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USE OF VIRTUAL LABORATORY WORKS IN TEACHING MEDICAL BIOPHYSICS

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Abstract. Medical biophysics is one of the first natural-science courses for medical students, and many of them find its physical and mathematical content difficult. Laboratory work is the main way to connect theory with practice, but traditional laboratories are limited by equipment, time and safety. This article describes the use of virtual laboratory works in teaching medical biophysics at Andijan State Medical Institute. The structure of a combined lesson is proposed, in which a virtual experiment precedes and supports a real one. A set of virtual works covering the main sections of the course is presented: mechanics and hemodynamics, bioelectric phenomena, membrane transport, optics and ionizing radiation. The approach allows each student to repeat an experiment, change its parameters and see the result immediately, which improves understanding of biophysical processes and prepares students for clinical disciplines.
Keywords: medical biophysics, virtual laboratory, teaching methods, medical education, simulation, laboratory work.

1. Introduction

Medical biophysics explains the physical basis of life processes and of the methods used in diagnosis and treatment: blood flow, nerve impulses, membrane transport, imaging and radiation [1, 2]. Without this knowledge students cannot understand physiology, radiology or the operation of medical equipment.

Many first-year students have a weak background in physics and mathematics, and abstract formulas are hard for them to link with the human body. Real laboratory work helps, but equipment is limited, several students share one setup, and some experiments involve radiation, high voltage or are too slow for one lesson.

Virtual laboratories reproduce experiments on a computer: the student changes parameters and immediately sees the result [3, 4]. Studies show that well-designed virtual experiments are at least as effective as physical ones for learning concepts, and their combination gives the best result [3]. The aim of this work is to develop the structure of a lesson and a set of virtual laboratory works for teaching medical biophysics.

2. Materials and methods

The work was carried out in the biophysics course for first-year students of Andijan State Medical Institute. Virtual laboratory works were selected for the course sections in which real experiments are most limited by equipment, time or safety. Each virtual work includes a short theory, an interactive model with adjustable parameters, a measurement task and control questions.

The virtual works are run on computer workstations connected to the instructor's computer, so the instructor can assign tasks, follow each student's progress and show selected results on a large screen. Where real equipment exists, the virtual work is followed by the same measurement on the real setup.

3. Results

A combined laboratory lesson of five stages was developed (Figure 1). The virtual experiment comes before the real one, so students arrive at the real setup already knowing what to expect.

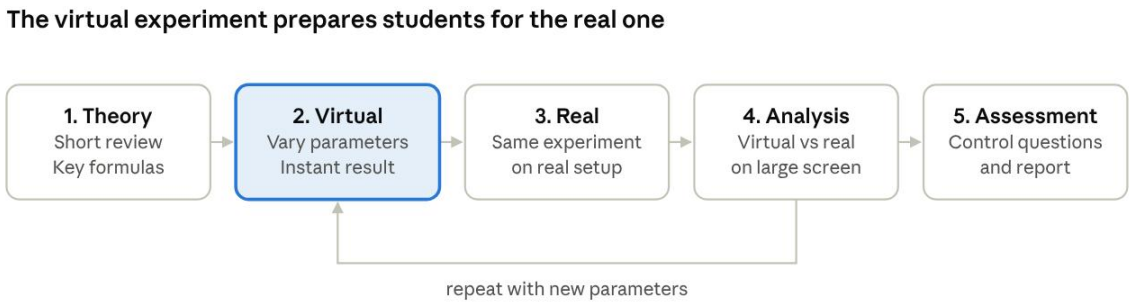


Figure 1. Structure of a combined biophysics laboratory lesson.

The set of virtual laboratory works covers the main sections of the course (Table 1).

Table 1. Virtual laboratory works in medical biophysics

Course section	Virtual laboratory work	Parameters the student changes	Clinical link
Mechanics and hemodynamics	Blood flow in vessels (Poiseuille law)	Vessel radius, length, viscosity, pressure	Atherosclerosis, blood pressure
Acoustics	Ultrasound in tissues	Frequency, tissue impedance	Ultrasound diagnostics
Bioelectric phenomena	Resting and action potentials	Ion concentrations, membrane permeability	Nerve conduction, ECG
Membrane transport	Diffusion and osmosis	Concentration gradient, membrane thickness	Edema, dialysis
Electrocardiography	Formation of ECG leads	Heart electrical axis	ECG interpretation
Optics	Microscope and the eye	Lens power, aperture	Refraction errors, microscopy
Ionizing radiation	Radioactive decay and shielding	Half-life, shield material and thickness	Radiation protection, nuclear medicine

The Poiseuille-law work shows the value of the approach. When the student reduces the vessel radius by half, the model shows a 16-fold fall in flow, because flow is proportional to the fourth power of the radius:

$$Q = \frac{\pi r^4 \Delta P}{8 \eta l}$$

This result, hard to see in a real experiment, explains to the student why even a small narrowing of an artery has a large clinical effect.

4. Discussion

The main advantage of virtual works is that every student performs the experiment personally and can repeat it with different parameters. In a traditional lesson a group of students often watches one setup, and only one or two actually take measurements. Virtual models also make visible processes that cannot be observed directly, such as ion flow through a membrane or the spread of excitation in the heart.

Virtual works do not replace real ones. Students must still learn to handle instruments, take readings and estimate measurement errors. That is why the proposed lesson places the virtual experiment before the real one rather than instead of it, in line with studies that recommend combining both forms [3, 4].

The approach requires computer workstations, prepared models and instructor training. Further work will include a comparative study of student results in groups taught with and without virtual works.

5. Conclusion

A five-stage structure of a combined biophysics lesson and a set of seven virtual laboratory works covering the main sections of the course were developed. Virtual works let each student experiment personally, change parameters and see clinically important relationships, while the real experiment that follows keeps practical skills. The approach can be used in teaching medical biophysics in medical universities of Uzbekistan.

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