

# Augmented and Virtual Reality Technologies in Teacher Retraining

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**Abstract.** Research goal: theoretical justification for the use of augmented and virtual reality technologies in the educational process and the development of a blended course "Using the technologies of augmented and virtual reality in the practice of modern educational institutions" for retraining teachers. Research objectives: to determine the role and place of augmented and virtual reality technologies in the educational process and their use in teacher retraining for the formation of professional competence. Object of research: the formation of professional competencies of teachers in the retraining process. Subject of research: augmented and virtual reality technologies as a component of the school educational environment. Used research methods: theoretical methods containing analysis of scientific sources; empirical methods of interviewing and questioning teachers. Research results: analysis of scientific publications allows us to define the concept of augmented and virtual reality, its types, directions of using augmented and virtual reality in education, examples of its application in the educational process. The developed course "Using the technologies of augmented and virtual reality in the practice of modern educational institutions" for the retraining of teachers allows the formation of professional information and communication technologies competencies of teachers. Main conclusions: the introduction of virtual and augmented reality technologies in the educational process increases the effectiveness of training, promotes the development of logical thinking of students and increases the level of motivation of participants in the educational process.

**Keywords:** Augmented Reality, Virtual Reality, AR, VR, Blended Course, Technology, Teacher Retraining, Professional Competences.

## 1 Introduction

Technology has been growing fast and noticeably influencing different aspects of life such as education. Studies have revealed that Augmented Reality (AR) and Virtual Reality (VR) have strong potentials for helping students to improve their skills and

knowledge. In fact, bridging AR/VR and education can bring teaching and learning experiences in an attractive and effective way [1].

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real-world are "augmented" by computer generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory [2].

AR allows combining and superimposing real objects with information and with virtual objects. Azuma defines an AR as a system to have the following properties:

- combines real and virtual objects in a real environment;
- runs interactively, and in real time; and
- registers (aligns) real and virtual objects with each other.

At the same time, the augmented information may not be limited to the sense of sight but may also be applied to all senses, such as hearing, smell and touch [3].

Supporting a variety of ways of presenting, acting, and many ways to engage students in the learning process makes AR a promising educational strategy.

Virtual reality (VR) is a popular information technology (IT) area that provides an indirect experience by creating a virtual space that interacts with the human sensory systems and overcomes spatial and physical constraints of the real world (Electronics and Telecommunications Research Institute (ETRI), 2001)

According to research in USA almost 80% of teachers have access to virtual reality devices, but only 6.87% use them regularly in the educational process. Wherein 97% of students would like to study a VR course. [4].

Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time. Mixed reality does not exclusively take place in either the physical or virtual world, but is a hybrid of reality and virtual reality, encompassing both augmented reality and augmented virtuality via immersive technology [5].

What is XR? XR – often referred to as “extended reality” – includes virtual reality (VR), augmented reality (AR), mixed reality (MR), and similar means of immersion.

Areas of AR and VR application in education is depicted in Fig.2.

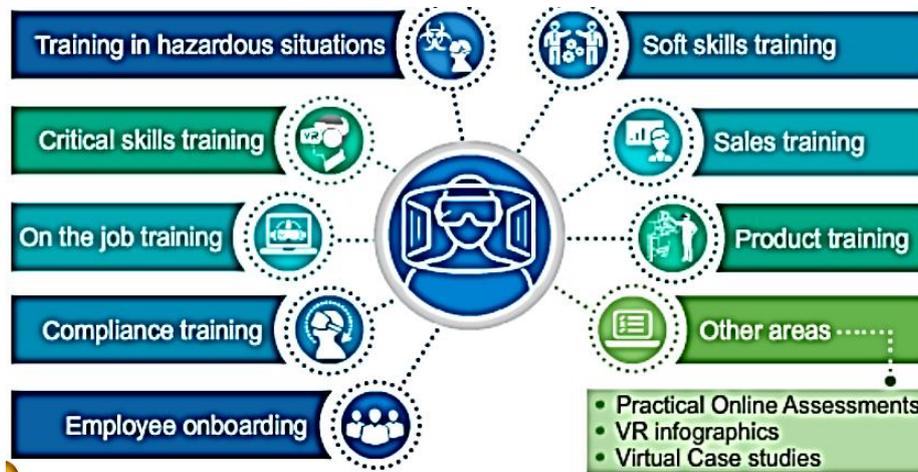


Fig. 1. Applications of AR and VR in E-learning [6]

In 2020, in Europe, the total production value of the XR industry should reach €15-34 billion, and the number of direct and indirect jobs 225,000-480,000 [7].

The vast majority – 86 percent – of respondents to the 2019 Augmented and Virtual Reality Survey Report agreed that by 2025, XR technologies will be as ubiquitous as mobile devices.

## 2 Related Work

A brief overview of the history of the development of VR and AR technologies and their use in education is presented in [8]. In these works, the authors explore the concept of Virtual and Augmented reality, its history and set out the ontological difference between virtuality, possibility and actuality.

World review of using AR and VR in education is published by Pellas, Fotaris, Kazanidis [9].

Studies have shown that with the rapid adoption of technological innovations and increased investment by large companies such as Apple, Facebook, Google, Samsung and Magic Leap to improve the availability of AR and VR technologies, educational institutions will benefit from the opportunity to conduct training in virtual environments. The possibilities of virtual technologies to overcome the boundaries of formal education are demonstrated [10].

Jaime Donally, an educational consultant and author of *Learning Transported: Augmented, Virtual and Mixed Reality for All Classrooms*, pays attention, that it's important for educators to have a plan and purpose for introducing XR in the classroom. The most important part of selecting what immersive technology to deploy, she says, is “defining goals and expectations for how mixed reality integration will benefit classroom instruction.” [11].

Issues of the impact of augmented reality technologies on increasing students' motivation level are considered in [12].

Ukrainian researches Mariya P. Shyshkina, Serhiy O. Semerikov, Viacheslav V. Osadchyi, Kateryna P. Osadcha, Oleksandr Yu. Burov, Svitlana H. Lytvynova, Andrii M. Striuk and others address issues implementation Augmented reality in science education and applying Augmented reality in professional training and retraining [13, 14].

EU Research and Innovation programmes aimed at providing breakthroughs, discoveries, and world-firsts pay particular attention to projects related to augmented and virtual reality technologies.

Erasmus+ project entitled VR@School - Future schools using the power of Virtual and Augmented Reality for education and training in the classroom was written and coordinated by Liceul Teoretic de Informatica "Grigore Moisil" (Romania) and involves Pixel in the transnational partnership. The project was funded by the European Commission in the framework of the Erasmus+ Programme, KA2 - Strategic Partnership for School Education. The VR@School project aims at supporting Virtual Reality as a teaching methodology, which helps students feel immersed in an experience, gripping their imagination and stimulating thought in ways not possible with traditional books, pictures or videos, and facilitates a far higher level of knowledge retention [15].

The main objectives XR4ALL as an initiative of the European Commission to strengthen the European XR industry are to create a pan-European (XR-tech) community, to discover existing EU XR technology, to develop a research agenda. to award grants for innovative technology projects, to increase investments and tech transfers to help products reach market [16].

A large number of international scientific and practical conferences (AR & VR World 2020, VRDAYS EUROPE 2020, EuroVR 2019, IEEE VR, XRDC, AREdu and etc.) confirms the relevance of the introduction of augmented and virtual reality technologies in education and the interest of the scientific community in these innovative problems.

In Kherson State University and in Communal Higher Educational Establishment "Kherson Academy of Continuing Education" of Kherson Regional Council there is an extending experience in teachers' trainings [17, 18].

### **3 Problem Setting**

In modern conditions of the development of technologies and changes in public life, one of the most important components of education is the development of information competence.

The issues of development of information competency of teachers are of special importance and urgency because the problem of development of information educational environment and the possibility of its use in professional activity is very important.

**The purpose of the article** is the theoretical justification for the use of augmented and virtual reality technologies in the educational process and the development of a blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” for retraining teachers.

**Tasks:**

- Analyze of main features and benefits of technologies of augmented and virtual reality;
- Find the attitudes of teachers to use augmented and virtual reality in education;
- Development of a blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” for retraining teachers;
- Implementation of the blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” in order to form the professional competencies of teachers in the field of information and communication technologies.

#### **4 Development of a blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” for retraining teachers**

In order to increase the level of professional information and communication technologies competencies of teachers at the Communal Higher Educational Establishment "Kherson Academy of Continuing Education" of Kherson Regional Council and at Kherson State University the blended course «Using the technologies of augmented and virtual reality in the practice of modern educational institutions» was developed.

The objective of the blended course is to prepare teachers in the system of continuous pedagogical education for the use of augmented and virtual reality technologies in everyday and professional activities, generalization, systematization and exchange of experience, raising the level of their professional mastery using digital technologies.

The target group of the course is teachers of different categories and specialties who see the potential of AR and VR technologies in education, striving by modern technology to minimize the digital divide between teacher and student, to improve the quality of education and the motivation of objects of educational activity.

The blended course «Using the technologies of virtual and augmented reality in the practice of modern educational institutions» is aimed at solving the following problems:

- disclosing the educational capabilities of augmented and virtual reality technologies;
- assistance to the quality development of the information educational environment of teachers;
- stimulation of the productive activities of teachers and students, oriented toward creative self-realization by means of augmented and virtual reality technologies;

- popularization of augmented reality as a factor that contributes to the generalization of experience, the dissemination of copyright developments, professional growth and development of teachers;
- effective use of modern digital technologies for educational purposes;
- increasing the interest of teachers in the active use of augmented and virtual reality to solve the problems of modernization of education;
- improving the effectiveness and efficiency of professional teaching activities;
- dissemination of advanced pedagogical experience.

As a result of studying the course, the teacher should know:

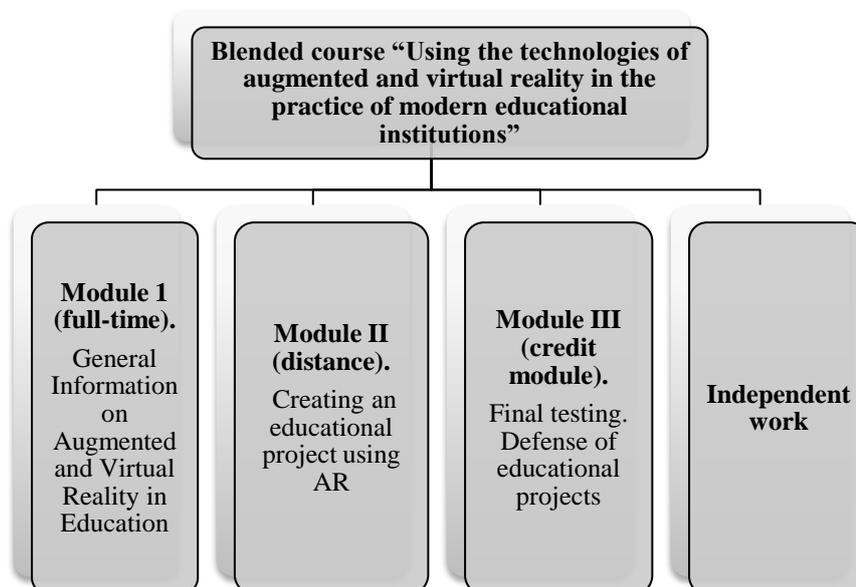
- the concept, types and possibilities of using augmented and virtual reality technologies in the professional activities of teachers;
- normative documents defining state policy in the field of information competence of teachers and students, as well as the basics of information security;
- types and features of the functioning of finished projects of augmented reality (Futurio, Quiver, Elements 4D, Octagon series cards, etc.);
- the purpose and basic functionality of the platforms for creating augmented reality (Futurio, Quiver, BlippAr, Wallame);
- programs and algorithms for creating marker augmented reality;
- methodological features of using augmented reality technology in the context of ordinary, flipped, blended and distance learning;
- methodology for introducing elements of augmented reality in the professional activity of a teacher.

As a result of studying the course, the teacher should be able to:

- apply ready-made augmented and virtual reality projects in education (Futurio, Quiver, Elements 4D, Octagon series cards, etc.);
- create augmented reality with the Wallame application tools and exchange messages in the real world with the help of augmented reality;
- create interactive maps of the area using the technology of augmented reality;
- create augmented reality scenes using the BlippAr application;
- apply augmented and virtual reality technologies in the organization of educational and extracurricular activities.

The program is based on the principles of scientific, systematic, accessibility; practical orientation, taking into account the experience of introducing courses on the study of digital technologies in educational institutions of various types, as well as the needs of students of continuing education courses, taking into account their professional and digital competencies.

Schema of blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” is depicted in Fig.2.



**Fig. 2.** Schema of blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions”

The blended course program is designed for 36 hours, of which 6 hours are lecture classes, 16 - practical classes, 18 - independent work.

The program includes the following training modules: full-time module "General Information on Augmented and Virtual Reality in Education"; distance module "Creating an educational project using AR"; independent work; credit module (individual project of each teacher).

The program provides for training sessions with various forms of cooperation, involving the use of active innovative organizational forms, interactive methods and based on the use of digital technologies with a professional focus. This creates the conditions for the manifestation of initiatives for students, creativity, independent search, ensuring the appropriate level of professionalism of students, the ability to introduce the knowledge into the educational process of modern educational institutions.

The distribution hours of classroom work to lecture and practical is approximate and can be changed while maintaining the total number of hours.

A significant part of the study time is devoted to independent work.

The educational strategy of the course is also implemented by distance learning through online consultations and the implementation of individual practical tasks; independent study by students of the training material recommended by the teachers of the course.

The training course is practice-oriented, and therefore, the predominant part of the time is devoted to the practical work of teachers with augmented reality applications: modeling and designing of a training project, creation, design, filling, optimization, etc.

Tasks for independent work are focused on self-study of the course; adding your own information resources; search for ways to implement educational projects using augmented and virtual reality technologies in the context of the traditional educational process or the introduction of flipped learning and etc.

The thematic plan for studying the blended course is presented in table 1.

**Table 1.** Thematic plan for studying the blended course «Using the technologies of virtual and augmented reality in the practice of modern educational institutions»

№ п/п	Lesson topic	Total hours	Of them		
			Lecture	Practice	Inde- pend- ent work
<b>Module I (full-time).</b> General Information on Augmented and Virtual Reality in Education		20	4	6	10
1.	Introductory questionnaire. The history of the emergence and development of augmented and virtual reality		1	1	
2.	An introduction to augmented and virtual reality. <i>Practical work № 1. Applications for Augmented and Virtual Reality</i>		1	1	2
3.	Application of augmented reality technology in education. <i>Practical work № 2. AR and VR in education. Work with ready-made augmented reality projects</i>		1	2	4
4.	Introduction to the applications of creation of augmented reality in education. <i>Practical work № 3. Creation of AR and VR projects</i>		1	2	4
<b>Module II (distance).</b> Creating an educational project using AR		14		6	8
1.	Wallame application and its fields of using in education. <i>Practical work № 4. Create an interactive map with the Wallame app.</i>			2	4
2.	BlippAr app. <i>Practical work № 5. Creating cards with elements of</i>			4	4

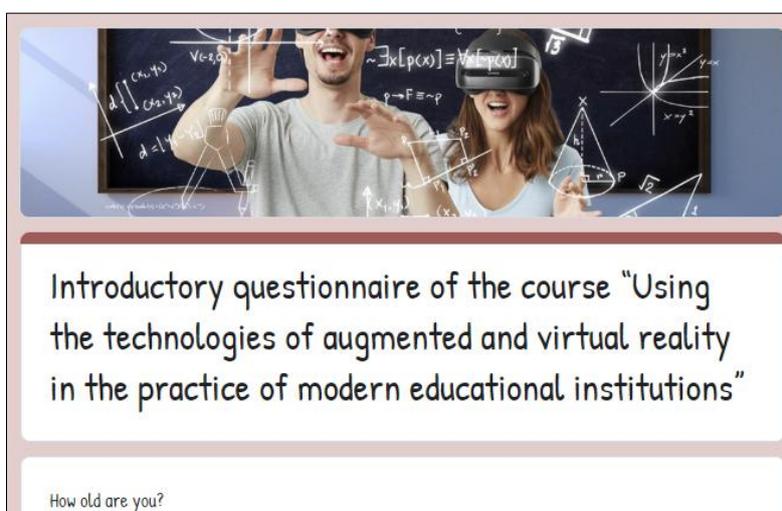
	<i>augmented reality using the BlippAr application.</i>				
<b>Module III (credit module).</b>	2		2		
<b>Total</b>	36	4	14		18

The curriculum of the blended course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” provides for the creation of individual and collective creative projects that have prospects for implementation in Ukrainian schools based on their own pedagogical experience.

## 5 Setting up the Pedagogical Experiment

The course was held for 198 students of continuing education courses (teachers of the Kherson region, Ukraine). There were 43 (21.7%) teachers of mathematics and computer science, 35 (17.7%) primary school teachers, 28 (14.1%) Ukrainian language and literature teachers, 22 (11.1%) biology teachers, 21 (10.6%) physics teachers, 19 (9.6%) chemistry teachers, 17 (8.6%) history teachers. The remaining categories did not exceed 2%.

To identify teachers' readiness to support and implement augmented and virtual reality technologies, the questionnaire was developed in Google Forms (Fig.3).

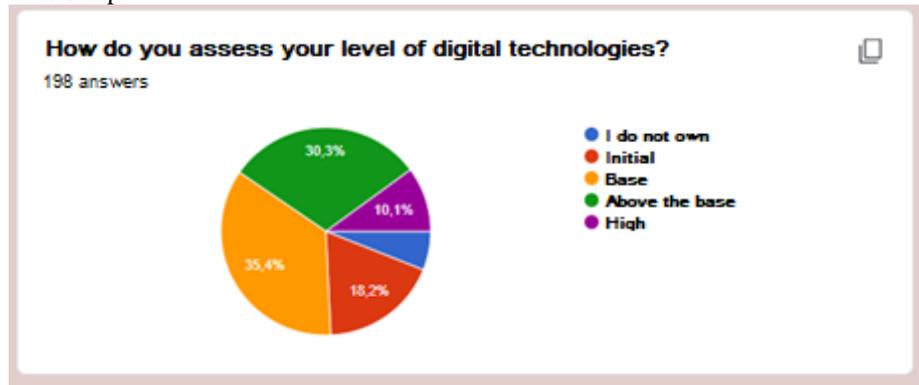


**Fig. 3.** Introductory questionnaire of the course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions”

The questionnaire survey showed that the overwhelming majority of teachers own digital technologies at the basic (35.4%) and higher than the basic (30.3%) levels. However, it should be noted that there were 12 teachers (6.1%) who did not have the

skills to work with digital technologies. These are mainly teachers of philological disciplines of the older age.

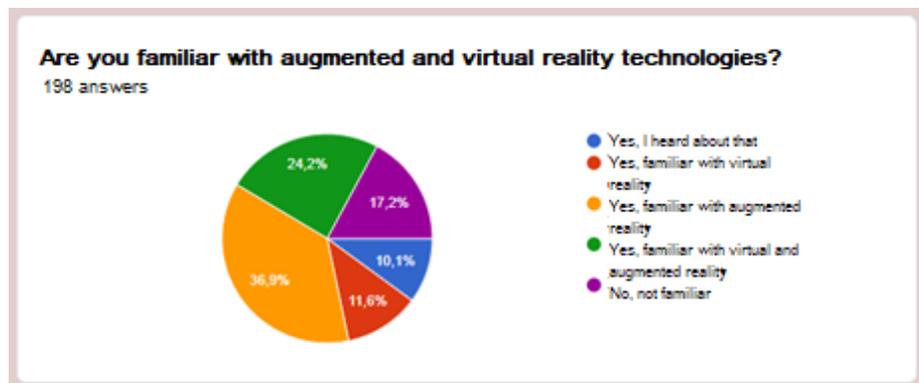
Figure 4 shows the responses of teachers about the level of digital technology ownership.



**Fig. 4.** Responses of teachers about the level of digital technology ownership.

A sufficiently large number of teachers have skills of using information and communication technologies in the educational process, as were show answers presented in Figure 4.

The level of awareness of teachers about augmented and virtual reality technologies turned out to be quite high. This is evidenced by the answers presented in Fig. 5.



**Fig. 5.** Answers to teacher awareness of AR/VR technology question

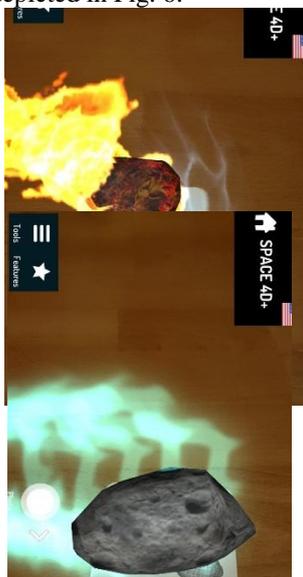
24.2% of respondents have an idea of both technologies, and also 48.5% are familiar with at least one of them. It should be noted that augmented reality technology is more popular among teachers than virtual reality technology. Among the main reasons for this: the prevalence of smartphones and tablets. lack of need for additional equipment, increasing distribution of software with support for augmented reality.

The results of a survey of teachers showed a high level of motivation to study the course “Using the technologies of augmented and virtual reality in the practice of modern educational institutions” for the development of digital competencies with the purpose the application of innovative technologies in educational process.

For different groups of teachers, topics of projects using augmented reality were selected that correspond to the disciplines they teach.

So, for teachers of elementary school, environmental studies, astronomy, it was proposed to use ready-made augmented reality projects based on Octagon Studio's live instruction cards. Flash cards Space 4D + allow you to study the properties of space objects. The application scans printed space maps and allows you to watch how space comes to life. Among the cards of the collection are: the Solar system, space objects, planets, satellites, etc.

Examples of the results of practical work of teachers with educational cards Space 4D + with augmented reality depicted in Fig. 6.



**Fig. 6.** Examples of using Space 4D + training augmented reality cards to study the properties of space objects

The use of such cards in the lessons can significantly increase the level of students' motivation and the degree of perception of the material.

Among similar applications, Octagon Studio also includes Humanoid 4D + for studying the structure of the human body, Octaland 4D (for studying professions), Animal 4D + (for studying animals), etc.

Practical work по изучению инструмента разработки учебных объектов дополненной реальности мобильного приложения VliprAR и веб-сервиса VliprBuilder предполагает создание интерактивных карточек.

An example of using augmented reality based on the development of interactive cards by teachers of mathematics is shown in Figure 7.

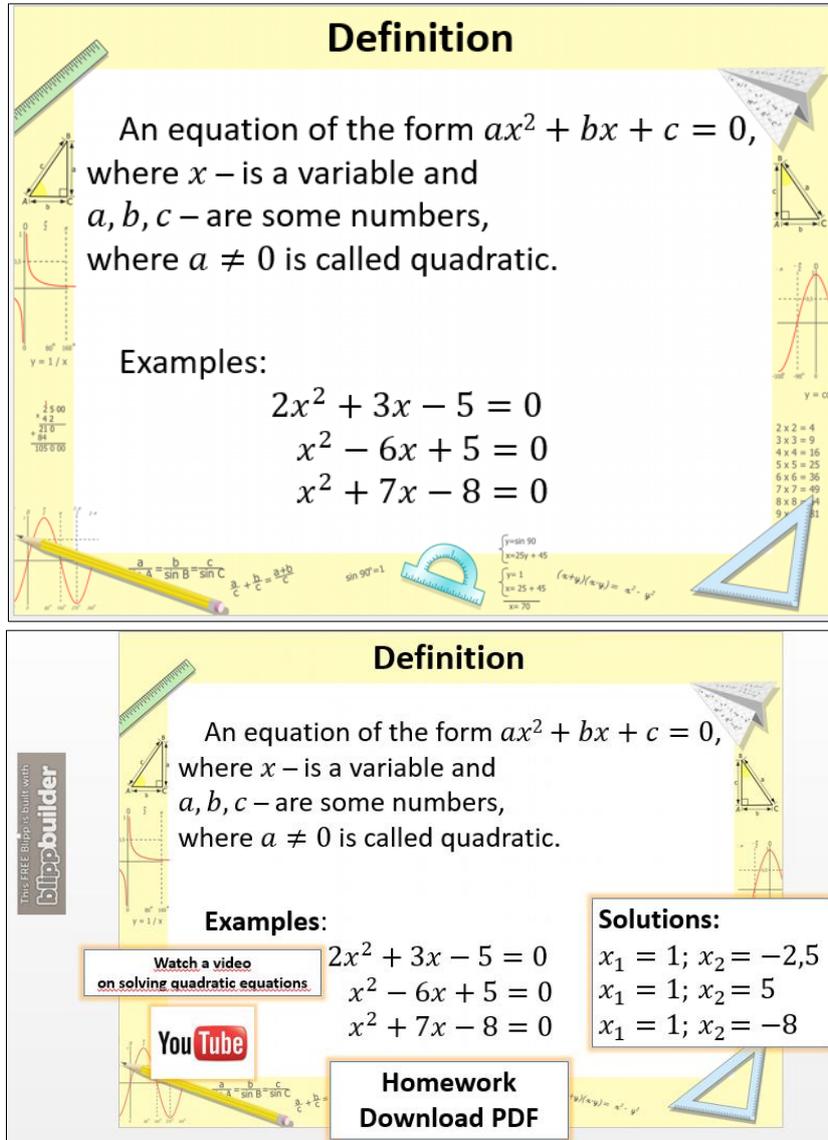


Fig. 7. An example of a project with elements of augmented reality, completed by teachers of mathematics, created using the BlippAr application

When creating a didactic card, the model of organizing access to educational objects of augmented reality using markers, mobile devices and augmented reality browsers, proposed in [19], is used. A card with a math assignment is marked with a special marker. To recognize the marker, a mobile device with a camera and an augmented reality browser installed is used. Once in the camera field, the marker is recognized by the program and the augmented reality scene is displayed on the device

screen. In this scene, elements such as an image, text (for example, with answers for self-testing), video (with an explanation of theoretical material or an algorithm for solving problems of this type), a three-dimensional model, etc. are superimposed on the image received from the device's camera. The interactive scene suggests the possibility of interacting with the user based on the script [19].

The task of the final control is to check the teachers' understanding of the material of the course as a whole, the logic and relationships between the individual sections, the ability to creatively use the accumulated knowledge, the ability to form their own attitude to a particular problem of academic discipline and apply augmented and virtual reality technologies in the educational process.

The final test provides for 2 groups of questions: questions that verify the degree to which teachers master the course material; questions that test the practical skills of teachers in using augmented and virtual reality applications.

As a final work, students are invited to develop a project that provides for the creation of an interactive laptop with elements of augmented reality and to develop a lesson summary using augmented reality technology within the chosen discipline.

## **6 Conclusions and Outlook**

Analysis of scientific publications allows us to define the concept of augmented and virtual reality, its types, directions of using augmented and virtual reality in education, examples of its application in the educational process. The developed course "Using the technologies of augmented and virtual reality in the practice of modern educational institutions" for the retraining of teachers allows the formation of professional information and communication technologies competencies of teachers.

Examples of using augmented reality applications in the study of mathematics and astronomy are considered.

The results of the pedagogical experiment showed a high level of motivation of teachers of elementary and secondary schools to study and use augmented reality technologies in the educational process.

The introduction of virtual and augmented reality technologies in the educational process increases the effectiveness of training, promotes the development of logical thinking of students and increases the level of motivation of participants in the educational process.

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