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METHODOLOGY FOR ORGANIZING VIRTUAL LABORATORY WORKSHOPS IN TEACHING PHYSICS TO STUDENTS IN TECHNICAL SCIENCES

Mislidinov Baxtiyor Zaynidinovich
PhD Student at Namangan State Technical University,
E-mail:baxtiyormislidinov@gmail.com

Abstract
Today, traditional education is being replaced by modern digital education. Distance learning is being implemented in all universities around the world. The use of virtual laboratories in organizing laboratory classes in physics has led to a qualitative and faster mastery of science by students. Students will gain knowledge, skills and qualifications that can be used in their future professional activities. The use of virtual laboratories helps students to expand their understanding of the laws of nature, the essence of the content and physical worldview, and the formation of a physical imagination.

Keywords: virtual laboratory, virtual environment, simulation, distance learning, STEM education, visualization, augmented reality, modeling.

Introduction

Education is a cornerstone of the 2030 Agenda for Sustainable Development and is inextricably linked to all 17 Sustainable Development Goals. In particular, education is central to the implementation of Sustainable Development Goal 4, which aims to expand access to lifelong learning opportunities based on the principles of inclusiveness, equity and quality, and is considered an important driver of sustainable socio-economic development[1]. In addition, the education system is one of the main mechanisms for implementing the United Nations 2030 Agenda for Sustainable Development [2,3].The scientific community has widely recognized that higher education institutions are crucial for achieving the Sustainable Development Goals [4,5], and that inefficient education systems have a negative impact not only on the learning process of learners, but also on the development of society [6].Modern educational technologies and online learning forms have become important supporting factors of 21st century education, in particular, education for sustainable development [2,7]. At the same time, the creation and use of open educational resources (OER) creates significant opportunities for expanding access to education, increasing the efficiency of the learning process, and improving the quality of education [8,9].The implementation of open educational resources and open educational practices (OEP) forms a sustainable educational infrastructure that serves to improve the quality of education and provides an effective learning environment.

The purpose of this article is to develop a virtual laboratory using the JavaScript programming language. It also provides a tool for creating and developing scientific computer simulations.

Literature Review

The work of Veljko Potkonaj et al. shows that distance learning and open universities are increasingly used in the modern education system, but the teaching process in science, technology and engineering (STEM) fields is relatively slow in adapting to online learning due to the high demand for laboratory training. The organization of traditional laboratories remotely is technically and organizationally complex, and software-based virtual laboratories are considered an effective alternative solution to solve this problem. In recent years, technologies such as computer graphics, augmented reality, computational dynamics, and virtual worlds have expanded the possibilities for the development of virtual laboratories.

The current state of the use of virtual laboratories and virtual environments in STEM fields has been analyzed. In particular, due to its multidisciplinary nature and high level of integration capabilities, special attention has been paid to the field of robotics, where virtual laboratories have allowed not only robotics, but also other scientific and technical and engineering disciplines to consolidate theoretical knowledge, develop practical skills, and support collaborative learning [10]. In the research of Khadija El Kharki et al., laboratory experiments have become important in science education, and the development of information and communication technologies is shaping virtual laboratories as an effective alternative to traditional practical training. Virtual laboratories provide sustainability in higher education, modeling scientific phenomena through computer simulation, and allowing students to deepen their understanding of scientific principles. Their research presents a low-cost virtual laboratory integrated into the Moodle platform, developed in JavaScript, and designed based on the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model.

This virtual environment was developed in Moroccan universities with the participation of European partners and has been implemented in 12 science faculties in the country. The virtual laboratory is intended for the first stage of the bachelor's degree and includes 12 virtual practical exercises in physics and is accessible via the Internet. The results of evaluations conducted by teachers and students confirm that the use of virtual laboratories has a positive impact on learning outcomes and justify their use as an alternative learning tool to physical laboratories[11].

Research Methodology

Laboratory exercises are an important pedagogical tool for the formation of professional and general competencies in science education, which allow students to consolidate the theoretical knowledge acquired in the classroom through practical activities. At the same time, due to the existing limitations of traditional, face-to-face laboratories, virtual laboratories have emerged as an alternative solution to overcome the shortcomings of physical laboratories and are considered one of the most promising e-learning technologies widely used in the higher education system [12]. In addition, research has confirmed that the use of virtual laboratories is an effective means of ensuring stability in the educational process. The design and implementation of virtual laboratories is a highly complex process. Due to the difficulty of adapting experiments performed in traditional practical laboratories to the online environment,

various technical solutions are required to digitally model the behavior of physical and scientific phenomena. In addition, these experiments often involve the use of special scientific equipment and measuring devices. The process of developing virtual laboratories requires the integration of interaction design, visualization, and pedagogical approaches, as well as the creation of text, graphics, virtual environments, and interactive elements. Their practical implementation is based on programming and animation technologies [13].

This work discusses a virtual development model for physics laboratory classes for students studying agricultural mechanization at technical universities. Students will use this software development to learn physics.

Results and Discussion

In this work, we have created a virtual laboratory software model for physics laboratory classes for technical students. This software development can be accessed directly via the link (https://vertualfizika.netlify.app/labaratoriyalar/erkintush) (Figure 1).

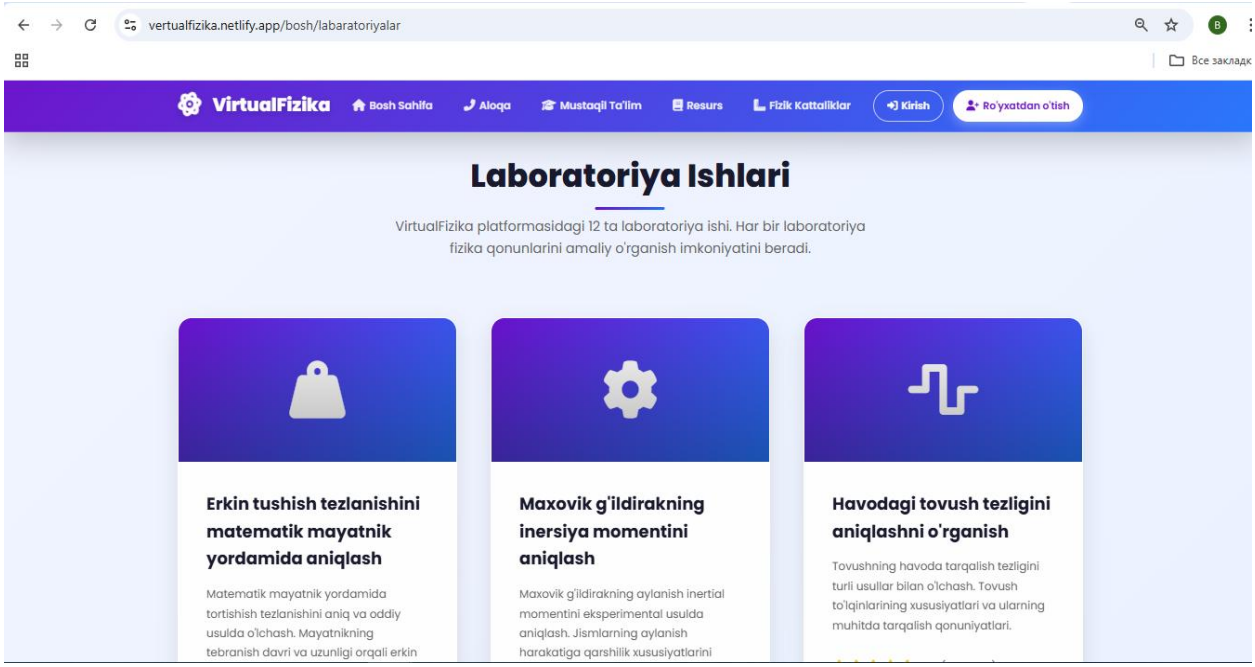

Figure 1. Virtual software development model working window.

The software development was developed for students of the technical and agricultural mechanization education direction, and allows you to perform a total of 12 laboratories in 2D and 3D. For example, the student can perform the laboratory “Acceleration of free fall using a mathematical pendulum” before performing real experiments (Figure 2). The value of the acceleration of free fall g can be determined through simulation. This software development, unlike other virtual experiments, provides a methodology for each laboratory. The student is provided with the purpose of the experiment, work instructions, necessary tools and equipment, videos posted by the author on the YouTube platform for the real implementation of this experiment, an electronic library, basic physical quantities, a glossary, and tests to consolidate

the topic. This platform provides the opportunity for independent study not only at a university, but also at home, in a vehicle, etc. Most importantly, there are all the opportunities for students to master physics laboratory work. This will certainly make the subject more interesting and in-depth.

Figure 2. A model for determining the acceleration of free fall in a virtual laboratory using a mathematical pendulum.

Conclusion

In conclusion, the effectiveness and practical benefits of the developed virtual laboratory were positively assessed by teachers and students. Students highly appreciated the use of the virtual laboratory environment, which served to increase their interest and motivation in studying physics. Also, feedback from teachers and students showed that the virtual laboratory supported the process of understanding the basic scientific concepts in physics. At the same time, it is not possible to fully model all practical activities performed in a real laboratory environment in a virtual environment. However, the results of many studies confirm that the use of virtual laboratories in science education increases learning efficiency. In addition, virtual laboratories are recognized as an effective and promising tool for ensuring the sustainability of scientific education in the higher education system and its development.

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