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# INTEGRATIVE AND INNOVATIVE APPROACHES TO TEACHING BIOPHYSICS

***Abstract.*** *This article analyzes the theoretical and methodological foundations of teaching biophysics based on innovative pedagogical technologies, interactive methods, the use of digital educational tools, the formation of research skills in students, and the importance of interdisciplinary integration. The effectiveness of innovative approaches is substantiated by practical examples.*

***Keywords:*** *biophysics, innovative education, digital pedagogy, STEAM, interactive methods, laboratory, simulation, competence.*

The methodology of teaching biophysics based on an innovative approach includes interactive teaching methods, the use of information and communication technologies (ICT), project-based activities, as well as the transformation of theoretical knowledge into practical skills relying on modern research methods. This approach places students at the center of the learning process, promoting active participation, deeper knowledge retention, and the development of critical thinking.

Biophysics is a science that studies biological processes based on physical principles and occupies a key position in the development of modern medicine, biotechnology, bioinformatics, and molecular biology. In recent years, the rapid advancement of science and technology has necessitated the implementation of innovative approaches in the teaching of biophysics.

## 1. Theoretical Foundations of the Innovative Approach in Biophysics Education

Innovative education aims to enhance the effectiveness of the learning process through the introduction of new ideas, technologies, methods, and approaches into the educational system.

In teaching biophysics, such innovations are based on the following principles:

- **Systems thinking** — interpreting biological processes through physical models;
- **Interactive learning** — transforming the student from a passive listener into an active researcher;

**2. Innovative Methods in the Teaching of Biophysics**

The application of modern teaching methods plays a crucial role in enhancing the effectiveness of biophysics education.

**2.1. Interactive Methods**

Techniques such as *Cluster*, *Brainstorming*, and *Branching Method* are used to systematize complex biophysical concepts. *Problem-based learning* — creating a problem situation that requires students to explain a biophysical process. *Case-study analysis* — examining real biological processes using physical models.

**2.2. Project-Based Learning**

Students can carry out group projects in the following areas:

- Physics of gel electrophoresis;
- Measurement of bioelectric signals;

**3. Implementation of Digital Technologies in Biophysics Education**

**3.1. Virtual Laboratories**

The use of platforms such as PhET, Labster, BioDigital Human, and Virtual Microscope allows students to:

- safely conduct complex experiments;
- observe biological processes at the cellular level in 3D format;
- measure and model biophysical parameters.

**3.2. Use of Artificial Intelligence**

With the application of artificial intelligence technologies, it becomes possible to:

- perform real-time graphical analysis;
- process bioelectric signals;
- classify data;
- solve complex physico-bioinformatic problems.

**4. Competency Development in the Process of Studying Biophysics**

During biophysics courses, the following competencies are developed:

- **Theoretical competency** — knowledge of physical principles and their connection with biological processes;
- **Practical competency** — conducting laboratory experiments;
- **Informational competency** — processing data from digital experiments;
- **Analytical competency** — analyzing signals, data, and graphical materials;
- **Creative thinking** — modeling processes and generating new ideas.

**5. Recommendations for Improving the Effectiveness of Biophysics Education**

- **Hybrid learning system** — combining traditional classes with digital laboratories;
- **Mini-research projects** — conducting week-long scientific assignments for each topic;
- **Interdisciplinary integration** — linking physics topics with biophysical processes;

**Conclusion**

Innovative approaches in biophysics education transform students from passive recipients of knowledge into active participants and problem-solvers. By combining interactive methods, digital technologies, interdisciplinary integration, and competency-based assessment, modern biophysics courses can better prepare future biomedical specialists for the challenges of research and clinical practice. These strategies not only enhance understanding of complex biological processes

through physical principles but also foster critical thinking, creativity, and digital literacy, which are essential for success in the rapidly evolving biomedical field.

This approach provides the following positive outcomes:

1. **Integrated understanding of physical and biological processes** — students develop the ability to explain physical and biological processes in an integrated manner. This contributes to the preparation of future researchers in medicine, biotechnology, bioinformatics, and related fields.

2. **Enhanced effectiveness of laboratory work** — by combining virtual and real experiments, students are exposed to all stages of the processes under investigation, improving comprehension and practical skills.

3. **Development of digital competence** — a key skill for modern specialists. Students gain proficiency in signal analysis, simulations, 3D modeling, and the use of analytical software.

Overall, teaching biophysics based on an innovative approach is an essential component in training future qualified doctors, biologists, biophysicists, biotechnologists, and researchers. This educational model fully aligns with modern scientific requirements, technological innovations, and national educational standards.

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