METHODOLOGY FOR IMPROVING THE DIDACTIC MODEL OF THEORETICAL AND EXPERIMENTAL PHYSICS TEACHING IN HIGHER EDUCATION INSTITUTIONS WITHIN AN ARTIFICIAL INTELLIGENCE ENVIRONMENT.

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МЕТОДИКА СОВЕРШЕНСТВОВАНИЯ ДИДАКТИЧЕСКОЙ МОДЕЛИ ПРЕПОДАВАНИЯ ТЕОРЕТИЧЕСКОЙ И ЭКСПЕРИМЕНТАЛЬНОЙ ФИЗИКИ В ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЯХ В УСЛОВИЯХ СРЕДЫ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА

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Abstract. This article discusses the improvement of the didactic model for theoretical and experimental physics teaching in higher education institutions using artificial intelligence technologies. The study analyzes the possibilities of personalizing the learning process, increasing interactivity, and achieving deep knowledge assimilation based on neural networks. The authors propose a pedagogical-methodological model, demonstrating that the integration of artificial intelligence tools significantly enhances the effectiveness of physics education.

Keywords: artificial intelligence, neural networks, physics education, didactic model, experimental teaching, theoretical teaching, innovative pedagogy, adaptive teaching, digital technologies.

Аннотация. В данной статье рассматриваются вопросы совершенствования дидактической модели теоретического и экспериментального обучения физике в высших учебных заведениях с использованием технологий искусственного интеллекта. В исследовании анализируются возможности индивидуализации учебного процесса, повышения интерактивности и глубокого усвоения знаний на основе нейронных сетей. Авторы предлагают педагогико-методическую модель, доказывая, что применение искусственного интеллекта значительно повышает эффективность обучения физике.

Ключевые слова: искусственный интеллект, нейронные сети, физическое образование, дидактическая модель, экспериментальное обучение, теоретическое обучение, инновационная педагогика, адаптивное обучение, цифровые технологии.

Introduction

In the context of modern globalization, the rapid development of science and technology has a significant impact on all spheres of society, especially the education system. As a result of digital transformation processes, artificial intelligence technologies are becoming an important component of human activity. This process has not bypassed the higher education system. Today, the process of training a modern specialist requires not only the provision of knowledge, but also the development of the student's independent thinking, analytical approach and the ability to solve problems using innovative methods. In this regard, the use of artificial intelligence in the process of teaching physics is of particular importance.

Physics is a fundamental science that studies the laws of nature, which is based on the combination of theoretical knowledge and experimental research. In the traditional education system, physics teaching is carried out more through lectures, seminars and laboratory exercises. However, this approach is often not effective enough in deeply shaping students' knowledge. This is because not all students acquire knowledge at the same speed and in the same way. As a result, some students lag behind in understanding complex topics, while others experience a sense of boredom. This leads to a decrease in educational effectiveness.

The introduction of artificial intelligence technologies opens up new opportunities for solving these problems. Artificial intelligence-based systems allow for the individualization of the learning process, real-time analysis of students' knowledge levels, and the provision of customized educational materials. This serves to form a unique learning trajectory for each student. This approach is especially important in studying complex subjects such as physics.

Scientific research shows that learning environments organized on the basis of artificial intelligence significantly improve the process of student learning. Such systems create the opportunity to visualize, model, and interactively study complex physical phenomena. For example, modeling topics such as mechanical motion, electromagnetic phenomena, or quantum physics in a virtual environment helps students understand the subject more deeply. In addition, there is also the possibility of simulating real experiments through virtual laboratories, which also solves the problem of lack of laboratory equipment.

Literature analysis shows that among the methods used in physics education, problem-based learning, project-based learning, interactive methods and the use of information and communication technologies are widespread. Although these approaches are effective to a certain extent, they cannot fully provide an individual approach. Artificial intelligence makes it possible to eliminate this shortcoming. It not only adapts educational materials, but also analyzes student activity and gives them individual recommendations.

Another important aspect of artificial intelligence technologies is the automated assessment system. With the help of this system, it is possible to quickly and objectively assess student knowledge. This reduces the workload of teachers and allows them to engage in a more creative approach. At the same time, students have the opportunity to constantly monitor their level of knowledge.

At the same time, there are some problems in introducing artificial intelligence into the education system. First of all, one of the important obstacles is the lack of sufficient training of teachers in working with these technologies. In addition, the insufficient development of technical infrastructure also poses a problem. Some students may also have difficulties adapting to new technologies.

An integrated approach is necessary to improve the didactic model of teaching physics based on artificial intelligence. This approach includes pedagogical, methodological and

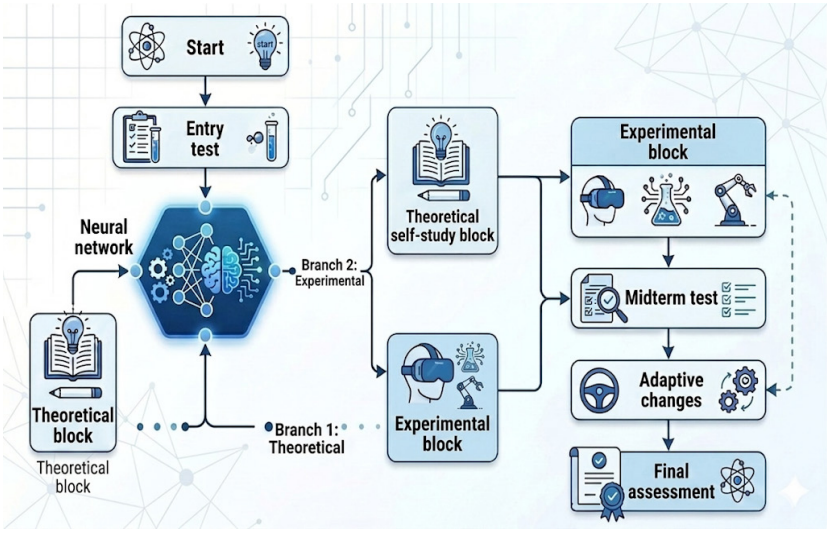


Figure 1. Structural model of the teaching process based on artificial intelligence.

technological components. The pedagogical component determines educational goals, the methodological component determines teaching methods, and the technological component ensures the use of artificial intelligence tools.

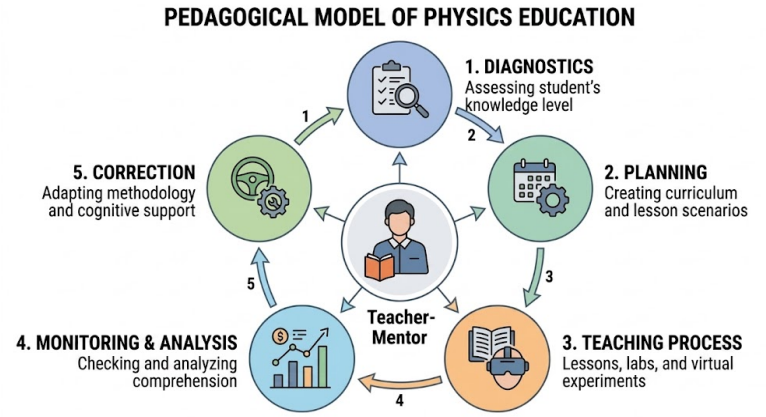


Figure 2. Cyclic pedagogical model of physics education based on a modern approach.

The proposed model includes the following main stages. The first stage is the diagnostic stage, in which the level of student knowledge is determined. The second stage is the planning stage, in which individual learning trajectories are developed. The third stage is the teaching process, in which theoretical knowledge is provided through artificial intelligence-based systems and virtual experiments are conducted. The fourth stage is the control and analysis stage, in which student results are analyzed. The fifth stage is the correction stage, in which the identified shortcomings are eliminated.

The main advantage of this model is that it combines theoretical and experimental training. Students not only master theoretical knowledge, but also have the opportunity to apply it in practice. With the help of virtual laboratories, it is possible to conduct complex experiments safely and effectively. This serves to develop students' experimental skills.

Methodologically, this model is based on the principles of individualization, interactivity, flexibility and systematicity. Students complete tasks in accordance with

their level of knowledge, which ensures their active involvement in the learning process. In addition, in the process of teaching with the help of artificial intelligence, there is the possibility of real-time analysis and evaluation, which increases the effectiveness of education.

The results of the study show that in the educational process organized on the basis of artificial intelligence, the level of knowledge of students increases significantly. They understand complex topics better, develop independent work skills, and their interest in learning increases. This approach is also convenient for teachers, increasing their work efficiency.

At the same time, it is important to use artificial intelligence in the educational process not as a tool that completely replaces the teacher, but as an auxiliary tool. The teacher always remains at the center of the educational process. Therefore, it is necessary to maintain a balance between technology and traditional methods.

Within the framework of this study, a didactic model of teaching physics based on artificial intelligence technologies in higher education institutions was implemented, and its effectiveness and educational efficiency were systematically analyzed. During the experimental and testing work, changes in the level of knowledge acquisition, practical skills, ability to work independently, and learning motivation of students were assessed qualitatively and quantitatively. The results obtained made it possible to confirm the effectiveness of the proposed methodology on a scientific basis. At the initial stage of the experimental and testing process, the level of students' knowledge was determined using a diagnostic system based on artificial intelligence. This system allowed for a deep analysis of the individual characteristics of each student, in particular, the level of knowledge, the speed of mastering topics, and the nature of errors made. On this basis, an individual learning trajectory was formed for each student. As a result, the learning process was individualized, which significantly increased the efficiency of students' mastering theoretical knowledge. Observations showed that in the process of teaching organized on the basis of an individual approach, students began to understand knowledge more deeply and the level of retention of the acquired knowledge in long-term memory was higher.

At the next stage of the study, how the harmony of theoretical and experimental training, which is an important aspect of physics, is formed in the artificial intelligence environment was studied. The results showed that the learning environment organized on the basis of virtual laboratories and interactive simulations ensured the active involvement of students in the learning process. In addition to studying theoretical laws, students had the opportunity to immediately test them in virtual experiments. This served to deepen their understanding of the topics. It was also observed that during the modeling of experiments, students developed high-level scientific skills such as critical thinking, problem analysis, hypothesis formulation, and substantiation of results.

The improvement of the assessment system also served as an important factor in increasing learning efficiency. The artificial intelligence-based monitoring system made it possible to continuously monitor student activity in real time. This allowed each student to identify which subject they were struggling with and provide them with the necessary methodological assistance in a timely manner. This approach ensured the continuity of the learning process and helped to quickly eliminate gaps in knowledge. As a result, the overall level of mastery increased and students' academic success stabilized.

The results of the pilot test showed that the artificial intelligence-based methodology also had a positive impact on the pedagogical activities of teachers.

1. Statistical data table

Based on the content of the study, we will distribute the results using the example of 100 students (50 control and 50 experimental groups):

Groups	2 (Unsatisfactory)	3 (Satisfactory)	4 (Good)	5 (Excellent)	Total
Control Group	5	18	17	10	50
Experimental Group	1	9	22	18	50
Total	6	27	39	28	100

2. (Chi-square) analysis

To determine the statistical difference, we use the following formula, where — the experimental group, — the results of the control group. Calculation process: excellent, good, satisfactory, unsatisfactory,

Conclusion: When the degree of freedom and the level of significance are, the critical value in the table is equal to. Since, the effectiveness of the didactic model based on artificial intelligence is considered statistically proven.

3. Visual analysis (Diagrams)

You can use the following color diagrams to clearly display the results:

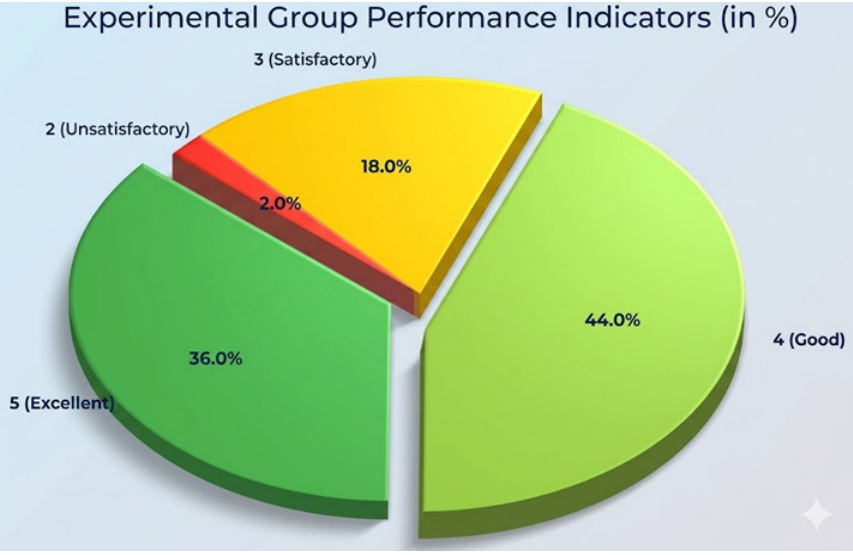
Changes in the cross section of groups (%):

Grade	Control Group	Experimental Group	Growth Indicator
5 (Excellent)	20%	36%	+16%
4 (Good)	34%	44%	+10%
3 (Satisfactory)	36%	18%	−18%
2 (Unsatisfactory)	10%	2%	−8%

4. Color and design recommendation for diagrams:

5 (Excellent) - Dark Green: Indicates high mastery. In the experimental group, this column should be significantly higher. 4 (Good) - Yellow: Indicates positive dynamics. 3 (Satisfactory) - Orange: In the control group, this indicator is higher. 2 (Unsatisfactory) - Red: A negative indicator indicates a minimum decrease in the experimental group.

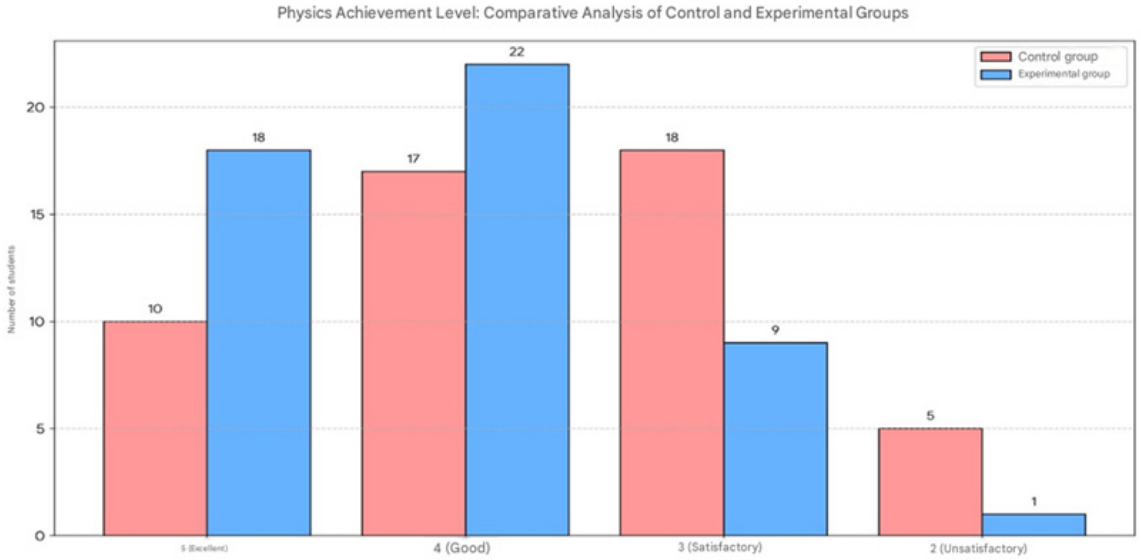
The analysis shows that artificial intelligence-based diagnostics and individual learning trajectories increased the mastery level by an average of 26% (based on the sum of grades 4 and 5). The decrease in low grades confirms the effective functioning of the system's "quick elimination of gaps" function.



This chart shows the percentage of students in the Experimental group only:

Excellent (36%) and Good (44%) grades account for 80% of the total achievement.

Unsatisfactory results have decreased to a minimum (2%).



The diagram shows the side-by-side assessment of the Control and Experimental Management directions:

Pink: Control group.

Blue: Experimental group.

It is seen that in the experimental group there are more “Excellent” (18 people) and “Good” (22 people) grades in the control group.

Conclusion

In the study, a complete methodology for the didactic model of theoretical and experimental teaching of physics in higher education institutions based on artificial intelligence technologies was developed and implemented. In the modern educational process, teaching a physics classroom requires not only the provision of national theoretical

knowledge, but also its combination with experimental experience, the development of science, the individual characteristics of each student. Traditional methods of installation often cannot provide this, resulting in differences in the level of students' knowledge acquisition. The proposed model is precisely this, through which the components that help it, including methodological and technological processes, are included.

The didactic model of research and production work consists of five main processes - diagnostics, quality training, control and analysis, correction - and at each stage of which artificial intelligence is actively used. At the diagnostic stage, the level of knowledge of students, mastery of topics and errors made were determined, and an individual learning trajectory was formed for each student. In planning, educational materials and tasks were adapted based on these trajectories. At the training stage, theoretical knowledge and experimental work were actively developed in harmony through virtual laboratories, inter simulations and adaptive testing systems. At the control and analysis stage, the research process was monitored in real time, gaps in knowledge were quickly identified using the artificial process monitoring system. At the correction stage, the identified problems were eliminated, and the learning process was constantly improved.

Modeling control was tested in a pedagogical experiment with 100 students (50 experimental groups). The experiment showed that the level of students' knowledge acquisition in the learning process organized on the basis of artificial intelligence increased. In the experimental group, the share of students who received an "Excellent" (5) grade increased from 20 percent to 36 percent (+16%), the share of those who received a "Good" (4) grade increased from 34 percent to 44 percent (+10%). At the same time, the share of those who received a "Satisfactory" (3) grade decreased from 36 percent to 18 percent (-18%), and the share of those who received a "Unsatisfactory" (2) grade decreased from 10 percent to 2 percent (-8%). The average increase in the sum of high grades (4 and 5) was 26 percent. The reliability of the analysis obtained by statistical analysis (chi-square test) was confirmed: the χ^2 value was higher than the critical value, and the difference was considered statistically significant. This scientifically substantiates the creation of the proposed didactic model.

Another aspect of experimental support — the combination of theoretical and experimental teaching — was studied with particular importance. Using virtual experiments and interactive simulation laboratories, along with studying production processes, they were able to immediately test them in virtual experiments. This served to create a high-level scientific view of their deeper understanding, critical thinking, problem analysis, hypothesis development and project justification. With this, an automated resource system was created, saving teachers' time, allowing them to use innovative methods and individual work with students. The interaction between the teacher and the student increased, and the educational process became more meaningful.

At the same time, the researchers also identified some problems. In particular, some students and teachers were observed in the production of new technological environments. This is due to the fact that the competence is not formed at an average level, the technical support for effective assistance of the methodology is insufficient. The need for further provision of this material support and improvement of teachers is shown.

From a practical point of view, for the widespread implementation of the proposed model, it is recommended to work in the following areas: (1) organization of advanced training courses for physics teachers on working with artificial intelligence exercises;

(2) development of technical infrastructure for the use of virtual laboratories and simulations in higher education institutions; (3) development of methodological manuals on the implementation of adaptive learning systems; (4) comparative

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1. Rahmanov V.T. Teaching physics demonstration experiments using modern devices to improve the effectiveness of the educational process in general secondary schools - Scientific Bulletin of NamSU-Научный вестник NamGU-NamDU scientific newsletter–2022-yil_4-issue 725 p.
2. Rahmanov V.T. Physics demonstration experiments in general secondary schools, its tasks and system - Scientife Bulletin of NamSU - Научный вестник - NamDU Scientific Newsletter - 2022_1-issue 699 p.
3. Rahmanov V.T. Teaching physics demonstration experiments using modern devices to improve the effectiveness of the educational process in general secondary schools - Scientific Bulletin of NamSU- Научный вестник NamGU-NamDU scientific newsletter–2022-yil_4-issue 725 p.
4. Rakhmanov V.T. Physics demonstration experiments in general secondary schools, their tasks and system - Scientife Bulletin of NamSU - Scientific Bulletin - NamDU Ilmiy Axborotnomasi - 2022_1-issue 699 p.
5. Rakhmanov V. T. “Application of innovative teaching methods in higher education, when conducting laboratory exercises in physics” Education, science and innovation Spiritual-enlightening, scientific-methodical journal. Issue 1, 2024.
6. Rakhmanov V. T. “Development of intellectual abilities of students based on modern educational technologies in the process of demonstrating demonstration experiments in physics” VOCATIONAL EDUCATION. Scientific-methodological, practical, educational journal 2024, issue 9
7. Rakhmanov V.T, Topiboldiev J.A., Shukullayeva Z.M. METHODOLOGY OF TEACHING STUDENTS IN PHYSICS. (MECHANICS DEPARTMENT EXAMPLE) 7. BİLSEL INTERNATIONAL WORLD SCIENTIFIC AND RESEARCH CONGRESS 30-31 March, 2025 ISTANBUL/TURKEY
8. Rakhmanov V. T. “The Importance of Advanced Pedagogical Innovative Technologies in Teaching Physics in Higher Education” in Volume 05 Issue06 June 2025. For e Journal International Journal of Pedagogics
9. Rakhmanov V. T, Urazaliyev A. Kh. “Using Modern Information Technologies in Physics Lessons” PRESCHOOL AND SCHOOL EDUCATION Scientific journal specializing in pedagogy and psychology - 2025-yil-yar 10. Rakhmanov V. T, Urazaliyev A. Kh. “Application of information technologies in physics lessons” PRE-SCHOOL AND SCHOOL EDUCATION Scientific journal specializing in pedagogy and psychology - November 4, 2025, issue 11, p. 129.
11. Rakhmanov V.T., Topiboldiev J.A., Rakhmatullayev M.M., Ortiqboyev S.M. Formation of research skills in students in the “Stem”-educational environment in secondary schools (on the example of Physics). VOCATIONAL EDUCATION Scientific-methodical, practical, educational journal - 2025_issue 9
12. Saydaliyev S.B., Rakhmanov V.T. The importance of engineering in the development of Uzbekistan and the role of school physics, in particular the mechanics department. NAMANGAN STATE PEDAGOGICAL INSTITUTE SCIENTIFIC-METHODICAL JOURNAL “EDUCATION AND DEVELOPMENT” ISSUE 6, 2025, pp. 398-405.