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STUDY OF AUGMENTED AND VIRTUAL REALITY TECHNOLOGY IN THE EDUCATIONAL DIGITAL ENVIRONMENT OF THE PEDAGOGICAL UNIVERSITY

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Abstract: *This article offers the didactics of studying augmented and virtual reality technology in the educational digital environment of the pedagogical university. The basic concepts and practical content of the course on the study of augmented and virtual reality technologies are highlighted. The peculiarities of studying augmented and virtual reality technology by students majoring in Informatics at Ternopil Volodymyr Hnatiuk National Pedagogical University are highlighted.*
The study and use of virtual reality equipment and software for 360 video is proposed. Two types of virtual reality video are considered: virtual reality 360 Video and virtual reality based on models. The expediency of using mobile devices in conducting research in STEM projects using virtual reality/augmented reality technologies and creating augmented reality objects using various tools is substantiated. The stages of creation of virtual reality objects are singled out. An example of tasks for the development of virtual reality projects is given. We look at how different augmented reality applications can help improve understanding of the objects being studied.
The proposed innovative approach to the study of augmented and virtual reality technology can be used as a basis for the development of digital didactic courses for students, pupils and teachers.

Keywords: augmented reality; virtual reality; STEM projects; augmented reality development tools; pedagogical university.

INTRODUCTION

Virtual and augmented reality (VR and AR) are new tools for education. These technologies can qualitatively complement learning, make it more accessible, simpler and more interesting. Therefore, the interest in these technologies in the field of education and the field of visualization of scientific data is justified (Akcayir & Akcayir, 2017). Scientific data visualization, as opposed to information visualization, involves the use of computer graphics to analyse and present simulated or real data. Scientific data are collected or generated from various scientific fields, such as meteorology, biology, medicine, etc. A common feature of scientific data is that they are usually very big. In other words, they are best displayed in 3D. AR and VR allow users to view and interact with this data in 3D. This is very useful in terms of education and training, as students can really understand and memorize data by immersing themselves in the virtual world and gaining an interactive experience easier than from texts describing. Research in the field of innovative educational technologies, tools and methods for e-learning is considered in the works of (Smyrnova-Trybulska et al., 2017; Balyk & Shmyger, 2017; Smyrnova-Trybulska, 2018; Hug, 2019). Research on the impact of virtual reality on human focuses on the study of VR / AR equipment impact and work with it, as well as the impact of computer games on the feelings, thoughts and actions of the individual (Bacca et al., 2014; Chavan, 2016; Goedert & Rokooei, 2016). A study (Merged reality) of merged reality has shown that 70% of users expect VR/AR technology to drastically change six areas: media, education, work, social communication, travel and retail. Also, 50% of users believe that VR/AR technology will be integrated into a single device, combining AR glasses and built-in VR features. 5G technologies will play a key role in merging virtual and augmented reality with the physical world, providing mobility, improving social communication and solving the problems a number of VR applications.

In our study, we will adhere to the following definitions of VR / AR.

VR is best described as an illusion of reality created by a computer system (Virtual Reality).

AR is an enhanced version of reality where the physical world is augmented with superimposed computer-generated content (What is Augmented Reality (AR)?).

The article (Virtual and augmented reality: how new technologies inspire learning) highlights the following characteristics of the virtual didactic environment:

Clearness. In the virtual space, you can easily look at any process or object in detail, which is much more interesting than looking at the pictures in the textbook.

Concentration. In a virtual environment, people are not distracted by external stimuli, which allows them to focus fully on the material.

Maximum involvement. Immersive technologies provide the ability to fully control and change the scenario of events.

Safety and effectiveness. With the help of VR and AR technologies, you can conduct training, perform complex operations in various fields.

The *objectives of this article* are:

- to explore the features of the study of augmented and virtual reality technology by students majoring in Informatics in the digital educational environment of the pedagogical university;
- to analyze the technological aspects of using different techniques and tools for development VR and AR mobile applications;
- to propose the innovative approach to the study of augmented and virtual reality technology and to develop a digital didactic course for students, pupils and teachers;
- to formulate the didactic recommendations on using augmented and virtual reality technologies in student training in the pedagogical university.

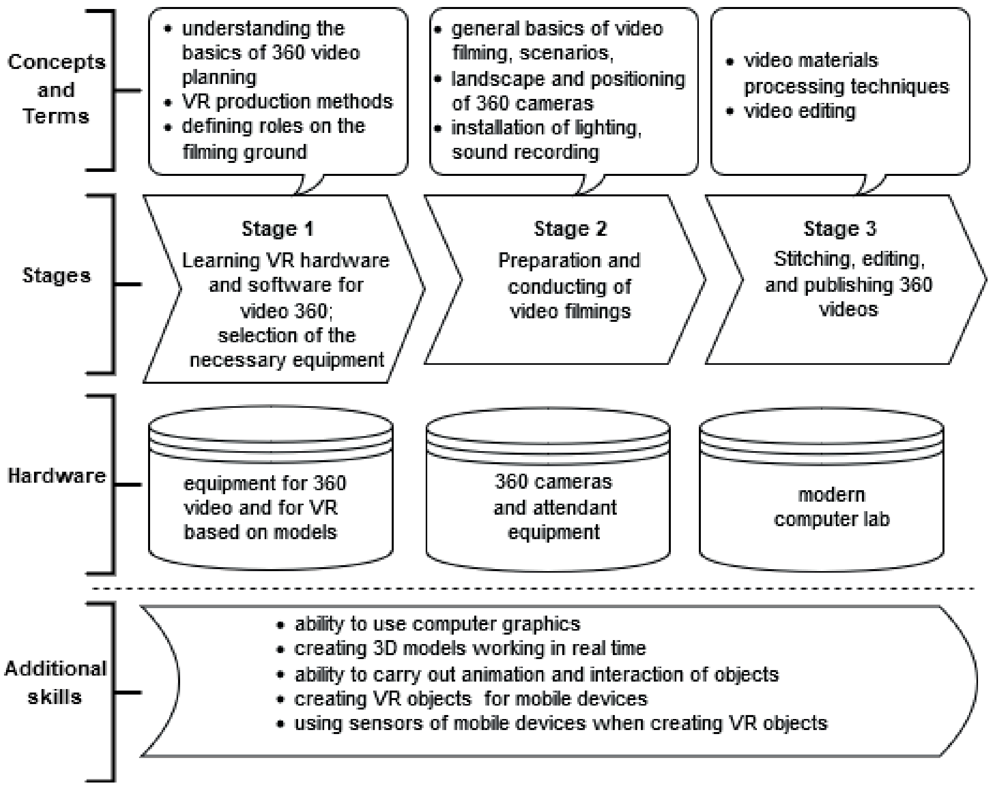
In order to achieve the objectives, the following *research methods* have been used:

- functional, structural, comparative analysis of literary and informational sources;
- analysis of VR and AR technologies and tools of mobile application development in order to determine the state of solving the problem of research and selection of tools for the development of virtual and augmented reality systems;
- synthesis of didactic requirements and technological possibilities at creation of a digital course on studying of VR and AR technologies;
- methods of pedagogical design to achieve the overall goal of the research.

Main results

In 2018, the educational programme for students majoring in Informatics was updated in Ternopil Volodymyr Hnatiuk National Pedagogical University. This programme involved a course on the study and use of augmented and virtual reality technologies.
During this course, students will get acquainted with AR / VR programs and gain practical experience in 360 video production. This course introduces them to virtual reality and 360 video production, with a step-by-step process of creating VR content (Figure 1).
In the first stage, students study the software and technical aspects of 360 video production, tools and processes, VR production methods needed to write, plan, create VR products, using modern equipment and software.
Basic concepts studied: understanding the basics of writing and planning 360 videos, knowledge of preparation for the development of 360 video products, defining roles on the filming ground and selection of the necessary equipment.
In the learning process, we first learn to use VR hardware and software for video 360. Students learn two different types: VR 360 Video and VR based models.
Video content is filmed in the real world with real people using a digital camera. This creates a realistic type of content. Most news, TV series and movies are produced this way or using a combination of video content and computer-generated content.
Based on VR models, computer-generated 3D graphics are used. So in this case, the VR content is based on 3D models, which are files that store mathematical descriptions of shapes and materials. The VR content also contains descriptions of the animation lighting of these models. With model-based VR models, participants can be able to control a virtual camera in real time and watch from any angle. In other words, users can move closer to the object to observe from a shorter distance. 360 videos and

360 VR images are based on pre-made images. They limit the user's point of view to one specific position or, in some videos, to a dynamic point of view chosen by the director rather than the user. From this fixed point of view, users can look left and right, up and down, but they cannot control their movements freely and they cannot observe objects from any position or place.



F i g u r e 1. Stages of creating VR content

S o u r c e: Own work.

Basic concepts studied: structure and features of 360 cameras, choosing the right 360 camera needed for your VR production, knowledge of the basics of video recording, understanding the basics of installed lighting, sound recording and camera positioning, creating your own 360 video.

At the final stage, students learn different options for stitching, editing and publishing 360 videos.

Basic skills: understanding the workflow editing for 360 videos, the ability to insert metadata and add text and titles to 360 videos, the ability to publish and share your 360 videos.

In addition to 360 video production, in the process of studying augmented and virtual reality technologies, students are also working on tasks to develop their own concepts of VR programs.

Students know the basic methods, functions of computer graphics and animation, the interactions used in the project, as well as the requirements for hardware VR tools. The most important thing they need to explain is how the design developed can benefit from the use of VR equipment, how the designed program uses the unique functions of VR. Students must describe the motivation to develop the program, describe what they want to achieve with the VR program.

Like existing VR programs, the created VR program should be designed to solve a problem, share experiences or learn new ways of self-expression.

Also in the task, students must indicate the technical specification of VR, give detailed information about their own VR application on the following aspects: VR display, VR content, and VR interaction.

In this case, students are proposed to familiarize themselves with two existing VR programs, which are either similar to those they create, or contain certain elements that can be borrowed for their own program.

Particular attention is paid to target users on whom the developed program can be focused. Focusing on a specific audience allows you to concentrate on choosing the right VR hardware and software.

The key moment in the project task is the ability to assess the risks of the VR project, to determine why the developed program needs to use VR as opposed to the standard on-screen interface, why the target audience can easily access the necessary VR equipment.

Currently, the Faculty of Physics and Mathematics of Ternopil Volodymyr Hnatiuk National Pedagogical University implements an educational programme involving Game study, in which students create images of 3D models for computer games on a computer.

When creating 3D content on a computer, students first develop and animate the desired three-dimensional models, then capture and animate them with virtual cameras. In this way, you can get not only computer-generated images that are captured by a virtual camera, but also 3D scenario that contain all the models and animations created and can be reused. Thanks to 3D content created by a computer, you can go beyond real life. If a 3D scenario was created, it can be visualized and animated in different ways.

This is very important for VR, because you can program 3D models to be interactive in real time. That's what 3D computer games do. Most of them are based on computer 3D models, where users can interact with animated objects in real time.

Understanding what type of VR content students are dealing with helps them make choices about the VR equipment they need. The model-based VR model is best viewed on high-performance VR displays with not only rotation but also with position tracking. In this way, you can benefit from being able to approach the object, to observe it from different positions. Position tracking allows users to use their body for natural observation of the object and thus use the full power of the equipment for viewing of model-based VR. On the other hand, 360 videos can be viewed via **mobile VR**. In this case, the image or VR content based on the video limits the way it is displayed. The user's point of view is limited by a certain tracking point and the position that comes with high-class VR displays doesn't really add anything. Because 360 VR content is stored as images rather than 3D objects, 360 videos are usually not interactive. The bound between 360 video and VR-based model may be blurred in the near future due to new technologies in the field of computer vision.

A practical step in the study and use of virtual and augmented reality technologies is to maximize the use of modern gadgets of students, pupils and teachers and ready-made VR software to create STEM projects (Balyk & Shmyger, 2018).

Modern mobile devices have many different sensors, which can be divided into the following categories: motion sensors (accelerometer and gyroscope), position sensors (magnetometer, GPS, proximity sensor), ambient sensors (light sensor, temperature sensor, etc.). They can assist in conducting research in STEM projects using VR / AR technologies. Augmented reality applications can help focus attention on certain elements of the image obtained from the camera; improve understanding of the objects of the surrounding world by providing the necessary information that is superimposed on the image in the form of a text message or visual image.

Augmented reality programs belong to the class of complex platforms. To create educational STEM-projects using VR and AR, it is advisable to use the most common platforms Google *ARCore* (on a base of Android 7.0 and higher) and Apple *ARkit* (on a base of iOS 11 and higher).

The primary capabilities of ARCore platform are: motion tracking, environmental understanding, light estimation, user interaction, anchoring objects. The primary capabilities of ARKit platform are: position tracking, lightning perception and landscape understanding, rendering. Table 1 contains the results of a comparison of three capabilities of ARCore and ARKit platforms.

Both AR platforms have similar capabilities and only developers will see their differences. Although the number of Android users is significantly higher than the number of iOS users (approximately 5 times), the market for Android devices is significantly fragmented into numerous devices that rarely use the latest operating system, which can lead to compatibility issues. Although all Apple devices have included the same basic sensor systems for years, the sensors on Android devices change significantly. ARCore requires a device with a back-facing camera, accelerometer and gyroscope. Although almost all phones have the required camera and accelerometer, the gyroscope requirement removes compatibility with most low-end Android devices.

The basis of the ARCore platform was the Project Tango project. Using an accelerometer and a conventional camera, ARCore recognizes surfaces, tracks movement and assesses lighting levels. This allows virtual objects to "respond" to changes in the environment.

The ARKit platform has the same features, but stores less data on previous locations than ARCore. Mobile devices make it possible not only to measure various environmental parameters, but also to analyse and statistically process the results using special applications.

Let's analyse mobile applications that can be used in various STEM-projects in combination with VR and AR technologies.

Table 1

Comparison of Google ARCore and Apple ARKit possibilities

Possibilities	ARCore	ARKit	Remark
Calibration	+	+	Both AR platforms can accurately calibrate the position of virtual object in the real surroundings.
Lighting	+	+	Both platforms provide a simple estimate of the essential lighting. But ARKit provides colour temperature and intensity, while ARCore offers a shader through the Unity API or a value of the pixel intensity through Android Studio API.
Simultaneous localization and mapping	+	±	On any of these two AR platforms, the tracker checks whether there is a map available or creates a new map. ARCore maintains larger maps, which makes the system more reliable. If the user's device loses tracking, ARCore will better recover a map.

S o u r c e: Own work.

The mobile application *Ruler* is useful in the implementation of the STEM project, it remembers the dimensions and allows you to show the length, width and depth at the same time. Using Apple's new ARKit technology, MeasureKit includes the following AR measuring tools:

- ruler (measuring straight lines on any surface),
- magnetometer (measuring the magnetic field around a mobile phone),
- marker pin (measuring the distance from the device's camera to fixed points in space),
- measuring the area of the room, etc.

The *Physics Toolbox Sensor Suite* application is useful for students and teachers in the field of STEM. It uses the sensor inputs of the device to collect, record and export data. Data can be displayed both graphically and digitally. Users can export the data for further analysis to a spreadsheet or any charting tool. The application menu allows the user to use more than twenty sensors in STEM projects: linear accelerometer, gyroscope, barometer, hygrometer, thermometer, proximeter, timer, ruler, magnetometer, compass, GPS, inclinometer, light meter, colour detector, sound meter, tone detector oscilloscope, etc. Information about each sensor can be obtained by clicking on its icon (name, manufacturer, data collection speed, principles of its physical operation, links to additional resources, etc.). All sensor data can be stored in a folder or on the SD card of the device. You can also export, email, or share on Google Drive or Dropbox.
The *Atom Visualizer* application (Android ARCore platform) makes it possible to move a 3D model of a nucleus with electrons into space. This is the first AR application for ARCore on Google Play. Atom Visualizer allows you to see and explore atomic models in augmented reality. Atom Visualizer is an interesting educational tool that helps to visualize well-known scientific models: Bohr model and the quantum mechanical model. The application uses AR technology to create 3D-animated visualization of both of these models in the real world using only a camera. AR Ex-

peditions is an application that presents virtual tours with virtual and augmented reality. The Google Expeditions app has more than 800 expeditions that can be carried out for educational purposes: to explore the underwater world, to visit the most remote corners of the universe, and to visit museums, etc.

STEM projects developed by students show that mobile technologies help to create an educational environment for the use of mobile devices with support for VR and AR technologies and the formation of modern digital competencies. In the process of implementing educational STEM projects, you can use mobile devices that support AR technology and are equipped with various sensors: motion sensors, position sensors and ambient sensors. STEM projects and products of project activities can be used in the process of teaching computer science, physics, mathematics, chemistry, biology, geography, etc. It is worth noting the need not only to learn using AR and VR technologies, but also to learn competencies to create products that use these technologies.

CONCLUSION

Currently, the conditions and way of life differ in the new characteristics of the information society. Young people, who are the "main consumers" of educational services, feel these differences very sharply, and therefore they increasingly demand a change in the content, level and quality of educational programmes.

The peculiarities of the study of augmented and virtual reality technology by students majoring in Informatics in the educational digital environment of the pedagogical university are a combination of VR/AR technologies, mobile technologies, and project technologies involved in the creation of educational STEM projects.

One of the innovative methods in the educational digital environment of the pedagogical university is the educational STEM project. Modern mobile devices help to conduct educational research in STEM projects using VR/AR technologies. Augmented reality applications can help focus attention on certain elements of the image obtained from the camera; improve understanding of the objects of the surrounding world by providing the necessary information that is superimposed on the image in the form of a text message or visual image.

Augmented and virtual reality technologies improve the flexibility and manageability of educational programs, individualize curricula, open access to educational digital resources, increase communication between students and teachers in the project activity process.

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