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APPLYING AUGMENTED AND VIRTUAL REALITY IN ONLINE AND OFFLINE EDUCAION

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ABSTRACT

The technologies of augmented and virtual reality are studied by the example of their use in education. The subject of the study is the study of well-known and previously developed teaching methods using AR and VR, advantages and disadvantages in terms of their use in educational purposes. The purpose of the work is to conduct an analytical literature review and analysis of known methods of using augmented and virtual reality, to present the most promising solutions in various tasks of science. The paper proves the capabilities of augmented reality technology and how they might be used in educational and project-based activities. The goal of this research is to prepare instructors to employ augmented reality technology in their classrooms in online and offline types of education. Moreover, the possibility of using AR technology to develop cognitive interest among students in the process of studying specialized disciplines is substantiated. In this report, it is suggested that components of AR technology be included in 10th grade physics classes, particularly while studying optics.

Keywords: *Virtual Reality, Augmented Reality, Education, Online Education, Offline Education.*

1. INTRODUCTION

One of the key directions of the digital transformation of society is the informatization of education. Both the effectiveness of their training and their readiness for life in modern society depends on the mastery of generalized methods of activity using information technologies [1]. Among modern information technologies, we will highlight the technology of interaction with multimedia resources.

Augmented reality technology allows you to simultaneously see and use virtual and real objects. For example, Google Glass or the Iron Man helmet, aiming systems in modern combat aircraft and navigation systems are also augmented reality [2]. This modern technology gives the user the opportunity to combine special computer 2D and 3D objects and images from a video camera and thus complement the real environment. The technology of "augmented reality" does not bypass education. Currently, it is used in the process of studying school disciplines of the natural-mathematical cycle: the convenience of using virtual 3D objects simplifies the process of explaining new material by the teacher, the lesson is based on fascinating interactive tasks.

The leading task of augmented reality is to determine the increase in potential users, i.e. their interaction with the environment, but at a much different level. With the help of a computer device, layers with a set of objects representing auxiliary information are applied to the drawing of the authentic environment.

The technology under consideration is developing in three directions [3-5]:

1. "Markerless" technology. It is based on recognition algorithms, where "reference" points are superimposed on the terrain captured by the camera, which help determine the exact place to which the model is attached (for example, the Ruler App).

2. Marker-based technology binds to a place for a virtual model (for example, the Dewar application). The structure of the marker resembles QR codes.

3. Technology linked to GPS tags. The application is activated if the GPS coordinates match the coordinates of the virtual object (for example, the StarRover application).

There are several variants in literary sources explaining augmented reality technology: "augmented reality is the combination of two initially independent spaces on the screen – the world of real objects around a person and the virtual world created on a computer" [6]; "augmented reality is technologies that allow you to supplement the image of real objects with various objects of computer graphics, as well as combine images obtained from different sources. Unlike virtual reality, which assumes a completely artificial synthesized world, augmented reality involves the introduction of synthesized objects into natural video scenes" [7].

Based on such definitions, the following definition can be given: "Augmented reality technology is a technology of interactive computer visualization that allows you to supplement a book image with virtual elements (animated three-dimensional models, video, audio, text, etc.) and displays it on the screen of a mobile device."

Currently, augmented reality technologies are widely penetrating the field of education [8]. Here we can mention, first of all, the use of ready-made educational technologies. For example, interactive tutorials; physical, chemical, biological AR experiments and experiments; accompanying guides-consultants in augmented reality of natural attractions, museums, exhibition complexes and much more [9].

The purpose of our work is to prepare a platform that could use augmented reality technology in the classroom and in the project activities of students.

2. AUGMENTED AND VIRTUAL REALITY IN EDUCATION

In this section, we talk applying augmented and virtual reality in online and offline education. Figure 1 demonstrates applications of virtual reality in education. It contains different types of learning as boost student engagement, experience based learning, virtual field trips, high tech training, and distance learning [10].

Figure 1: Applications of Virtual Reality in Educaiton

It is fair to state that VR technology has provided learners and educators with several opportunities in the field of education. VR technology has a stronger effect on a variety and teaching root than conventional techniques, and it is also cost-effective and filled with the ability to make instruction engaging and relevant due to its extensive and adaptable technology presence [11].

In certain circumstances, learning and live presentations are friendlier for students than explicit instruction, which may help maintain it injury-free and waste-free since no gadgets or materials are lost in online classes and repetition. This can be done with only a mobile phone and an internet access, and the results are noticeable.

Figure 2 demonstrates design process of augmented and virtual reality tools. For device specific implementation some tools are considered as phone or tablet, mobile VR tool, roomscale VR tool, mixed reality tool, and costoms devise. Applications serve as a gamification platform. There can be used 2D or 3D representation, and deployment solution stage that contains design simulation, visualization, learning and development, and field servicing [12].

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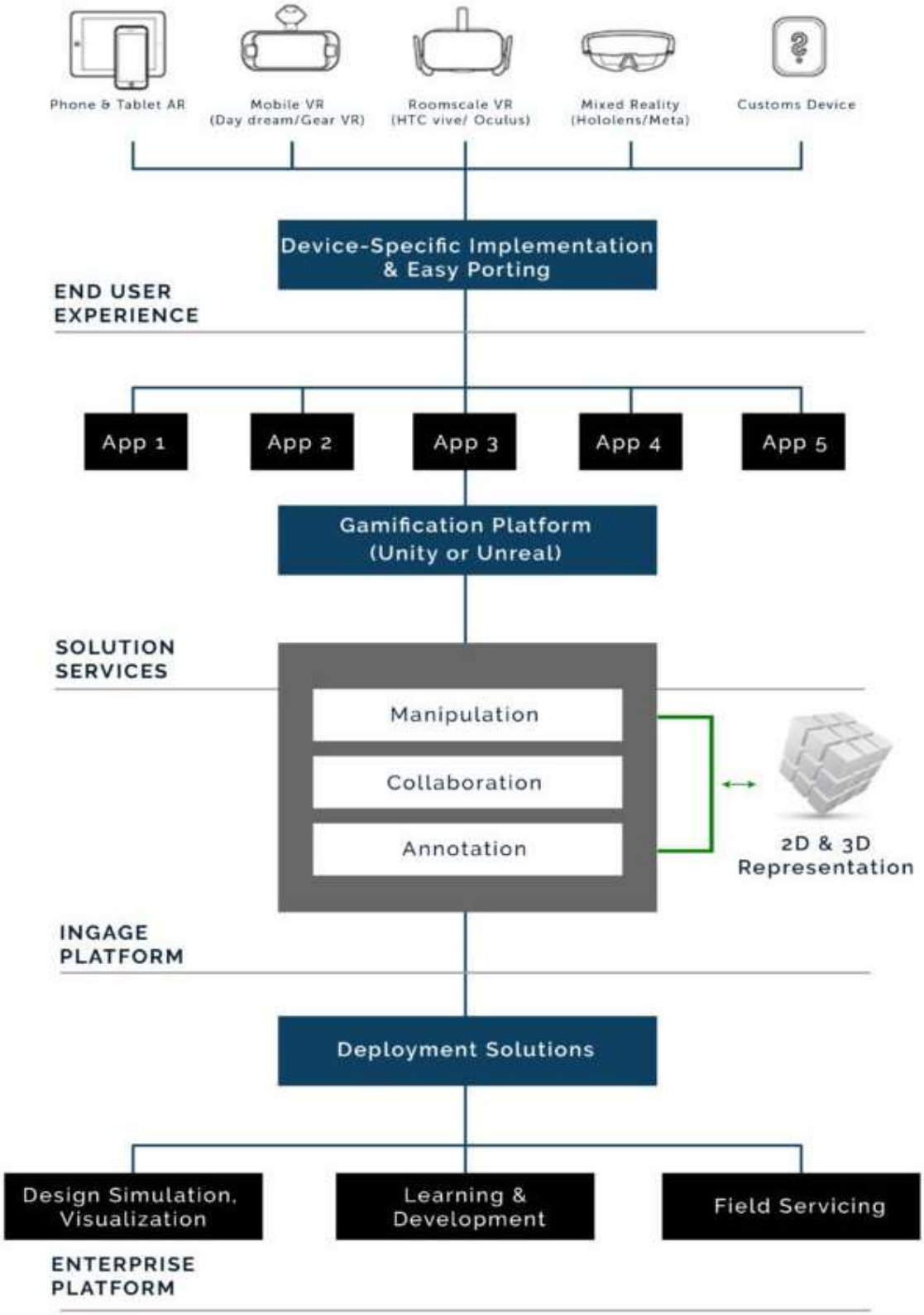

Figure 2: Design process of augmented reality and virtual reality tools

2.1 Augmented and Virtual Reality in Online Education

Online learning is the acquisition of knowledge and skills using a computer or other device connected to the Internet. This is online, here and now, learning through connection. This format appeared in the field of distance learning and became its logical continuation with the development of the Internet and digital technologies [13].

Lecture videos appeared on the Internet in the late 1990s, but became very popular only after 2010. At that time, companies like Coursera, Udacity and Udemy could raise money and make their courses available en masse, for free and for money [14].

Since then, online courses have become not only a means of online knowledge and exams, but also a kind of channel of direct communication between teachers and students. Online learning allows students to fully immerse themselves in the educational environment - watch/ listen to lectures, complete assignments, consult with teachers and communicate with classmates thanks to a network connection.

In semantic connection with online learning, the words and phrases "e-learning" and "e-learning" are used. They indicate the student's ability to acquire knowledge in various formats: audio, video, hyperlinked text, infographics, programs, games, tools and materials for acquiring knowledge through augmented reality, etc [15-17].

The similarities and differences between online learning and distance learning are the learning itself, that is, the process of acquiring new knowledge and skills [18]. Outside of classrooms and without direct contact with teachers. This process requires much more self-discipline and consciousness from the students.

Learning using virtual reality is based on immersive technologies – a virtual extension of reality that allows you to better perceive and understand the surrounding reality. That is, they literally immerse a person in a given event environment.

Virtual space allows you to explore in detail objects and processes that are impossible or very difficult to track in the real world. For example, anatomical features of the human body, the work of various mechanisms and the like [19]. Flying into space, diving hundreds of meters under water, traveling through the human body: virtual reality opens up huge opportunities.

In the virtual world, external stimuli practically have no effect on a person. He can fully focus on the material and learn it better.

The scenario of the learning process can be programmed and controlled with high accuracy. In virtual reality, students can conduct chemical experiments, see exceptional historical events and solve complex problems in a more exciting and understandable way [20].

A significant part of the information can be submitted in a playful way. After all, "in the choice between playing and learning, the game wins" [21]. And in the same way to consolidate the material, conduct practical exercises and much more. Thus, dry theory becomes clear, understandable and much more interesting, which further engages students and increases the effectiveness of education. This allows "developing active educational content and making the learning process more effective" [22].

Observing the current trends, we can say with confidence that virtual reality equipment will become more affordable over time. One of the key factors in the spread of technology will be the increase in available VR content. Not only for schools, but also for universities and other institutions. At the same time, virtual reality can be used in teaching at any age – both for primary school students and for adults who have decided to master a new profession or improve their qualifications [23].

Educational VR content can now be found in a variety of sources, for example:

1. VR apps in the App Store, Google Play or Steam. These services contain dozens of different applications aimed at learning and acquiring new skills.

2. YouTube videos are created specifically for VR. 360-degree video is becoming more and more popular every day, and YouTube copes with it perfectly.

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3. Universe Sandbox 2. A space simulator in which students can clearly see how gravity, climate and physical interactions work in space.

4. The Body VR. A travel simulator inside the human body, created for medical students. It allows you to walk through blood vessels, see real cells and deadly viruses.

5. Google Earth VR. It gives you the opportunity to see the sights of the world "in full growth" and consider them from all sides. Egyptian pyramids, Eiffel Tower, Niagara Falls: all the most unique objects are getting closer and closer.

6. The VR Museum of Fine Art. Contains the most famous museum exhibitions. No safety glasses, crowds of tourists and security guards. And with the ability to see every detail thanks to exceptional graphics.

AR enriches the world with the latest technologies, creating audiovisual images, allowing students in classrooms to see the educational material and making it more vivid, memorable.

The effectiveness of this training method has been confirmed by a number of tests and experiments. For example, an experiment was conducted in which subjects of two groups were asked to obtain material in different ways. One group received visual material in the form of stands and posters, the other - visual material with AR [24]. It was revealed that the group that received materials using augmented reality assimilated them by a percentage of 90%, and the concentration of attention reached 95% of the entire audience, while the group using two-dimensional materials had half the indicators [25].

The reason why such indicators have become possible is that AR creates a presence effect, showing the connection between the real and virtual world, which psychologically looks much more attractive to a person, and increases his receptivity to receiving new information.

Guided by the data of these experiments, as well as the works of G. P. Shchedrovitsky, in 2020, a team of authors created an augmented reality application that clearly shows the practical significance of the educational process of both school subjects and additional education [26]. The objective of this study was to arouse a conscious interest in learning outside the school subject "Project activity".

To date, several main advantages of the introduction of AR/VR technologies in education have been identified:

1. Visibility. 3D graphics allow you to reproduce in detail those processes that are invisible to the human eye - chemical reactions, the decay of the atomic nucleus, the movement of electrons or the process of cell development at different stages.

2. Security. There is no need to explain the advantages of creating virtual cabins for pilot training, medical operations, developing skills for managing technological equipment in hazardous industries, etc.

3. New opportunities for distance learning. Thanks to modern technologies, it is now possible to create a simulated space with a first-person view, which gives the effect of presence. Such technology will be useful, for example, in history lessons, where each participant will have the opportunity to become a participant in the events they study in the virtual world [27].

4. Engagement. Visualization of the mechanics of actions, for example, the human body gives undeniable advantages over traditional teaching methods. Virtual and augmented reality makes possible "time travel" or deep into the universe [28].

5. Focusing attention. Detailing and full immersion in the VR space allow you not to be distracted from the influence of external factors, and AR tools aimed at creating a mixed reality allow you to exclude external factors.

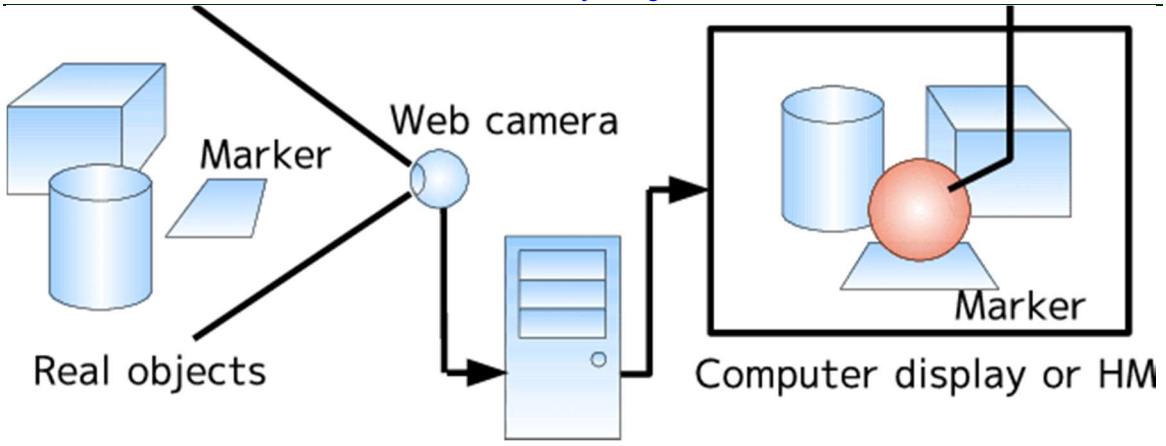

Figure 3: A general augmented reality architecture for online education

Figure 3 presents a general augmented reality systems architecture for online learning classroom that requires only web camera, computer, and mobile devices. It is useful for offline and online learners, too. In pandemic situation it allows to students to continue their lessons at home or another places in online mode, without interrupting their education programs [29]. This advantage was noted by students and teachers, too as a main benefit of VR and AR technology.

2.2 Augmented and Virtual Reality in Offline Education

In the process of preparing students as future specialists, Augmented Reality technology (hereinafter referred to as AR) has become increasingly used. It should be noted that the use of augmented reality technology in educational practices is a promising area of research. Analysis of literature covering the problem of using augmented reality technology in education [30-32], it allowed us to identify a number of advantages of this technology: concentration of the student's attention in the learning process; strengthening the motivation of learning; independence of learning educational content; formation of digital competencies of the learner; personalization of learning (individualized learning process); strengthening of the learner's involvement in the learning process; increasing the effectiveness of cognitive development. Along with the highlighted positive aspects of the use of AR in education, there is also a critical view of this technology when it is used in the educational process: excessive enthusiasm for AR by students can distract them from studying the discipline as a whole; insufficient number of studies of this technology in the scientific environment, which does not answer a number of questions related to the positive impact on learning; high cost of hardware and software for the full implementation of this technology in education; lack of diversity of software designed for the development of augmented reality [33].

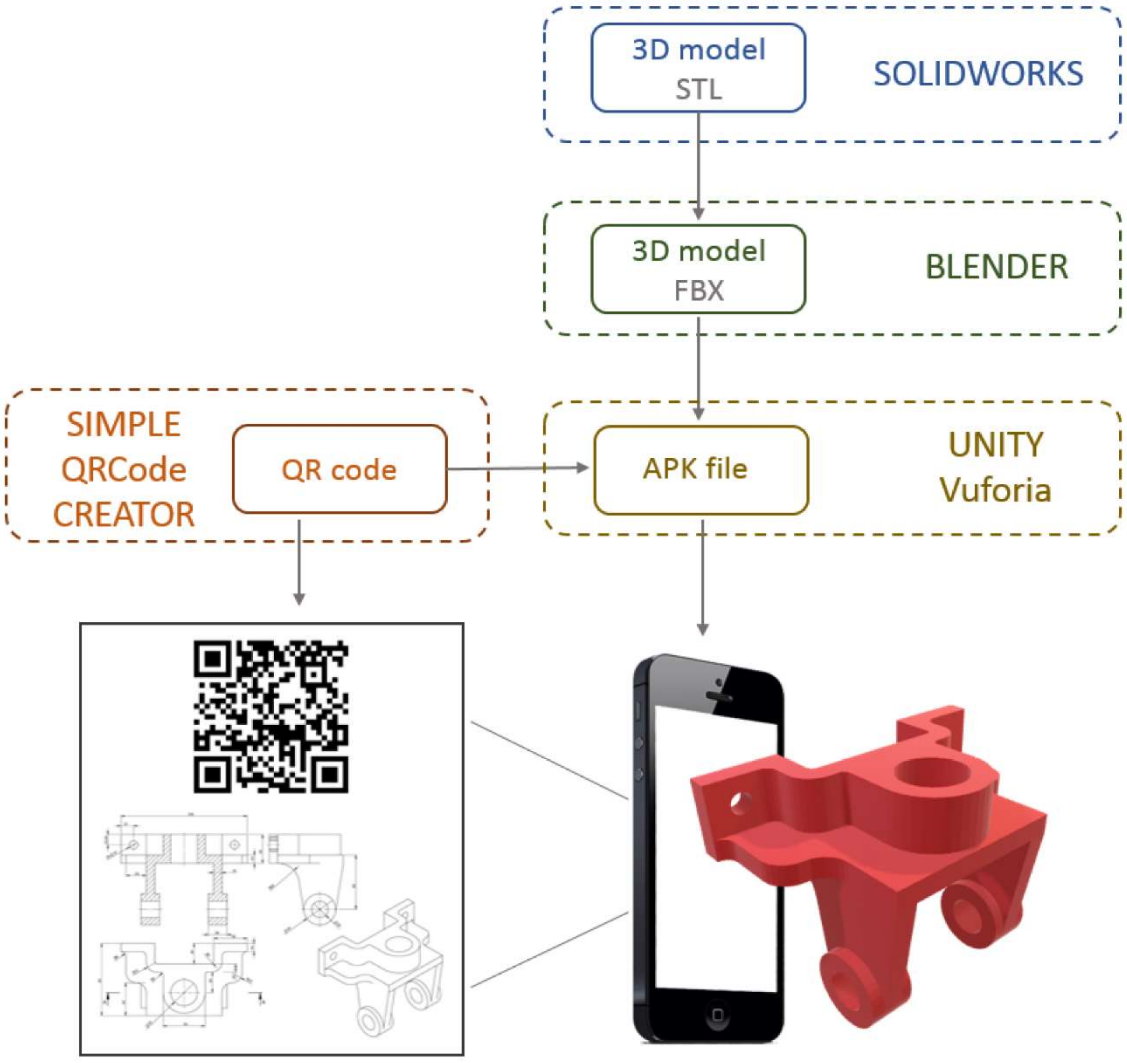

Figure 4: Augmented reality in offline education

Figure 4 demonstrates one example of applying augmented reality in offline education. It should be noted that augmented reality technology is rapidly developing, therefore, in the near future, some of the critical issues on the use of AR in education may be removed.

2.3 Applying Augmented Reality in Various Spheres

Virtual reality has long ceased to be just a game story and is actively being introduced into all spheres of human activity [34].

Let's take a closer look at how VR is used in the educational field today and why this technology is the future, as well as what its prospects are.

What is the advantage of virtual and augmented reality? They allow you to create an environment that is perceived by a person through the sensory organs. In fact, VR/AR allows you to simulate comfortable conditions for obtaining new knowledge, and especially for teaching children, teenagers and young people. No one thinks for the student, he himself rethinks all the perceived information [35].

Not only start-ups, but also large companies offer their solutions in the field of virtual reality for educational purposes [36]. We already know

successful examples of using VR in training, for example:

- At Yale University, a VR training for performing a surgical operation on the gallbladder has been tested. The group using VR was 29% faster and 6 times less likely to make mistakes.

- A study "The impact of virtual reality on academic activity" was conducted in Beijing. The children were taught the same discipline, but one group was taught using the classical method, and the second group was taught using VR. As a result, a test was conducted. The first group was 73% successful, and the second group was 93% successful. In addition, the VR group showed a deeper understanding of the topic and consolidated the acquired knowledge better (according to the test results two weeks later).

- In 2018, anthropology students from Cambridge and class students from Eastern China examined the symbols painted along the tomb on the Giza Plateau. Nothing ordinary. That's just two groups were in completely different parts of the world and not a single person was directly in Africa. This was made possible thanks to the rumii VR program developed by Doghead [37]. A virtual classroom was created in it and three-dimensional models of the objects under study were loaded. And the students controlled their virtual avatars, being thousands of kilometers away from the real place of study.

- Google Corporation is working on creating virtual tours of world attractions. For example, at the end of 2019, a virtual tour of the Palace of Versailles was launched, for which 132,000 photos were used to create. There are also tours of the Bolshoi Theater in Moscow, Buckingham Palace and other cultural heritage sites. And their number is growing every year.

- In the modern world, the use of augmented reality technology is becoming more and more common, for example, in human life, in industry, for military purposes, in science and art [38]. To date, the following areas of use of mixed, augmented reality can be distinguished [39]:

- Geolocation and tourism. Thanks to the built-in navigator, the use of augmented reality will allow you to quickly plot a route, navigate the terrain or simply read information about the attraction. At the same time, you should just point the gadget at the object to get information about it.

- Advertising business. If you have a gadget with the right application, you can read information about a product or service from special stands. Unique interactive kiosks have also started to be in demand. In China, you can buy products in a virtual store, which simplifies the formation and delivery of an order.

- Medicine. The German Palpsim AR program allows you to train doctors to palpate patients. Software has also been developed to monitor the patient's condition during surgery without sensors.

- Construction, design and architecture. With the help of a special application, the architect will be able to see the final result, which will avoid a number of design errors even at the initial stages.

- The gaming and entertainment industry actively uses augmented reality technology, creating various applications based on virtual reality overlays on the surrounding world.

- Education. For example, augmented reality glasses allow you to get as much information about the world as possible. Prototypes of models are being created that allow students to immerse themselves in a certain situation. Augmented reality layers enable the student to explore a fully functional 3D model of any object, as well as visually demonstrate the entire cycle of a process [40]. At the same time, the student receives the most realistic sensations. All this causes a certain interest among students. Nevertheless, due to low funding, this category of application is still at the initial stage [41].

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There are quite a lot of examples of using augmented reality. It is obvious that the modern education system must compete with the entertainment sphere and needs perception mechanisms that will allow students to be involved in the process of acquiring new knowledge [42]. The results of modern studies of the digital educational environment indicate that effective learning is driven by interest, which must first be formed and then supported [43].

Modern students are representatives of generation Z and A, born in the period from 2002 to 2005. A generation is an objectively formed socio-demographic and cultural-historical community of people united by age boundaries and general conditions of formation in a specific historical period of time [44]. Generation Z and A have their own specific cognitive sphere.

Multitasking – quickly completing multiple tasks or quickly switching between them. Research shows that the key characteristics of multitasking are working memory (the ability to hold information in the head that is needed to carry out current activities), fluid intelligence (speed and accuracy of information processing) and arbitrary attention [45]. Problems with attention – a decrease in the level of voluntary attention, as well as concentration of attention associated with a large amount of digital information [46]. Critical thinking - representatives of generation Z and A, as well as adolescents of other generations, have a low level of development of critical thinking skills [47]. At the same time, representatives of this generation mostly have digital competence – the ability to confidently, effectively, critically and safely choose information and communication technologies and apply it in their activities [48]. This is due to the fact that digital information and technology are an integral part of their lives. In this context, an important problem is that it is difficult to attract such students with drawings, watching old movies or reading rapidly aging literature. Therefore, devices with support for augmented reality technologies are becoming more and more popular in education today [49].

3. MATERIALS AND METHODS

In this research, we developed a portal for digital education with a possibility of virtual and augmented reality tools. For implementation of virtual and augmented reality experiments we used Unitiy technology. Unity is a platform that can be used games. In our case, we use it for virtual experiments. Unity is far from the last place among game engines. It is used by both large developers and (much more often) small independent studios. In this article we will talk about the features, strengths and weaknesses of the engine, as well as the types of projects in which its use will be most appropriate.

Unity is more than a game engine; it's a development environment for computer games that incorporates numerous software tools used in software development, such as a text editor, interpreter, and debugger. Simultaneously, Unity's simplicity of use makes game development as easy and pleasant as possible, while the engine's multiplatform nature enables to support as many gaming platforms and operating systems as feasible.

First and foremost, as previously said, the Unity3D engine enables game development without the need for specialized skills. A component-oriented technique is used here, in which the developer develops objects (such as the main character) and then adds other components to them. The engine enables you to build maps and organize things in real time and test the results quickly thanks to a user-friendly Drag&Drop interface and a powerful graphics editor.

The inclusion of a large library of assets and plugins, which may substantially speed up the game creation process, is the engine's second benefit. They may be imported and exported, and whole blanks – stages, monsters, AI behavior patterns, and so on – can be added to the game. There's no need to worry with programming. Many cassettes are accessible for free, while others may be purchased for a modest fee. You can also develop your own material, which you can then sell on the Unity Asset Store. Figure 5 demonstrates an example of game engine process in unity technology.

Figure 5: Unity technology

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Unity 3D's third strength is its compatibility for a wide range of platforms, technologies, and APIs. Games built using the engine may be readily transferred to different operating systems as well as virtual reality and augmented reality devices. Unity works with all contemporary rendering effects, including the newest real-time ray tracing technologies, and supports DirectX and OpenGL.

4. EXPERIMENTS

In this section we tell about the platform for digital education that applies virtual and augmented reality. Figure 6 represents main page of the proposed platform. The digital education platform is available by the electronic address https://diged.kz/. The portal contains different types of teaching motivations as 4D incentive, analogy, katena mapping, random stimulation, coaching method, function matrix, omega meppin Method, phila-coaching, virtual reality, and augmented reality. As scope of our paper is virtual and augmented reality, in this paper, we will tell only about experiments that applied AR and VR technology.

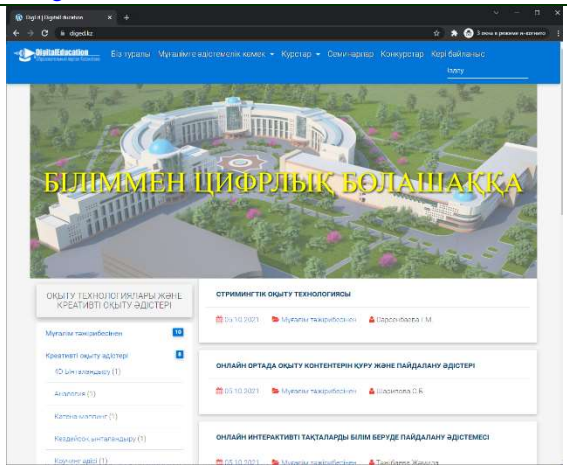

Figure 6: Main page of the digital education platform

There we present learning materials and virtual experiments. For example, Figure 7 and Figure 8 illustrates virtual experiments in Physics studying.

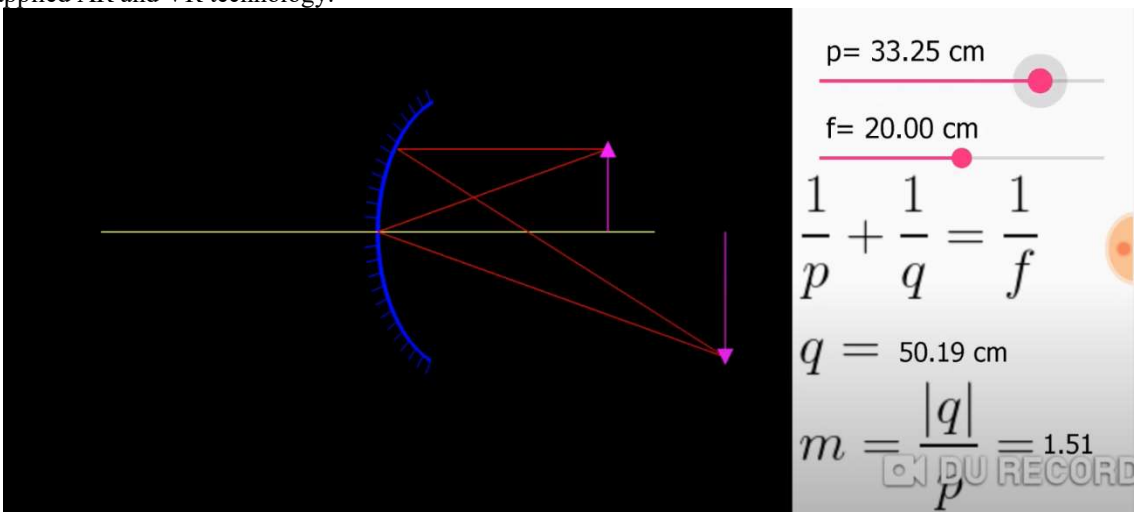

Figure 7: Virtual experiment in physics

Figure 7 demonstrates a virtual experiment in Optics domain of Physics. Next figure demonstrates the continue of the previous experiment. There, students can do different experiments in virtual form by changing p and f measures. During changing the p and f measures, the results of reflection of rays change too. In the result, students will have more representation about reflection of rays than practical lessons.

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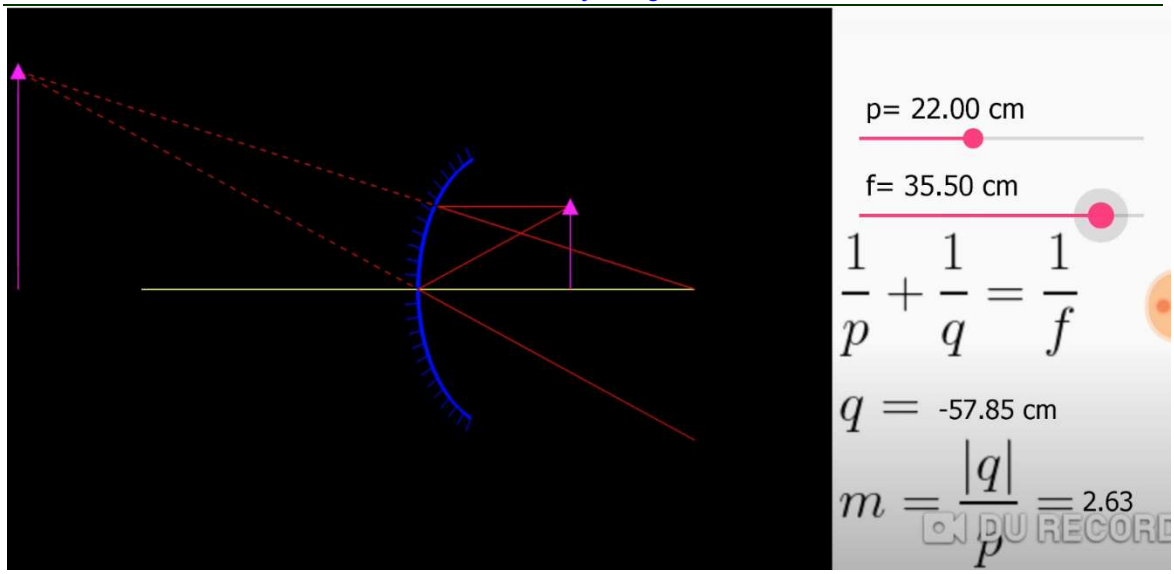

Figure 8: Virtual experiment in physics (continue)

The questionnaire of students shows that the motivation of the students during applying the AR and VR technologies was increased. In addition, the students told that it more useful for understanding new themes.

It should be emphasized that the students did not find the application itself interesting, although it was fascinating and unusual. They noted an increased desire and interest in further study of the discipline. Consequently, the AR application attracts students' attention to the material, promotes better assimilation of knowledge; involves students in the learning process due to a high degree of interactivity, which, in turn, improves the quality of education. We also noticed that students during the class were more inclined to cooperate with fellow students and the teacher.

Thus, it is obvious that augmented reality applications have a huge educational potential. We are convinced that in the context of the digital transformation of education, special attention should be paid to the use and development of this means of learning.

5. CONCLUSION

Summing up this research, it can be noted that, indeed, the increase in the volume and acceleration of information flows put a modern person in a difficult situation of its perception and development. The abundance of information makes it difficult to concentrate attention; the overload of heterogeneous information and its availability reduce the consistency and creativity of thinking, analytical thinking becomes unclaimed in the era of ready-made and accessible cliches. Clip presentation of information changes the civilization of books (texts) to the civilization of visual images.

Technologies are developing so fast that the field of education, as a fairly conservative sphere (this, as you know, has its advantages) does not have time to react to all the innovations. Virtual and augmented reality technologies are being implemented faster in the sphere of business, trade, advertising, and the electronic games industry.

In conclusion, we note that the technology "Augmented Reality" qualitatively changes the process of acquiring new knowledge, skills and abilities within the framework of school education from standard theoretical study to living the phenomenon, a deep understanding of abstract processes and objects. Training with the use of technology "Augmented Reality" has material advantages: there will be no need to purchase stands and bulky posters, boards and other visual aids. The main advantages of using the technology in question are its visibility and interactivity, enhancing the learning effect, increasing the information literacy of students, information completeness, which allows them to develop imaginative and algorithmic thinking, spatial and creative imagination.

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