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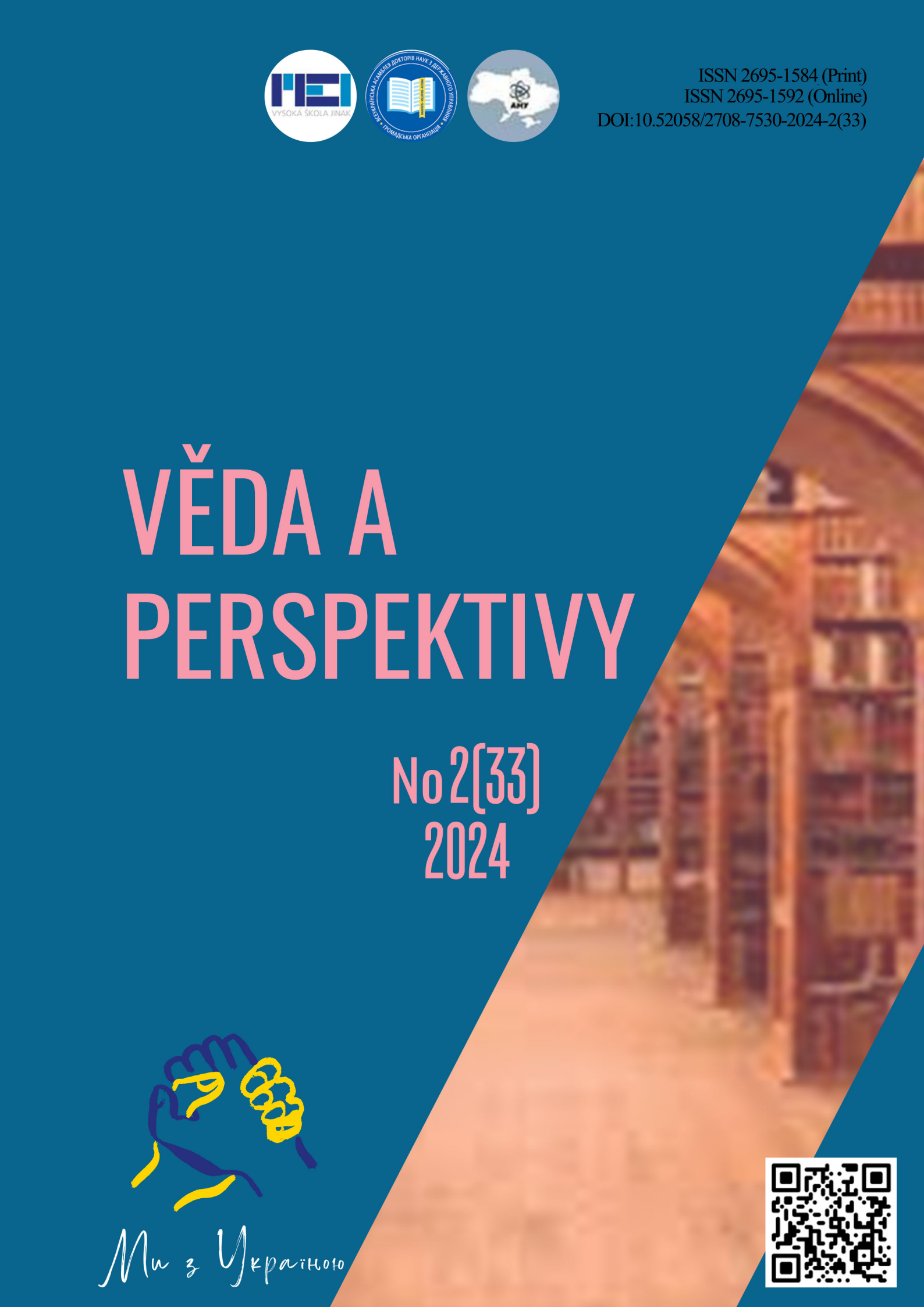

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OVERVIEW OF APPLICATIONS WITH AR AND VR TECHNOLOGIES IN EDUCATIONAL ACTIVITIES

Abstract. The latest technologies, characterized by rapid development, penetrate all spheres of human life, including education. In the modern information society, where the development of technology is unrestrained, the idea of using immersive technologies, such as virtual, augmented, extended reality and others, is becoming increasingly relevant and promising. These technologies open up endless opportunities for modern education to create a more interesting, effective and accessible educational environment.

The article notes that immersive technologies represent a huge innovative potential in educational activities. They make learning interesting, interactive, and individualized, helping to develop the skills necessary to succeed in the modern world. The most common applications are considered, including GeoGebra AR, AR Solar System, Anatomy Learning – 3D Anatomy, Google Arts & Culture, CleverBooks Geometry, MondlyAR, AR Intro programming video, Electric AR Circuits, Google Tilt Brush, Microsoft HoloLens, Blocksmith XR, VRMath2, Lecture VR, Labster.

However, despite the potential benefits of these technologies, it is noted that there are several key problems that hinder their widespread use and implementation in the educational process. In particular, the high cost of equipment, the lack of qualified personnel to ensure the use of immersive technologies in the educational process, and the significant time and resource requirements.

Keywords: immersive technologies, organization of the educational process, students, augmented reality, virtual reality, mixed reality.

Formulation of the problem. In the modern educational environment, there is an increasing emphasis on the use of advanced technologies to optimize the educational process. One of the promising areas is the use of augmented (AR) and virtual (VR) reality applications in educational activities.

Despite the many advantages of immersive technologies, there are also challenges associated with their implementation in the educational process:

- High cost of equipment. Due to the lack of funding for the education sector, not all educational institutions are able to provide themselves with the expensive equipment needed to implement immersive technologies in the educational process.

- Lack of qualified personnel to ensure the use of immersive technologies in the educational process. This is due, firstly, to the lack of necessary equipment, and, secondly, to the lack of research on this issue in our country.

- Significant time and resources are required, including the creation of multimedia content for the development of virtual environments.

Nevertheless, immersive technologies represent a huge innovative potential in educational activities. They make learning fun, interactive and individualized, helping to develop the skills needed to succeed in the modern world. The possibilities of using immersive technologies in education are significant, and they have the potential to transform learning approaches and educational practices.

Analysis of recent research and publications. A large number of scientific publications by domestic and foreign researchers are devoted to the emergence and application of VR and AR technologies in education. This problem has been studied by such scholars as O. Slobodianyk, T. Hranchak, L. Shkliar, J. Słupska, O. Shkurenko, Y. Trach, N. Khmil, T. Halytska-Didukh, V. Tsiantsi, L. Titova, G. Tkachuk, O. Hrybiuk, Hsin-Kai Wu, Silvia Wen-Yu Lee, Hsin-Yi Changc, JyhChong Liang, Eric Klopfer, Kurt Squire, S. Yuen, G.Yaoyuneyong, E. Johnson, Lee K., Yun Zhu, Hui Ye, Shukun Tang, S. Giasiranis and L. and others. However, given the pace of development of immersive technologies, the selection of applications with AR and VR technologies for use in educational activities requires constant monitoring and evaluation of new applications to determine their potential for the educational process.

The purpose of the article: is to describe the most popular applications with AR and VR technologies and their use in educational activities.

Presenting main material. Augmented and virtual reality technologies are still under development, but they are already being used in education around the world. AR and VR allow you to create interactive learning environments that allow students to immerse themselves in the content and gain a deeper understanding of the material. These technologies can be used to study various academic disciplines, from natural sciences to history and art.

There are two main types of immersive technologies used in education: AR and VR. Both technologies have their own peculiarities. Augmented reality technology projects digital information (images, videos, texts, graphics, 3D objects) onto a real environment, not just a device screen, and can connect virtual objects with real environments using only a mobile gadget. At the same time, virtual reality

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can transport people into a fully artificial virtual world, especially with the use of special helmets and VR glasses that can display a full 360° image.

AR provides digital content that complements what is in front of our eyes through special AR glasses or cameras on mobile phones, tablets, etc. Virtual reality is the use of computer technology to create simulated environments [1].

Based on these two immersive technologies, a large number of applications have been developed to implement them in the educational process. Let's consider the most common applications.

GeoGebra AR: is an application for mobile devices that allows users to create and view three-dimensional mathematical objects in the real world (Fig. 1). It uses augmented reality (AR) technology to overlay virtual objects on the real world. The application allows you to create three-dimensional objects such as curves, surfaces, bodies, and function graphs. Users can interact with math objects, such as scaling them, moving them, and changing their properties. The application can be used for teaching mathematics, in particular when studying geometry and functions in the algebra course, providing visual support for learning complex concepts and visualizing complex geometric constructions that require the activation of abstract thinking.

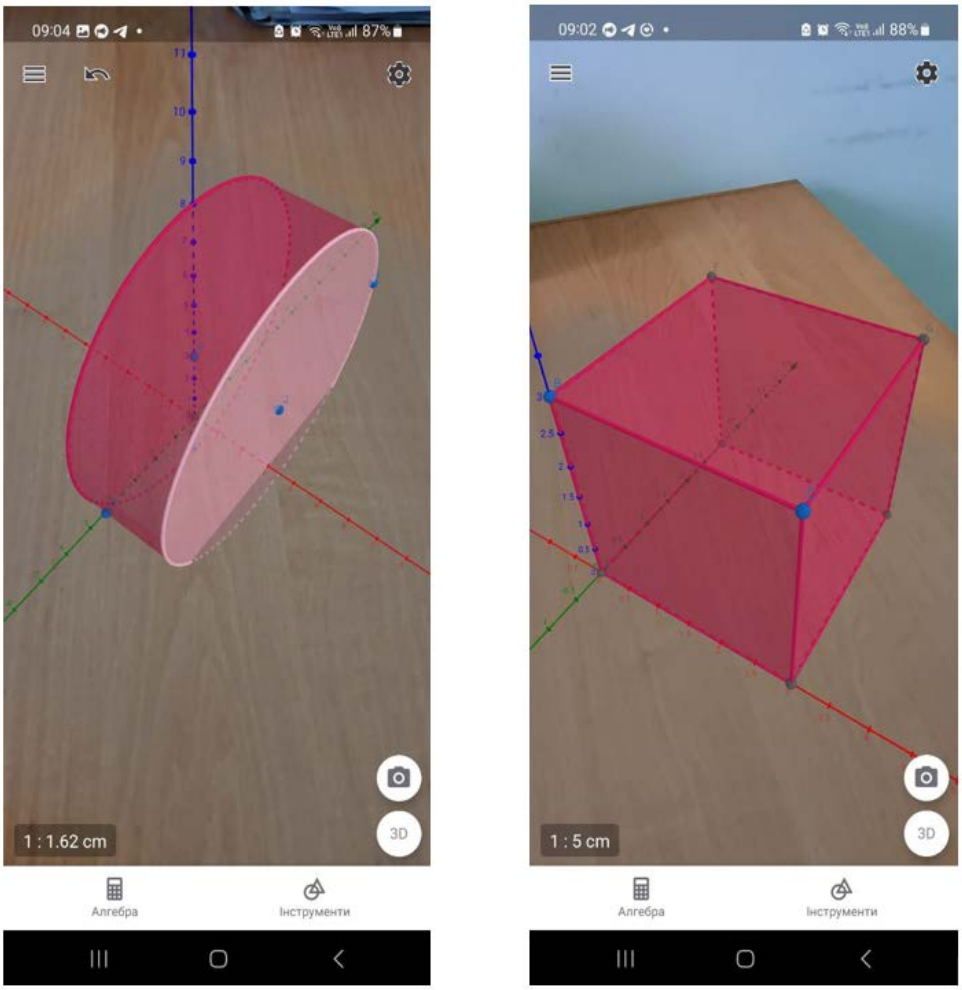

Fig. 1. *Three-dimensional objects in the GeoGebra AR application*

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AR Solar System: is a mobile application that is a free resource for astronomical research that allows users to study the solar system in a new format. The application allows users to view a 3D model of the solar system on the gadget's screen and observe its orbit, as well as study 3D models of all the planets. This approach allows users to explore the solar system and outer space in the form of a realistic model.

Anatomy Learning – 3D Anatomy: is an augmented reality (AR) application that allows users to study the anatomy of the human body through interactive 3D models and AR elements. Anatomy Learning – 3D Anatomy contains detailed 3D models of various organs and body systems. Users can rotate, scale, and explore them from different angles. The models in the app often have a high degree of detail and realistic textures, which helps to better understand the structure of organs. In addition to static models, the app can include animation effects and virtual tours that demonstrate how organs and systems work. The app uses AR to allow users to point their smartphone camera at special markers or images in textbooks and learn anatomy in real time. Therefore, it can be used in educational institutions to teach anatomy and biology.

Google Arts & Culture: is an educational app and platform that uses augmented reality (AR) and virtual reality (VR) for learning, including creating interactive journeys for students to visit various historical, tourist, or natural sites. The app supports both VR and AR technologies. VR allows students to really immerse themselves in the virtual world, while AR allows them to expand the real world with additional information. Applicants can be accompanied by virtual guides who provide information about the places they visit and ask questions to enhance learning. Another interesting feature of this application is that teachers can create their own virtual tours for their students by adding various multimedia content (Fig. 2).

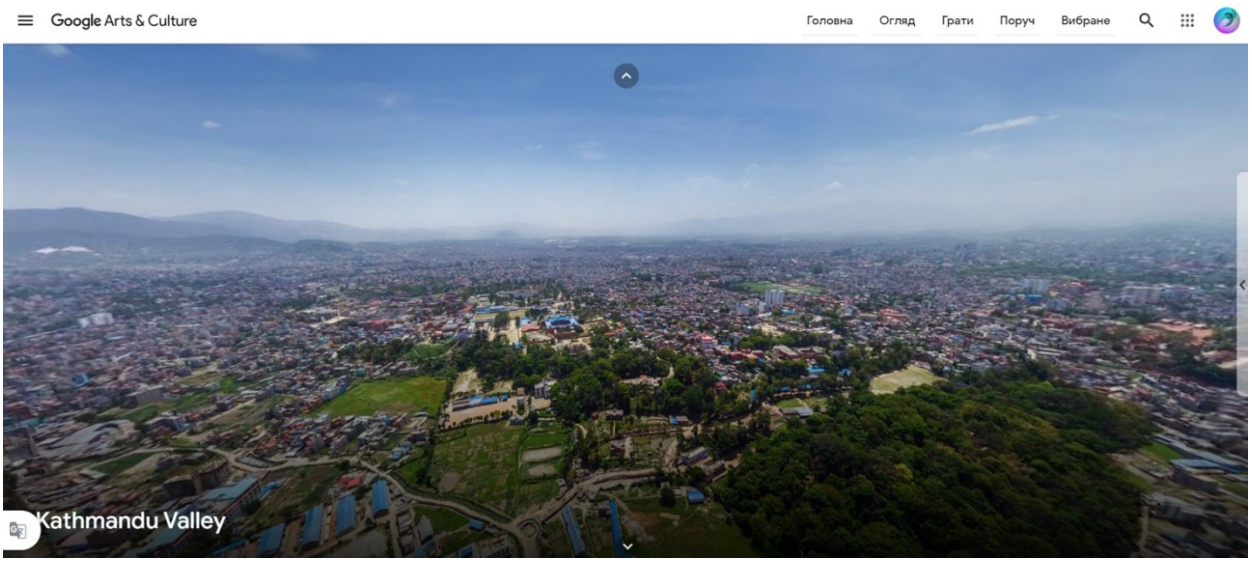

Fig. 2. *A virtual trip to Kathmandu (Nepal)*

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CleverBooks Geometry: is an application for mobile devices that allows users to learn geometric shapes and concepts using augmented reality (AR). It contains 3D models of the five basic 2D geometric shapes (circle, rectangle, cube, hexagon, and triangle), as well as interactive exercises and tests that help users test their geometry knowledge. These tests include multiple-choice, open-ended, and typed questions. However, the application requires special cards for the full realization of augmented reality.

MondlyAR: is a mobile language learning app that uses your device's camera to place AR objects and characters in the real world. This allows you to learn a foreign language and make the learning process more fun. MondlyAR combines traditional lessons with augmented reality. This allows you to learn a language using different learning methods. The app offers lessons in more than 30 languages, including English, French, German, Spanish, Italian, Chinese, and more (Fig. 3).

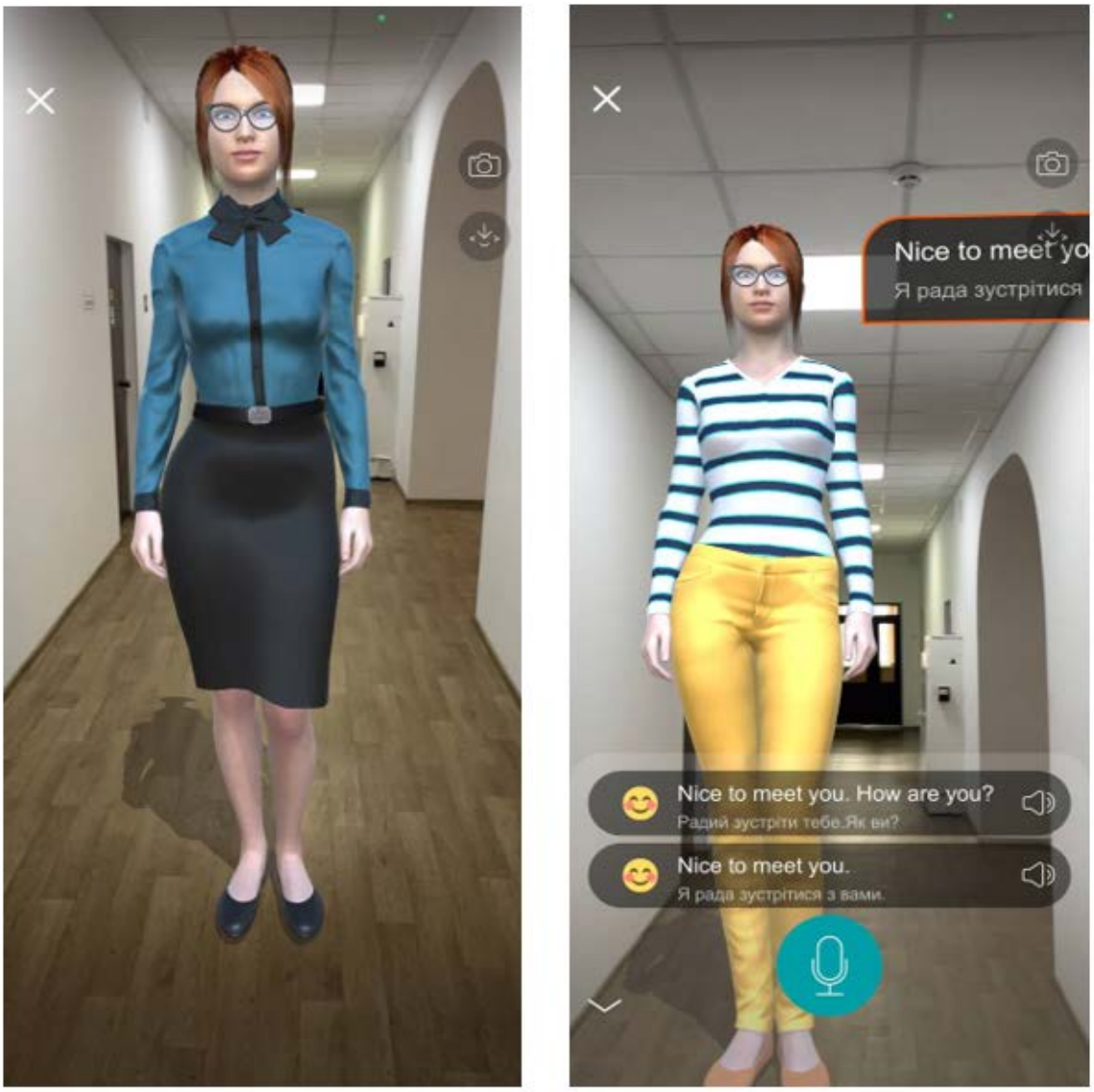

Fig. 3. *Learning English in the MondlyAR app*

AR Intro programming video: is a mobile application that uses augmented reality (AR) to teach programming. It is available on Android and iOS devices. The app offers lessons on learning various programming languages, including PHP, Java, JavaScript, Python, C++, and C#. The videos are easy to understand, even for beginners. Instructors explain concepts in a clear and concise manner.

Electric AR Circuits: is a mobile application that uses augmented reality (AR) to teach electronics. It is available on Android and iOS devices. The app offers lessons on the basics of electronics, including various components for building a circuit and how they work. It also requires the purchase of a special book (Fig. 4).

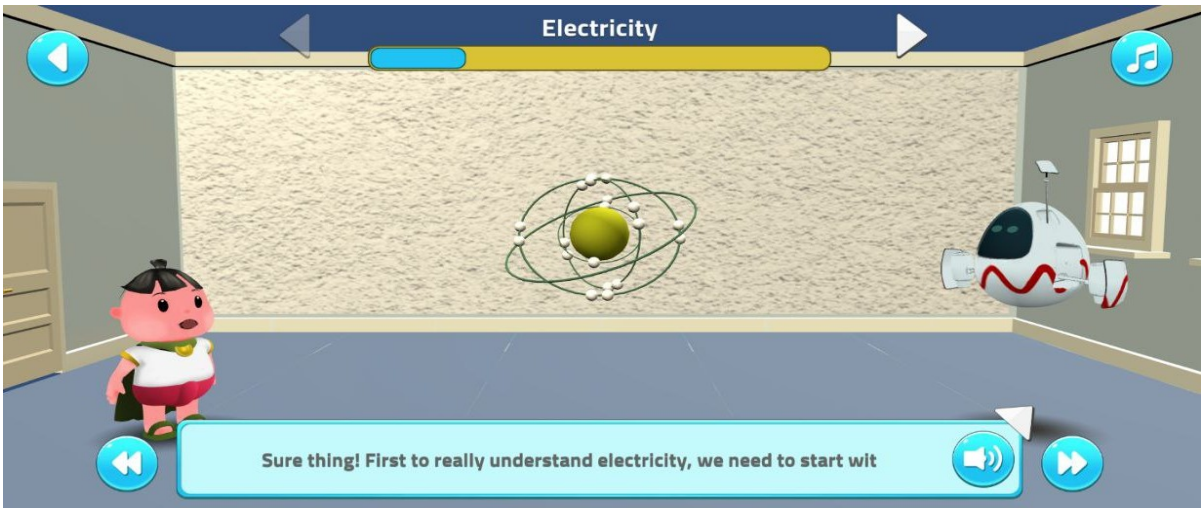

Fig. 4. *Electric AR Circuits training manual*

Google Tilt Brush: A VR application for drawing and creating 3D objects. It allows users to draw in three-dimensional space using special controllers. Google Tilt Brush was released in 2016 and has gained popularity among both ordinary users and artists. Users can use various brushes and tools to create effects. Google Tilt Brush works with VR headsets such as HTC Vive and Oculus Rift. It allows users to feel like they are inside their own creation. Users can rotate, scale, and move their creations. They can also interact with other users in the virtual space.

Microsoft HoloLens: is a standalone holographic computer headset that allows users to see and interact with holographic objects in the real world. This product was released in 2016 and is used in various fields, including education, industry, and entertainment. Microsoft HoloLens does not require connection to a computer or other device. The program allows users to rotate, scale, and move holographic objects. Users can also interact with holographic objects using gestures and voice. Microsoft HoloLens uses motion tracking to determine the user's position and orientation. This way, the holographic object can stay in one place even if the user is moving.

Blocksmith XR: is a tool for creating 3D models, scenes, and projects. It is available on a variety of platforms, including Windows, macOS, Chromebook, iOS, and Android. Blocksmith XR can be used to create educational content, such as

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models of the solar system or historical monuments, to create art and design objects, such as sculptures, paintings, and furniture (Fig. 5).

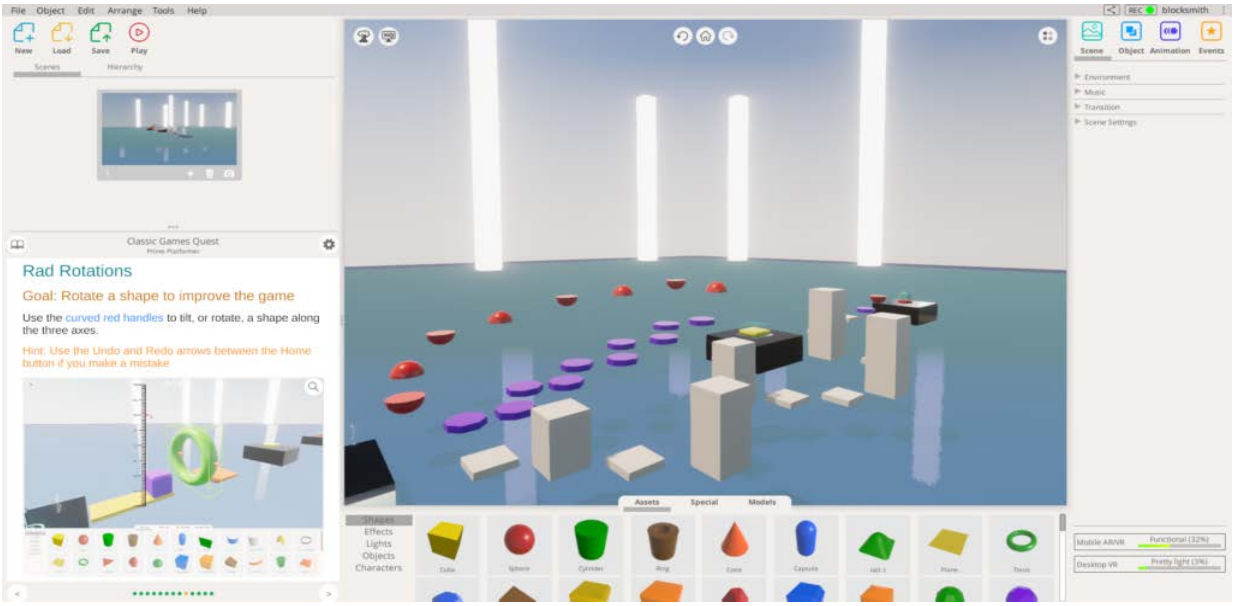

Fig. 5. *Working in the Blocksmith XR environment*

VRMath2: VR application for learning math in virtual reality, available for Windows, macOS, and Linux platforms. The application supports a wide range of VR headsets, including Oculus Rift, HTC Vive, and PlayStation VR, and contains comprehensive video tutorials explaining various math concepts (Fig. 6).

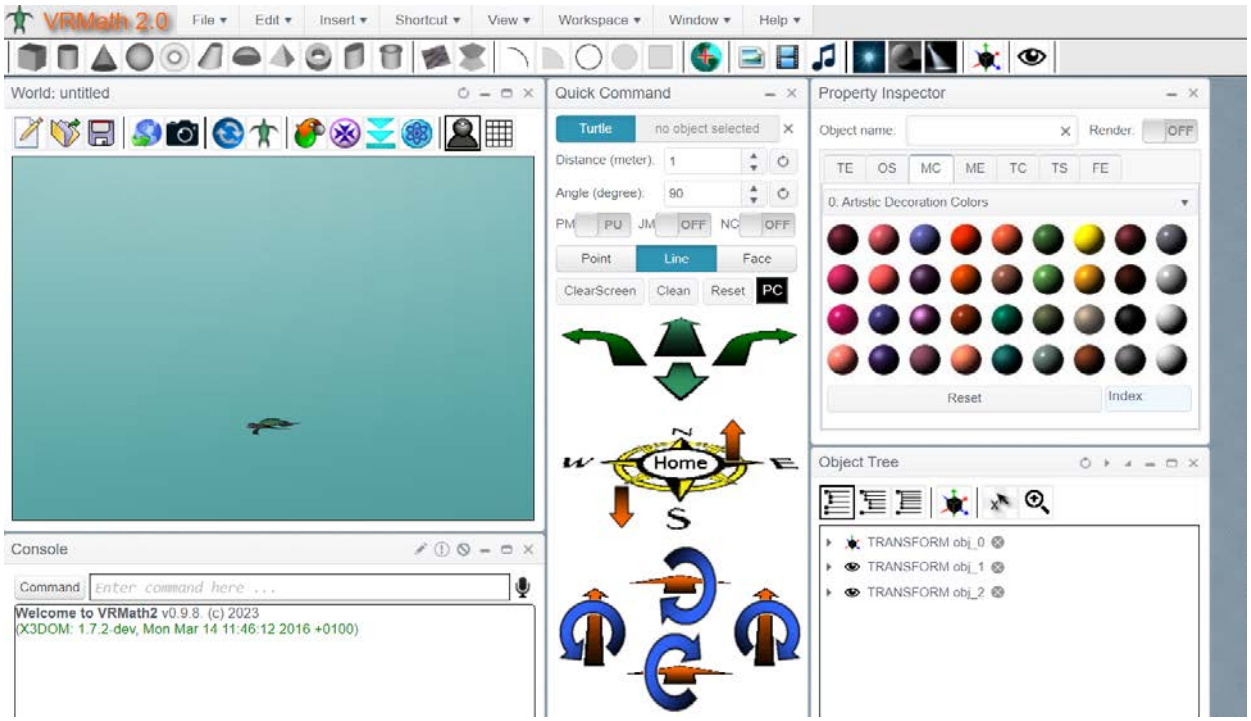

Fig. 6. *Creating a 3D model in VRMath2*

Lecture VR: is an educational VR app that allows users to attend virtual lectures on subjects such as physics, chemistry, biology, math, history, geography, and culture. It is available on Windows, macOS, and Linux platforms. VR lectures allow users to adapt the learning process to their needs. For example, users can adjust the speed of lectures or the level of difficulty of the material.

Labster (Fig. 7): a virtual laboratory platform developed in partnership with leading US higher education institutions such as MIT, Harvard, and Stanford. Labster allows users to conduct experiments and research in a virtual environment [5].

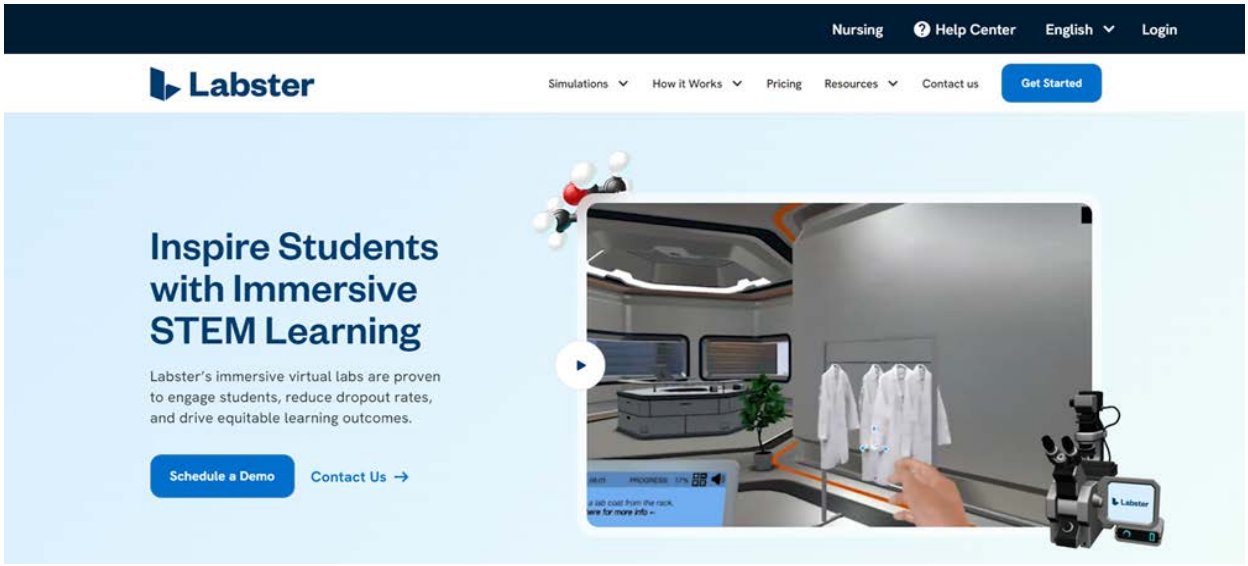

Fig. 7. *Labster platform*

Conclusions. Thus, there are a large number of apps and services that use virtual environments, AR and VR technologies to optimize the educational process. The use of such environments allows visualizing complex theoretical material, performing practical tasks in conditions close to reality, as well as engaging and motivating students in learning activities.

However, despite the potential benefits of these technologies, there are currently several key issues that prevent their widespread use and implementation in the educational process.

First, it is important to determine which AR and VR applications are available on the market and which ones are most effective for use in the educational process. Not all applications may be equally useful for different subjects or levels of study, so it is important to find out which technologies best suit the needs of the educational institution and its students.

Secondly, there are issues with the availability of hardware and software needed to use AR and VR applications. Often, the cost of specialized equipment can be high, which creates obstacles to the wider implementation of these technologies in educational institutions.

Finally, it is important to consider the issue of teacher training for the use of AR and VR applications in the educational process. Many teachers may not have sufficient training or experience in this area, which hinders their ability to effectively integrate these technologies into the classroom.

Therefore, for the successful implementation of applications with AR and VR technologies in educational activities, it is necessary to study and solve these problems in detail.

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