VIRTUAL LABORATORY WORKS IN PHYSICS IN DISTANCE EDUCATION BASED ON THE FRAME MODEL

Xalilov Sarvar Samadovich

Muhammad al-Khwarizmi Tashkent University of Information Technologies

e-mail: sarvarsamadovich@gmail.com

https://orcid.org/0000-0002-4725-2251

Suyarov Kusharbay Tashbayevich

Tashkent Region Chirchik State Pedagogical University

e-mail: kusharbay@gmail.com

Abstract

In distance learning, professors and students are separated by distance or time when exchanging ideas and feedback, creating an opportunity for independent learning in a virtual environment. In distance learning, organizing students' independent learning by delivering educational content through modern didactic methods (video lectures, demonstrative practical exercises, virtual laboratories) rather than question-and-answer sessions in the online platform teaching virtual environment leads to positive results.

Key words: *Distance learning, independent study, video lecture, demonstration practical session, virtual laboratory, computer technology, platform, resource, online.*

INTRODUCTION

"Currently, the education sector in Uzbekistan is rapidly developing. One of the key reforms has been the establishment of new higher education institutions in the regions, the development of modern education and specialization areas for training professionals, as well as the introduction of forms of education such as correspondence, evening, and distance learning, and the increase in admission quotas. Nowadays, it has become increasingly important to introduce modern teaching methods that include blended learning formats in the education system.

The distance learning format focuses on the development of students' independent thinking skills, as stated in the new edition of the Law of the Republic of Uzbekistan "On Education," approved on September 23, 2020, which defines: “Independent learning is carried out individually and serves the professional, intellectual, moral, and cultural development of the learners” [1].

Distance learning is an opportunity for independent study in a virtual environment due to the physical or time separation between the professor and the student, where they interact through feedback and discussion. Organizing students' independent study in the

context of distance learning using modern didactic methods (such as video lectures, demonstration practical sessions, and virtual laboratories) rather than traditional question-and-answer methods can lead to positive results through online platforms [6-7].

Currently, a number of initiatives are being carried out to further improve the curricula and programs of distance education, based on the extensive integration of new pedagogical technologies and teaching methods, the qualitative updating of the bachelor's scientific-educational process, and the introduction of modern organizational forms [8-9].

In the context of globalization, it is essential to utilize advanced pedagogical technologies and active methods in distance learning, apply newly developed technical tools, encourage more students to think independently, and widely use various ways of learning from advanced experiences. Another important aspect is ensuring the effective organization of teaching natural and exact sciences in higher education to develop students' professional interests, capabilities, knowledge, and skills, as well as their formation as specialists in their chosen fields [4-9].

The fundamental reform of higher education has introduced new approaches in the education system, similar to other areas of life. These include integrating modern information technologies into the educational process and addressing the issues of computerizing education. At present, the main form of educational work in higher education institutions is increasing attention to effectively organizing the teaching process and objectively evaluating students' knowledge levels. During a period of socio-economic and scientific-technical changes, there is a need for positive changes and innovations in the educational process. The development of science and technology and the introduction of new pedagogical and information technologies into the education process demand improvements in the forms and methods of teaching sciences, aligning them with content, enhancing efficiency, monitoring the students' learning process, and evaluating the knowledge they have gained through computer technologies. The research focuses on developing methods for using the Freym model in the independent learning of physics."

MATERIALS AND METHODS

"The analysis of scientific literature shows that improving the teaching of physics, which is the foundation of technical sciences, is one of the urgent problems of modern engineering education. Many textbooks on teaching physics and its improvement have been developed by Uzbek scholars, including K.P. Abdurakhmanov, E.Z. Imamov, and V.S. Vohidov. Since the development of engineering education, virtual laboratory lessons in physics have become of significant importance in the training of engineers and technicians. The physics

course and other general education subjects in undergraduate education address issues related to the development of the necessary skills for the formation of highly qualified specialists. These required competencies include consistent and logical thinking, planning and organizing work, operating devices and equipment in a virtual environment, and applying these skills in future professional activities. Psychological research has shown that motivation plays a crucial role in this process [4].

Regarding the effectiveness of work aimed at developing students' independent thinking skills in the context of distance education at higher education institutions, it is important to focus on increasing students' awareness and activity. The current reforms in the education system emphasize developing students' independent thinking, reflection, speech techniques, and the application of scientific knowledge and methods. It is necessary to pay attention to developing the mechanisms for improving students' independent thinking abilities in distance learning [9-10].

This work examines the content, goals, tasks, and principles of using factors to develop students' independent thinking skills in the form of distance education. One of the main tasks is to introduce advanced pedagogical technologies, curricula, and teaching materials based on international education standards into the educational process. The research focuses on developing methods for using the Freym model in the independent study of physics [2].

In the 2022-2023 academic year, the Tashkent University of Information Technologies named after Muhammad al-Khwarizmi introduced the distance learning format alongside full-time and part-time education. Students were admitted to distance learning in educational programs such as Computer Engineering, AT Services, Multimedia Technologies, and Software Engineering. A special distance learning faculty was organized at the university, and professors developed curricula for each subject (syllabi, video lectures, practicals, virtual laboratories, electronic textbooks, electronic libraries, etc.) [3]. All educational content was created for students enrolled in distance learning and placed in the learning management system.

Distance learning technologies have several advantages, such as providing students with a convenient learning environment, allowing them to choose the time and direction of their independent study (students can watch video lectures, participate in virtual laboratory sessions, and review materials) [11].

For example, a student can study physics by reading the information in the electronic textbook, reviewing video lectures and virtual laboratory sessions, completing assignments, and even conducting small experiments to reinforce the knowledge gained [14].

The specificity of distance learning methods for students can be exemplified by the use of modern technical equipment to deliver high-quality lessons (such as video lectures, virtual laboratory work, electronic resources, and educational films). The responsibility for the effectiveness of learning outcomes lies with the students and their parents [10].

Distance learning has been accepted as a necessary measure, but in the future, there may be additional forms of distance learning that are suitable for various age groups, learners, or students with specific needs. These include:

Distance learning is effective in the following cases:

For children with disabilities;

For those wishing to study at advanced higher education institutions but unable to access qualified pedagogical support due to geographical distance;

For additional education;

For working with talented students according to their individual learning pace;

For students who need to study at home temporarily due to illness or other reasons.

At the same time, organizing the distance learning process imposes a number of modern requirements on professors and teachers:

Transition to new, innovative solutions to improve competence through independent work;

Professors should create their own digital libraries, i.e., collect, store, update, and share digital educational resources with students;

Provide opportunities for working with computer technology, local networks, and internet access;

Effectively use didactic, methodological, and electronic teaching resources (official educational portals and websites) [2-6].

Independent learning allows students to develop self-management, independent thinking, working on new ideas, and self-discipline skills. This success not only has a positive impact during their university education but also in their future professional careers and personal lives.

In distance learning, while students have many opportunities, some limitations do exist, such as:

The professor being unable to monitor all students simultaneously in a classroom setting;

The inability for professors and students to communicate face-to-face at the same time.

As a result, significant problems may arise. Additionally, in offline classes, students can ask questions and discuss topics with their peers. In distance learning, students may feel isolated. However, this should not be seen as a disadvantage, but rather as an opportunity to develop independent thinking and decision-making skills. If a student can recognize the positive development of their skills, this is a success [8-9].

Our analytical work methodology is based on using scientific literature to understand the process of conducting virtual laboratory work through the Phet pedagogical software, synthesizing personal experience in the field of remote education, and implementing the Freym model in distance education for teaching physics.

The analysis of scientific literature shows that improving the teaching of physics, the foundation of technical sciences, remains one of the urgent issues in modern technical education. From the development of technical education, the organization of virtual laboratory lessons in physics has been of great importance. The physics course and other general education subjects in undergraduate programs address the problem of developing the necessary competencies for the formation of highly qualified specialists. These competencies include consistent and logical thinking, planning and organizing work, using equipment in a virtual environment, and applying these skills in future careers. Psychological research indicates that motivation plays a significant role in this process [3].

In a virtual environment, performing virtual laboratory tasks requires additional effort from both the student and the professor. This process includes subjects such as "Circuits and Electronics," "Systems and Signal Processing," "Antennas and Radio Transmissions," "Multimedia and Communication Networks," and Artificial Intelligence, which are essential for learning physics. The goal is to help students independently engage in virtual laboratory tasks and gain the knowledge and skills necessary for their future professional activities [11-13].

Through the Phet pedagogical software, students can conduct virtual laboratory work on electromagnetic oscillations and waves, such as measuring physical quantities (period, frequency, cyclic frequency, decay factor, wave length, etc.), understanding the harmonic oscillation equation, and applying theoretical calculations based on measurement results. They will also compare results and draw conclusions on the physical processes they observe [14].

RESULTS AND DISCUSSIONS

This virtual laboratory work is carried out in a virtual environment, where professors can assign tasks using Phet simulations. We suggest conducting this process in a different

way. The professor will introduce the scientific problem to the students, explaining electromagnetic oscillations, waves, and their characteristics, and then guide them to explore these characteristics using virtual laboratory equipment. We can create a data frame based on the following table using the Freym model:

1st Slot: Tasks assigned by professors through the Phet simulations website for virtual laboratory work in the distance education format.

2nd Slot: Students in the chosen field independently complete virtual laboratory work according to the process and fill out reports, draw conclusions.

1-slot:

№	The title of the topic	The division into groups	Types	Collision	Connection	Division into groups	Condition	Excitation	Events
1.	Harmonic oscillations	Mechanical Oscillations	Free Oscillations	Mathematical Pendulum, Pendulum of Purijan, Physical Pendulum	Waves	Mechanical waves	Coherent waves	Standing wave	Diffraction (conditions for maximum and minimum)
2.		Electromagnetic Oscillations	Forced Oscillations	Electromagnetic Oscillations in an Inductive Coil in		Electromagnetic Waves		Transverse wave	Interference (conditions for maximum and minimum)

				a Closed Circuit					

2-slot:

№	Collaboration	Directions	Fields	Connection
1-slot:	Professors and Lecturers of the Department of Physics	Physics II (Theoretical and Practical)	Oscillations and Waves. Optics. Atomic and Nuclear Physics.	Electromagnetic Oscillations and Waves (in the example of the section).
2-slot:	Students of distance education form	60610500 – Computer Engineering (“Computer Engineering,” “IT Services,” “Multimedia Technologies”)	"Circuits and Electronics," "Systems and Signal Processing," "Antennas and Radio Broadcasting," "Multimedia and Communication Networks," Artificial Intelligence.	
		60610600 – Software Engineering		

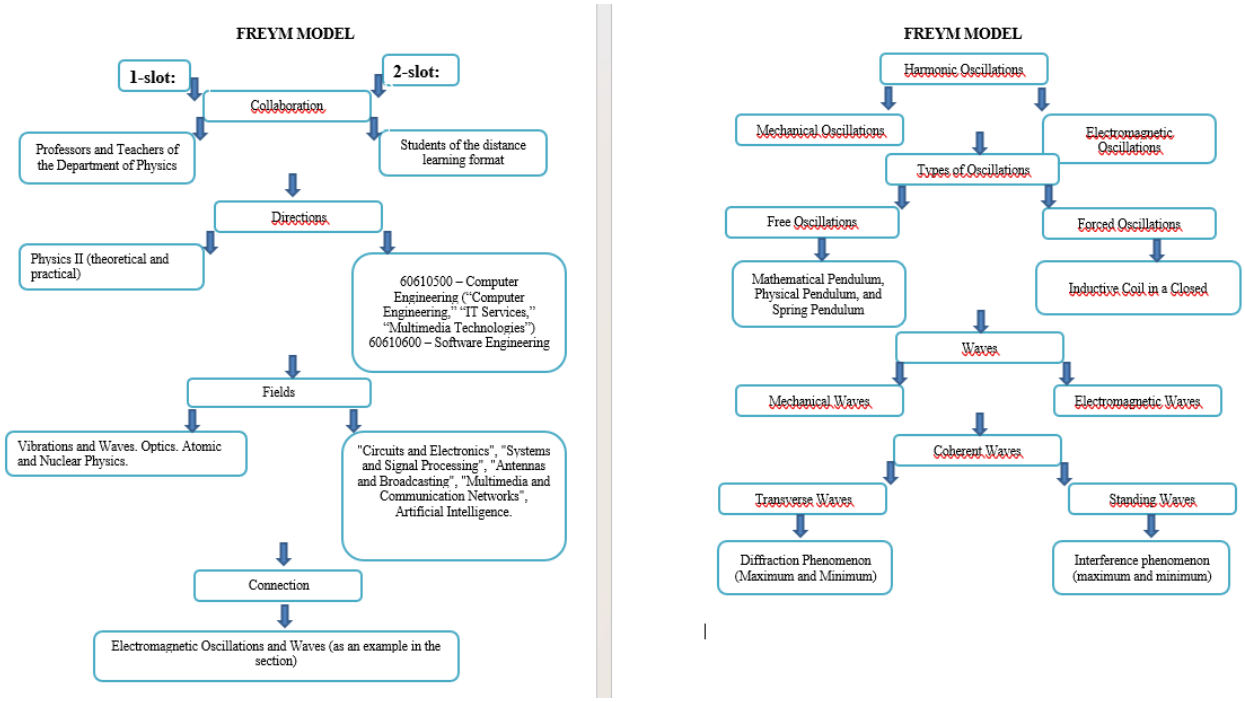

Figure 1. Framework model usage diagram

Secondly, in the form of distance education, students should be able to determine electromagnetic oscillations and waves (such as frequency, cyclic frequency, logarithmic decrement, phase coefficient, wavelength, amperage, voltage, and electromagnetic oscillations in an inductive coil in a circuit) while performing virtual laboratory work. At the same time, students will become familiar with the following [12-13]:

Virtual laboratory works using the Phet pedagogical software tool.

Determining the values based on experimental results in the section on electromagnetic oscillations and waves.

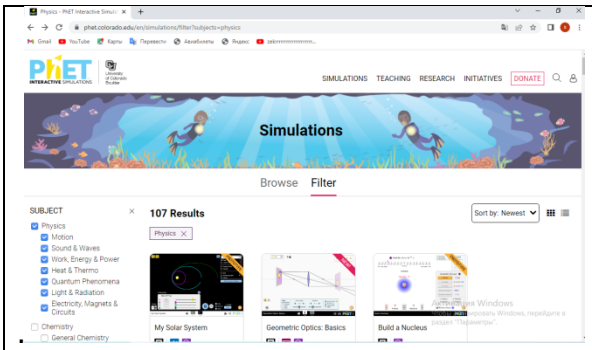

Figure 2. General view of the open-source "Phet" software package

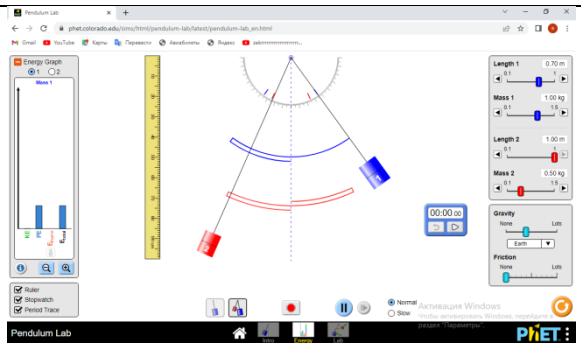

Figure 3. Mathematical pendulum

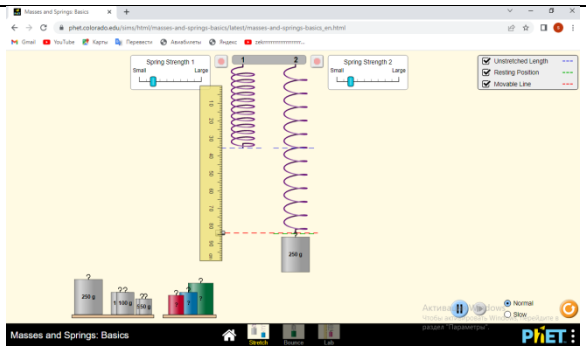

Figure 4. Pendulum of Puruginal

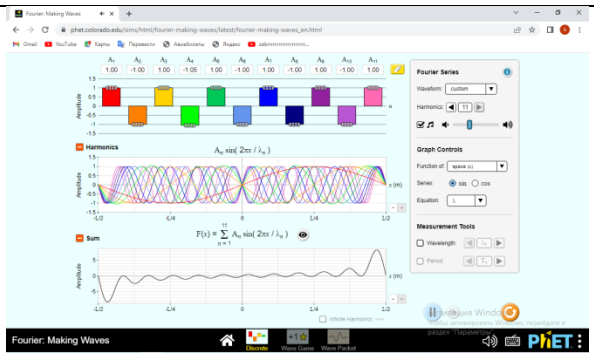

Figure 5. Sinusoidal graph

Using the Freym model, after selecting topic-related virtual laboratory tasks through the open-source Phet pedagogical software, students can gain an understanding of concepts such as harmonic oscillations and electromagnetic oscillations equations (studying whether oscillations follow the sine or cosine law). In the Physics subject, virtual laboratory tasks in the section on electromagnetic oscillations and waves should be carried out sequentially, with students observing and analyzing these tasks independently, concluding the work with written reports of their findings. The tasks should help students understand how

electromagnetic oscillations and waves are generated, under what conditions they can be observed, and how they can be applied and analyzed in various practical contexts [2].

In distance learning, using the Freym model to conduct virtual laboratory tasks brings more benefits compared to traditional laboratory tasks. The advantages of this approach include: determining the goal of the virtual laboratory task, compiling reports, working with physical devices in the virtual environment, conducting experiments correctly, making precise measurements, identifying errors, drawing conclusions, and other important aspects. Such tasks, as discussed earlier in this article using the Freym model, help address global problems such as forming necessary knowledge and skills, successfully completing the course, and mastering specialized subjects at the university [4].

Conclusion

The large number of virtual laboratory tasks available in the Phet pedagogical software for distance learning students allows them to select and discuss topic-related laboratory tasks. The specific virtual laboratory task assigned to a student, the relevance of the task to educational and production outcomes, and the organization of these tasks based on varying levels of student knowledge are key. Conducting virtual laboratory tasks using the Freym model, processing measurement results, and comparing them to traditional laboratory practices leads to more efficient results. The advantage of this model is that it facilitates a discussion of the cause of each physical process from the execution of a virtual laboratory task to obtaining the final results. At the end of these tasks, students' knowledge is further tested for stability, significantly improving the effectiveness of teaching.

REFERENCES:

1. **Lex.uz** The Law of the Republic of Uzbekistan, new version of the "Law on Education" approved by the -637-decree dated 23.09.2023.
2. S.S. Khalilov, K.T. Suyarov, "Strengthening Students' Knowledge in Physics through the Freyim Model in Distance Education," *Science and Innovation International Scientific Journal*, Tashkent-2022, 2181-3337, Tashkent-2022, No. 7, pp. 1570-1573.
3. S.S. Khalilov, "Organization of Virtual Laboratory Learning Using the Frame Model," *Science and Innovation International Scientific Journal*, Tashkent-2023, 2181-3337, Tashkent-2023, No. 2, pp. 567-573.
4. S.S. Khalilov, "Organization of Independent Education Through Modern Information Technologies in Physics in Distance Education," *Progressive Academic Publishing, UK*, page 56, www.idpublications.org, *European Journal of Research and Reflection in Educational Science*, Vol. 11, No. 4, 2023, ISSN 2026-5852.

5. S.S. Khalilov, "Developing Independent Thinking Skills in Students," *Education and Innovative Researches*, Bukhara-2023, No. 12, pp. 323-327.
6. S.S. Khalilov, "Organizing Independent Learning Using Modern Educational Technologies," *Gulistan State University Bulletin*, Humanities and Social Sciences Series, No. 4 (105), "University" Publishing House, Guliston-2023, ISSN 2181-7367, E-ISSN 2181-1172, pp. 26-29.
7. S.S. Khalilov, E.Z. Imamov, Kh.N. Karimov, A.Z. Imamov, "The Future Lies in Education with Active Student Self-Education Processes," *Science and Innovation International Scientific Journal*, 2181-3337, Tashkent-2022, No. 5, pp. 479-482.
8. S.S. Khalilov, K.T. Suyarov, A.K. Ashirbayeva, "Opportunities for Students' Independent Development in Distance Learning Through the ELMS System," *11th International Scientific and Practical Conference 'Science and Education in the Modern World: Challenges of the 21st Century'*, Astana-2022, pp. 67-69.
9. S.S. Khalilov, K.T. Suyarov, A.K. Ashirbayeva, "Methods of Self-Education in Physics with the Use of ICT Information and Computer Technologies," *International Scientific and Practical Journal 'XVII Global Science and Innovations 2022: Central Asia'*, September, Astana-2022, pp. 6-9.
10. S.S. Khalilov, Sh. Karshiboyev, M.U. Raymova, O.O. Ochilova, "Methods of Laboratory Work in Physics," *Journal of Pedagogical Inventions and Practices*, ISSN NO: 2770-2367, https://zienjournals.com, Date of Publication, pp. 74-78.
11. S.S. Khalilov, K.T. Suyarov, "Organization of Distance Learning in Higher Education via the ELMS System," *Branch of the Federal State Autonomous Educational Institution of Higher Education 'National Research Nuclear University 'MEPhI' in Tashkent*, "Modern Problems of Physics, Energy, and Heat Engineering," Tashkent-2022, Theses of the Scientific and Practical Conference for Young Scientists, pp. 249-251.
12. S.S. Khalilov, K.T. Suyarov, "Opportunities for Independent Learning through the ELMS System in Distance Education in Higher Education," *'Current Problems of Physics in Modern Times'* International Scientific and Technical Conference Materials, Bukhara-2022, pp. 607-609.
13. S.S. Khalilov, "Using the Phet Simulations Program for Virtual Laboratory Work in Teaching Physics in General Education Schools," *Innovative Approaches in Enhancing Teacher Professional Competence: Problems and Solutions* Materials of the Republican Scientific and Practical Conference, Tashkent-2019, pp. 257-258.

14. S.S. Khalilov, K.B. Khaydarov, "Using Electronic Educational Resources in Online Physics Classes," *Issues of Applying Modern Systems and Technologies in Training High-Quality Personnel in Current Conditions*, Materials of the Republican Scientific and Methodological Conference, Tashkent-2021, pp. 276-277.