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Application of immersive technologies in Education

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ABSTRACT

In recent years, immersive technologies, including virtual reality (VR), augmented reality (AR), and mixed reality (MR), have received significant attention in various fields, including education. This article examines the integration of immersive technologies into the educational environment and explores their potential impact on teaching and learning processes. By providing users with interactive, multisensory experiences, immersive technologies offer unique opportunities to engage students, enhance understanding, and facilitate experiential learning. Current trends, challenges and benefits associated with the implementation of immersive technologies in education are examined. The experience of using immersive technologies is presented using the example of the International University of Information Technologies (Almaty, Kazakhstan). The development of the MetaUniversity, the main advantages and disadvantages are presented. The development concept and architecture of IITU MetaUniversity is shown. It is shown that the potential of using immersive technologies is enormous in shaping the future of education, developing creativity, critical thinking, and cooperation between students.

Keywords: education, immersive technologies, software application, virtual reality tools.

I. INTRODUCTION

In recent decades, technological advances have significantly changed our understanding of education, moving it from outdated classrooms and textbooks to virtual spaces and interactive platforms. One of the most exciting and promising areas of this evolution is immersive technologies [1]. Virtual reality (VR), augmented reality (AR), and mixed reality (MR) offer new approaches to learning, opening up exciting opportunities to engage students and improve learning.

One of the main benefits of immersive technologies is their ability to enhance the learning process through engaging and interactive teaching methods. In addition, immersive technologies promote deeper learning through multi-sensory experiences and personalized learning capabilities. Students with different learning styles and ability levels may find learning more accessible and interesting when they can interact with information according to their individual needs.

However, despite all the potential benefits, the use of immersive technologies in education also faces certain challenges. This includes the need for accessible infrastructures and equipment, training teaching staff in new technologies, and developing content that effectively takes advantage of the capabilities of immersive environments.

This article discusses current trends, problems and advantages associated with the introduction of immersive technologies in education. The own developments of the International Information Technology University (Almaty, Kazakhstan) using immersive technologies are presented.

II. RELATED WORKS

Every year, immersive technologies are increasingly penetrating various areas of human activity, transforming our view of the world and the principles of interaction with it. Startups and large companies are

actively investing in the development and promotion of immersive technologies, which contributes to their spread and improvement [2, 3].

AR allows us to superimpose virtual objects and information onto the real world, thereby expanding our ability to perceive the environment. VR, on the other hand, immerses us in the digital space, creating full-fledged visual and auditory scenarios, separating us from reality and providing a new level of interaction with the virtual world.

The number of publications on the application of immersive technologies from 1992 to 2023 (Fig. 1) indicates that the number of articles is growing exponentially. The data was obtained from the unified bibliographic and abstract database of peer-reviewed scientific literature Scopus.

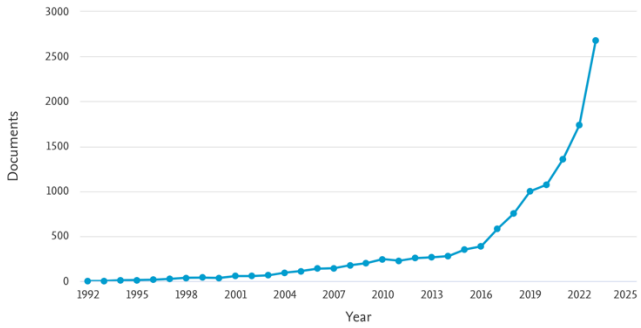


Figure 1 – Number of publications by year on the use of immersive technologies

If you look at the field of knowledge, the leading area is Computer Science, Engineering, Social Sciences, Mathematics, Medicine and others. There is a lot of work in interdisciplinary areas, for example, at the intersection of computer science and sociology. Among the countries that make the greatest contribution to the development of this area are the USA, China, Great Britain, Italy, Germany, Australia, Spain and so on.

The use of immersive technologies finds its application in various areas of human activity. For example, using augmented reality, students can look inside the human body to study physiological processes. Augmented reality simulation can also integrate other digital biomedical data, such as a patient's computed tomography (CT) and magnetic resonance imaging (MRI) scans. Augmented reality technology can be especially useful for learning anatomy and procedures because it allows students to prepare, practice, and repeatedly test their work in an environment without real-world consequences.

AR/VR is also being used to create realistic simulations that can help medical students and other healthcare professionals learn new skills. The main advantages of using these technologies are increasing the accuracy and efficiency of treatment [4], the ability to reduce stress and pain in patients without the use of medications [5], and improving the training process for healthcare workers [6].

Virtual reality also plays an important role in improving diagnostic accuracy [7]. With VR, doctors can simulate various clinical scenarios such as surgeries or procedures and train in a virtual environment, which helps them improve their skills and prepare for real-life situations without putting patients at risk.

In addition, AR and VR technologies help improve the effectiveness of treatment. They allow doctors to better visualize the treatment plan, perform more precise surgical interventions and monitor the patient's condition in real time [8]. For example, using AR for navigation during surgical procedures can reduce surgical time and the risk of complications.

Another direction of rapid development of immersive technologies and the global response to the COVID-19 pandemic, according to the authors [9], will be the development of extended reality in tourism. Tourism is the “creation of exceptional spaces” for tourists to escape from the mundane realities of life [10].

The authors of the following works [11] noted that extended reality technologies, such as virtual reality, augmented reality and mixed reality, represent a paradigm that expands and supports industry 4.0 in various conditions. Another example of the use of Augmented Reality in manufacturing [12] was a paper where the authors presented the results of six case studies with more than two hundred respondents from academia and industry on the use and strategies of where and when to implement which AR technology. This work used comparisons of the use of augmented reality (AR), virtual reality (VR) and mixed reality (MR) in tasks related to remote management and training of personnel, as well as complex tasks such as maintenance.

One of the most common areas for using immersive technologies is education. This includes training at school, university, postgraduate and additional education in various areas of training, training for employees of industrial organizations, training and/or retraining of doctors, and so on. There are a huge number of articles that offer various options for using immersive technologies in education - the development of mobile applications, software products, services, information systems, platforms, methods, and so on.

For example, in [13] a methodology for learning a foreign language is considered. Based on the Unity game engine, a program was developed with built-in speech recognition technology that helped improve the pronunciation of Flemish words. [14] presents a visualization of vector arithmetic in virtual reality with full hand presence and lateral movement. [15] used immersive virtual reality (VR) to teach students basic

biochemistry concepts. With the development of immersive technologies in the world, there is a movement of the "University" into a virtual or meta-space - that is, a web platform that offers students and organizations a platform for communication, knowledge sharing and achieving interdisciplinary academic goals [16]. In [17], the evolution of educational institutions from traditional universities to the concept of a meta-university is studied. The importance of adapting to changes in the educational environment and the opportunities that open up with the transition to more flexible and inclusive educational models are shown. [18] shows that the success of transformation requires not only technological innovation, but also deep organizational and political changes aimed at supporting interdisciplinarity, openness and collaboration at all levels of educational activity.

The use of immersive technologies in education offers a number of significant benefits: engaging learning, multi-sensory experiences, increased motivation, support for personalized learning, a safe environment for practice, global access to education, development of critical thinking and problem solving. These benefits make immersive technologies a powerful tool for modern education, facilitating more effective and interactive learning.

While immersive technologies hold much promise for education, they also have some limitations and disadvantages: significant investment in equipment, infrastructure requirements, potential health risks, lack of content, the need for specialized training, and lack of standards and evaluation criteria. Given these shortcomings, it is important to recognize both the potential challenges and benefits of immersive technologies when integrating them into the educational process.

III. PROBLEM STATEMENT

The main problem we solve is the development of a system that will immerse the user in learning using immersive technologies.

In this case, we will consider virtual reality as a special information environment in which all objects are presented in three dimensions, there is extensive animation, a changing picture in real time and experiencing the effect of presence in it.

To implement it, we use the integration of Unity Game Engine and Oculus Rift virtual reality glasses. The program code is written in the C# programming language.

EasyAR was used as a library to ensure the application operates in AR mode. The rationale for this was a wide range of tools: tracking several markers simultaneously, tracking both objects and markers, as well as surfaces.

The choice of software development methodology is as important as the choice of the development environment itself.

The Agile methodology is fully consistent with the new agile style of software development. All of its methods are based on iterative development, where requirements and decisions are made through the interaction and collaboration of the team. The main difference between Agile methodology and the traditional view of development is adaptive planning and a people-oriented approach.

IV. THE USE OF IMMERSIVE TECHNOLOGIES USING THE EXAMPLE OF IITU

JSC IITU is a leading higher education institution not only in Kazakhstan, but also in the countries of Central Asia in training IT specialists. JSC IITU has experience in its own developments using immersive technologies.

Thus, a set of virtual laboratory works [19] was developed for the study of physics, which consists of a theoretical description, an experimental part, testing and questions for testing and monitoring knowledge. One of the features of this application is multilingualism (Kazakh, Russian, English). This complex is successfully used for teaching physics at the University.

Applications have been developed to gain practical skills in solving physics problems using augmented reality [20]. The application is designed in such a way that newly developed tasks can be easily integrated into existing ones. The user is given the opportunity to choose Kazakh, Russian or English language for interaction with the application.

A virtual laboratory application was developed [21], which allows you to perform virtual physical experiments using a Leap Motion controller (Fig. 2). It runs on personal computers or laptops running Windows, Linux or Mac OS operating systems. The app requires a Leap Motion controller to provide interactivity and a multimedia approach.

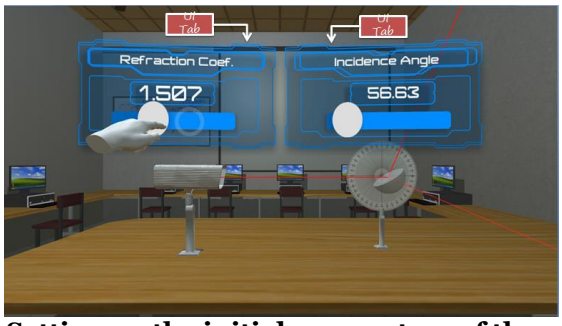


Figure 2 – Setting up the initial parameters of the experiment

A mobile application was developed based on the Unity3D multiplatform development environment (Fig. 2) [22]. To implement the augmented reality functionality, the Vuforia library was used, developed on the basis of the OpenCV open library.

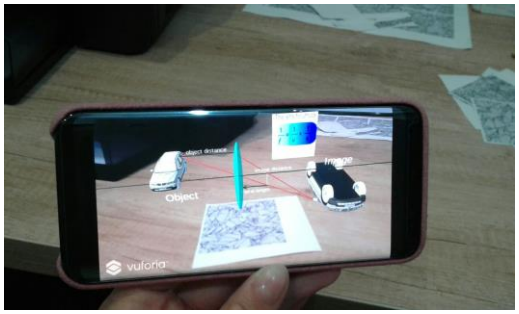
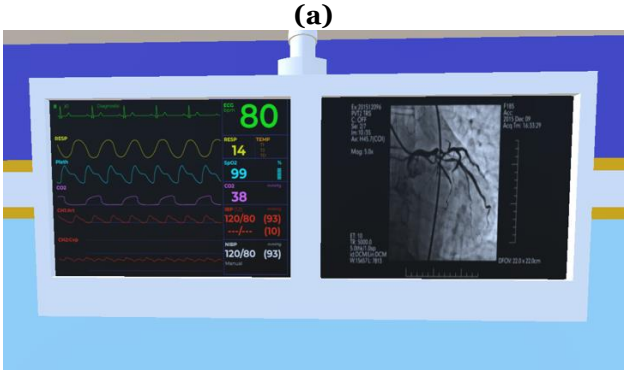


Figure 3 – Operation of a mobile application demonstrating AR animations

Since cardiovascular diseases in Kazakhstan remain one of the main causes of mortality, the use of virtual simulators for cardiac surgery is a relevant solution for Kazakh medicine. At MUIT, work is underway on a project to develop a virtual reality simulator to study the performance of coronary artery stenting operations [23]. To bring the user experience closer to the real one, video and photographic materials of the operating room, as well as other necessary premises, were obtained. This data became the basis for organizing the application scene, camera angles, and installations within the virtual space (Fig. 4). For example, for the procedure, a coronography is performed, the results of which are displayed on a separate monitor. In addition, the surgeon has access to a monitor with the patient's vital parameters.

(a)



(b)

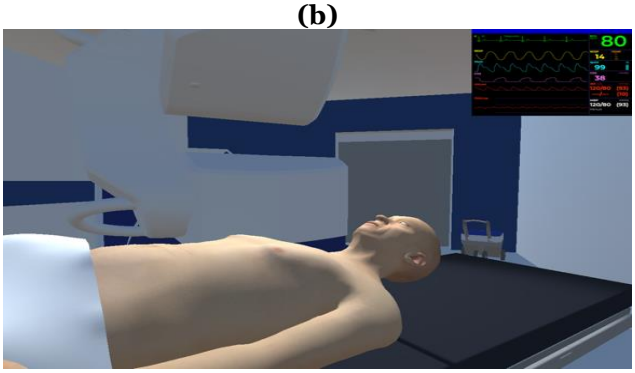


Figure 4 – Coronary artery stenting simulator

Meta-university is a new concept in higher education that uses virtual reality technology to create immersive educational experiences. Meta-universities offer students the opportunity to study a wide range of subjects in an interactive and fun way and have a number of advantages over traditional universities:
• accessibility: the ability to study from anywhere in the world, regardless of physical limitations;
• interactivity: the ability to study subjects in an interactive and fun way;
• personalization: the ability to personalize learning for each student, allowing you to learn more effectively.
IITU offers its own MetaUniversity model, which is presented in Fig. 4.

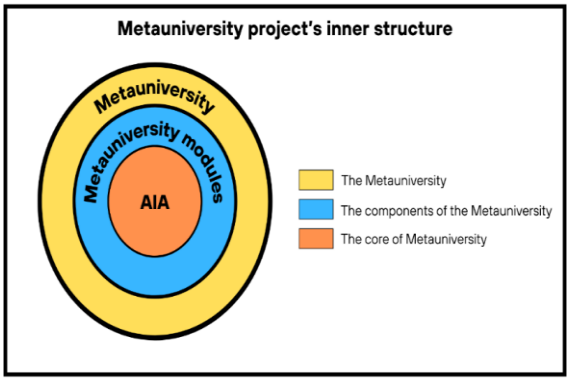


Figure 4 – Internal structure of the IITU MetaUniversity

The meta-university consists of three main layers:

Layer 1: This layer represents the meta-university itself, which contains digital copies of educational buildings, classrooms and other objects.
Layer 2: this layer represents individual modules of a virtual copy of the university, including avatars, interaction modules, interface, etc.
Layer 3: This is the agent layer, which is a software agent that manages the meta-university. The agent layer is responsible for user interaction with the meta-university, as well as for ensuring the operation of all its components.
Thus, JSC IITU uses modern technologies in teaching, which have a positive effect on the quality of student training. For example, in addition to saving time and resources, as well as increasing the accessibility of education, there is an improvement in the assimilation of the materials being studied, increased motivation and involvement. Surveys show that immersive technologies are an effective learning tool that allows students to expand and consolidate the knowledge acquired in lectures, as well as increase interest in the subject as a whole.

CONCLUSION

Nowadays, online education has become an inevitable reality, and there are several reasons for this. Firstly, the development of information technology makes it possible to reduce distances between people, including virtually. Constantly emerging methods and means of communication leave their mark on the development of new learning technologies. Secondly, the coronavirus pandemic, which the whole world faced in 2020, contributed to the forced and global transition of education to distance learning. In this regard, more and more training programs using immersive technologies are appearing on the market.
The article provides an overview of the use of immersive technologies in various areas of human activity, showing the main advantages and disadvantages. Using the example of JSC IITU, our own educational developments are presented and the results of introducing the developed programs into the educational process are analyzed.
These findings demonstrate the potential of immersive technologies to transform the educational process and improve its effectiveness. However, the implementation of such technologies requires careful planning, teacher training, and evaluation of their effectiveness.

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