VIRTUAL LABORATORY TECHNOLOGIES AS A MEANS OF IMPROVING THE QUALITY OF UNIVERSITY STUDENTS' TRAINING

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Abstract
The paper describes an approach to organizing laboratory workshops on electromagnetism, which consists in using the "Virtual Laboratory". This approach made it possible to implement part of the educational process in a remote or front-line mode, reduce the costs of implementing laboratory workshops, reduce the risks of expensive equipment being damaged due to unskilled use, and implement new forms of work that are difficult to implement within a traditional laboratory (such as, for example, the introduction and troubleshooting). Practical classes in physics are an integral part of the discipline being studied. A clear and deep understanding of the basic laws of physics and its methods is impossible without working in a physics laboratory, as well as without performing home laboratory work. By conducting laboratory research, students not only confirm the known laws of physics, but also learn to work with physical instruments and master the skills of practical research. Interactive virtual laboratory and practical work is a learning environment that, using computer interactive visualization, allows schoolchildren to simulate a real experiment and conduct educational research. This is an educational environment aimed at ensuring the development of the student's skills to independently generate new knowledge, formulate ideas, concepts, hypotheses about objects and phenomena, including previously unknown ones, recognize the deficits of their own knowledge and competencies, and plan their development.

Keywords: Organization of laboratory workshops, virtual instruments, laboratory workshop, models of measuring instruments, virtual laboratory stands.

Introduction

Over the past decade, distance learning or e-learning has matured and is now a widely used form of higher education throughout the world. Most of these systems only provide a platform for accessing static content, such as textbooks and other course materials. Virtual laboratories are also common nowadays, especially in engineering disciplines, where laboratory activities play a key role in helping students connect lexical knowledge with the real world . These systems make it possible to provide interactive learning tools. Virtual laboratories are designed to organize distance education, conduct experiments and

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laboratory work on a virtual desktop in various subjects. In the context of this article, remote virtual laboratories are considered, which allow access at any time.

1. Advantages of virtual laboratories

From the university and professor's perspective, virtual labs provide an opportunity to break out of the physical confines of a traditional lab and make exercises accessible to a wider audience. Because all of these labs use info-communication technologies, they can track student behavior and collect statistics that can be used to generate useful feedback, and virtual labs can provide information about learning effectiveness to identify problems with the material. From the students' point of view, the most attractive advantage is the ability to carry out the experiment at their own pace and have the laboratory accessible at any time from anywhere. A large number of laboratory experiments are either dangerous or involve expensive equipment, so a supervisor must be present in the laboratory and the student's necessary theoretical knowledge must be tested before they can begin the experiment. These two factors exclude the possibility for a student to simultaneously conduct an experiment and gain theoretical knowledge during the learning process.

In a virtual laboratory, students can safely conduct experiments, and the virtual laboratory can simulate extreme conditions, such as altered gravity or very high ambient temperatures, that would be impossible or very expensive to do in a traditional laboratory.

The lack of actual equipment or limited quantity means that everyone will not be able to carry out laboratory work at the same time. Virtual labs are limited only by system resources, virtual hardware does not age or wear out, which means lower operating costs.

2. Disadvantages of virtual laboratories

One of the disadvantages of virtual and remote laboratories is the lack of practical skills in contact with devices and equipment, so a virtual or remote laboratory cannot improve manual labor, that is, the dexterity that is necessary to achieve the same experimental result when working with real equipment is not achieved. This effect can be reduced to some extent by using high-fidelity 3D models of the equipment. Another disadvantage is that the virtual environment is similar to video games. Students tend to view the virtual experiment as a game, so they lose the sense of seriousness. In remote laboratories, a student cannot cause damage by making a mistake because all controlled components have predefined and environment-tested limits. These laboratories do not require the same level of discipline and care required to conduct a safe experiment in a traditional laboratory. Therefore, it is important to remember that the model and simulation must be sufficiently reliable to cover all important aspects of the experiment. It is important to correctly model the phenomena that are the subject of the laboratory (for example, the accuracy of measuring equipment depends on the ambient temperature, etc.).

3. Approaches to implementing virtual laboratories

Since virtual laboratories have many advantages over traditional ones, the design and development of virtual laboratories has become a widely researched topic in the past few

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years. Many research groups, universities and even industrial corporations have developed their own virtual laboratories, covering a very wide range of disciplines. In modern scientific literature, there are two main categories of virtual laboratories [1].

In the first category, there are virtual laboratory implementations that have been designed and are suitable for one specific purpose, i.e. for one experiment. These implementations do not apply systematic design approaches, such as reusability or implementation of different components of the system, and cannot be used to create a new type of experiment. Instead, the focus is on the experiment itself and the software components that already play a role in that experiment are also used to implement the necessary services for the remote laboratory, such as a web server. In most cases, this approach gives quick results because the teacher (researcher) is already familiar with the software, but in the long run it is the source of many problems.

First, software that is ideal for the experiment may contain a module to implement a web server. However, they were not designed to handle the problems, such as large numbers of simultaneous requests, for which web server software was designed. Secondly, it is impossible to integrate components with external services, such as authentication and authorization, accounting and data storage. Third, it is very difficult to create a consistent user experience for end users of the system.

The second category offers reference-based virtual lab systems that were created following a systematic design approach, using design patterns and best practices from the field of web development. This approach successfully addresses the problems mentioned in the first category. However, this creates a new requirement for teams that want to conduct a new experiment, namely that they must learn to use new tools specific to web development. In engineering disciplines this is often not a problem because teachers already have some knowledge and experience in this area. However, in other disciplines such as astrology, chemistry and medicine, where virtual laboratories are also very useful, this problem makes it difficult to involve teachers in creating new virtual experiments. Recently, active research has been carried out to fill the gap between these two categories. Thus , they are still only suitable for a specific set of experiments or rely on software components that were not designed for a given purpose [2].

4. New look at virtual laboratories

To ensure the ease of use of the various virtual laboratories, the scientific community, which is also the users of these systems, conducted an evaluation, focusing most of its time on didactic aspects, i.e. how the use of a virtual laboratory would improve students' grades, as well as on the development technologies, i.e. What software products are best to use. The most common assessment method involves surveying teachers and students on subjective indicators and processing the accumulated data using statistical methods. In a number of these articles, one can find suggestions about what characteristics of the virtual laboratory have the greatest impact on the didactic success of the laboratory. However, no attempt has been made to evaluate these systems in terms of cognitive info-communication synergies. To better understand what makes a virtual laboratory system successful, it is necessary to

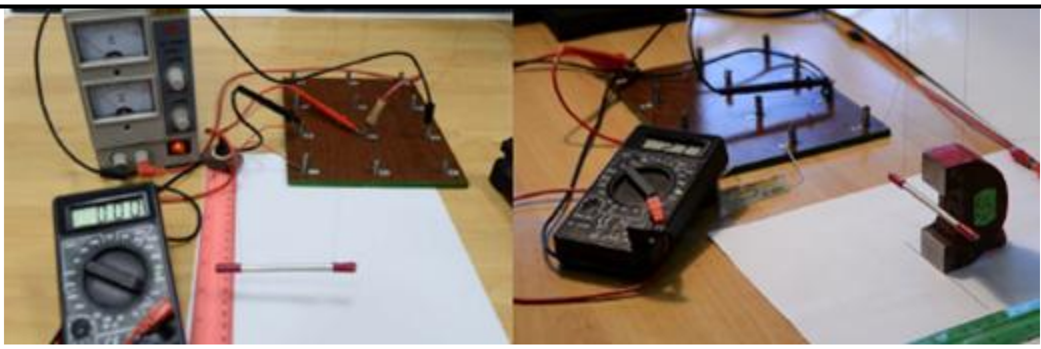
connect the cognitive learning process and the virtual laboratory as a single information and communication system. This can be done by evaluating virtual laboratories from the participants' perspective. This can help identify key factors to consider when designing a new virtual laboratory system. The purpose of a traditional laboratory course is to supplement the theoretical knowledge gained in lectures. The parties involved are the institution, that is, the university, the teacher or laboratory manager, and the student.
A virtual laboratory can be described as an information and communication system that is used by teachers to create virtual experiments and teaching materials, and by students to gain knowledge through these virtual experiments. In the virtual laboratory there is no teacher or supervisor during the experiment; instead, the necessary guidance is provided in the description of the experiment. Teachers create these descriptions and additional reference materials to provide a narrative during the virtual experiment. This way, many students can do the same experiment at any time, at their own pace. The assessment aspects described in previous works can be extended with a cognitive aspect as follows.

5. Design of a new virtual laboratory environment

Looking at existing virtual lab implementations and looking at the shortcomings of virtual labs, it is obvious that there is no consistency at the presentation level, that is, in the user interfaces. From this problem, the first requirement can be defined as follows; The main user interface, including the administrative interface for teachers and the user interface for students, should be consistent and intuitive [2-5]
The second requirement, which comes from the cognitive aspect, is to minimize the necessary context switches during the experiment, i.e., present all relevant and relevant materials in a single user interface. Nowadays, most of the students mainly use smart-phones and tablets to access web services instead of desktop and laptop computers, it is necessary to support these devices.

6. Studying the effect of a magnetic field on a current-carrying conductor, studying the phenomenon of electromagnetic induction

This topic is devoted to the study of the section of physics in the 8th and 9th grades related to the magnetic field and the phenomenon of electromagnetic induction. When performing virtual work, students are asked to complete four experiments. In the first experiment, students investigate the effect of a magnetic field on a current-carrying conductor placed between the poles of a horseshoe magnet. At the same time, they will be able to observe the deviation of the conductor from its original position and establish that the direction of movement of the conductor depends on the direction of the current in it and on the location of the poles of the magnet.



Experimental setup

This experience can be recommended to be carried out both in the 8th and 9th grades as preparation for the State Examination. One of these important properties of a magnetic field is the fact that its field lines turn out to be closed. This indicates that the magnetic field, unlike the electrostatic field, is not central. The non-central nature of the magnetic field means that the force acting from the magnet on a body or conductor with current is not directed along the line connecting the pole of the magnet with individual sections of this body or conductor. In other words, the pole of a magnet cannot be considered as a certain center of localization of magnetic force.

It is this feature of the magnetic field of permanent magnets that the second experiment is devoted to, in which students will be able to empirically study the interaction of a permanent magnet and a body made of a material capable of magnetization (iron, steel, nickel, etc.). The third experiment shows the phenomenon of electromagnetic induction from an unexpected side. As numerous experiments that underlie the theory of electrical and magnetic phenomena have shown, when a magnet moves relative to a massive conductor, volumetric eddy currents (the so-called Foucault currents) begin to circulate in this conductor. The interaction between currents and the magnetic field that arises in this case has a braking effect on the nature of the movement of the magnet relative to the conductor. Students will be able to establish experimentally the nature of the fall of a small magnet inside an aluminum tube, which is more uniform than uniformly accelerated. They will experimentally measure the force that acts from the tube on the magnet. Surprisingly, it turns out that it is equal to the weight of the magnet moving in the tube. This work can be carried out outside of school hours and become the basis for individual projects [6-8].

We have also used virtual labs for students in laboratory classes to enhance their competence in information and communication technology. In this case, the perception of objective existence using natural senses is replaced by artificially created computer information using a special interface, computer graphics and sound. Today, virtual existence is used in various spheres of human cultural activity. A virtual entity is primarily used in the field in which it was created, in science, including physics, when modeling the dynamics of liquids and gases. In education, digital literacy of teachers plays an important role, who can freely use a personal computer, communicate with the community and students; in education they update their resources with the help of electronic technologies, which implement a system of tasks performed by students in electronic form [9]. At the end of the course, we readministered a questionnaire to test students' competence in the field of information and communication technologies; the results of the study are presented in Table 1.

Table 1. Indicators of student use of information and communication technologies at the end of the electromagnetism course.

CT name	Usage indicators			
	constant, %	often, %	rarely, %	habitual
Online classes	3	12	65	20
Virtual laboratory is working	0	60	40	0
Power Point program	45	45	8.5	1.5

The table shows that the use of electronic whiteboards, electronic textbooks during lectures, as well as the use of virtual laboratories during laboratory work created the opportunity to increase the competence of students in the field of information and communication technologies (Table 1). From Table 1, we can see that students' use of online database and power point has increased. The reason is that during the course, students used an electronic database for independent work and a Power Point program for preparing presentations [10]. The results of the study show that according to the survey conducted at the beginning of the course, we see that by the end of the course, students' use of ICT increased by 10-15%. Therefore, the use of electronic textbooks, electronic whiteboards and virtual laboratory programs during the lesson plays a key role in improving the information and communication skills of students. Modern information technologies speed up all stages of the educational process. Based on the use of information technology, we can observe an increase in the quality and efficiency of the educational process, and an increase in the cognitive activity of students.

Conclusion

The results of the work make it possible to conduct practical classes in disciplines related to measurement technologies in a frontal or remote format without the need to purchase and use real laboratory equipment, and also help to develop software and methodological support for the educational process. In addition, the creation and implementation of new educational technologies, including digital ones, is one of the most important components of the development program of leading universities. Digitalization of education stands out as an important factor in increasing the efficiency of the educational process. Further development and implementation of the "Virtual Laboratory" will achieve the following results:

- implementation of a full-fledged educational process in engineering educational
- programs in a distance format, expanding the range of additional education programs, obtaining a competitive educational product;

- efficient use of laboratory resources, active implementation of digital educational technologies, development of educational and methodological support;
- increasing the interactivity of laboratory and practical classes for better student engagement, obtaining a flexible software tool to simplify the organization and conduct of classes in a distance format;
- full development of educational competencies, correspondence of experience with virtual models to the use of real equipment.

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