

RESEARCH ARTICLE

Improving the Methodology of Teaching Physics in Specialized Schools

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Abstract

This article examines the pedagogical and methodological aspects of improving the methodology of teaching physics in specialized schools. The study examined the impact of modern educational technologies, the STEAM approach, virtual laboratories, ICT tools, and interactive methods on the effectiveness of physics education. The importance of innovative methods in increasing students' interest in physics, activity in the lesson process, and knowledge level was also analyzed. The research results showed that modern pedagogical approaches are an important factor in developing students' scientific thinking, independent thinking, and practical skills.

KEYWORDS

Physics education, specialized school, STEAM, virtual laboratory, ICT, interactive methods, PhET simulation.

INTRODUCTION

The large-scale reforms being implemented in the education system today define improving the quality of education, developing the scientific worldview of students, and forming modern competencies as important tasks [1,12]. The issue of in-depth study of natural sciences, including physics, is becoming particularly relevant in specialized schools [3,6]. This is because physics is one of the main subjects in developing students' logical thinking, scientific thinking, and technical and engineering skills.

Modern education requires students not only to acquire theoretical knowledge but also to be able to apply the acquired knowledge in practice [7,14], analyze problem situations, and have the skills to make independent decisions. Therefore, alongside traditional methods in teaching physics, there is a growing need to use innovative pedagogical technologies,

interactive methods, and digital tools [4, 6].

In recent years, the use of STEAM approaches, virtual laboratories, PhET simulations, AR/VR technologies [2], and ICT tools [5] in physics education has become increasingly popular. These technologies allow for the visual explanation of complex physical phenomena, the organization of experiments in a safe and comfortable environment, and the development of students' independent research skills. In particular, virtual simulations facilitate the practical understanding of physical laws and increase student engagement in the lesson [1,4].

The main goal of teaching physics in specialized schools is to form the scientific worldview of students, prepare them for working with modern technologies, identify talented youth, and develop their scientific potential. From this perspective, it

is important to organize physics lessons based on innovative methods [8,15] and to combine them with practical exercises.

In the system of specialized schools, special attention is paid to the in-depth study of physics. In addition to theoretical knowledge, these schools also organize laboratory classes, preparation for Olympiads [14, 7], scientific projects, and integrated STEAM-based lessons. This serves as an important factor in increasing students' interest in research activities.

The aim of this study is to analyze the methodology of teaching physics in specialized schools, determine the effectiveness of modern pedagogical technologies, and develop methodological recommendations for improving physics education.

The study utilized methods of pedagogical observation, interviews, questionnaires, and analysis. The results obtained showed that innovative approaches to teaching physics are of great importance in enhancing students' knowledge, developing scientific thinking, and forming practical skills.

METHODS

The study utilized methods of pedagogical observation, interviews, questionnaires, comparison, and statistical analysis. The Specialized School was selected as the object of the research. To determine the organizational and methodological effectiveness of the physics teaching process in the specialized school, a comprehensive survey and pedagogical observation studies were conducted. During the research process, students in grades 9 - 11, physics teachers, and laboratory sessions were fully covered. The total number of participants was 60 students and 5 teachers. Observations were conducted over 2 weeks, analyzing 8 physics lessons and 3 laboratory sessions.

In this study, a number of pedagogical research methods were used to determine the effectiveness of physics teaching methodology in specialized schools and to develop ways for its improvement. The research process was carried out on the basis of theoretical analysis, practical observation, and experimental work.

At the initial stage of the study, scientific sources on scientific and methodological literature on physics education, state educational standards, curricula, and modern pedagogical technologies were studied. On this basis, the significance of innovative approaches in teaching physics and existing methodological problems were analyzed.

The method of pedagogical observation was widely used during the study. Physics lessons were observed, and teachers' methods of organizing the lesson, the level of use of interactive methods, and student activity in the lesson were analyzed. In the course of observations:

- methodological structure of the lesson;
- organization of laboratory sessions;
- State of use of ICT tools;
- students' independent work skills;
- participation in Q&A

aspects such as.

Interviews and survey methods were also used between students and teachers. Through questionnaires, students' interest in physics, difficulties in mastering complex topics, their attitude toward laboratory sessions, and their opinions on classes organized based on modern technologies were studied. During conversations with teachers, methodological problems encountered in physics education and ways to address them were discussed.

Methods of comparison and analysis were also used in the study. The effectiveness of lessons organized on the basis of traditional teaching methods and innovative pedagogical technologies was compared. In particular, the results of lessons using the STEAM approach, virtual laboratories, PhET simulations, and interactive methods were compared with traditional lessons.

During the practical research, it was observed how classes organized on the basis of virtual laboratories and simulations affect the level of students' mastery of the topic and their activity in the lesson. In particular, it was found that the use of virtual models and experiments in the sections of mechanics, electrical phenomena, optics, and electromagnetism has yielded effective results.

Furthermore, during the research process, the method of statistical analysis was used, and students' knowledge indicators, test results, and questionnaire data were summarized. The results obtained were analyzed in the form of diagrams and tables, and the positive impact of innovative methods on educational efficiency was determined.

The methodological basis of the study consists of scientific views on modern pedagogy, physics teaching methodology, the competency-based approach, and innovative educational

technologies. On this basis, scientific and methodological recommendations aimed at improving the methodology of teaching physics were developed.

According to the research results, it was found that in lessons using interactive methods and virtual laboratories, student activity and the level of subject mastery increased significantly (Table 1).

RESULTS

Table 1

Nº	Date	Class	Subject	Lesson type	Methods used	ICT tools	Student activity	Observation result
1	12.02-10.03	9	Mechanical motion	New knowledge	Question-answer, problem-based method	Interactive whiteboard	Upper	The lesson is effective
2	14.02-10.03	10	Electric current	Laboratory	Experimental method	Sensors	Upper	Students are active
3	18.02-22.03	8	Pressure	Mixed lesson	Group work	Video material	Medium	Activity increased

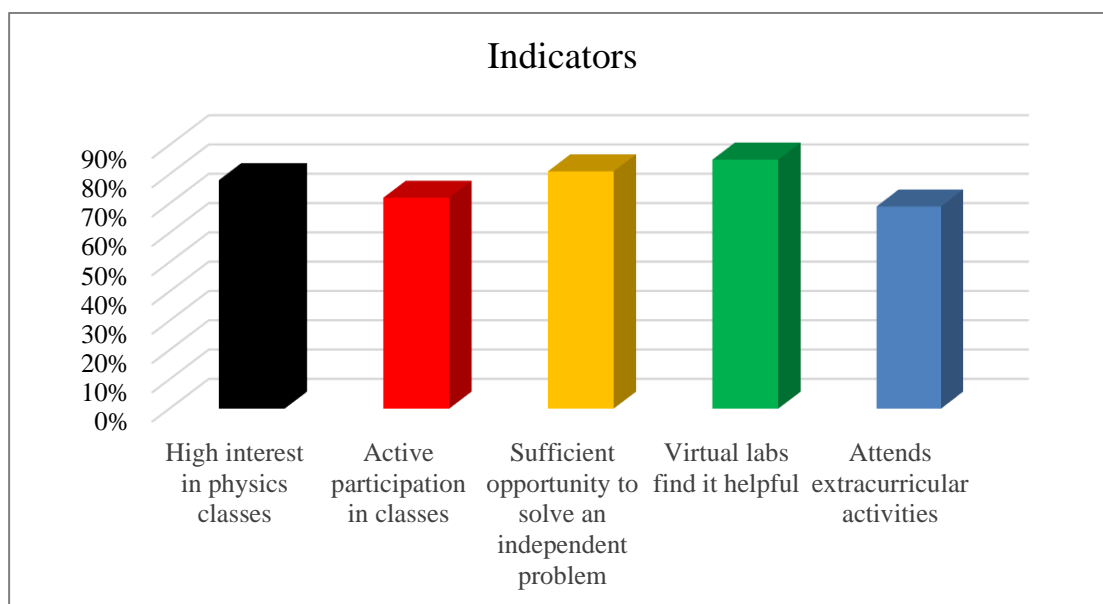
In the survey results:

1. Observations conducted among students were aimed at

determining the organization of physics lessons, the effectiveness of methods, and the level of student interest. The results are presented in Table 2 and the diagram.

Table 2.

Indicators	Result (%)
High interest in physics classes	78%
Active participation in classes	72%
Sufficient opportunity to solve an independent problem	81%
Virtual labs find it helpful	85%
Attends extracurricular activities	69%



2. Results of the teacher survey

The results of the survey conducted among teachers showed the following:

- 100% of teachers believe that ICT and virtual laboratories increase lesson effectiveness;
- 80% of teachers rated the problem-based learning method as the most effective;
- 60% of teachers noted that the greatest difficulty for students is solving complex problems independently.

3. Direct observation of the educational process and laboratory sessions. The results of the survey revealed the following aspects:

- Student activity in class is at an average level of 75-80%.
- Participation rate in group work is 70%;
- The completion rate of laboratory assignments was 82%.
- The share of active participants in Olympic training showed a trend of growth from 55% to 68%.

Including:

- increased interest of students in physics;
- active participation in laboratory sessions;
- improved understanding of complex physical phenomena.

It was determined that the organization of physics clubs in specialized schools in theoretical, practical, and olympic directions is an important factor in developing the scientific potential of students. Engaging in complex problems, non-standard tasks, and laboratory work in physics clubs develops students' analytical thinking skills.

It was also observed that integrating elements of physics, robotics, and programming in STEAM-based classes develops students' creative thinking.

DISCUSSION

The results of this study demonstrated that the use of modern pedagogical technologies and innovative methods in teaching physics in specialized schools significantly increases educational efficiency. In particular, the integration of the STEAM approach [18], virtual laboratories [20], PhET simulations [10], ICT tools, and interactive methods into the lesson process has made it possible to link students' theoretical knowledge with practical activities [20].

The analysis showed that in traditional teaching methods, students participate more as listeners and primarily receive knowledge in a ready-made form. In lessons using innovative methods, students are involved in the process as active participants. This develops their skills in independent thinking, analysis, problem-solving, and drawing scientific conclusions [9].

As a result of observations and surveys conducted during the study, the majority of students noted that studying physical phenomena through virtual simulations and laboratory experiments is more effective than traditional explanatory methods. In particular, visually demonstrating complex topics such as electrical phenomena, optics, mechanics, and electromagnetism helped students gain a deeper understanding of the topic.

Another important aspect of using virtual laboratories and PhET simulations is the creation of a safe and cost-effective learning environment [18]. Performing some physical experiments in a real laboratory requires a large material base or complex equipment [12]. Virtual platforms allow such experiments to be carried out on a computer or mobile device. As a result, students take an active part in the experimental process and understand physical laws on a practical basis.

During the discussion, the importance of the STEAM approach was also emphasized. Integrating physics with elements of mathematics, technology, programming, and engineering serves to develop students' creative and technical thinking. In particular, classes related to robotics, Arduino platforms, and technological projects [16] serve as an effective tool for forming students' practical competencies.

During the study, it was established that the use of interactive methods in lessons increased students' activity during the lesson. Methods such as cluster, brainstorming, project-based learning, and problem-solving have increased students' interest in the topic. Additionally, working in small groups developed students' competencies in teamwork, exchange of ideas, and communication.

Additionally, certain problems were identified during the study. In particular, it was noted that all schools lack modern laboratory equipment and digital technologies, and the competence of some teachers in using ICT tools is insufficiently developed. This creates certain difficulties for the full implementation of innovative methods.

Based on the analysis, it can be stated that the widespread

introduction of modern pedagogical technologies in teaching physics, the enhancement of teachers' professional competencies, and the development of digital educational resources serve to further improve the quality of education. Especially in specialized schools, the organization of physics based on practical and innovative approaches is an important factor in the development of students' scientific thinking.

CONCLUSION

In conclusion, the use of modern pedagogical technologies and innovative methods in teaching physics in specialized schools is of great importance in increasing the effectiveness of education. The research results showed that the STEAM approach, virtual laboratories, PhET simulations, and ICT tools increase students' interest in physics and help connect theoretical knowledge with practice.

Based on observations and analyses conducted at the specialized school, it was determined that the use of interactive methods develops students' activity in class, independent thinking, and problem-solving skills. It was also noted that physics clubs and laboratory classes are an important tool for developing the scientific potential of gifted students.

During the study, problems such as the lack of modern laboratory equipment and ICT tools were observed in some schools. Therefore, the widespread introduction of digital technologies in physics education, the enhancement of teachers' professional competencies, and the effective use of innovative methods serve to further improve the quality of education.

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