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METHODOLOGY OF USING INTERACTIVE WEB-SIMULATIONS IN TEACHING MAGNETIC FLUX AND INDUCTANCE CONCEPTS TO NATURAL SCIENCE STUDENTS

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МЕТОДИКА ИСПОЛЬЗОВАНИЯ ИНТЕРАКТИВНЫХ ВЕБ-ТРЕНАЖЕРОВ ПРИ ОБУЧЕНИИ ПОНЯТИЯМ МАГНИТНОГО ПОТОКА И ИНДУКТИВНОСТИ СТУДЕНТОВ НАПРАВЛЕНИЙ ЕСТЕСТВОЗНАНИЯ

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Annotation. The article deals with the methodology of teaching the "Electromagnetism" section, particularly the concepts of "magnetic flux" and "inductance", for undergraduate students of natural science directions (biology, geography, chemistry). Taking into account the cognitive characteristics of non-physics majors, the didactic advantages of utilizing interactive web-based simulations instead of complex mathematical derivations are substantiated. A step-by-step teaching technology aimed at fostering scientific thinking and spatial reasoning is proposed, alongside the results of a pedagogical experiment.
Keywords: natural science directions, physics teaching methodology, magnetic flux, inductance, interactive web simulation, HTML5 Canvas, experiment, scientific thinking.

Аннотация. В статье исследована методика преподавания раздела «Электромагнетизм», в частности понятий «магнитный поток» и «индуктивность», для студентов направлений естествознания (биология, география, химия). С учётом познавательных возможностей студентов непрофильных специальностей обоснованы дидактические преимущества применения интерактивных веб-тренажеров на базе HTML5 вместо громоздких математических выводов. Предложена поэтапная методика формирования научного мышления и пространственного воображения, а также представлены результаты педагогического эксперимента.
Ключевые слова: направления естествознания, методика преподавания физики, магнитный поток, индуктивность, интерактивный веб-тренажер, HTML5 Canvas, эксперимент, научное мышление.

Introduction

At the core of the large-scale reforms being carried out in the education sector of our country lies the task of training competitive specialists who meet the priorities of socio-economic development and international standards. These strategic goals are reflected in the normative decrees of the President of the Republic of Uzbekistan on fundamentally improving the higher education system and raising the quality of education. Today, alongside traditional teaching methods, the wide introduction of innovative pedagogical technologies, modern information and communication technologies (ICT), and interactive methods in higher education institutions is considered the key factor ensuring the guaranteed effectiveness of the educational process.

Teaching physics to students of natural science directions (biology, geography, chemistry, soil science, etc.) in higher pedagogical and natural-science institutions has its own didactic features. Since students of these directions are not specialist physicists, the problem of correctly selecting the volume and style of the study material arises when teaching them fundamental laws. Teaching the subject to non-specialist students should be oriented not toward dry mathematical formulas and complex calculations, but toward revealing the physical meaning of natural phenomena and forming scientific worldview and independent thinking skills.

In particular, teaching abstract concepts in the "Electromagnetism" section such as "magnetic flux", "Faraday's law of electromagnetic induction" and "self-induction and inductance" requires a high level of spatial imagination from students. Explaining the angular relationships between magnetic induction lines and the normal of a rotating surface through static 2D drawings on the board makes it difficult for students to grasp the dynamics of the process. Therefore, developing interactive web-simulations that run on any device through a browser and applying them in lessons is an urgent pedagogical task.

Aim of the research. To develop a methodology for teaching the concepts of magnetic flux and inductance based on new pedagogical technologies and HTML5 web-simulations, in accordance with the cognitive capabilities and thinking characteristics of natural science students, and to substantiate its effectiveness in practice.

Materials and Methods

The research is of a theoretical-methodological and practical-experimental nature. The research materials included the normative documents of the Republic of Uzbekistan in the field of higher education, the approved general physics curricula for non-specialist natural science directions, state educational standards, and advanced psychological-pedagogical and methodological sources on the topic.

The following set of methods was used in the course of the research:

- Theoretical analysis of normative sources and methodological literature, and determination of the criteria for selecting the content of the physics course for natural science directions;
- Modeling of physical phenomena and computer animation: software modeling of the magnetic field, surface normal, loop rotation, and the dynamics of the induced EMF using HTML5 Canvas and JavaScript;
- Methodological design: integrating demonstration experiments, interactive web-simulations, and rapid knowledge-check methods (step-by-step tasks, "interactive poll") within the lessons;
- Pedagogical experiment and mathematical-statistical analysis: comparative evaluation of the achievement indicators obtained in equalized control and experimental groups.

The following were defined as the conditions for achieving the planned learning outcomes in natural science directions: the teacher's readiness to deliver the core curriculum in an

adapted form to a non-specialist audience; students' conscious perception of the topics; and the availability of modern visual teaching-methodical tools that meet the requirements of state educational standards.

Results

Criteria for selecting course content in natural science directions and the role of visualization

As a result of the analysis carried out, the following main didactic criteria for selecting the content of physics lessons for natural science directions were identified:

- The course content should be limited to the obligatory minimum of the subject, while the teacher should form physical concepts mainly through demonstration experiments, laboratory work, and computer simulations;
- In presenting the study material, experimental facts, models of theories, and their practical significance should come first;
- Taking into account students' cognitive activity, it is expedient to study many laws without complex mathematical proofs (providing ready final formulas) and without overly heavy computational problems.

Explaining to non-specialist students the phenomena of the microworld or the electromagnetic field that cannot be seen directly with the eye (the motion of electrons in a magnetic field, magnetic induction flux, the phenomenon of self-induction) only through static images does not yield results. Dynamic visual support increases students' mental activity and fundamentally improves the effectiveness of mastering the material.

Interactive web-simulation model for magnetic flux and inductance

The created web-simulation is based on the formula for the magnetic flux through a flat loop placed in a uniform magnetic field: . This process is visualized in the HTML5 Canvas environment, and its main parameters are as follows:

- Magnetic induction (B): when changed via a slider, the density of the field force lines changes dynamically;
- Loop area (S): the geometric dimensions of the loop and the effective area intersecting the field change;
- Spatial angle (α): when the loop is rotated from 0° to 360°, the angle between its normal vector (n) and the field lines is updated in real time;
- Results indicator: the exact value of the magnetic flux (in webers) is calculated, and its character (maximum flux, zero flux, intermediate state) is shown through a text-visual indicator.

Methodology of organizing the lesson

The following sequential step-by-step teaching technology was applied in teaching the topic:

1. **Stage 1: Introduction and creating a problem situation.** The teacher draws students' attention with the question: "Why can the magnetic flux be equal to zero even when the field is strong?";
2. **Stage 2: Interactive investigation in the web-simulation.** Students open the simulation on their individual computers or smartphones, change the angle to 0°, 90°, 180°, and see with their own eyes how the flux changes from zero to maximum;
3. **Stage 3: Interactive assessment ("puzzle-poll" and mini-test).** Students consolidate the concepts they have mastered through interactive tasks.

Results of the pedagogical experiment

In order to test the effectiveness of the proposed methodology, a pedagogical experiment was conducted with the participation of 50 bachelor students of natural science directions (25 in the

control group, 25 in the experimental group). The control group used traditional lectures and static posters, while the experimental group applied the developed interactive web-simulation methodology. The test results are presented in Table 1.

Table 1 Dynamics of the achievement indicators of natural science students.

Assessment levels	**Control group (n_1 = 25)**	**Experimental group (n_2 = 25)**	**Change (Δ)**
High (Excellent, 86–100%)	5 (20%)	11 (44%)	+24%
Medium (Good, 71–85%)	12 (48%)	11 (44%)	-4%
Satisfactory (56–70%)	8 (32%)	3 (12%)	-20%
Average achievement score	71.4 points	83.8 points	+12.4 points
Quality indicator	68%	88%	+20%

Discussion

The obtained results show that the use of demonstration computer models and interactive simulations fully corresponds to the thinking characteristics of natural science students. Animating the microworld and field processes that cannot be observed directly creates a foundation for the student to deeply understand the essence of a physical law.

The interactive web-simulation transforms the student from a passive listener into an active experimenter. When the student changes the angle or the field strength with their own hand and the result updates in real time, their cognitive independence increases. As a result, compared to the control group, the high achievement indicator in the experimental group reached from 20% to 44%, and the quality level rose by 20%.

Limitation of the research. The proposed methodology was tested mainly within the basic topics of the "Electromagnetism" section. In the future, it is planned to further expand the capabilities of the simulation and create a complete virtual laboratory complex for the sections on alternating current generators, transformers, and electromagnetic waves.

Conclusion

In teaching physics to students of natural science directions, the use of a methodology that relies on new pedagogical technologies and modern ICT tools and is adapted to the cognitive needs of non-specialist students is an important factor in forming their scientific worldview and independent thinking.

Interactive web-simulations created on the basis of HTML5 technology require no installation, are platform-independent, and serve to develop the student's spatial imagination. The conducted pedagogical experiment proved in practice that this methodology increases the quality of mastery by 20%. It is recommended to apply this methodology in the practice of teaching general physics in the biology, geography, and chemistry directions of higher education institutions.

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