

The project formation of virtual graphic images in applications for distance education systems

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Abstract

Projects on the creation of programs, using virtual reality, primarily stimulate human thinking. Virtual reality contributes to the progressive formation of the characteristics of human thinking, and also develops forms of mental activity. Working in educational VR projects improves the usual indicators of figurative short-term memory, observation, stability, concentration of attention, ability to generalize and classify. Thus, an educational application using virtual reality technology has been developed. During the development process, the main goal was to make the application as interesting and comfortable as possible for the target audience to use, to achieve the set goals and to realize all the useful opportunities that virtual reality provides.

Keywords

virtual reality, educational application, virtual classroom, educational project

1. Introduction


In connection with the mass transition of educational institutions to distance education, many people have found both advantages and rather serious disadvantages in this. When the question arose of replacing the traditional form of education with distance education, it was necessary to quickly solve the problems of establishing an effective organization of

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distance education. In modern conditions, traditional education in institutions of higher education is gradually supplemented or even replaced by new distance learning technologies. The project principle of distance learning has already become an important part of the education system [1,2]. But never before has it been so widespread in the world: both universities and schools work online. Virtual reality technology can help improve perception and increase immersion in this form of learning.

Virtual reality is being used by many industries to achieve new levels of user engagement, and thus its popularity is growing every year. More importantly, the price of virtual reality devices is gradually decreasing, and it is becoming affordable for a mass audience. As anyone who has tried a VR headset before can attest, the ability to accurately perceive spatial relationships in a virtual reality world cannot be replicated through traditional 2D media such as screens or paper.

2. Problem statement and related works

Nowadays, virtual reality projects are used in a huge number of different fields: medicine, the army, production, museums, education, etc [3,4]. For educational processes, the use of virtual reality technologies has only just begun. In the last two years, almost all educational institutions were forced to switch to distance education in connection with the pandemic. In the conditions of distance education, acquiring practical skills is impossible immediately after mastering theoretical knowledge, because it can be dangerous for a person without experience, or the cost of conducting it is very expensive [5]. In the conditions of a pandemic and martial law, the use of virtual reality technologies in the educational process is particularly relevant [6].

Scientists distinguish the following methods of distance learning [7]:

- D-learning (distance learning) is a method that allows learning remotely. Not to be confused with e-learning. The student does not meet the teacher or other students in real time. Despite this, two-way communication between them is a prerequisite. You can communicate, for example, by email, Skype, messengers;
- E-learning is one of the types of distance learning that is often chosen for conducting courses. For the lesson, the student needs the Internet and a computer. Thanks to e-learning, you can participate in seminars, complete courses or even university without leaving your home. A huge number of companies, trainers, universities have chosen e-learning for training their employees and students. Because e-learning is suitable both for classes in small teams and for teaching groups of thousands;
- M-learning – if a mobile device or a laptop with a stable Internet connection is used for distance learning, then it is already m-learning, from English mobile learning [8];
- B-learning (or blended learning) is a method that allows you to combine traditional and distance learning. Depending on the goals of the course, different forms of communication with the teacher are used. If the topic requires practical skills, then students come to the classroom. At the same time, part of the information is sent by

email or taught in the form of a video lecture. Sometimes students meet with the teacher online at webinars or trainings [9];

- Webinar is a presentation, lecture, seminar or training organized using webcast technology. Webinars provide two-way communication between the teacher and students. This technology is ideal for synchronous learning, as on a webinar you can not only send and receive information in real time, but also conduct discussions, questionnaires, etc.

There are a large number of Internet resources and programs that allow teachers to establish remote communication with students and organize the learning process as productively as possible [8]:

- sending messages (email, WeChat, WhatsApp, etc.);
- joint work in documents (Google documents, interactive online boards IDroo, MIRO, WikiWall, etc.);
- social networks (Facebook, Instagram and others);
- course management system or virtual learning environment (Moodle, Ilias, Sakai, TrainingWare Class, etc.);
- video conferencing (Zoom, Google Meet, Microsoft Teams, Skype, etc.).

A certain leader among these programs is Zoom. To date, this program has perhaps the richest functionality, including in the basic version. Zoom is a service for conducting video conferences, online meetings and distance learning. With its help, it is possible to hold large interactive events with video, sound and screen broadcasting (up to 100 participants can participate in the free version of the program). Zoom is configured to manage large audiences with registration, host controls, polls, Q&A, hands-on voting, chat, event video, and more.

Having analyzed all the features, software tools, advantages and disadvantages of distance learning, it was found that many of the actual disadvantages of the above-mentioned method of training can be eliminated by using the latest technologies, namely by implementing distance training using virtual reality technology, which will be able to give training participants a sense of presence in the virtual world, will be able to convey depth and accurate perception of geometric properties of objects in three-dimensional space. With the help of visualization of the participants of the scientific process through virtual images that will be able to reproduce gestures, movements, emotions. Also, virtual reality will be able to solve the problem of conducting practical classes to a greater extent, as students will be able to interact with virtual objects using hand tracking. And of course, students and teachers will have the opportunity to discuss various topics with the help of microphones built into the headsets.

The purpose of this article is to reveal the features of the organization of educational projects for distance learning using virtual reality technologies, the formation of virtual graphic images and the development of an educational VR application that would allow the use of VR technology to significantly expand the possibilities of distance learning.

3. Requirements for projects of D-learning application with virtual reality technology

Few of even the most effective education systems are sufficiently well equipped to quickly and efficiently transition the learning process to online mode. Such attempts often proved unsuccessful, and success in many cases was ensured by experience and the realization of opportunities to learn from the mistakes made in the past. Technical progress often outstrips the development of the capacity of responsible authorities to use new opportunities. Costs are usually very high. Creating the necessary infrastructure is often a major challenge along the way. But with all the importance and high cost of infrastructure, much more serious problems are related to providing methodological and technical support to teachers so that they, in turn, can help learn in a new educational environment; creating high-quality digital content, relevant curriculum, and assessment tools; formation of digital skills for the successful use of technical means of education; introduction of reference and information management systems; monitoring and evaluation of processes and their impact; and introducing the necessary rules.

The term "virtual reality" is interpreted as "near reality", but it usually refers to a certain type of reality emulation [10]. Everything we know about our reality comes through our senses. In other words, our entire experience of reality is simply a combination of sensory information and our brain mechanisms that perceive that information. It can then be said that if you can represent your feelings with composite information, your perception of reality will also change in response to it. You may be presented with a version of reality that does not actually exist, but from your point of view it will be perceived as reality.

If a virtual reality implementation manages to achieve a combination of hardware, software and sensory synchronicity, then a sense of presence is achieved. Where the subject really feels as if he is present in the virtual environment.

There are different types of virtual reality: with the effect of full immersion, without immersion, VR technologies with a common infrastructure. The VR everyone is raving about is virtual reality with a fully immersive effect, because it's an explorable and interactive 3D world that can take you to places you can't go in real life: whether it's walking on Mars or driving through mountains in sports car.

Non-immersive VR technology includes simulations with images, sound and controls projected onto the screen. Such systems are classified as virtual reality, since they far exceed other multimedia tools in terms of the degree of impact on the viewer, although they do not fully implement the requirements for VR.

Having evaluated the possibilities of virtual reality today, it was decided to create a product using this technology. Having studied the problems of distance education, the development of the software product was aimed specifically at solving certain problems of distance education.

The main purpose of the application is to conduct training sessions and conferences using the technologies that virtual reality can currently provide us.

The application should provide users with an opportunity to:

1. Create a joint session;
2. Display the speaker's virtual model: visual model, movement, gesticulation;
3. Synchronization of the image from the interactive whiteboard between all participants of the session.

4. Software of virtual reality systems

Since the trends of using virtual reality in various fields are growing, and the headset is becoming more and more accessible to ordinary users, many developers are starting to adapt their products to the VR platform.

When learning VR development, you need to rely on programming guides and tutorials. Whether you're learning to code in C#, developing in Unity, or building VR apps, there are essential skills and tips you should know. Learning how to develop quality products on your own is difficult, but possible. Many people start their development journey as a hobby. But then this hobby successfully turns into a job.

So, first you need to decide on a game engine. There are two leading choices of game engines: Unreal Engine and Unity. Both are capable of fulfilling any need, are reliable and have their pros and cons. However, most prefer Unity.

Unity has been on the market since 2005, and it has become one of the most stable and powerful game engines. Developers create 3D and 2D games, apps, simulators, and more. More than 50% of mobile games and 60% of VR/AR applications are created using Unity [11].

The engine supports a range of SDKs and integrations for all major VR and AR devices. The Unity Asset Store will allow you to download the necessary ready-made 3D models, SDKs and more, from free to expensive. A developer can work with basic assets, work on more complex ones, and develop their own.

Unity has a lower entry point for new developers. With a large community of developers, Unity and its supporters create a space where anyone can just start and learn.

While Unreal excels in high resolution graphics. However, Unity is catching up, and this is no longer the main differentiating factor between these engines.

Much of Unity's power comes from using C# for programming, a language that works best when creating desktop, mobile, and VR applications. It is widely used in game and VR development, as over 90% of VR/AR developers use C# .

Unreal uses C++, which has a less consistent syntax than C#. C# is a statically typed language, meaning that code is checked by Unity before the program is executed. Errors are detected and corrected more easily.

Each VR device has its own SDK: HTC Vive uses SteamVR, Oculus products use Oculus Integration, etc. Therefore, it is important to determine which hardware you want to create a product for before starting development.

Deciding which VR device to build a product for requires deciding what the user will be able to do in the app. Does the app need to be widely available? Had full immersion with the ability to interact with virtual objects? Was it mobile or stationary?

Otherwise, the development of an application with virtual reality technology is reduced to the development of a regular application. However, several factors should be taken into

account to create a gaming stereo camera that will be able to broadcast objects that the user looks at from different angles at the same time. Typically, major VR headset developers provide access to libraries that allow you to quickly and easily link the physical device and provide access to its functionality in your app.

Special attention should be paid to game performance. VR games require quite a lot of power from the machines on which they will be executed. The first reason for this is stereo cameras, which, unlike a regular camera in games, reproduce two images at once to achieve the effect of depth of objects. Also, for VR applications, it is necessary to achieve a high frame refresh rate so that all movements in the game are smooth and the player is comfortable in the virtual world. This is usually 60 fps, but more expensive VR headsets already support 90 fps or even 120 fps.

Although virtual reality immersion devices are usually similar, the way images are projected in front of our eyes is very different. For example, in HTC Vive and Oculus Rift, all calculations and operations are calculated on the basis of the PC to which they are connected. But some big companies, such as Google and Samsung, offer more affordable VR devices that require a smartphone connection to receive data from it. Sony also managed to produce a virtual reality helmet for the PlayStation platform known to all gamers. Also, I would like to highlight autonomous platforms that appeared not so long ago. And in order to plunge into the virtual world, there is no need to use any additional devices. All calculations take place inside the built-in processor, which receives information from sensors that are also built into the device. In 2018, Oculus introduced the Oculus Go and Oculus Quest stand-alone helmets, and Lenovo released the Lenovo Daydream stand-alone headset.

Once the headset and power source are identified, some information is also required to get started – be it via head tracking, controllers, hand tracking, voice, on-device buttons or trackpads.

Immersion is what everyone who makes a VR headset, game or app strives for - to make the VR experience so real that people forget about the computer, headgear and accessories and act just like in the real world. But how to get such an effect?

VR headsets such as Oculus Rift and PlayStation VR are often called HMDs (head-mounted displays), which means that these devices can open up the world of virtual reality to you just by being placed on your head. Even without tracking sound or hand movements, holding Google Cardboard over your head and using your smartphone's display can be enough to half-immense you in a virtual world.

Video is sent from the console or computer to the headset via an HDMI cable in the case of devices such as the HTC Vive and Rift. As for Google's Daydream headset and Samsung's Gear VR - the video is shown on a smartphone installed in the headset.

VR headsets use either two channels sent to a single display, or two LCD displays, one per eye. Lenses are also installed in helmets, which are placed between a person's eyes and the original image, which is why the devices are often called glasses. For the most part, they can be adjusted to match the distance between your eyes and the display, depending on each individual person to achieve the best detail.

These lenses focus and transform the image for each eye and create a stereoscopic 3D image by setting the angle between the two 2D images to mimic what each of our eyes see.

One can try closing one eye and then the other to see how separate objects move from side to side and one might understand what it's all about.

One of the important parameters of a VR headset that can increase the sense of presence is the field of view, that is, how wide the "corridor" will be between the eyes and the display. A 360-degree display would be too expensive and unnecessary. Most high-end headsets are made with a field of view of 100 or 110 degrees, which is enough to get the effect of presence.

How your head movements are tracked is also important. Head tracking means that when you wear a VR headset, the output image shifts based on your movements, simulating what a person in the real world would see with those movements at that point in time. When a person looks up, down, sideways or tilts his head, the image adjusts accordingly.

The system, called 6DoF (Degrees of Freedom), places your head in view on the X, Y, and Z axes to measure forward and backward, side-to-side, and shoulder-to-shoulder head movements.

In the case of a 3-DoF headset, we can track rotational motion, but not translational motion. From the movements of the user wearing the VR headset, it is possible to track whether the user looks left or right, turns his head down, up or to the sides. With 3-DoF, we cannot tell if the user has moved (translational motion) in the scene while moving in real life.

There are several different internal components that can be used in a head tracking system: a gyroscope, an accelerometer, and a magnetometer. Head tracking technologies need low latency to be effective. It's about 50 milliseconds or less. Otherwise, a person will not be comfortable in the virtual world, he will be able to feel these lags between when the head turns and when the VR environment changes. The Oculus Rift has an impressively minimized lag of just 30ms. Lag can also be a problem for any input required for motion tracking, such as PS Move-style controllers that measure hand movements.

After the virtual environment changes visually according to the person's movements, the immersive effect can be further enhanced with sounds. 3D audio can be used by developers of applications and games to give the user a sense of space, directionality of sound: coming from behind, from the side, or away from the user.

Head tracking is one of the main advantages of premium headsets over other 3-DoF VR headsets. But big companies are still working on tracking traffic. When you look down with a VR headset, the first thing you want to do is see your hands in virtual space. For a while there was a Leap Motion accessory – which uses an infrared sensor to track movements – strapped to the front of Oculus devices. Movement could also be tracked using the Kinect 2 cameras. But now there are advanced input systems from Oculus, Valve and Sony.

Oculus Touch is a set of wireless controllers designed to give a person a sense of how they can use their hands in VR. The player simply holds each controller and uses its buttons, panels and triggers while in the virtual world. Each controller also has a set of sensors to detect human gestures.

In addition to all of the above motion tracking devices, eye tracking technology has recently been discussed. Eye tracking is perhaps the final piece of the virtual reality

puzzle. It's not yet available for the Oculus Rift, HTC Vive, or PlayStation VR, but it will be featured in Fove's highly promising VR headsets. Eye tracking can now be seen in HTC Vive's implementation of Tobii technology.

Inside the Fove headset are infrared sensors that track eye movements, so the headset knows where your eyes are looking in virtual reality. The main benefit of this, aside from allowing in-game characters to respond more accurately to where the player is looking, is to produce a more realistic depth of field.

In standard VR headsets, everything is in sharp focus, which is not quite what we are used to seeing in the real world. If our eyes look at an object from afar, the foreground is blurred, and vice versa. By tracking our eyes, Fove's graphics engine can simulate this in 3D VR. The ability to focus your gaze on an object will only complement the sensations provided by the virtual world.

Today, helmets still require higher resolution displays to avoid the pixelated image effect. Also, what our eyes focus on should look as real as possible. Without eye tracking, all objects are in sharp focus, and when you move your eyes instead of your head, the human brain still knows something isn't real.

5. Project development and the structure of the virtual reality educational application

The application should include two roles (actors): speaker (teacher) and listeners (students). On the main screen, it is possible to create a session for conducting a virtual lesson, or to connect to an already existing session. When creating a new session, the user sets the name of the virtual room and the maximum number of students who will be able to join. After creation, the user enters the virtual audience. With the help of a virtual reality helmet, the movements, positions and turns of the hands and head are monitored. In turn, the received data is transferred to a 3D model (virtual image) of the speaker. With the help of the microphone built into the headset, the speaker has the opportunity to speak, and with the help of the headset controllers – the opportunity to reproduce hand gestures and interact with virtual objects.

The role of the presenter includes the ability to turn off the audio, show a presentation, interact with the virtual board, and show various three-dimensional models of objects. Listeners have the opportunity to ask a certain question (clarification) to the speaker by pressing a key at the workplace. There is an interactive whiteboard in the classroom, with the help of which the teacher can familiarize the students with visual content. At the end of the work, the creator of the session has the option to delete the session, thereby all users of the session get back to the main menu.

Comparing the game engines Unreal Engine and Unity in the development vector of the distance learning application, Unity is preferred. The largest manufacturer of virtual helmets Oculus has full support for the Unity game engine and provides a package of necessary libraries to access the functions of the helmet. Oculus also releases updates to its autonomous helmets quite often. It is for virtual reality helmets of this type that the application is aimed at. Being able to quickly access new helmet features thanks to the

Oculus Integration package for Unity is a big plus for this game engine. In addition, there are many other advantages.

In general, Unity 3D is a package that contains all the necessary functions. Unity makes game development easier, faster and more efficient. Currently, it is one of the best tools for creating small and medium games. In addition, it is very easy to master and has an affordable price policy [12].

First, a simple blank 3D project was created in Unity. After that, the necessary settings were made, including the installation of the development platform - Android. OpenGL ES3 was taken as the graphics core.

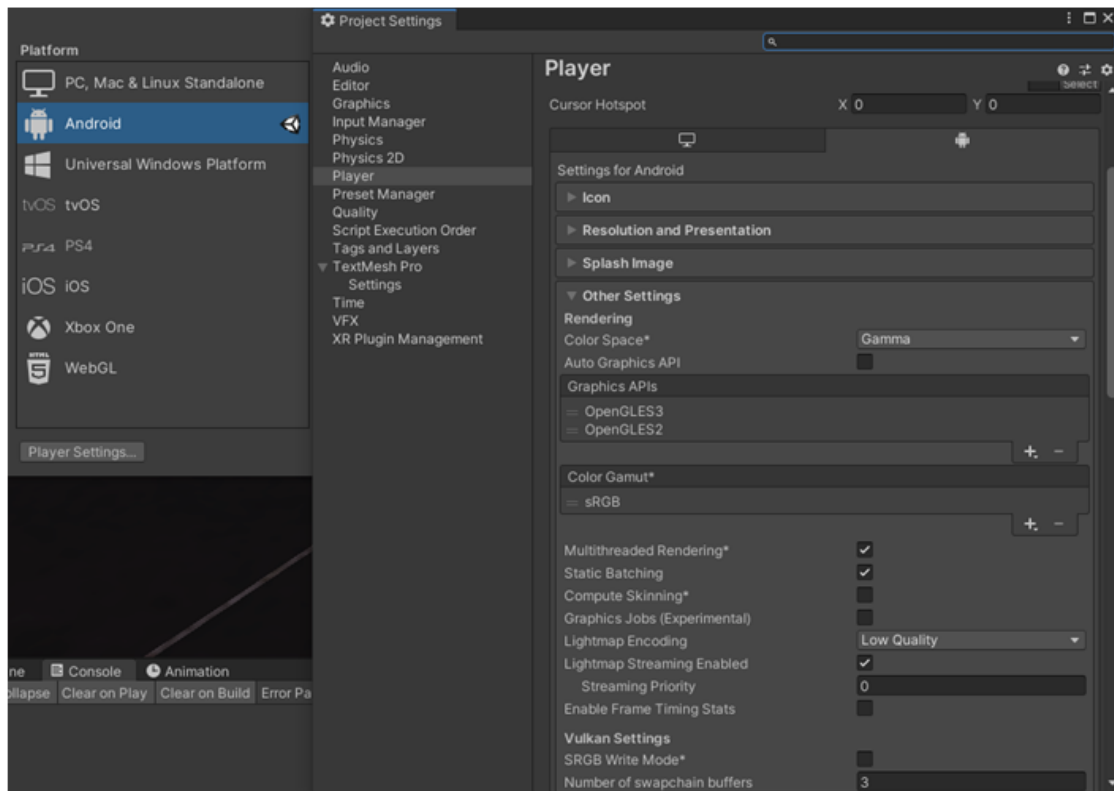


Figure 1: Initial settings of the project

Since it was decided to develop the application for virtual reality helmets from the Oculus company, the Oculus Integration package for Unity was imported into the project.

It was decided to develop the application according to OOP paradigms. Therefore, different scenes will be created in the project according to their tasks. Scenes contain objects. They can be used to create the main menu, individual levels, and anything else. With the help of scenes, you can break the scenario of using the application in the educational process into separate blocks.

In the created project, 2 scenes were created: a lobby, where users will be able to create a virtual room or enter an already created one; the auditorium is actually the main stage where the educational process itself will take place.

Each scene has its own manager, which controls other subsystems. A manager is a general script of a certain structure, which contains information about smaller objects that make up this structure. In turn, managers manage objects on the scenes to which they are attached. Each manager knows and monitors the work of only those components to which he is attached.

6. User interface development

Figma graphic editor was chosen to create the interface layout. Figma is a web design tool that is completely based on cloud computing. It allows the user to work simultaneously with his team members on the same file without any difficulty. It helps to achieve flawless performance and better design in website business.

This tool has many amazing features that can bribe any user. Many useful functions and ease of use and simple export of vector images have been implemented. There are many more obvious advantages.

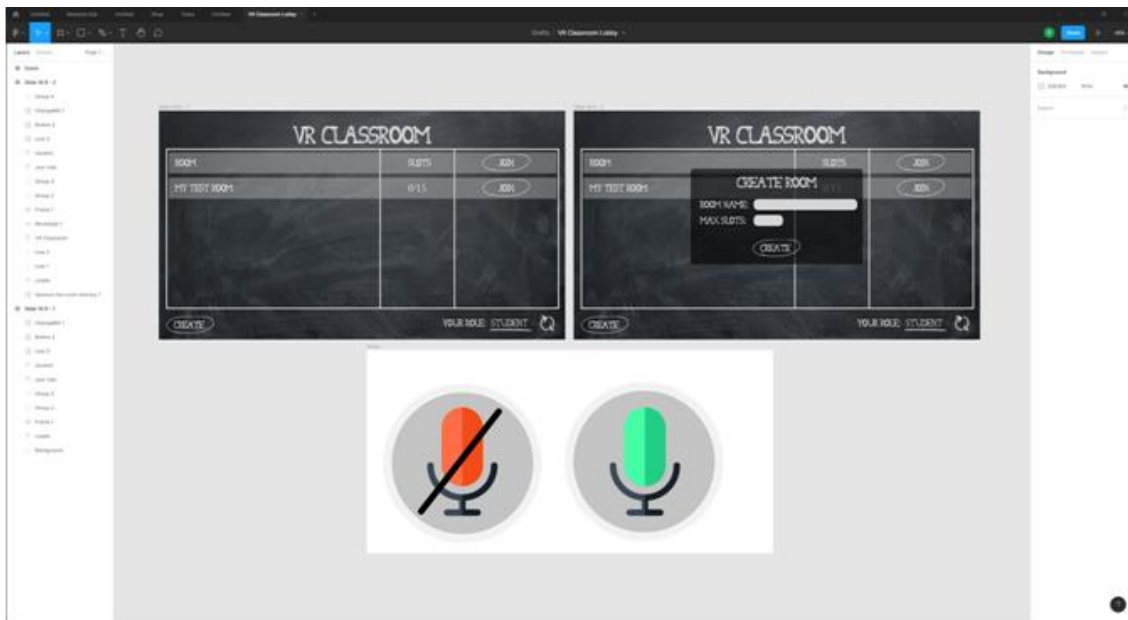


Figure 2: Layout development for the Lobby game scene

After creating the layout, the necessary textures were exported and the layout was already done in the Unity game engine. It was decided to develop the distance learning application in two versions - for autonomous virtual reality helmets and for ordinary phones on the Android platform. This will expand the capabilities of users who, for some reason, will not be able to connect to the virtual room using a helmet. But in turn, this imposed certain difficulties, because different EventSystem components need to be configured for different platforms to interact correctly with the user interface. The EventSystem is responsible for handling events in the Unity scene. And only one EventSystem object is allowed to be created in a scene. Therefore, during development, we

had to work on separate versions of the user interface separately for mobile devices and helmets.

To implement the interface, unlike a mobile device where the interface is superimposed on top of all objects in the scene, in a helmet it is important to place the interface on a certain three-dimensional plane, since the virtual reality user will be able to move around the interface. Based on this, the entire interface was placed inside the created 3D room.

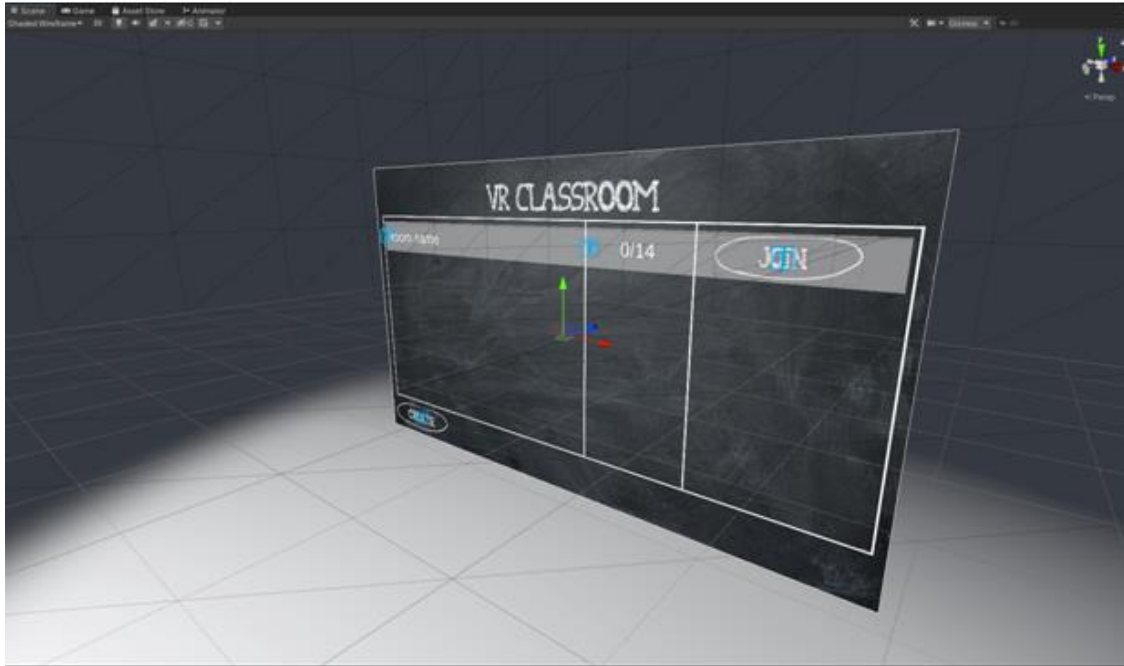


Figure 3: Developed interface in Unity

A separate camera and event processing system were created to display the interface on a mobile device. When initializing the Lobby scene, the scene manager determines on which device the application is running, and according to this information activates the corresponding camera.

After the realization of the scene from the lobby, it was decided to develop a pleasant audience for user perception. Autodesk 3Ds Max software was used to develop the 3D model of the classroom virtual room. It is a computer graphics program for creating 3D models, animations and digital images. It is one of the most popular programs in the computer graphics industry and is well known for having a solid set of tools for 3D artists.

This program allows you to easily and quickly create professional quality animations. Many industries use 3Ds Max to create graphics that are mechanical or even organic in nature. Engineering, manufacturing, education, and medical industries also use 3Ds Max for their visualization needs. The real estate and architecture industries use 3Ds Max to create photorealistic renderings of buildings during the design phase. In this way, clients can accurately visualize their living spaces and offer critiques based on real models.

3ds Max uses polygon modeling, which is a common technique in game design. Thanks to polygon modeling, artists have a high level of control over individual polygons, giving them a greater range of detail and precision in their work.

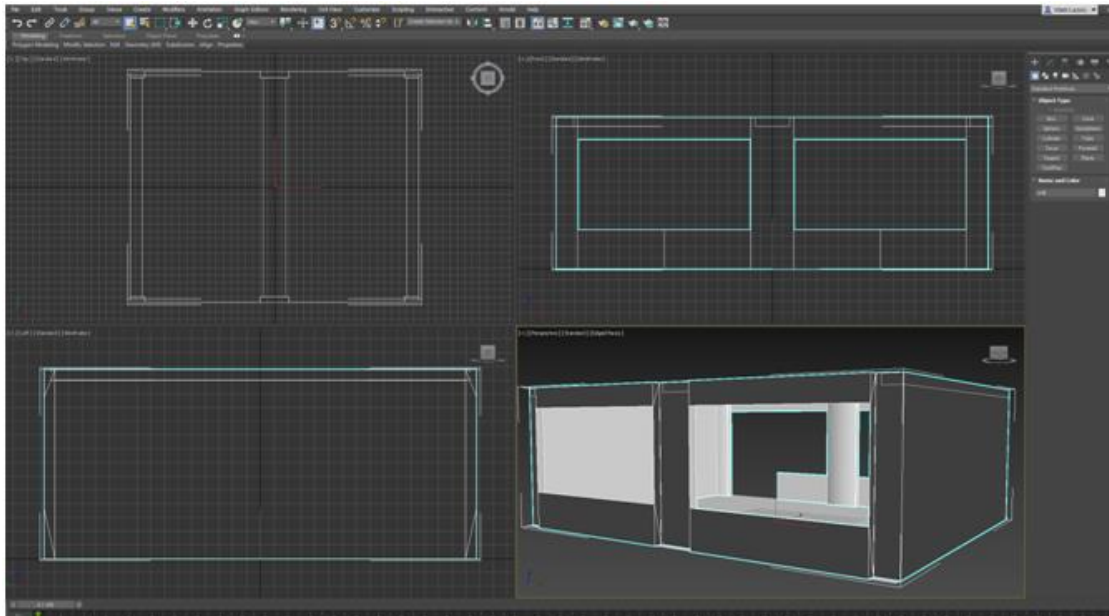


Figure 4: Creating a virtual audience in 3Ds Max

After the process of creating the 3D model itself, textures were searched from free sources on the Internet. Also, some models of scenery in the virtual audience were taken from free sources. Accordingly, when the 3D models were developed, they were exported in FBX format and imported directly into the game engine environment. Colliders have been added to required objects so that they can be interacted with in the future. After all the objects in the scene were placed, it was time to add the light sources, Post Processing and Reflection Probes. All this was necessary to achieve the most pleasant visualization of the virtual world.

Added PostProcessing to cameras. It uses full screen filters and effects to the camera. The image enters the buffer, where various visual effects are applied to it, and only after that it is displayed on the screen. Post-processing can greatly improve the visual component of an application with little setup time.

PostProcessing offers quite a large selection of effects. Various post-processing profiles have been created for different situations, with the help of which you can convey a certain mood in a particular game situation.

Also, it was decided to use Reflection Probes to implement correct reflections on suitable surfaces. Such a reflection resembles a camera that captures a spherical view of the surrounding environment in all directions. The captured image is then saved as a Cubemap, which can be used by objects with reflective materials. Multiple such reflection spheres can be used in a single scene, and objects can be set to use the cubemap produced

by the nearest sphere. The result is that reflections on an object can convincingly change according to its surroundings.

The virtual reality application was developed for the Android platform, both for mobile devices and for autonomous helmets that also work under the Android system. Therefore, it was decided to use static light reflection maps for reflections, using the Reflection Probe – Baked type. This decision made it possible to "bake" low-quality images (maps) of light reflection, which will be stored in the RAM and will show only static objects in the reflections. For this, many spheres were created with reflections throughout the scene at a short distance from each other. Depending on the camera on the map, the reflection system will select the nearest sphere and receive data from it about which reflections will be shown for a certain position of the player's camera.

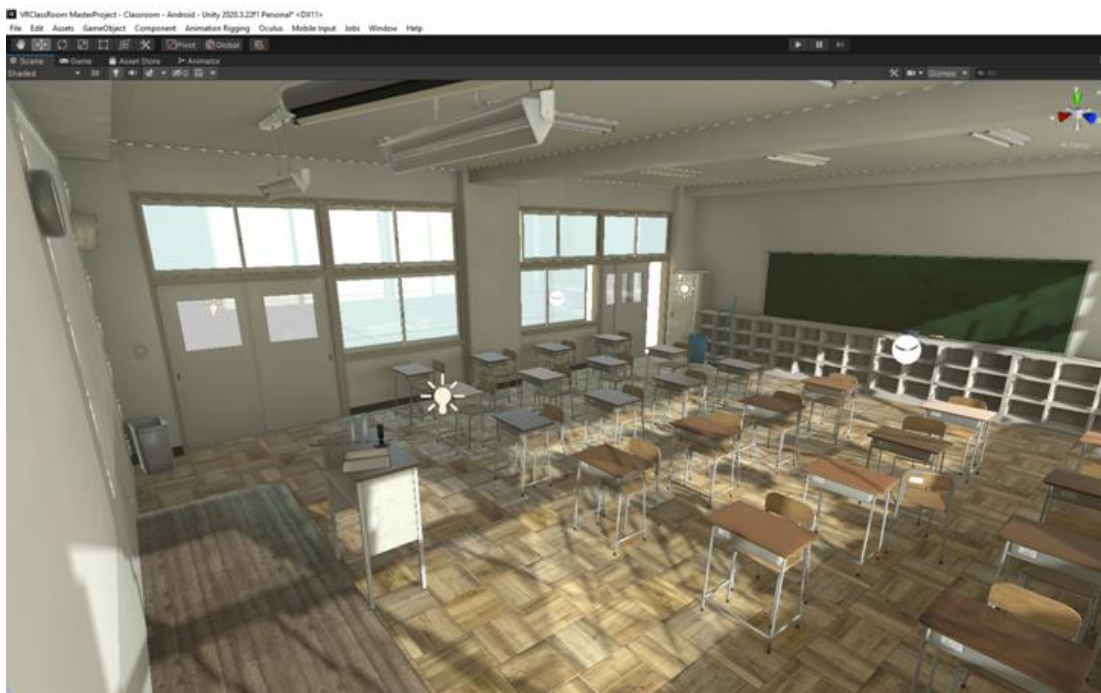


Figure 5: The result of creating a virtual classroom

As a result, a rather comfortable and pleasant virtual audience turned out. If it is not so important on the mobile phone version, then for the user who uses the application in a virtual reality helmet, such visualization greatly adds to the sense of presence and after a few minutes a person forgets that he is in a virtual environment.

Thus, the developed software product is an educational and fascinating application using virtual reality technology. It will help users receive new information and insights, as well as give an opportunity to talk about various topics and complete certain tasks. The use of VR technology gives the application novelty, and the participants will experience the educational process completely differently, immersed in the virtual.



Figure 6: View of the mobile version on the Android platform

VR is a computer interface that, in the educational process, is designed to simulate the real world outside a flat monitor to provide the user with immersion in a virtual world. It is often difficult to reconstruct the scale and distance between objects in static 2D images. Thus, virtual reality expands the possibilities of information perception in the learning process.

7. Conclusions

In connection with the transition of educational institutions to distance learning, many people found both advantages and rather serious disadvantages in this. Having analyzed the main disadvantages of distance learning platforms, we can come to the conclusion that many problems can be avoided if we use virtual reality technology.

In modern conditions, virtual reality under the control of teachers makes it possible to create innovative educational materials and organize VR laboratories. After that, all the selected and created information is gathered together in a certain program, in order to get unique educational resources in a three-dimensional image as a result.

As a result, the developed software product is an interesting and useful application that uses virtual reality technologies. With its help, users will be able to gain new knowledge, discuss various topics and perform some practical tasks. VR technology gives the application a special charm, participants will be able to experience the entire educational process in a new way, with complete immersion in the virtual environment.

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