstrated the effects of ocean oxidation on coral reefs was conducted at Punahou International University.

So after the application of immersive technologies, in particular, using elements of the game, students gained some interactive experience. They ran their hands through bubbles coming out of coral reefs, causing students to have negative emotions about the environmental problem. The students noted that they are very disappointed that human activities can harm a beautiful and pristine ecosystem [25, p. 7].

Thus, analysing the world experience of implementing immersive technologies in the educational space of universities, we can identify the positive aspects of their use:

- *Visualization*. In the virtual space, a person can view any process or object in detail without obstacles. For example, for medical students through the application Anatomyuo [41] (3D application that teaches human anatomy for minimally invasive procedures, a person can study the structure of the body in the smallest detail), and for students of natural sciences it is advisable to offer the application Operation Apex [42] which can demonstrate with the help of the adventure game all the riches of the underwater world.

It is worth noting that the demand for exciting and interactive experiences continues to grow not only in the sphere of education but also in other areas.

- *Concentration and effectiveness.* Concentration is focusing on educational material. In the virtual environment, students are not distracted by external irritants.
- *Effectiveness.* Students who have used virtual reality technologies to study the learning material show better learning outcomes. Thus, Wu et al. [43] during an experimental study confirmed the effectiveness of the use of virtual technologies to improve student learning outcomes. Scientists conclude that immersive learning technologies can improve both students' knowledge and develop practical skills by supporting the effect of "real-time learning" [43].
- *Maximum involvement.* Immersive technologies provide the ability to fully control and change the scenario of events. Students at history faculties can witness historical events, students at physics and chemistry faculties can conduct their own physics or chemistry experiments, and math students can solve a problem in a playful and understandable form. Art students can attend a virtual tour, exhibition or concert.
However, it should be noted that research and teaching staff are increasingly choosing the means of immersive learning technologies due to the potential pedagogical benefits. Immersive technologies, when used correctly and strategically, can provide a basis for increasing student engagement, immersion, interaction, enjoyment, and thorough deeper learning process. However, due to the development of understanding of the potential of immersive technologies teachers should begin to develop the quality content of education, rather than using technology as a fashion trend or end in itself [44].
- *Security.* With the help of immersive technologies a person can work as a lifeguard in a fire, for architects, engineers for computer simulation of any complex project, to conduct a complex operation, control military equipment, space shuttle, to conduct an experiment with hazardous chemicals without harming oneself or environment.
- *Reducing the financial costs* of training tools in training specialists, because software or virtual training tools are cheaper than real machines and equipment used in training the future professionals (using a smartphone or tablet a person can get a virtual endoscope, tomograph, model airplane, tank etc. [23, 45]).

Immersive technologies play the important role in educating students with special educational needs. After all, with the help of immersive technologies, one can create an inclusive learning environment, taking into account the needs and capabilities of each. This can be one of the important steps in democratizing knowledge.

By studying the experience of using immersive technologies in the world's leading universities, we can determine how they can affect the results of training of the future professionals – for example, reduced cognitive knowledge, brain load, allowing to gain real experience through the visualization of complex ideas and structures. This not only dramatically increases the involvement of students, but also allows students to absorb complex information more effectively and retain it longer. Perhaps most importantly is the fact that this is achieved in the holistic context that significantly increases the transfer rate (i.e. the ability to successfully adapt and apply what is learned in different real-life scenarios) [25, p. 2].

At the same time, with all the positive aspects of their use in the educational space of higher education institutions, their capabilities should not be overestimated. After all, immersive learning technologies cannot completely replace a highly qualified teacher in the educational institution. For example, a team of scientists studying the problem of implementing immersive and interactive educational technologies (Education 5.0 and Industry 4.0) in Malaysian universities identified the following disadvantages of their use: insufficient logistical infrastructure and high financial costs for the development of the content [16].

Today, scientists often note a negative trend, when the use of information technology has priority over the traditional educational process, i.e. educational decisions are implemented without proper consideration and study of the pedagogical context in which they will be applied. This can be seen in education in particular, where success is invariably associated with the effective interaction of the student with the teacher and building feedback with the student, which gives priority to the learning outcome.

4. Discussion

We studied the problems of implementation of immersive technologies in higher education institutions of Ukraine. In order to determine the level of awareness of students and research-teaching staff of Ukrainian educational institutions with the use of immersive learning technologies, we conducted anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. Teachers and students (a total of 112 people) were asked a number of questions. The list of questions and answers are given in table 1.

Let us analyze the answers of respondents. To the question: “Do you use virtual or augmented reality technologies in your classes?” 75 respondents said they had never used it, 37 respondents said they had used augmented reality technology and only 2 said they had “written augmented reality software”.

To the question “Do you know that today a person can plunge into virtual reality even with a regular smartphone?” 102 people said yes, but there was also the answer: “And yesterday a person could plunge into virtual reality with the help of an ordinary book”.

To the question “Do you know which virtual or augmented reality technologies are supported in other higher education institutions?” only 30 respondents answered yes and only 1 respondent stated that such technologies are used in Tech StartUp School of Lviv Polytechnic.

During the survey, 64 respondents (all students) answered that they like to use a smartphone, tablet, augmented reality glasses for games. However, only 56 respondents answered that they visited museum exhibitions, art galleries, and virtual reality concerts, as there were no other options in 2020.

It is interesting that 108 respondents who took part in the survey said that they actively use computers, tablets, smartphones and other gadgets, which improve the quality of education, while 6 people stated that they do not use any technical teaching aids during their classes.

Based on the analysis of the answers to the question “Are you familiar with the term “immersive technology”? What do you think it is?” we concluded that the essence of this word is clear to 100 % of teachers, but a small percentage of students. However, in individual conversations

Table 1

The results of a survey of teachers and students.

Question	The number of positive responses / % of the total quantity	The number of negative responses / % of the total quantity	Note
1. Are you familiar with the term “immersive technology”? What do you think it is?	35 / 48.2 %	54 / 47.4 %	5 / 4.4 % answered inaccurately, incompletely
2. Do you use virtual or augmented reality technologies in your classes?	37 / 32.4 %	75 / 65.8 %	2 / 1.8 % respondents answered that they wrote software for AR
3. Do you know which virtual or augmented reality technologies are supported in other higher education institutions?	30 / 26.3 %	84 / 73.3 %	
4. How do you use computers, tablets, smartphones and other gadgets in your classes?	108 / 94.7 %	6 / 5.3 %	All interviewed teachers answered that they actively use gadgets for distance learning
5. In your opinion, is it possible to safely gain practical experience with the help of virtual and augmented reality technologies?	92 / 80.7 %	18 / 15.8 %	4 / 3.5 % of the respondents found it difficult to answer, 2 answered “maybe”
6. Do you know that today a person can plunge into virtual reality even with a regular smartphone?	102 / 89.5 %	12 / 10.5 %	
7. Have you visited museum exhibitions, an art gallery, a concert in virtual reality?	56 / 49.1 %	58 / 50.9 %	
8. Have you used a smartphone, tablet, augmented reality glasses for games?	64 / 56.1 %	50 / 43.9 %	

we found that teachers and students are interested in learning more about the features of the use of immersive technologies and there is a need for a deeper critical analysis of the use of immersive technologies in the educational process of higher education on the example of other universities.

Thus, having analyzed the answers, in particular a large number of negative answers to the first, second, third and sixth questions, we consider a promising area of improving the educational process of Ukrainian universities, studying world experience of using immersive learning technologies for their implementation in the future, creating opportunities for digital learning.

During the research in order to determine the level of awareness of students and research-teaching staff of national educational institutions on the use of immersive learning technologies,

we conducted the anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. After analyzing the answers of research-teaching staff and students, we came to the conclusion that today a promising area for improving the educational process in Ukrainian universities is to study world experience in the use of immersive learning technologies for their implementation in the future.

5. Conclusions and future work

Our study of the use of immersive technologies in university education has revealed their application in training future archaeologists, architects, engineers, pilots, rescuers, and physicians. We also found that immersive technologies play an important role in creating inclusive learning environments for students with special educational needs.

Our analysis of global experiences with immersive technologies in university education has uncovered their use in unexpected ways, including distance learning, empathy training for social issues such as homelessness, and environmental education on topics such as ocean oxidation and coral reefs.

We conclude that immersive technologies are used not only for professional training but also for gaining social and emotional experiences and raising awareness of environmental issues. However, our research does not cover all aspects of the use of immersive learning technologies in university education. Further research is needed to explore this promising area and to facilitate the adoption of immersive technologies in higher education institutions worldwide, taking into account positive global experiences.

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