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ADVANTAGES OF VIRTUAL LABORATORY IN A PHYSICS COURSE AT HIGH SCHOOLS

Tilavova Turdixol Baratovna
Jizzakh State Pedagogical University,
Sharof Rashidov-4, 100130, Uzbekistan,
Email: turdixol@mail.ru

Abstract
In the paper we discuss the types of lecture demonstrations, as well as the requirements for its conducting at the high school physics department. Physical knowledge obtained through the combined use of mathematical analysis and experimental research will be stronger and more durable than the knowledge of mathematicians or experimenters alone. The effectiveness of a physics lecture course is largely determined by the lecture demonstrations that are part of the course. Demonstration experiments improve the quality of the educational process, contribute to a deeper assimilation of theoretical knowledge, and activation of students' mental activity. A lecture demonstration allows for an introduction to the theory, confirms the conclusions of the theory, and makes it possible to demonstrate the application of the theory in practice.

Keywords: Physics; lecture; lecture experiment; lecture demonstration, quality of the educational process, physical phenomena, damped oscillations.

Introduction

In our opinion, a virtual laboratory "is a software and hardware complex that allows you to conduct experiments without direct contact with a real installation or in the complete absence of one. In the first case, we are dealing with a so-called laboratory installation with remote access, which includes a real laboratory, software and hardware for controlling the installation and digitizing the obtained data, as well as communication tools. In the second case, all processes are simulated using a computer." So, virtual laboratories mean two types of software and hardware systems:
laboratory installation with remote access - let's call such complexes remote laboratories
software that allows you to simulate laboratory experiments - virtual laboratories (in the narrow sense)

1. Virtual laboratories

What are the advantages of virtual laboratories over real ones?
According to the source mentioned above [1], the main advantages of virtual laboratories are:
• No need to purchase expensive equipment and reagents. Due to insufficient funding, many laboratories have old equipment, which can distort the results of experiments and serve as a potential source of danger for students. In addition, in such fields as, for example, chemistry,

in addition to equipment, consumables (reagents) are also required, the cost of which is quite high. Of course, computer hardware and software are also expensive, but the versatility of computer technology and its widespread use compensate for this disadvantage.

The ability to simulate processes, the occurrence of which is fundamentally impossible in laboratory conditions.

Visualization on a computer screen. Modern computer technologies will make it possible to observe processes that are difficult to distinguish in real conditions without the use of additional equipment, for example, due to the small size of the observed particles.

The ability to penetrate into the subtleties of processes and observe what is happening on a different time scale, which is important for processes that occur in a fraction of a second or, on the contrary, last for several years.

Safety. Safety is an important advantage of using virtual laboratories in cases where work is carried out, for example, with high voltages or chemicals.

Due to the fact that the virtual process is controlled by a computer, it becomes possible to quickly conduct a series of experiments with different values of input parameters, which is often necessary to determine the dependence of output parameters on input parameters.

Saving time and resources for entering results into electronic format.

Some work requires subsequent processing of fairly large arrays of obtained digital data, which are performed on a computer after a series of experiments. The weak point in this sequence of actions when using a real laboratory is entering the received information into the computer. In a virtual laboratory, this step is absent, since the data can be entered into a spreadsheet of results directly when the experiments are performed by the experimenter or automatically. This saves time and significantly reduces the percentage of possible errors. And finally, a separate and important advantage is the possibility of using a virtual laboratory in distance learning, when in principle there is no possibility of working in university laboratories.

Examples of virtual laboratories

STAR (Software Tools for Academics and Researchers) is a Massachusetts Institute of Technology (MIT) program to develop virtual laboratories for research and teaching. The program's activities include the development of educational and research applications in general biology, biochemistry, genetics, hydrology, and in the field of distributed computing.

- StarBiochem - 3D visualizer of protein molecules. Has flexible and detailed settings. • StarGenetics. - allows you to simulate crossing processes, study the patterns of inheritance of monogenic traits (the so-called Mendel's laws).
- StarMolSim is a series of tools that simulate molecular dynamics processes. Each of the tools has a wide range of input values and, likewise, a wide range of output values for analysis and exploration.

Only relevant specialists can evaluate these virtual laboratories, but it can be said with a certain degree of confidence that they are fundamental, cover a wide range of tasks in a certain field of knowledge, and have a rich set of tools.

Virtual laboratories Vi rtuLab

VirtualLab is a project to develop virtual laboratory work for students in physics, chemistry, biology, and ecology. Virtual laboratory work is implemented using Flash technology. They are distinguished by their narrow specialization, in most cases the linearity of experience (the entire sequence of actions and results of the experience are predetermined). VirtualLab products have educational value and solve the problem of conducting laboratory work in the absence of the necessary equipment.

Examples of laboratory work:

- Study of particle interactions and nuclear reactions
- Comparison of molar heat capacities of metals
- Study of Ohm's law for a complete circuit
- Familiarity with samples of metals and alloys

Algodoo virtual laboratories

Algodoo is a program designed for 2D physical simulations. It has a very rich toolkit for creating various objects, mechanisms and systems in order to simulate their physical interaction and properties. For example, you can create a model of a working clock, a model of a planetary rover or an air rifle. The program is capable of simulating not only mechanical processes, but also optical ones, and the ability to program using the Thyme scripting language allows you to create objects with original physical properties, various functions, effects and phenomena. It is also possible to load drawings: the drawing becomes a simulation object and you can assign any physical properties to it.

PhET virtual laboratories

PhET - project. developed by the University of Colorado. The project includes a large number of virtual laboratories demonstrating various phenomena in the field of physics, biology, chemistry, mathematics, and earth sciences. The experiments have a high educational value and are also very exciting.

Wolfram Demonstrations Project

Wolfram project Demonstrations Project is a visual demonstration of the concepts of modern science and technology. Wolfram claims to be a single platform to create a unified catalog of online interactive laboratories. This, according to its developers, will allow users to avoid problems associated with the use of heterogeneous learning resources and development platforms.

2. The scientific results and its discussions

Modern practice of teaching physics courses in higher educational institutions requires, in addition to well-equipped stationary educational laboratories, the presence of a mobile laboratory workshop, which is especially necessary for work in out-of-town branches of universities, where often there are no laboratory classrooms at all. Naturally, this can only be a virtual, computer laboratory workshop that fits on a regular flash drive and can be

launched without first installing the program on the computer. In addition, it is desirable to use elements of this workshop both as lecture demonstrations of physical phenomena and as an element of practical classes (virtual laboratory work). Finally, such a workshop turns out to be indispensable during periods of "peak" teaching loads on classrooms, when regular laboratory classrooms may not be enough to conduct laboratory classes according to the calendar-thematic plan of the academic discipline.

Internet resources offer a wide variety of virtual and mobile laboratory work in various disciplines, including physics [5]. The virtual workshop is both a lecture demonstration and a simple laboratory work on the study of damped oscillations; the interface is extremely laconic (there are almost no controls and settings), which again contributes to the efficiency of work and improves the learning process. There are quite a lot of Internet portals offering virtual laboratory work on a variety of topics, and they can be performed both online and offline [9]. For example, the free online resource Virtulab.Net [6]. This is one of the developed specialized portals dedicated to virtual educational laboratories. The site presents educational interactive works that allow students to conduct virtual experiments in physics, chemistry, biology, ecology and other subjects. However, to conduct this kind of laboratory workshop, it is necessary to ensure constant access to the Internet. In addition, it is necessary to adapt the workshop within the framework of the course being taught (depending on the direction of the students' training), which in principle is not possible. This leads to an understanding of the need to create and develop a virtual laboratory workshop, adapted for students of a particular university. Moreover, it is very useful to involve students themselves in this work, since this will stimulate the development of their engineering, physical thinking [4]: during modeling, they become familiar with the basic technical means used in constructing the model, which facilitates the understanding of physical phenomena and increases interest in the discipline being studied, expands the research component in the study of natural sciences, and also teaches how to use information technology as a modern and convenient tool. Students get the opportunity to observe the modeling process, independently on its parameters, and analyze graphical information reflecting changes in physical quantities that describe interactions [2].

Depending on the educational topic, the goals set for the computer program for simulating a physical process, a virtual workshop can simulate a real laboratory installation as completely as possible or, conversely, almost completely abstract from its unnecessary details; makes it possible to carry out work, including demonstrating consequences that are unattainable or undesirable in a full-scale experiment (fuse blown, electrical measuring device; change in the polarity of switching on devices, etc.). Thus, virtual laboratory work has undeniable advantages, namely the possibility of conducting a laboratory workshop when setting up a real experiment is difficult, when it is necessary to instantly process the results obtained.

The above circumstances encourage many teachers to independently create educational computer programs, including virtual laboratory workshops. Of course, they will not differ in the quality of programs made by professional programmers, but there will be no violations of the methodological plan. It is worth noting that the excessive "beauty" of program

elements only distracts the student's attention from the physical essence of the phenomenon being studied - everything is good in moderation. Attempts have been made to develop our own software products, taking into account the peculiarities of teaching a general physics course, all of them were made within the programming capabilities of a standard office suite of any computer, so the programs are launched directly from a flash drive and do not require preliminary installation, which is necessary for the development of a mobile laboratory workshop. Practice of use, including during field work in out-of-town branches of the university, has shown their full functionality and suitability for physics classes. Some of the listed programs are as close as possible with their interface to a real stationary laboratory installation, i.e., the devices shown on the screen are equipped with all the necessary controls - switches, regulators, toggle switches, etc. An example of virtual work should be given in which excessive detail of laboratory equipment is not necessary at all and is even methodologically "harmful": work devoted to the Compton effect [6]. In real laboratory work, an X-ray machine with all the attributes is required. Obviously, in virtual laboratory work, technical difficulties will only distract students from the essence of the physical phenomenon, therefore the model of the laboratory setup should be extremely concise (Fig. 1).

Fig.1. Installation for studying the Compton effect

In this work, we study the dependence of the wavelength of X-ray radiation scattered on electrons on the angle of this scattering. The entire interface consists only of the symbolic "ON" button of the X-ray machine, the receiving X-ray sensor and the scattering angle indicator (in the figure, for example, this is 45°). Here we can see both the original wavelength of the X-ray radiation and the wavelength of the scattered radiation, i.e., all the data necessary for the experiment is given. The simplicity of the interface helps to understand the very essence of the effect, without being distracted by the technical difficulties of a real experiment, and also to quickly complete all laboratory work, even with only a single computer, when students have to do the work one by one. The use of a mobile laboratory workshop even shows some advantage of virtual work over full-scale work:

sometimes they make it possible to demonstrate what is either difficult or impossible for a real experiment. For example, work on the topic “Balmer series in the spectrum of hydrogen” [3]. Most of this series is in the ultraviolet region of the spectrum and is invisible to a real optical spectroscope (only four spectral lines out of their total are visible). However, it is possible to simulate the most modern type of spectrometer (obviously quite expensive), which, with the help of its electronics, can record the invisible ultraviolet part of the Balmer series. We present drawings of a virtual laboratory setup for studying the Balmer series in the hydrogen spectrum (Fig. 2).

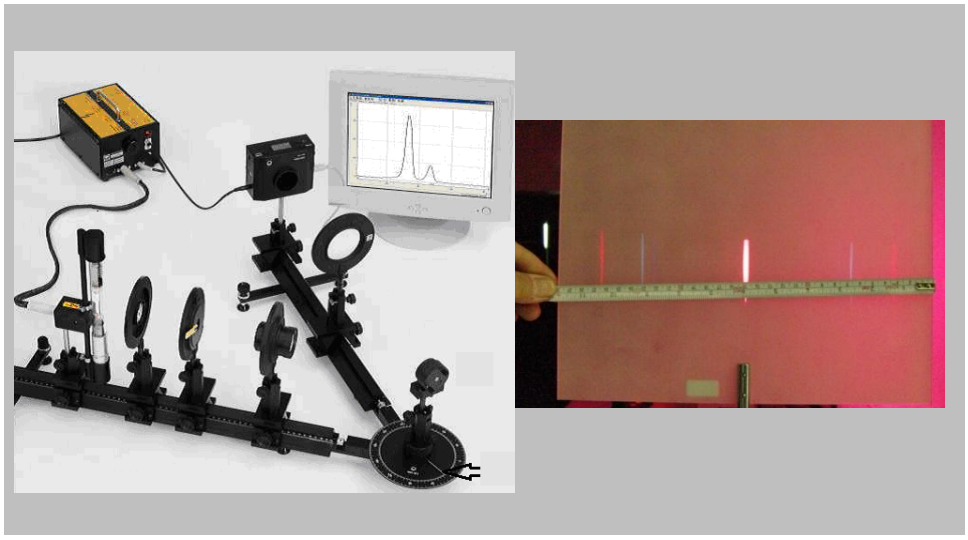

Fig. 2. The overall spectrum of the Balmer series (at the bottom of the screen) and an enlarged part of it (rectangle) within the electronic magnifying glass (at the top of the screen)

In addition to laboratory work, this is also a good lecture demonstration. The minimal and clear interface also allows students to complete this lab quickly and with the proper level of understanding. It should be borne in mind that virtual laboratory work also has disadvantages. The main one is the lack of direct contact with the object of study, instruments, and equipment. It is absolutely impossible to train a specialist who has seen a technical object only on a monitor screen. Therefore, in the educational process it is necessary to combine traditional and virtual laboratory work, taking into account their advantages and disadvantages.

Conclusion

Thus, it should be emphasized to students that any model only gives an idea of the phenomenon and cannot be identified with the real process. Based on the results of the work done, the following conclusions can be drawn.

❖ Lecture demonstrations clearly present the physical phenomena of the main branches of physics, allowing students to better understand and assimilate the educational material.

❖ The use of demonstrations developed by the authors makes it possible to clearly present the features of some complex concepts and processes.

❖ There is a need to publish a catalog of the lecture experiment available at the department, including a description of homemade demonstrations. This will expand the range of demonstrated physical phenomena.

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