

RESEARCH ARTICLE

Organizing Profession-Oriented Physics Education and Its Advantages

A.R. Turgunov

Namangan State Technical University, Uzbekistan

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Abstract

This article analyzes the effectiveness of profession-oriented physics teaching, its methodological foundations, and the possibilities for integration with industry. The primary objective of the research is to identify and evaluate innovative approaches that enable students to acquire not only theoretical knowledge but also practical and professional skills during the process of learning physics. Within the scope of the study, empirical observations were conducted using project-based learning, group work, laboratory sessions, and practical assignments. The experiment was carried out with the participation of students from Namangan State Technical University. The results of the observations revealed that profession-oriented instruction significantly enhances students' motivation toward physics and improves their subject-related professional competencies. This approach, based on the integration of education and industry, allows for more effective structuring of academic curricula. The findings of this research may serve as a valuable resource for developing practical recommendations on profession-oriented physics instruction using modern pedagogical technologies, as well as for improving vocational education.

KEYWORDS

Physics education, profession-oriented teaching, industry-based projects, practical training, technical thinking, innovative methodology, student motivation, problem-based approach.

INTRODUCTION

In the context of globalization and the rapid advancement of industrial technologies, the teaching of physics in higher technical education institutions demands new pedagogical approaches. Physics plays a fundamental role in the training of technical specialists by developing students' analytical thinking, enabling them to assess and solve technical problems based on scientific principles. In particular, the concept of profession-oriented teaching necessitates a strong integration of physics education with practical application.

Although certain reforms have been implemented in higher education in Uzbekistan, particularly in technical universities, the systematic integration of profession-oriented physics

instruction remains underdeveloped. Current educational processes insufficiently incorporate industry needs, integration with production environments, and project-based approaches [1].

The aim of this study is to develop profession-oriented methodological approaches for teaching physics, implement them in practice, and evaluate their impact on the educational process. The subject of the research is the content and teaching methodology of physics in technical education, while the object is the students of Namangan State Technical University. The main hypothesis posits that if physics is taught using profession-oriented methods, students' motivation,

practical competencies, and professional preparedness will improve.

Literature Review (Theoretical Foundations)

Global Experience: Physics and STEM, Competency-Based Approaches

In recent years, physics education worldwide has been increasingly shaped by the STEM (Science, Technology, Engineering, Mathematics) approach. This model serves not only to impart theoretical knowledge but also to develop skills in solving real-world problems, creativity, and critical thinking. Specifically, in countries such as the United States, Finland, and Japan, physics lessons are conducted based on industry-oriented projects closely aligned with the needs of the industrial sector [2;3]. The competency-based approach focuses on the integration of students' knowledge, skills, and attitudes, becoming a fundamental paradigm in modern physics education [4].

Research on physics education within the higher education system of Uzbekistan predominantly focuses on theoretical approaches, instructional manuals, and interactive forms of teaching. Although existing studies highlight the effectiveness of teaching physics using modern methods, most of them do not adequately address factors related to profession-oriented instruction [5]. At the same time, there is a lack of comprehensive empirical research on physics education integrated with industrial production.

Concept of Profession-Oriented Education. Profession-oriented education is a learning process aimed at developing practical knowledge and skills aligned with a student's future profession. However, this approach is still not widely applied in the teaching of physics. In countries such as Germany, South Korea, and Singapore, physics lessons are conducted in close connection with industrial environments. This approach prepares students for professional settings and provides them with a clear understanding of their chosen field [6;7]. Gradual implementation of this concept, especially in technical universities in Uzbekistan, remains a pressing issue.

Pedagogical Foundations of Industry-Oriented Physics Education. Importance of Profession-Oriented Teaching

The methodology of industry-oriented teaching significantly enhances students' motivation and engagement [8]. Through

the integration of practical and theoretical knowledge, students actively participate in the educational process. They connect their studies with professional goals and strive to adapt their knowledge to real-world conditions. As a result of group work, projects, and practical exercises, their activity and responsibility increase. Moreover, this approach helps students develop professional competencies and prepares them to apply their knowledge in practice. Consequently, the overall effectiveness of the learning process improves.

Integration between Education and Industry

Students test their knowledge in practice by working on real industrial problems and grasp physical laws through problem-based scenarios. During lessons, group discussions, presentations of solutions, and critical analyses help develop students' critical thinking and collaboration skills. The primary goal of industry-oriented classes is to prepare students to apply their theoretical knowledge in practical industrial settings. Education relying solely on theoretical knowledge may be insufficient for modern professional activities. Therefore, it is essential to link lessons with industrial problems and technological processes [9]. This approach enables students to apply their knowledge in practice, develop technical thinking, and enhance problem-solving skills.

The Role of the Approach in Training Competitive Personnel

Industry-oriented classes familiarize students with real working conditions, strengthen their professional competencies, and lay the foundation for becoming competitive specialists in the labor market [10]. This educational approach directs students towards a deep understanding of technological processes, the development of innovative solutions, and independent creative thinking. Moreover, practical training, project work, and problem-solving conducted in collaboration with industrial enterprises significantly enhance students' professional skills. As a result, industry-oriented teaching becomes an essential tool for improving education quality, increasing students' interest in natural sciences, and facilitating adaptation to modern technologies and production processes. This approach also plays a crucial role in developing scientific and practical skills, bringing the learning process closer to real-life conditions, and advancing professional preparedness to a new level.

Integration of Innovative Methods and Technologies

By organizing an industry-oriented educational process, students gain the opportunity to connect theoretical knowledge with practical industrial problems. This approach integrates modern technologies, software tools, and real industrial experiences into

the educational process (see Figure 1). This method ensures high effectiveness in preparing students for their future professional activities.

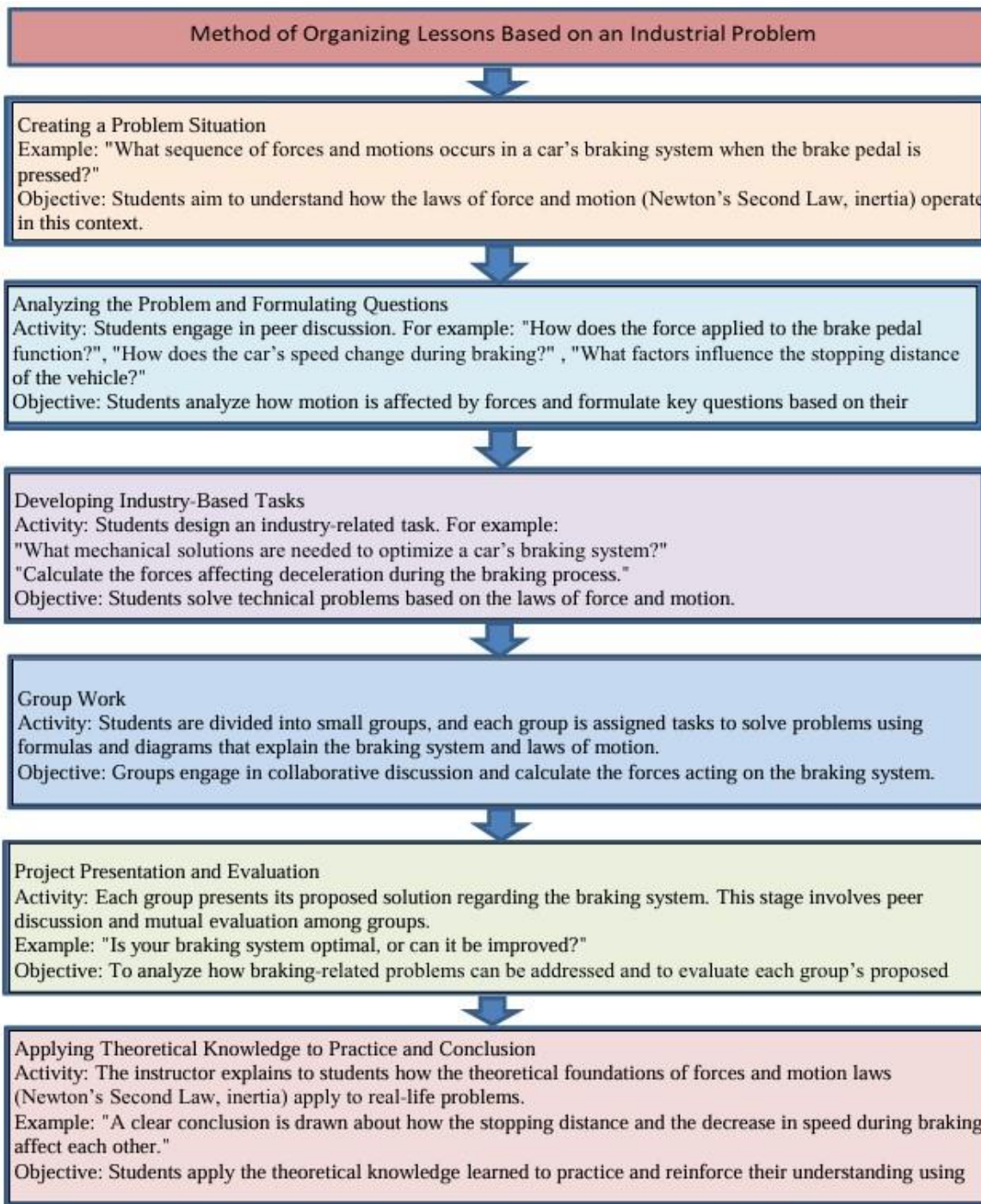


Figure 1. Organizing the Lesson Process Based on Problem Situations and Industrial Tasks.

The application of an industry-oriented problem-based approach in laboratory sessions plays a crucial role in preparing students for their professional careers. During the lessons, students are introduced to situations based on real industrial problems that require the practical application of physical laws to solve. This approach encourages active thinking, understanding of cause-and-effect relationships, and the integration of theoretical knowledge within a technical context. Consequently, it enhances the effectiveness of education in training engineers and technical specialists equipped with modern competencies that meet industry needs.

The methodological comparison of traditional and industry-oriented approaches in teaching physics is presented in Table

1.

Comparison Criteria	Traditional Education	Industry-Oriented Teaching
Content of Education	Theoretical knowledge dominates	Integrated with practical application
Student Activity	Passive participant	Active participant, project executor
Motivation	Low, often dependent on external incentives	High, oriented towards professional goals
Teacher's Role	Main source of information	Guide, mentor, facilitator
Level of Mastery	Based on memorization	Focused on understanding and practical use

Industry-oriented teaching increases students' motivation and professional activity. Through the integration of theory and practice, as well as project and group work, professional competencies are developed. Students are engaged in solving problems close to real production conditions, which enhances their responsibility and practical skills. This methodology significantly improves teaching effectiveness [11].

The main components of the "industry-based project method" in teaching physics are presented in Figure 2. Each component serves to connect physics knowledge with practical industrial processes, as well as to develop creative thinking and problem-solving skills. The diagram illustrates project-based learning, interactive methods, collaboration with industry, use of modern technologies, assessment systems, and motivation processes.

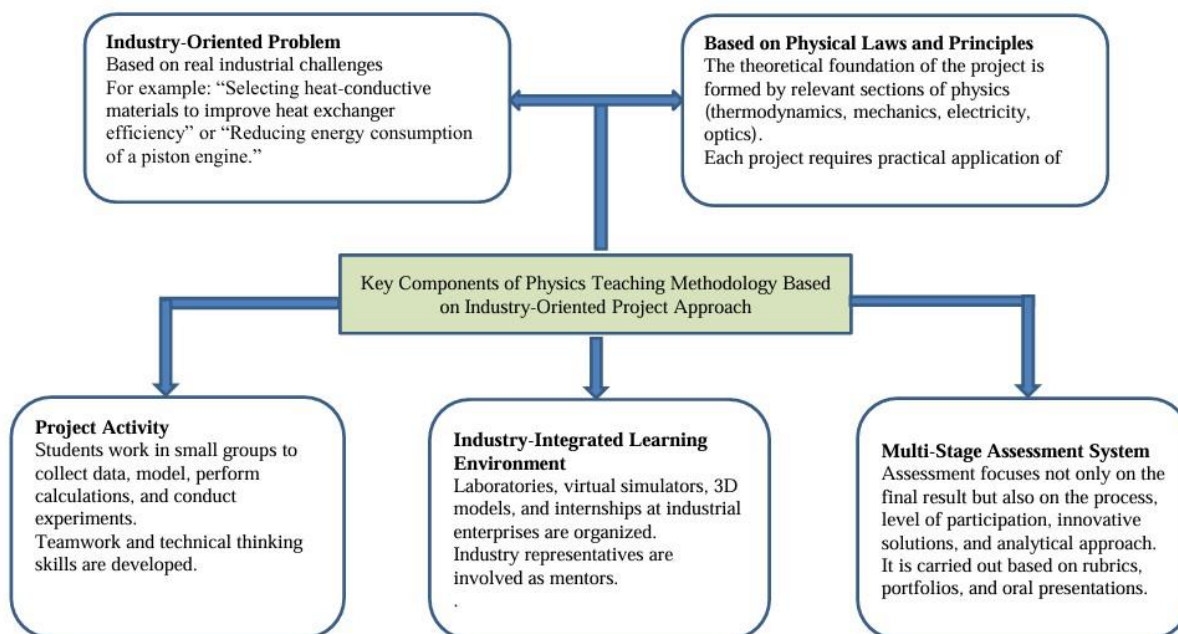


Figure 2. Components of the Industry-Oriented Physics Teaching Methodology

To ensure the effectiveness of the industry-oriented project method in teaching physics, the curriculum must be revised based on modern production requirements. This necessitates a critical review of traditional topics and the selection of subjects related to technologies, equipment, and processes used in the industry. Particular attention should be given to areas such as energy efficiency, heat transfer, electromechanics, materials science, sensor systems, and automated control. The updated

curriculum will develop students' skills in solving physics problems based on real industrial objects. Furthermore, integrating industry-related tasks, project work, and laboratory sessions ensures a strong connection between theory and practice and brings students closer to the industrial environment.

The process of implementing the industry-based project method for teaching physics into the educational process involves several stages. For this methodology to be effective, each stage must be carried out correctly and consistently. Figure 3 below presents the main recommendations developed for the implementation of the industry-based project method in teaching physics.

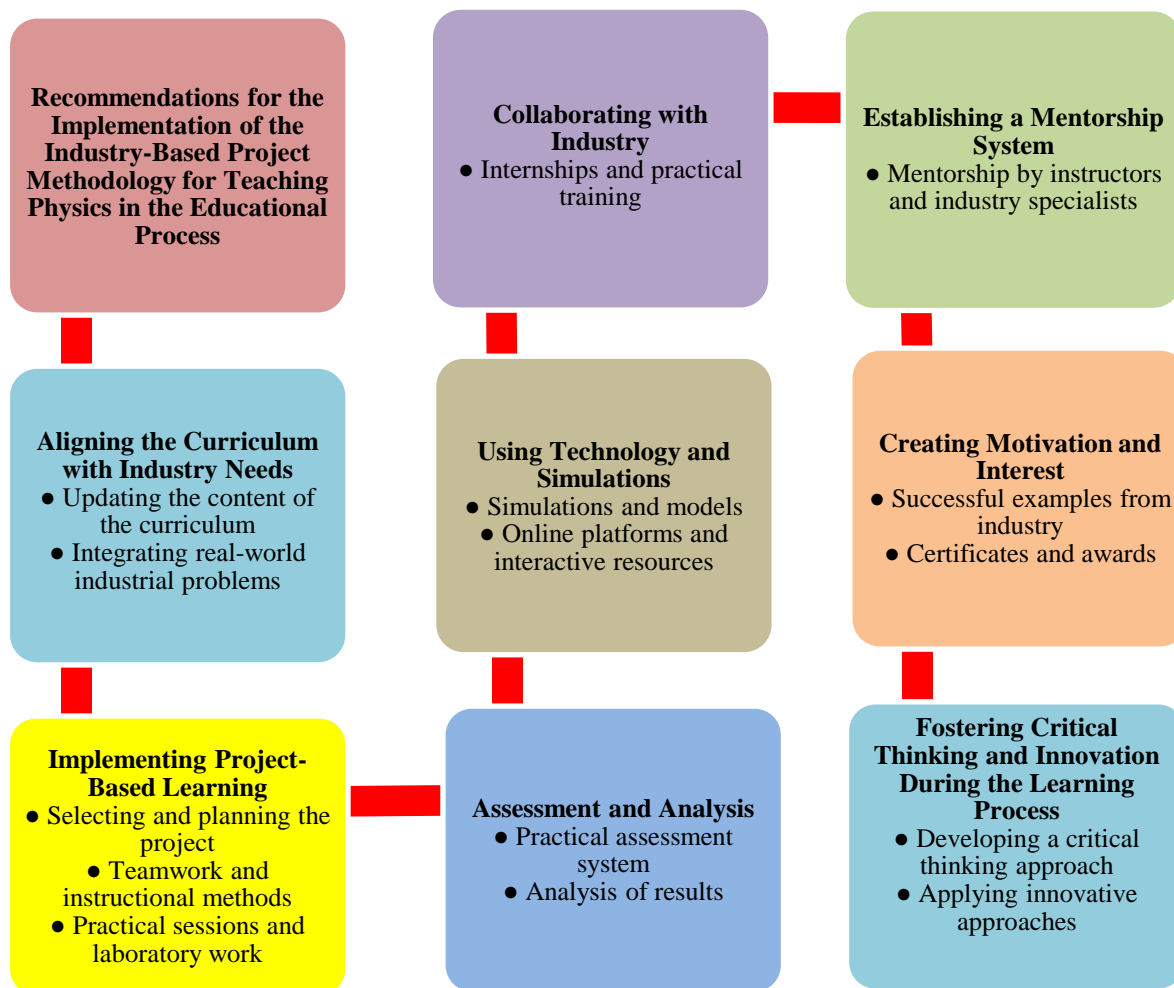


Figure 3. Directions for Implementing the Industry-Based Project Method in the Teaching Process

Adapting the Curriculum to Industry Needs

To increase the effectiveness of teaching physics using the industry-based project method, the curriculum must be aligned with modern industrial requirements. This involves critically analyzing traditional physics topics and selecting subjects related to widely used technologies, equipment, and processes in the industry. In particular, physical principles in areas such as energy efficiency, heat exchange, electromechanical devices, materials science, sensor systems, and automated control should be studied in greater depth. The updated curriculum directs students to analyze and solve problems based on real industrial challenges. Additionally, incorporating professionally oriented tasks, projects, and industry-related laboratory sessions into the educational process harmonizes theory and practice, directly connecting students with the industrial environment [12].

Optimizing the curriculum by taking into account industry needs not only strengthens interdisciplinary integration but also demonstrates the relevance and practical value of physics for students. This, in turn, increases students' motivation toward their studies and contributes to the development of practical competencies.

Scientific and practical recommendations for adapting the physics curriculum to industry needs are presented in Table 2.3.1.

Recommendations for Adapting the Physics Curriculum to Industry Needs
<i>Selecting Topics Based on Analysis of Industry Sectors.</i> It is necessary to include relevant topics in the physics curriculum related to energy, mechanical engineering, electrical engineering, and automation sectors, such as heat transfer, electromagnetic fields, mechanical vibrations, and optical systems
<i>Connecting Theoretical Knowledge with Practice.</i> It is recommended to integrate each topic with real technological processes in the industry and explain physical laws through practical examples.
<i>Strengthening Interdisciplinary Connections.</i> It is necessary to integrate the physics course with technological subjects (electronics, mechanics, automation) to develop students' comprehensive technical thinking.
<i>Incorporation of Industry-Related Projects and Assignments.</i> It is effective to include small projects, calculations related to industrial equipment, and assignments aimed at solving real-world problems in the curriculum.
<i>Establishing Cooperation with Local Enterprises.</i> It is recommended to link physics lessons with production facilities, organize technical excursions, and hold practical seminars involving industry specialists.
<i>Implementing a Competency-Oriented Assessment System.</i> It is necessary to develop evaluation criteria that assess not only students' theoretical knowledge but also their practical skills, such as analyzing physical problems, creating models, and proposing technical solutions.

The "Industry-Based Project Method" for Teaching Physics differs from traditional approaches in its content and practical orientation and consists of the following main components:

1. *Industry-Oriented Content.* The curriculum content is based on real industrial problems. Physics topics are taught in connection with technological processes, equipment, and devices used in the industry.
2. *Project-Based Learning.* Students are assigned projects based on real or simulated industrial problems. They work in teams, conduct research, and develop technical solutions based on physical laws.
3. *Problem-Based Approach.* Lessons are organized around problems, encouraging students to ask questions, analyze issues, and develop scientifically grounded solutions. This helps develop their critical and systematic thinking skills.
4. *Innovative Educational Technologies.* The methodology widely employs virtual laboratories, computer simulations, multimedia tools, and industry-related video materials. These tools help visualize theoretical knowledge and bring it closer to practical application.
5. *Collaboration and Integration.* Higher education institutions cooperate with industrial enterprises to develop educational projects. Industry representatives participate in lessons, provide practical advice, and are involved in the assessment process.
6. *Integrated Assessment System.* Student evaluation includes not only traditional tests but also project outcomes, quality of practical solutions, teamwork abilities, and presentation skills. The assessment process integrates self-assessment, peer review, and expert evaluation.

In the traditional approach, assessment is mainly based on students memorizing theoretical knowledge and reproducing it. In this approach, the student is a passive listener who focuses only on memorizing information received from the teacher and being tested through exams. The opportunity to assess creative thinking or practical skills is limited. Therefore, this method does not prepare students to solve real-life problems [13].

In the proposed method, assessment focuses on how the student applies knowledge, their readiness for industry, teamwork skills, and the ability to propose innovative solutions.

Table 2.3.2 presents the key differences between the evaluation criteria of the traditional method and the "Industry-Based Project Method for Teaching Physics" in a brief and clear manner.

Table 2.3.2.

Evaluation Criteria for the Effectiveness of the Traditional Method and the Industry-Based Project Method in Teaching Physics	
Traditional Method	Industry-Based Project Method
Purpose of assessment	
Measures the level of knowledge retention and recall	Measures the ability to apply knowledge in practice and solve problems
Type of activity and approach	
The student is a passive listener	The student is an active participant and problem solver
Uses ready-made formulas	Adapts physical laws to real problems
Assessed based on written tests	Assessed based on projects, practical work, and simulations
Skills being assessed	
Theoretical knowledge, tests, laboratory work	Readiness for practice, project development, STEAM, teamwork
Problem-solving skills	Innovative thinking, critical approach, working with technology
Class participation activity	Participation in real projects, expressing opinions, proposing solutions
Assessment tools	
Test, written assignments, laboratory work	Simulation, project presentation, group assessment

During the experimental testing process aimed at improving the methodology for developing the professional competencies of technical students through physics education, experienced teachers monitored several factors: the alignment of each textbook topic with the State Educational Standard (DTS), quality indicators of students' comprehension of the learning material, the gradual progression of topics, the consistency and continuity in presenting the topics, as well as the degree of interrelation with other subjects.

The experimental testing was conducted in three stages. Formative and confirmatory experiments identified effective ways to improve the methodology for developing the professional competencies of technical students through physics education, with the level of improvement determined according to the criteria mentioned above.

At the final stage of the experiment, alongside the pre-established criteria, the results of tests and questionnaires aimed at determining the effectiveness of teaching methods for improving the professional competencies of technical students through physics education were taken into account during the analysis of statistical indicators. During the experimental-testing phase of the study on improving the methodology for developing the professional competencies of technical students in the physics teaching process, comparative analysis of group results was conducted at the beginning and at the end of the program.

As noted above, in the experimental-testing work, a total of 323 students participated as respondents: 109 from Namangan State Technical University, 120 from Fergana State Technical University, and 94 from Tashkent State Technical University. According to the essence of the mathematical statistical

method, at the initial stage, based on the test conducted on improving the methodology for developing the professional competence of technical specialty students in the process of teaching physics, the initial and final response results can be designated as samples, and variation series can be formed according to the levels of assessment.

The overall results before (Pre-test) and after (Post-test) the experimental-test work conducted on improving the methodology for developing the professional competence of technical specialty students in the process of teaching physics are presented (Table 1).

Table 1.

The overall results at the beginning (Pre-test) and at the end (Post-test) of the experimental work conducted to improve the methodology for developing the professional competence of students in technical fields through the teaching of physics.

№	Experimental-Test Questions		Experimental Group				Control Group			
			Total number of students – 160				Total number of students – 163			
			Excellent	Good	Satisfactory	Unsatisfactory	Excellent	Good	Satisfactory	Unsatisfactory
1	Students' productive (effective) learning-cognitive activity	At the end of the experiment	43	51	52	14	17	40	81	25
		At the beginning of the experiment	16	44	75	25	16	41	77	29
2	Students' partially productive (effective) learning-cognitive activity	At the end of the experiment	42	51	50	17	15	42	80	26
		At the beginning of the experiment	14	45	74	27	14	42	79	28
3	Students' reproductive learning-cognitive activity	At the end of the experiment	41	48	51	20	13	44	79	27
		At the beginning of the experiment	12	46	73	29	15	40	78	30
Average	Average	At the end of the experiment	42	50	51	17	15	42	80	26
		At the beginning of the experiment	14	45	74	27	15	41	78	29

Based on the essence of the mathematical statistical method, at the initial stage, the preliminary and final test results conducted on improving the methodology for developing the professional competence of technical specialty students in the process of

teaching physics can be designated as samples, and variation series can be formed according to assessment levels.

For the mathematical statistical analysis of the survey data on improving the methodology for developing the professional competence of technical specialty students in the process of teaching physics, the average values of the initial and final responses are presented by universities in this section (Table 2).

Table 2.

Results at the beginning (Pre-test) and at the end (Post-test) of the experimental work on improving the methodology for developing the professional competence of students in technical fields through physics education (by universities).

Objects of the Experimental Study	Groups	Number of students	Evaluation criteria							
			High		Average		Satisfactory		Unsatisfactory	
			Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Namangan State Technical University	Experimental Group	54	4	14	15	16	26	19	9	5
	Control Group	55	5	5	13	13	28	29	9	8
Fergana State Technical University	Experimental Group	60	6	16	17	20	27	17	10	7
	Control Group	60	6	6	16	17	27	28	11	9
Tashkent State Technical University	Experimental Group	46	4	12	13	14	21	15	9	5
	Control Group	48	4	4	12	12	23	23	9	9
Total	Experimental Group	160	14	42	45	50	74	51	27	17
	Control Group	163	15	15	41	42	78	80	29	26

Note: Pre-test – before the experiment, Post-test – after the experiment.

The statistical indicators before the experimental trial on improving the methodology for developing the professional competence of technical students in the process of teaching physics were compared across higher education institutions (see Table 3).

Table 3.

Comparative table of data at the beginning of the experimental study

Experimental Group	Objects of the study	High	Average	Satisfactory	Unsatisfactory	Total
	Namangan State Technical University	4	15	26	9	54
	Fergana State Technical University	6	17	27	10	60

	Tashkent State Technical University	4	13	21	8	46
	Total	14	45	74	27	160
Control Group	Objects of the study	High	Average	Satisfactory	Unsatisfactory	Total
	Namangan State Technical University	5	13	28	9	55
	Fergana State Technical University	6	16	27	11	60
	Tashkent State Technical University	4	12	23	9	48
	Total	15	41	78	29	163

Table 4.

Analysis of the initial results of the experimental study (in numbers and percentages)

Groups	Number of students	Learning outcomes (in %)			
		High	Average	Satisfactory	Unsatisfactory
Experimental groups	160	14	45	74	27
		9	28	46	17
Control groups	163	15	41	78	29
		9	25	48	18

Based on the pre-experimental results, it was found that there were no significant differences in knowledge, skills, and competencies between the students in the experimental group involved in the study and those in the control group. According to the essence of the mathematical statistical method, at the initial stage, the statistical indicators recorded in the experimental and control groups were designated as samples and variation series were formed based on excellent, good, satisfactory, and unsatisfactory levels. The diagram obtained is shown in Figure 5.

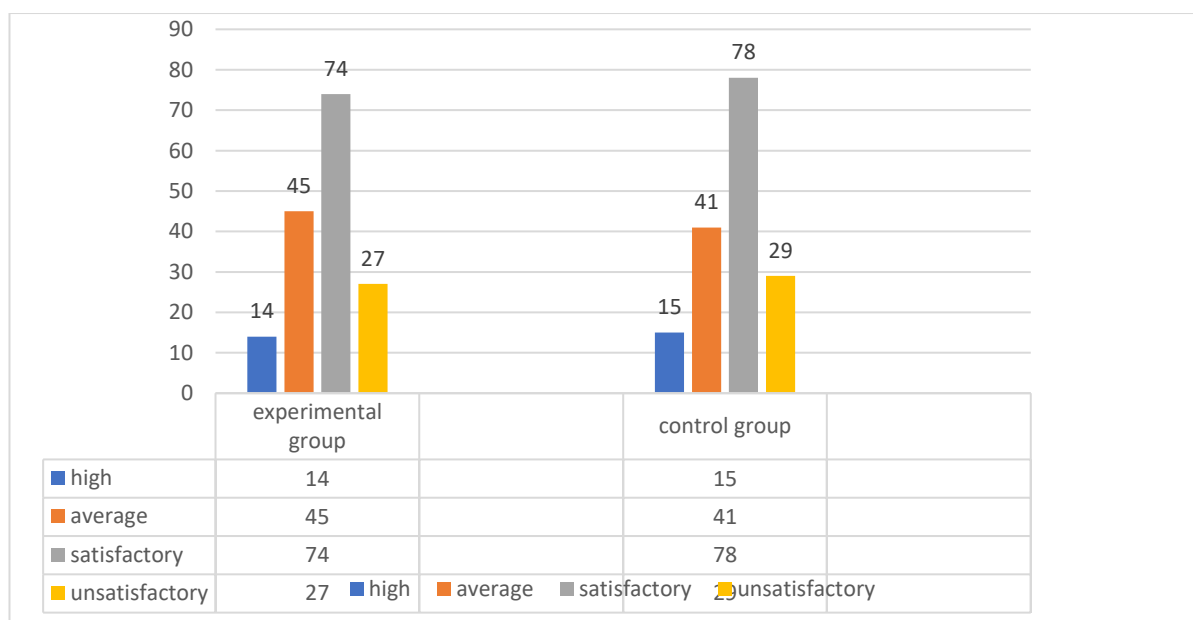


Figure 5. Diagram of the results at the beginning of the experimental study

The diagram clearly shows that the excellent and good performance levels in the experimental group did not significantly differ from those in the control group.

Based on statistical research and according to Table 2, a comparison was made of the statistical indicators of students' readiness for professional socialization activities at the conclusion of the experimental work across higher education institutions (see Table 5).

Table 5

Final comparative table of the experimental study results

Experimental Group	Objects of the study	High	Average	Satisfactory	Unsatisfactory	Total
	Namangan State Technical University	14	16	19	5	54
	Fergana State Technical University	16	20	17	7	60
	Tashkent State Technical University	12	14	15	5	46
	Total	42	50	51	17	160
Control Group	Objects of the study	High	Average	Satisfactory	Unsatisfactory	Total
	Namangan State Technical University	5	13	29	8	55
	Fergana State Technical University	6	17	28	9	60
	Tashkent State Technical University	4	12	23	9	48
	Total	15	42	80	26	163

Table 6.

Final analysis of the experimental study results (in numbers and percentages)

Groups	Number of students	Learning outcomes (in %)			
		High	Average	Satisfactory	Unsatisfactory
Experimental groups	160	42	50	51	17
		26	31	32	11
Control groups	163	15	42	80	26
		9	26	49	16

The diagram appeared as follows (Figure 6).

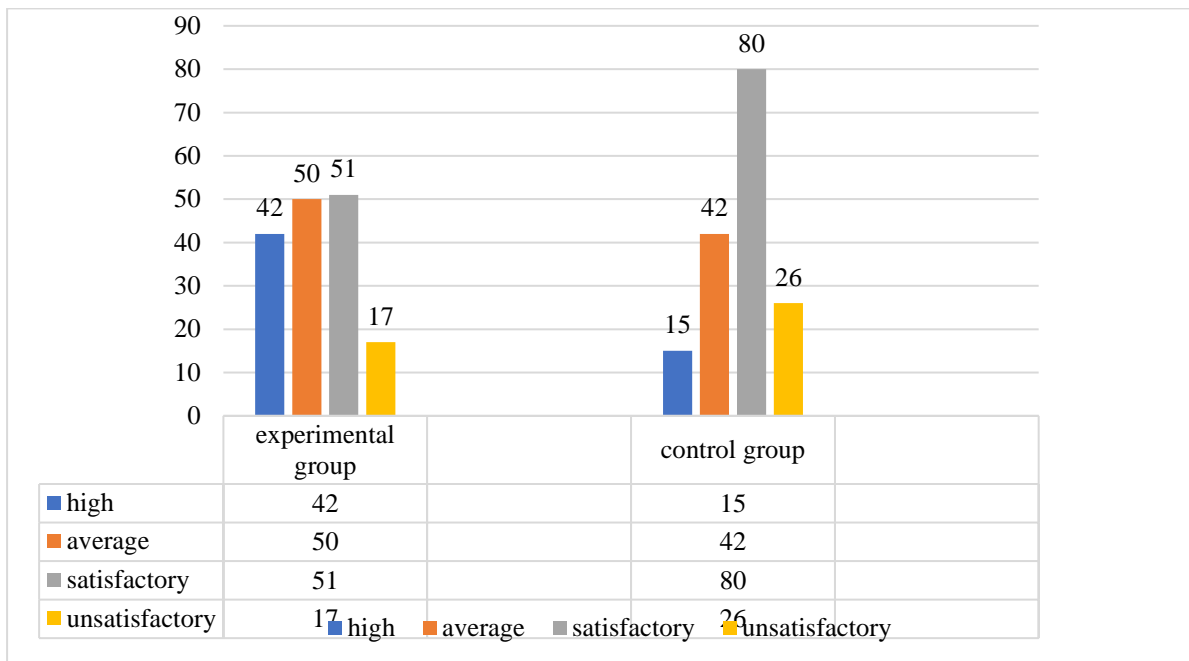


Figure 6. Final chart of the experimental study

The diagram clearly shows that the excellent and good results in the experimental group are higher than those in the control group.

The results of the pedagogical experimental work were reprocessed using Microsoft Excel. The statistical analysis indicators of the data obtained during the experimental process aimed at improving the methodology for developing the professional competence of technical students in the process of teaching physics are presented in Table 7.

Table 7.

Statistical indicators on improving the methodology for developing the professional competence of technical students in the process of teaching physics

Nº	Indicators	At the beginning of the experiment		At the end of the experiment	
		Experimental group, n = 160	Control group, m = 163	Experimental group, n = 160	Control group, m = 163
1.	Arithmetic mean	3,29	3,25	3,72	3,28
2.	Efficiency indicator	1,012		1,134	
3.	Coefficient of variation (%)	2,04	2,05	2,05	2,03
3.	Confidence interval of the mean	[3,16;3,42]	[3,12;3,38]	[3,51;3,87]	[3,15;3,40]
4.	Standard error of the mean	0,85	0,85	0,97	0,84
5.	Pearson’s statistic	0,3694		21,7627	
6.	Student’s t-statistic (T)	0,4211 (0,4211 < 1,96)		4,3564 (4,3564 > 1,96)	
7.	Summary of indicators	The null hypothesis (H ₀) is rejected		The alternative hypothesis (H ₁) is accepted	

As a result of our research, it was mathematically and statistically proven that by the end of the experimental work conducted across all selected experimental sites, the level of improvement in the methodology for developing the professional competence of technical students in the process of teaching physics in the experimental group was 1.134 times, or 13.4%, higher compared to the control classes. This indicates the effectiveness of the conducted research work. The efficiency of the experimental work on improving the methodology for developing the professional competence of technical students in the process of teaching physics was confirmed from a mathematical-statistical perspective.

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