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SESSION 8. ICT IN EDUCATION AND RESEARCH

Development of the Educational Software based on A Game Engine

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***Abstract* – In the article the results of the development of educational software based on the game engine Unity 3D for study physics are presented. An overview of virtual educational systems and rationale for selection of a game engine are conducted. The information technologies for the design and development of the virtual laboratory works are described. The distinguishing features of the presented application are identified. Shown, that educational virtual laboratories are the successful examples of application of information technologies in the training process.**

Keywords* – *educational software, virtual experiments, physics, Unity 3D.

I. Introduction

New technologies in education, like in any sphere of our life, have a significant effect on the core processes, including the interaction of teachers and students in the context of the transfer of knowledge. In this field, educational software gains popularity [1]. Areas of application of such systems, as well as courses, where they are used, are varied. For example, in the process of teaching physics such training systems are implemented as virtual physical laboratories for experiments simulation [2]. The authors of the article develop such virtual laboratories that are used in teaching physics for students of the International Information Technology University (Kazakhstan, Almaty) of all the academic programs. These laboratories include stand along laboratory works that help to conduct physical experiments, and simple animations that help to visualize various physical phenomena from different sections of general physics course for students of technical academic programs. The technologies used for the implementation of these applications vary as well. Game engines, as well as technologies of augmented and virtual reality are employed within the development process. The presented article is devoted to the development of such applications that allow performing virtual physical experiments; these programs are based on a game engine.

Among the examples of such computer-based educational programs the following applications can be distinguished.

LabinApp organization uses modern technology for the benefit of education [3]. They create software using 3D graphics, which helps people to interact, visualize and study the science. Today they have developed 4 laboratories in two subjects: physics and biology. In each program, users can conduct experiments to study the object interactively, with detailed visualization.

Newton programs are the virtual physical laboratories, presented in the form of software [4]. These developments make it possible to study the kinematics, dynamics, thermodynamics, optics and other fields of physics using a single computer. The whole process of experiments is controlled by a user. He/she assembles mechanisms, gradually watching the process on auxiliary video.

Virtual Star Laboratories – is a project of MIT (Massachusetts Institute of Technology), which was created to develop laboratories for research and training [5]. Its main function is to develop training and research applications in biology, genetics, hydrology and others.

NASA has used the Unity 3D to simulate the solar system and the objects within a project Eyes on the Earth [6]. There is also a realistic astronomical simulator Universal sandbox, where you can observe the interaction between the various celestial bodies, based on physical laws [7].

The company FX Palo Alto used Unity3D to create 3D models of the chocolate factory. A user is able to monitor all the processes occurring in the production in real-time [8].

MIT Media group used Unity3D for the similar purpose, as well as to accelerate the visual analysis of the information they put into the 3D space created by them [9].

The experimental psychologist and engineer of the human interface developed Virtual Game Lab, which helps to solve the problems of people with various mental diseases, to study cognitive abilities, behavior of humans [10].

II. Rationale for Selection of a Game Engine

Recently many powerful game engines have become available for general use. Thus, using them, it is possible for independent developers to visualize the reality they want more accurately. Unity, UDK, Cry ENGINE, Torque 2D/3D and HeroEngine (special MMO-engine) are the most popular game engines. Each of them is powerful software with specific strengths.

Unity is a game engine with a wide range of possibilities and a friendly user interface. The main distinguishing feature of this engine is that Unity is multiplatform. It allows easy and quick porting of games to such platforms as Android, iOS, Windows Phone 8 and BlackBerry. This feature makes Unity foreground while choosing the software for mobile games development [11].

Unreal Development Kit (UDK) is a free version of Unreal Engine 3. It is created by Epic Games and used for the AAA games development, including Gears of War shooter game. UDK has excellent graphics capabilities and can be used for the mobile games development. Unlike Unity, UDK has its own powerful tool directly in the engine for the game levels design [12].

CryENGINE is an extremely powerful game engine, created by Crytek Company and first introduced in Far Cry version 1. This engine allows designing games for PC and consoles like PS4 and Xbox One. The graphic features of CryENGINE are significantly superior to that of the first two engines, because they include art house light, realistic physics, advanced animation and others. CryENGINE was used to develop Ryse: Son of Rome. Like UDK, this engine is highly intuitive and has powerful features for the levels design [13].

Torque 2D/3D is a cross platform game engine with the code implemented in C++ and C#. It is fully equipped with special tools and an interface for applications and games development. Using Torque 2D/3D it is possible to create projects for Web. It has its own script language TorqueScript. For the visualization purposes OpenGL is used in the 2D engine version and DirectX – in 3D version [14].

HeroEngine is a 3D engine created for MMO games. It has its own programming language HeroScript and it is possible to use C++. The scripts in HeroScript run faster than Python programs, therefore, all game actions and events handling are implemented in HeroScript. HeroEngine suggests visualization in DirectX 9.0c and supports a large number of technologies, like PhysX, FaceGen, FMod, SpeedTree and others. It is possible to develop an application on-line [15].

After the examination of the available engines the Unity 3D was chosen. Apart from the fact that it is easy to use, the engine meets all the requirements of the authors, such as availability of sources of information and user manuals, as well as graphical capabilities.

III. DEVELOPMENT OF AN EDUCATIONAL SOFTWARE

According to the work done, a piece of educational software for physics study was developed. This program includes the implementation of laboratory works on the following topics:

1) Diffraction of electrons;
2) Determination of the coefficient of viscosity of liquids by the Stokes method;
3) Measure the speed of a bullet;
4) Verification of the Malus law and the study of elliptically polarized light.

Each of the above laboratory works has a pleasant and convenient interface that allows students to easily manage the program. The functionality of each virtual laboratory work meets the requirements of real experiments. Users can adjust the virtual equipment and set the initial values of input parameters. The results of the conducted experiments can be exported to a text file for further calculations, analysis and conclusions.

The following distinguishing features of the developed applications compared to the existing analogs can be identified.

First, the authors have chosen the physical experiments to create software for from the various fields of general physics course according to the model curriculum. It is provided by the State Educational Standard, which suggests the content of compulsory courses for all the academic programs in Kazakhstan. Physics is the mandatory course for all the technical academic programs. In such a way, the developed applications can be used in teaching physics for students of any technical major in Kazakhstan.

Second, a user of the developed virtual laboratory works can choose the most familiar language for him/her, namely Kazakh, Russian or English. The user interface as well as methodological guidance for performing experiments is provided in these three languages, since all of them are used as languages of courses delivery in Kazakhstani universities.

Figure 1 shows the menu of the main window of the developed application.

Fig. 1. Main application menu.

The entire set of programs was implemented using the game engine Unity 3D and 3D Blender editor. The functionality of laboratories is written in the programming language C#. Blender allows creating a wide variety of models, and C# helps to recreate their behavior in a real environment in virtual space. Unity 3D combines these elements into a single whole. All elements of the application are shown in Fig. 2 and combined in a component diagram. In order to start the execution of any of the laboratory work, a user needs to run the program and click the "Laboratories" button. Then he/she can choose one of the 4 available experiments. In accordance with the selected task, the start scene will open. Demonstration of the scenes that correspond to the virtual laboratory works is shown in Fig. 3-6.

Each experiment of this software complex is not only virtual laboratory work, but also methodical material, which describes in detail all the stages of the task. Due to this, the user can perform the experiment without assistance. This, in its turn, will help to remember better the studied physical processes and laws.

To control the application user-familiar keyboard buttons are used, the mouse is used to change the camera's view. Every move inside the application is intuitive and does not require special skills or knowledge.

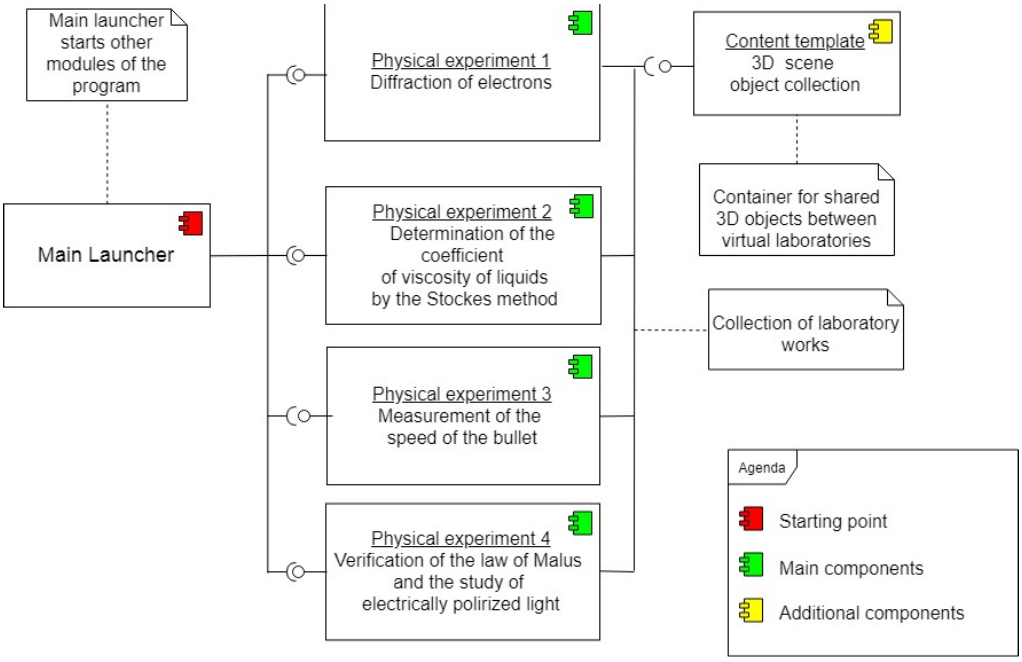

Fig. 2. Component diagram.

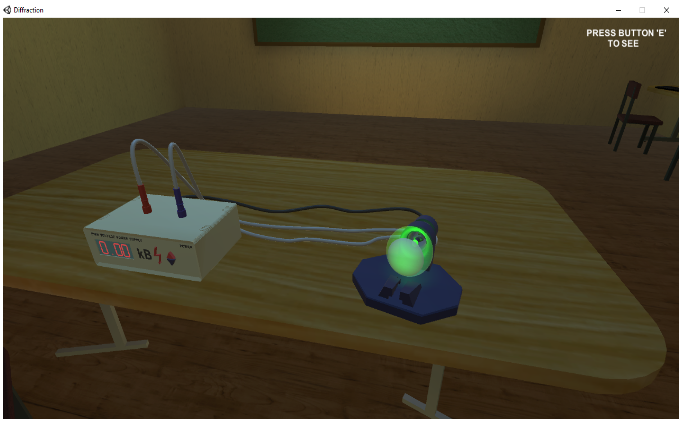

Fig. 3. Diffraction of electrons.

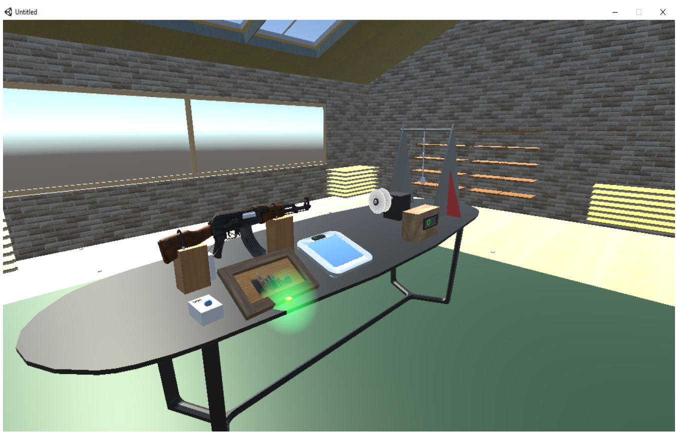

Fig. 4. Measurement of the speed of the bullet.

In order to help the user to perform the task, in addition to the methodical material available in application, during the laboratory work prompts are shown on the screen as it is depicted in Fig. 3.

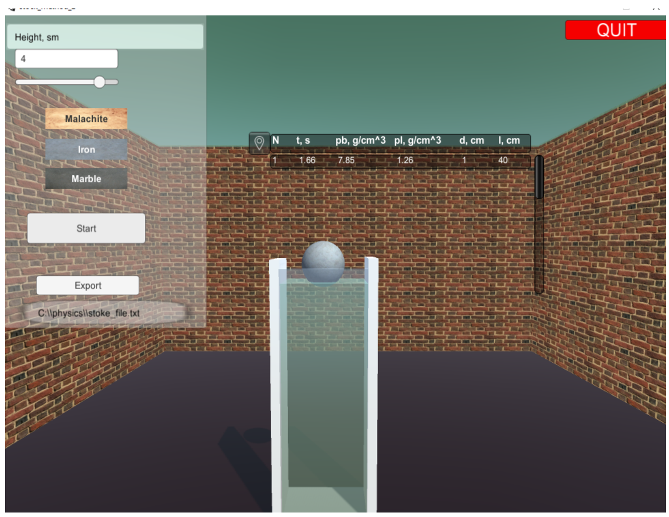

Fig. 5. Determination of the coefficient of viscosity of liquids by the Stokes method.

Depending on the task, the equipment and the view of the scene as a whole change. For example, in the tasks «Determination of the coefficient of viscosity of liquids by the Stokes method» (Fig. 5) and «Verification of the Malus law and the study of elliptically polarized light» (Fig. 6), tables that are filled in during the experiments are displayed. In addition, in the laboratory works users can set the initial values of input parameters. For example, it is possible to choose the bullet caliber before measuring its speed. During the determination of the liquids viscosity coefficient it is possible to choose the material of the ball that falls in to liquid. And depending on the initial parameters the visualization of the experiments changes.

For instance it is can be visually observed that the iron ball reaches the bottom of the vessel quicker than the marble one.

Fig. 6. Verification of the Malus law and the study of elliptically polarized light.

IV. CONCLUSION

Thus, each element of this software complex allows not only to observe the flow of the physical phenomenon, but also to conduct one's own experiments with obtaining certain parameters that correspond to real indicators. In this case, the execution of the experiment in a virtual environment is much easier and faster. The assimilation of material under such an approach is also higher due to greater involvement in the process and the game form of the presentation of the material being studied.

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