Using of ICT in E-Learning

Development of the Virtual Learning Environment for Physics Study

Y.A. Daineko, M.T. Ipalakova, M.V. Yunnikova, M.A. Brodyagina, Zh.Zh. Bolatov
Computer Engineering and Telecommunication Department
International Information Technology University (IITU)
Almaty, Kazakhstan
yevgeniyadaineko@gmail.com

***Abstract*—The article is devoted to application of information technologies in e-Learning; usage of infocommunication technologies in higher education for implementation of e-Learning training technology. A brief review of international experience in the field of virtual laboratories is provided. The virtual computer laboratory on physics with 3D elements of computer modeling and its benefits in learning process are provided. Features of configuration and representation of theoretical and experimental materials in the virtual computer laboratory are presented.**

Keywords—infocommunication technologies; e-Learning; virtual laboratory; physics

I. INTRODUCTION

At present, the rapid development of information and communication technologies leads to the fact that they always penetrate into all spheres of our lives, dramatically affecting the processes and modifying them. Education, and in particular e-learning, are not exceptions. Introduction of new information technologies, computerization of institutions, along with innovative activities of faculty staff are the main directions of modernization of education, to which special attention is paid currently all around the world and in Kazakhstan in particular [1, 2].

E-learning is a general term used to describe a broad range of the applied electronic technologies in education, with a special emphasis on training through the Internet. As of today electronic technologies have influenced the management of educational institutions and corporations. They have strengthened research networks, restructured libraries, books, magazines and newspapers production process and design. New educational institutions, which are mainly based on e-learning, have been created; there have been various changes in educational and methodical processes at all levels of education. Among new digital educational resources it is possible to note the automated education tutorials, library systems, multimedia training systems or training simulators, and others. A huge number of works in this field has been published recently.

The increasing popularity among similar learning tools is gained by virtual laboratories. It is explained by the following. Firstly, some of higher education institutions are not able to equip real laboratories for carrying out educational experiments on various disciplines. It is connected with financial aspects, and also with safety issues of students. In addition, not all experiments can be carried out on the basis of university laboratories. In such cases, application of virtual laboratories is an excellent solution. They allow carrying out experiments many times with the least costs, and it is absolutely safe for people around. With the development of infocommunication technologies application of virtual laboratories in educational process becomes more available. Secondly, these learning tools are indispensable in those cases when the real installations are not accessible, such as distance learning, which is quite widespread against the background of the development of ICT.

II. A BRIEF REVIEW OF THE WORLD EXPERIENCE OF VIRTUAL LABORATORIES USAGE IN E-LEARNING

The first thing that needs to be noted is the program simulator of the data communication network Packet Tracer, which is developed by Cisco Systems. The program simulator is one of the famous virtual laboratories in the field of computer technology. Packet Tracer allows imitating work of the various network devices. All the settings in the virtual laboratory are presented as in the real network. Besides, Cisco Packet Tracer can be used as a network application to simulate a virtual network through the real network and to construct not only logical, but also physical model of a network, providing skills of design. Consequently, Cisco Packet Tracer is a unique tool for training in network technologies.

Secondly, TechNet Virtual Labs is an interesting training resource, which is developed by Microsoft Company. It is a virtual environment that helps to familiarize users with new products and technologies of Microsoft. The learning process is designed in the form of practical tasks with instructions. The duration of one task is 90 minutes or less. Download and installation of products are not required; work is carried out remotely via a browser.

The scientific community and companies do not remain away from the development of virtual training systems that are used in teaching of some disciplines. For example, in the work [3] the development of virtual computer laboratory for teaching the Python programming language is discussed. The virtual laboratory is implemented using GraphTerm server. The laboratory contains the following components: the virtual instrument panel and the gradually filled in notebook for tracking the students' performance.

The combination of audio, video and animation is proposed in [4]. This virtual laboratory is designed for

978-1-5090-5443-5/17/$31.00 ©2017 IEEE

students of IT majors for studying logical schemes and allows practicing skills of the circuit board design using a variety of methods and tools.

In [5] a similar virtual laboratory based on Ejs (Easy Java Simulations) is presented. The laboratory is designed for the study of electrical machines in marine equipment.

The training environments that are based on the use of 3D graphics are "new" tools in education system [6]. Such environments provide easy and flexible interaction that is necessary to generate interest among students. This paper presents a complete view of the interactive 3D worlds used in the implementation of training activities through the Internet. The authors propose a system for the study of the computer graphics course, which is based on the interactive 3D virtual learning environment. In this system students can virtually participate in simulating laboratory experiments.

One more similar example is the development of 3D virtual radio-pharmaceutical laboratory [7]. In the laboratory students are represented by 3D avatars. They can perform experiments on radio-pharmacy equipment through specific learning scenarios and interact with other students and mentors.

The next perfect project is a 3D service of Labster Laboratory to study natural sciences. The Labster contains laboratories for 15 subjects, such us: zoology, botany, virology, general medicine, bioengineering, chemistry, microbiology and others.

STAR (Software Tools for Academics and Researchers) is a program of Massachusetts Institute of Technology (MIT) to develop virtual laboratories for research and training. This program includes training and research applications of general biology, biochemistry, genetics, hydrology, in the area of distributed computing.

III. VIRTUAL COMPUTER LABORATORY

In this paper the authors present the virtual laboratory developed in the International University of Information Technologies (IITU, Almaty, Kazakhstan) at the Department of Computer Engineering and Telecommunication. The laboratory provides the 3D visualization of physical experiments and user interface in three languages (Kazakh, Russian and English).

The list of works offered in the framework of the Virtual Laboratory (VL), is designed for students of IITU, studying on the Computer Science and Software Engineering, Information Systems, Mathematical and Computer Modeling and Radio Engineering, Electronics and Telecommunications programs. In the future, the laboratory can be used in teaching students of any programs, in which physics is an obligatory subject.

The theoretical material presentation in the VL differs from the real lab. In the VL a detailed description of the process of theoretical and experimental studies is provided. Links and tips, using the animation tools are presented. The references to additional literature that extend the capabilities of students in answering questions are available. Thus, each lab has its own characteristics, but a set of laboratory works grouped in certain areas, is presented as a whole in accordance with the above requirements.

From the software point of view the virtual laboratory work is a project compiled in C# language. The project consists of many parts, but they can be generalized into two groups. The first one combines the game resources, and the second one – the program code. Graphics, music or other resources required for the registration of the project, refer to the game resources. They make the scene realistic. Program resources include classes and procedures, which are written in C# language and are responsible for the interaction with other resources. The term "class" refers to a program unit, where the data, its structure and possible functions available with this data are strictly defined. Classes are combined in software libraries. Working with the XNA Framework, it is possible to connect third-party libraries, as well as to program and use later own libraries.

For each experiment, a separate 3D model was designed and the physics engine was implemented to calculate the interaction models of objects, which in combination led to very precise modeling and visualization of objects and processes of the real world. Models were created using 3ds Max, Blender and Google SketchUp, the implementation of virtual laboratory works carried out in Microsoft .NET XNA and Unity 3D environments using C# and JavaScript programming languages.

The VL designed for "Physics" course (Fig. 1, 2, 3, 4, 5, 6) is composed of laboratory works from such sections of physics as mechanics, dynamics, thermodynamics, hydrodynamics, atomic and quantum physics.

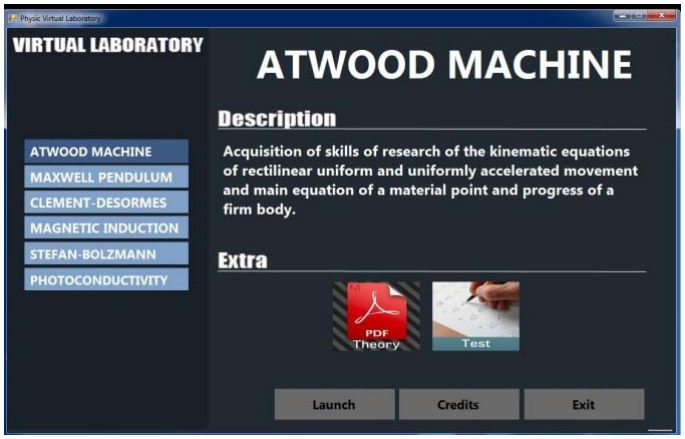

Fig. 1. Main window of the developed virtual laboratory

978-1-5090-5443-5/17/$31.00 ©2017 IEEE

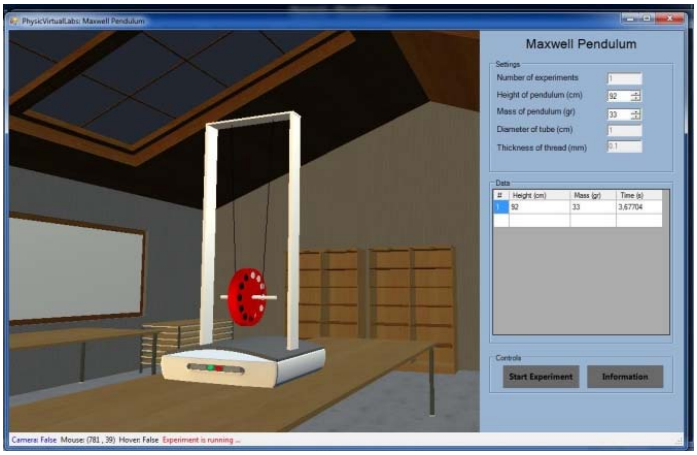

Fig. 2. Screen shot of "Maxwell pendulum" virtual laboratory work

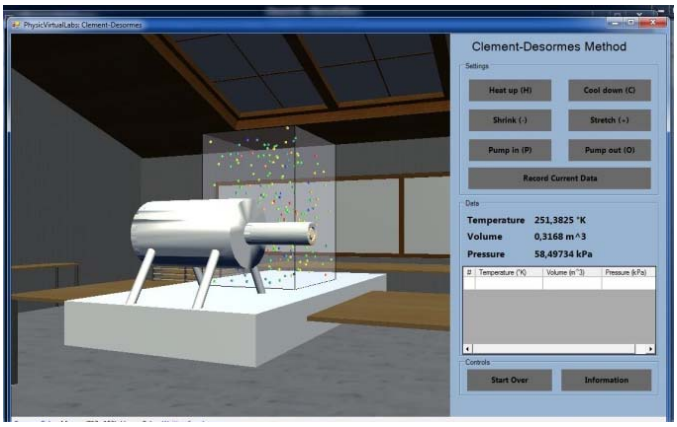

Fig. 3. Screen shot of "Clement-Desormes Method" virtual laboratory work

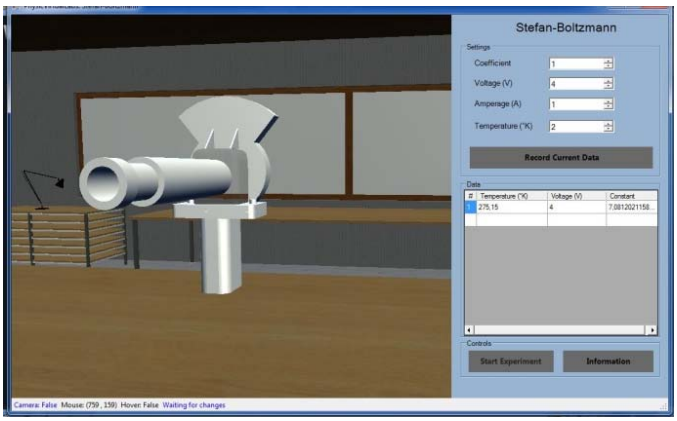

Fig. 4. Screen shot of "The study of Stefan-Boltzmann constant" virtual laboratory work

VL in physics provides instructions and guidelines for the implementation of the laboratory works. The guidelines are designed according to the following structure:

- goal of the work,
- theoretical material,
- experimental device,
- execution order of the work,
- report.

Fig. 5. Screen shot of "The study of fluid viscosity" virtual laboratory work

Fig. 6. Screen shot of "Measuring the speed of a bullet" virtual laboratory work

The instructions contain the necessary theoretical material for students that needs to be carefully explored for the successful implementation of the laboratory work. Therefore, in the virtual computer laboratory this section of guidelines is presented in more detail than in the classical laboratory work.

The "experimental device" section provides a diagram and the description of the experimental installation and the necessary equations.

In the "execution order of the work" section a student receives step by step instructions on how to perform a laboratory work and how to calculate the unknown quantities and errors.

In the "report" part a student fills in the appropriate sections, captures the values obtained during the experiment, builds diagrams, fills in the tables and writes the final calculated results.

IV. Future Work

At present time the developed virtual laboratory is actively employed within the physics course in the International University of Information Technologies (Almaty, Kazakhstan). Besides, the laboratory can be used by other technical universities and training centers.

978-1-5090-5443-5/17/$31.00 ©2017 IEEE

The authors continue to develop new virtual physical laboratory works to include them to the virtual laboratory. The special attention is paid to the use of augmented and virtual reality technologies for 3D visualization of physical experiments.

V. CONCLUSION

Thus, modern information and communication technologies make it possible to carry out any form of experimentation and open up broad prospects for the creation of original and sometimes radically new physical works. We believe that developed by us the virtual laboratory works on Physics course for students of higher educational institutions of the natural sciences and technical programs is the modern incarnation of innovative new generation computerized learning systems.

ACKNOWLEDGMENT

The project was accomplished with the financial support of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan according to the Program of grant funding of scientific research in 2015-2017, 2622/ГФ4, reg.№ 20150115РК01145.

REFERENCES

[1] Yevgeniya Daineko, Madina Ipalakova, Viktor Dmitriyev, Andrey Giye nko, Nazgul Rakhimzhanova. 3D Physics Virtual Laboratory as a Teaching Platform. AVR 2015, LNCS 9254, pp. 458–466, 2015.

[2] Madina Ipalakova, Yevgeniya Daineko, Alibek Jakupov, Mariya Brodyagina, Marina Yunnikova, Zhiger Bolatov. The virtual laboratory work “Measurement of the horizontal component of the Earth magnetic induction”. 11th International Conference Distance Learning in Applied Informatics (DiVAI 2016), 2-4 of May, Sturovo, Slovakia, pp. 159-168

[3] Ramalingam Saravanan, “Creating a browser-based virtual computer lab for classroom instruction,” Proceedings of the 13th Python in Science Conference, pp. 77-84, 2014.

[4] Rosilah Hassan, Nazlia Omar, Haslina Arshad, Shahnorbanun Sahran, “A Design of Virtual Lab for Digital Logic,” Proceedings of the 7th WSEAS International Conference on E-ACTIVITIES, pp. 139-142, 2008.

[5] Pau Casals-Torrens, Ricard Bosch-Tous, “Virtual Labs for learning Electrical Machines in Marine Engineering,” Proceedings of the 3rd International Conference on Maritime and Naval Science and Engineering, pp. 108-112, 2010.

[6] Konstantinos Barbatsis, Panagiotis Fotaris, Theodoros Mastoras, Athanasios Manitsaris, “A web-based learning environment exploiting 3D Virtual Worlds,” Proceedings of the 1st WSEAS / IASME Int. Conf. on EDUCATIONAL TECHNOLOGIES, pp. 24-27, December 2005.

[7] A. Alexiou, C. Bouras, E. Giannaka, V. Kapoulas, M. Nani, Th. Tsiatsos, “Using VR Technology to Support e-Learning: The 3D Virtual Radiopharmacy Laboratory,” Distributed Computing Systems Workshops, pp. 268-273, March 2004.

978-1-5090-5443-5/17/$31.00 ©2017 IEEE