THE ROLE AND SIGNIFICANCE OF METHODOLOGICAL COMPETENCE IN THE PROFESSIONAL TRAINING OF A PHYSICS TEACHER

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Abstract: This article analyzes the role, components, and significance of methodological competence in increasing educational efficiency within the professional training of a physics teacher. Additionally, the influence of experimental and digital skills on student performance is scientifically substantiated.

Keywords: *Methodological competence, professional training, physics teaching methodology, pedagogical mastery, STEM education, digital didactics, experimental skills, virtual laboratory, cognitive activity, innovative approach, educational effectiveness, lesson design, problem-based learning, PHeT simulations, didactic transformation, mastery coefficient, integrative phenomenon, engineering thinking, variability, competency-based approach.*

SIGN IN

The current stage of human civilization is characterized by the rapid penetration of achievements in fundamental sciences, particularly physics, into technological and social life. In the modern educational paradigm, physics is gaining strategic importance not only as a science that teaches the laws of nature but also as the foundation of technical progress and innovative thinking. Therefore, within the framework of modernizing the education system in the Republic of Uzbekistan, specifically raising the quality of teaching exact sciences to a new level, the requirements for the professional skills of teaching staff, especially their **methodological competence**, have fundamentally changed. In the context of implementing the National Curriculum, the teacher's task requires abandoning the "reproductive" approach, which consists of transmitting ready-made knowledge,

and transitioning to a "constructive" approach aimed at developing the student's independent search and research skills.

The methodological competence of a physics teacher is the ability to simplify complex physical concepts in accordance with the student's age and individual characteristics, present them in an engaging form, and connect them with practice, combining theoretical knowledge of the subject with pedagogical and psychological patterns. This competence encompasses multifaceted skills such as didactic design, working with digital technologies, organizing experimental research, and objectively assessing students' knowledge levels. Physics is distinguished from other disciplines by its abstract concepts and the complexity of its mathematical apparatus. Therefore, the teacher's methodological training serves as the primary factor in preventing the emergence of a "cognitive barrier" in the student's attitude toward the subject.

The relevance of this research work is explained by the introduction of the STEM (Science, Technology, Engineering, Mathematics) approach into the educational process today and the widespread use of virtual laboratories. A modern physics teacher must not only convey information from the textbook but also model physical processes and conduct lessons by combining ICT tools (e.g., PHeT simulations) with real laboratory instruments. Methodological competence allows the teacher to design every lesson as a scientific discovery, which in turn develops students' logical thinking and shapes their engineering thinking. This article theoretically and practically analyzes the components of methodological competence in the professional training of a physics teacher, the stages of its formation, and its role in increasing educational efficiency. The aim of the research is to highlight the scientific and pedagogical foundations of ensuring the competitiveness of future personnel by improving the methodological training of physics teachers.

METHODOLOGY

In the course of this study, methods of systematic analysis, comparative-pedagogical observation, and methodological modeling were utilized. To determine the level of professional training of physics teachers, the components of pedagogical competence were analyzed based on classical and modern approaches. The principles of competency-based and STEM education were chosen as the methodological basis of the study. The correlation between international best practices and the requirements of the National Curriculum was also studied. The results obtained were summarized based on the efficiency indicators of integrating physical experiments with digital technologies.

LITERATURE ANALYSIS

The concept of methodological competence has been interpreted in pedagogical research by scholars such as N.V. Kuzmina and A.K. Markova as the fundamental basis of professional mastery. At the international level, in the field of physics teaching methodology, the theory of cognitive development by J. Piaget and the ideas of social constructivism by L. Vygotsky serve as the main pillars in the formation of physical concepts. Among the scientists of our country, N.G. Akhmedov and R. Ibragimov emphasized in their research that the experimental skills of a physics teacher are an integral part of methodological training. Additionally, the approach and issues of digital didactics have been extensively covered in scientific literature in recent years. Analysis shows that modern methodological competence manifests as an integrative phenomenon that encompasses not only knowledge transfer methods but also technological and creative approaches.

ANALYSIS AND RESULTS

During the study, the level of methodological competence of physics teachers and its impact on student performance were studied. The collected data were systematized based on the following indicators.

Table 1.

Analysis of self-assessment of physics teachers regarding the components of methodological competence

Components of competence	Low (%)	Average (%)	High (%)
Theoretical and methodological knowledge	8.	42	50
Experimental skills (laboratory)	15	55	30
Working with ICT and digital resources	22	48	30
Application of innovative methods (STEM)	25	50	25

Analysis: The statistical data presented in Table 1 indicate a discrepancy between the components of the methodological competence of physics teachers. According to the results of the analysis, the absolute majority of respondents (50%) rated their theoretical and methodological knowledge as "high." This indicates that educators possess fundamental training in textbook materials and traditional teaching methods. However, a high level of theoretical knowledge does not fully guarantee practical effectiveness.

An unexpected decrease is observed in the "Experimental Skills" section of the table: only 30% of teachers reported having high competence in laboratory work. Given that physics is a science based on experience and observation, the low level of experimental skill is a serious gap in methodological training. This may be explained by a lack of educational laboratory equipment or insufficient mastery of the methodology for using existing equipment.

The indicators "ICT and digital resources" (30% higher) and "Application of innovative methods (STEM) " (25% higher) showed the lowest results. These indicators reveal the main methodological problem facing modern physics education:

1. Technological disruption: Although teachers know the theory, they face difficulties in visualizing it through virtual simulations (e.g., *PhET, Crocodile Physics).*

2. Methodological conservatism: 50% of respondents report an "intermediate" level of innovative methods, confirming that the traditional, more lecture-style teaching method still prevails in the lessons.

In conclusion, the analysis of Table 1 provides a scientific justification for the need to focus on the formation of practical, methodological, and technological competencies within the system of physics teacher training and retraining. Today's requirement is for the teacher to become not only an informant but also a moderator who creates a "research environment" using modern tools and digital technologies.

Table 2.

Indicators before and after training aimed at improving methodological competence (N=50)

Evaluation criteria	**Before training (points)**	**After training (points)**	**Growth rate**
Lesson design skills	62	84	+22%
Creating problem situations	54	78	+24%
Manage virtual labs	45	82	+37%

Analysis: The dynamic indicators presented in Table 2 prove that the methodological training of physics teachers is a field that can be purposefully developed. According to the research findings, a significant increase was observed across all criteria following specialized methodological training, indicating the professional adaptability of the teachers.

The most noteworthy part of the table is the "Management of Virtual Laboratories" indicator. Efficiency in this area increased from 45 to 82 points, recording the highest growth rate (+37%). This result indicates that modern physics teachers are highly motivated to master digital technologies, yet they lack systematic methodological manuals and practical skills. Virtual simulations (for example, in complex topics such as quantum physics or relativity theory) are emerging as a powerful methodological tool that visualizes real experiments rather than replacing them.

The 24% increase in the "creation of problem situations" (Case-study and problem-based learning) skill confirms that teachers are transforming the lesson

from merely informational to a process that encourages the student to explore. Creating a problem situation in physics lessons (for example, by asking questions like "Why is the heat capacity different in different substances?") activates the student's critical thinking.

The 22% increase observed in "lesson design skills" indicates that teachers have developed the ability to systematize each stage of the lesson (motivation, presentation of a new topic, reinforcement, assessment) into a single methodological chain.

In conclusion, the results of Table 2 scientifically substantiate that methodological competence is not stable, but has a transformative character. In the professional training of teachers, the shortest and most effective way to improve the quality of education is not only to provide theoretical knowledge but also to equip them with specific methodological cases and modern digital laboratory tools.

Table 3.

The relationship between a teacher's methodological skills and students' cognitive outcomes

Groups	**Teacher's methodological level**	**Student performance (%)**	**Practical application of knowledge (%)**
Control group	Traditional	68	42
Experimental group	Innovative and methodological	86	74

Analysis: The comparative data presented in Table 3 show that the level of a teacher's methodological competence is the primary determinant directly determining the quality of education and the effectiveness of students' knowledge acquisition. The difference between the control and experimental groups conducted within the framework of the study scientifically proves how important the teacher's "methodological approach" is.

According to the analysis results, although the mastery rate of students in the control group (using the traditional methodology) was 68%, the lowest indicator was recorded in the "Practical Application of Knowledge" criterion (42%). This

situation highlights a fundamental flaw of traditional education: even if a student knows a theoretical formula, they cannot apply it to real-life processes or engineering problems (i.e., the phenomenon of "dead knowledge").

Conversely, in the Experimental group (learned by a teacher with innovative-methodological competence), the mastery rate increased to 86%. The most important achievement here is that the level of practical application of knowledge has reached 74%. This coefficient is 32% higher than in the control group, achieved through the following factors:

Contextual learning: The teacher explained physical laws using real-world technical devices and natural phenomena as examples, rather than mere theory.

Cognitive activity: Thanks to methodological skills, the student transformed from a passive listener into an active researcher, ensuring the long-term retention of knowledge.

Transformation of skills: Students learned not only to "know physics," but also to "work with physics" (solving problems, creating projects, conducting experiments).

In conclusion, the analysis of Table 3 confirms that the methodological competence of a physics teacher is not merely a method of teaching, but a means of realizing the student's intellectual potential. The more methodologically prepared the teacher is, the more effectively the student acquires the ability to understand complex physical systems and manage them in practice.

Table 4.

Rating of effectiveness of methodological methods used in physics lessons

Methodological approach	**Student motivation**	**Knowledge sustainability**	**Overall performance**
Problem education	Upper	Upper	88%
Inverted Classroom	Medium	Upper	82%
STEM project work	Very high	Medium	85%
Traditional lecture	Low	Medium	54%

Analysis: The data presented in Table 4 allow for a comparative analysis of the impact of various methodological approaches used in physics education on student motivation and knowledge stability. These indicators are important in determining which areas the methodological competence of a modern physics teacher should focus more on.

According to the analysis results, the problem-based learning methodology demonstrated the highest overall effectiveness (88%). The success of this method lies in the fact that it forces the student not to memorize ready-made facts, but to understand the essence of physical laws through fundamental questions such as "Why?," "How?" This, in turn, ensures both motivation and the long-term retention of knowledge in memory (knowledge stability).

Although the STEM project work showed a "very high" result in increasing student motivation, it received an "average" indicator for knowledge stability. The scientific reason for this is that in STEM projects, the main focus is on the result (building a device or model), and sometimes the complex theoretical calculations behind it can be secondary. However, the overall efficiency of 85% confirms that this method is integral to the formation of engineering thinking.

The "Inverted Classroom" methodology showed a high result in terms of knowledge stability (82%). In this method, students study the theory independently before the lesson and engage in only practical issues and discussions during the lesson, which increases their responsibility and the level of deep understanding of the topic.

Conversely, the Traditional Lecture Method showed the lowest efficiency (54%). The "Low" level of motivation is explained by the student's participation in the lesson process only as a passive object, which does not meet modern educational requirements.

In conclusion, the analysis of Table 4 highlights the feature of variability (the ability to choose methods depending on the situation) in the methodological competence of a physics teacher. The teacher's ability to integrate problem-based

learning and digital technologies based on the lesson objective is a key factor guaranteeing the quality of education.

The results of this research confirm that the methodological competence of a physics teacher is a fundamental construct that determines the quality of modern education. Systematic analyses show that the abstract nature and experimental nature of the subject require not only profound theoretical knowledge from the teacher but also the skill of their didactic transformation. Statistical data obtained during the study proved that integrating digital technologies and the STEM approach into the teacher's methodological training allows for an increase in students' cognitive activity by up to 32%. In particular, the ability to combine virtual laboratories with real-world experiences significantly enhances students' efficiency in visualizing physical processes and constructing logical models.

Conclusion

In conclusion, it should be noted that the methodological competence of a physics teacher is dynamic and variable in nature, serving as the primary mechanism for forming students' engineering thinking and scientific worldview. Comparative analysis showed that traditional teaching models are ineffective in the face of today's requirements, and problem-based learning and project-based methodologies prevail. In the process of training and retraining pedagogical personnel, primary attention should be paid to the development of the teacher's technological and creative competencies. This not only increases the mastery rate of students but also serves as the scientific and pedagogical foundation for creating a competitive personnel reserve in the age of high technology.

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