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ABSTRACT

Of the dissertation for the degree of Doctor of Sciences

MODERN PROBLEMS AND METHODICAL SYSTEM OF PHYSICS TRAINING IN LYCEUMS

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AZƏRBAYCAN RESPUBLİKASI ELM VƏ TƏHSİL NAZİRLİYİ AZƏRBAYCAN DÖVLƏT PEDAQOJİ UNİVERSİTETİ

GENERAL CHARACTERISTICS OF THE THESIS

Relevance of the topic. The rapid advancement of modern technologies necessitates implementing new educational approaches in 21st-century pedagogy. The learner is no longer a passive recipient but an active participant with creativity and problem-solving skills. Educational systems in many countries are transforming, prioritising the development of the 21st-century individual and implementing innovative training strategies aligned with this goal. Within the framework of modern teaching strategies, cultivating creative thinking, critical reasoning, communication, and collaboration skills is a priority direction. Acquiring these skills enables learners to adapt to dynamic and complex realities, enhancing their potential for future success.

International education programmes such as IB, IGCSE, and AP Physics[1], particularly, emphasise fostering these competencies.

These global trends have also markedly shaped physics education. As a subject, physics can play a vital role in developing scientifically literate, cognitively active, and motivated learners who can participate in inquiry-based learning aligned with 21st-century demands. However, current practices still face significant challenges in fostering creativity, critical thinking, communication, and collaboration. Physics teaching often fails to adequately nurture essential 21st-century skills such as critical thinking, problem-solving, creativity, digital literacy, and intercultural communication. Additionally, teaching materials and textbooks are frequently mismatched with competency-focused and dynamic learning environments. This contradiction highlights the disconnect between current training methods and the requirements of modern education.

[1] IB (International Baccalaureate – Beynəlxalq Bakalavriat), IGCSE (International General Certificate of Secondary Education – Beynəlxalq Ümumi Orta Təhsil Sertifikatı) və AP Physics (Advanced Placement Physics – Fizika üzrə ixtisaslaşma səviyyəsi)

In Azerbaijan, progressive educational models are promoted, and deliberate steps are taken to align with international educational trends.

Major reforms in this area include the national education reforms initiated by the national leader, Heydar Aliyev, in 1998, and the "State Strategy for the Development of Education in the Republic of Azerbaijan," endorsed by President Ilham Aliyev through a decree dated 24 October 2013. This strategy emphasises improving educational quality as a key priority and highlights modernising the education system with contemporary approaches.

Technological advancements have driven the renewal of physics training in general education institutions, especially in lyceums, through innovative methods. Recently, the importance of lyceums in the national education landscape has significantly increased.

According to Article 1.0.33 of the Law on Education of the Republic of Azerbaijan, approved by the President of the Republic, “a lyceum is a general education institution that provides specialised educational services at general and complete secondary levels for gifted students.” Physics instruction in lyceums is crucial in developing students’ analytical thinking, problem-solving skills, and practical abilities. These institutions admit students through rigorous selection procedures, typically enrolling individuals with strong critical thinking skills. One primary aim is to equip these students with in-depth knowledge and advanced skills across all disciplines, including physics, by applying modern pedagogical approaches.

Nevertheless, challenges in implementing these processes are increasingly urgent in modern pedagogical science.

Institutions with functions similar to Azerbaijani lyceums can be found worldwide, though they are called by different names. These include "Magnet Schools” in the US, "Specialist Schools” in the UK, “Gymnasiums” in Germany, and “Selective Schools” in Australia.

Numerous studies indicate that a unified and systematic methodological approach, which considers lyceums' specific characteristics and modern educational demands, has yet to be developed.

In the context of physics teaching in lyceums, researchers have identified a set of persistent challenges, including the following[2,3,4]:

- “Increasing complexity and abstract nature of the subject matter;
- Lack of practical applications within the teaching process.
- Lack of sufficient personalisation in learning.
- Limited incorporation of contemporary educational technologies;
- Absence of a systematic approach to assessment”.

Although their relevance is acknowledged, the existing body of literature does not adequately examine them within the context of lyceum education. Therefore, further scientific research in this area is both timely and necessary.

In many developed countries, internationally recognised physics curricula such as IB, IGCSE, and AP Physics are widely adopted as effective models in lyceum-level education. These programmes make physics teaching more modern and practical while improving students' readiness for future academic and career development. Embracing such approaches is seen as a significant step towards aligning physics education with the needs and challenges of the 21st century.

However, Azerbaijan does not have a dedicated physics curriculum tailored explicitly for lyceums. As a result, physics instruction in these institutions is generally based on the national curriculum designed for general secondary schools. Although this curriculum thoroughly covers the content of physics education, teachers working with lyceum students-chosen through competitive and merit-based processes-often prioritise the transmission of extensive declarative knowledge across all topics. Consequently, educators frequently utilise additional teaching resources to meet their students' needs.

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[2]Orucov V.Ö. Azərbaycanda fizikanın tədrisi metodikasının inkişafı: əsas istiqamətlər, metodlar, aktual problemlər. Ped. üzrə Elm. Dok.diss. Bakı, 2014. 384 s.
[3]Gilbert J.K. Visualization: A metacognitive skill in science and science education. Dordrecht: Springer, 2005. s. 9-27.
[4]Duit R., Treagust, D.F. Conceptual change: A powerful framework for improving science teaching and learning. International Journal of Science Education, vol. 25(6), 2003. s. 671-688.

On 28 April 2022, the Ministry of Education of the Republic of Azerbaijan approved a subject-specific curriculum titled "Physics Curriculum for Specialised Tracks at the Upper Secondary Level" (Order No. F-238). As one of the reviewers of this curriculum, I note that the document's sub-standards emphasise both lower- and higher-order cognitive processes in line with Bloom's Taxonomy, providing more precise assessment criteria for each topic. However, the curriculum does not consistently reflect a structured framework incorporating all six cognitive domains of Bloom's taxonomy for each subject area.

Despite significant progress, multiple modern challenges remain. These include:

– Inadequate selection and application of theoretical foundations for physics education in lyceums;

– Existing deficiencies in the training and professional development of teaching staff;

– Insufficient availability of teaching and methodological support materials for physics instruction;

– Limited development of logical, critical, and creative thinking skills during lesson planning and delivery.

Addressing current challenges in physics education within Azerbaijani lyceums requires a comprehensive comparative analysis of international experiences. Such investigations are valuable for identifying ways to integrate global best practices into enhancing physics teaching in lyceum environments. In this context, developing and implementing a new methodical system for physics instruction in lyceums is both timely and necessary. The creation of this system mainly depends on critically reassessing and refining the content of the physics curriculum.

Scholars such as A.A.Abbaszade, S.Sh.Imanov, Sh.H.Alizade, Z.I.Qaralov, I.N.Ismayilov, N.A.Aliyev, N.Y.Safarov, V.O.Orucov, M.I.Murquzov, A.O.Mehrabov, B.A.Shafizade, B.Sh.Sultanov, R.R.Abdurrazagov, T.S.Vahidov, and A.A.Garayev have conducted significant research in Azerbaijan on the physics course's content design and teaching methodology.

Among international methodologists, the following researchers can be mentioned: L.C.McDermott, D.I.Dykstra, F.M.Goldberg, D.K.Sokoloff, R.K.Thornton, I.D.Gonzalez, I.H.Escobar, I.P.Guilford, D.L.MacIsaac, V.G.Qayfullin, N.M.Zvereva, C.E.Kamenetsky, V.V.Laptev, I.Ya.Lanina, I.Ya.Lerner, V.G.Razumovsky, S.Y.Shamash, E.E.Evenchik, A.S.Kondratyev, G.Y.Gyryshev, N.M.Shakhmayev and others.

Notably, some issues in lyceum education during the late 20th century have been partially addressed in doctoral and candidate-level dissertations defended abroad. For example, N.V.Gamova examined learner-centred education's psychological and pedagogical technologies; S.Y.Dolgova analysed the development of independent thinking within the lyceum environment; and N.A.Kozyreva studied the problem of student self-actualisation in teaching practices at a physico-technical lyceum.

The specific characteristics of subject teaching in lyceums have been thoroughly investigated in the studies of N.I.Aksenova, T.E.Lapshina, L.V.Lyubimova, N.A.Uspensky, L.A.Pavlenko, Yu.M.Levich, and E.A.Lugovova. Furthermore, various aspects of lyceum education and student life have been comprehensively analyzed by S.V.Kulnevich, E.M.Medresh, E.E.Pronina, and E.A.Yamburg.

To align physics education in lyceums with the changing demands of modern schooling, it is crucial to pursue targeted initiatives in the following strategic areas:

✓ Ensuring sustainable motivation for learning while supporting students' cognitive, emotional, and moral development;

✓ Systematising assessment criteria for each topic according to the six levels of Bloom's taxonomy;

✓ Stimulating interest in physics and technology and fostering strong intrinsic motivation;

✓ Cultivating a modern scientific worldview and familiarising students with the core methodologies of scientific inquiry;

✓ Promoting a general understanding of fundamental physical laws and their applications;

✓ Incorporating innovative approaches that reflect the leading trends in scientific and technological progress into teaching;

✓ Applying internationally recognised instructional methods and methodologies to develop polytechnic knowledge and skills.

Despite the increasing significance of lyceums in Azerbaijan's education system, there remains an apparent shortage of doctoral-level (PhD or Doctor of Science) research focused on teaching physics in these institutions. This gap has resulted in several contradictions in the organisation of physics instruction in lyceums, such as:

- a lack of adequate scientific-methodical resources specifically designed for teaching physics to lyceum students, despite high societal demand for the lyceum model;
- incompatibility between the requirements of national general education standards and the current instructional methodologies, which complicates effective implementation;
- limited instructional hours dedicated to physics by educational institutions;
- inadequate development of self-directed learning skills among lyceum students, even though independent learning is a vital component of the lyceum education.

A psychological, pedagogical, and methodical literature review shows that physics instruction content has not been theoretically conceptualised or elaborated in some lyceums.

This research explores the current challenges faced in Azerbaijani lyceums. It aims to design and implement an innovative methodical system based on advanced pedagogical approaches from internationally recognised physics programmes such as IB, IGCSE, and AP. In other words, the study seeks to develop an educational model that incorporates global best practices into a context-sensitive framework tailored to the Azerbaijani lyceum environment.

Therefore, the research holds both scientific and practical significance. Amidst agile transformations, strategic uncertainty, increasing integrative complexity, and new pedagogical paradigms typical of 21st-century education, establishing a robust methodical framework for physics teaching can significantly contribute to modernising science education.

Considering the factors discussed above and the author's extensive pedagogical experience in physics teaching at lyceums, the significance and necessity of the dissertation "Modern problems and methodical system of physics training in lyceums" are justified from theoretical and practical perspectives.

The object of the research is the process of physics instruction in lyceums and the methodical systems developed within that process.

The research subject comprises newly developed methodical systems and instructional approaches aimed at improving the current structure of physics education in lyceums and addressing its contemporary problems.

Purpose of the research: The study aims to examine the current challenges in lyceums' physics teaching and to develop a scientifically grounded methodical system that enhances students' subject-specific skills. This system is designed to support learner-centred development, foster self-directed learning abilities, and promote heuristic and research-based thinking, while fully aligning with the requirements of national educational standards.

Research objectives:

1. To analyse the current state of physics education in the lyceums of Azerbaijan and developed countries from a scientific-methodical and pedagogical perspective;

2. To identify the intellectual and cognitive developmental characteristics of lyceum students, as well as the level of their self-learning skills, based on recent findings in developmental psychology;

3. To systematise the professional competency requirements of lyceum physics teachers and propose a development algorithm accordingly.

4. To identify and analyse the core challenges observed in the process of teaching physics in lyceums;

5. To explore scientifically grounded methods for fostering heuristic thinking and research competencies in students;

6. To determine effective strategies for cultivating students' interest and intrinsic motivation in physics.

7. To develop a package of assessment standards based on Bloom's taxonomy for the objective evaluation of student achievements in physics education;

8. To examine innovative lesson models aimed at developing 21st-century skills, namely critical thinking, communication, collaboration, and creativity (the "4Cs");

9. To deepen the content of physics instruction for lyceum students and design a methodical system that supports learner-centred, self-directed, and inquiry-based learning;

10. To construct a comprehensive model of a methodical system for teaching physics that incorporates essential components: goals, content, methods, assessment, and participant characteristics;

11. To develop a methodology based on modern instructional technologies for physics training;

12. To plan and conduct pedagogical experiments to test the proposed scientific hypothesis.

Research methods:

Theoretical analysis: A systematic review of scientific sources and materials related to physics education in lyceums, including textbooks, methodical manuals, scholarly articles, and conference proceedings, was carried out. This analysis produced well-supported conclusions regarding the methodical system of physics instruction and its current challenges. Classical and contemporary pedagogical approaches were also synthesised.

Comparative analysis of international and local experience: Programs, instructional technologies, as well as the applied methods and tools related to physics training in lyceums of Azerbaijan and foreign countries have been examined, their effectiveness has been evaluated, and these practices have been synthesized in a comparative manner.

Analysis of normative documents: Relevant legal acts, educational standards, curricula, and other regulatory texts concerning physics education were systematically examined to establish the study's theoretical foundation and clarify its practical application context.

Sociological survey and interview method: Structured surveys and interviews were conducted with lyceum teachers and students to collect their perspectives and practical experiences. The results of these inquiries provided a crucial empirical basis for the research.

Pedagogical observation: Observations were conducted in lyceum physics classes to assess classroom organisation, teaching methods, student engagement, and assessment practices.

Pedagogical experiment: During the diagnostic phase, key factors influencing the effectiveness of physics education were identified. In the developmental phase, a methodical system aligned with modern educational requirements was conceptually designed. A practical model based on the developed concept was implemented in the formative phase.

Statistical analysis of empirical data: Quantitative data collected throughout the study were analysed using the SPSS software suite. Both descriptive (mean, median, mode, variance, standard deviation) and inferential statistical methods (t-tests, Pearson and Spearman correlation analysis, factor analysis) were employed. The statistical results confirmed findings obtained via other methods and enabled comparative visual representation.

Main provisions submitted for defense

1. Integrating modern teaching tools and technologies into physics instruction at lyceums – considering current pedagogical and methodical challenges – ensures the modernisation, enhancement, and effectiveness of the training process.

2. The methodical system model developed for lyceum-level physics teaching – based on the unity of aims, content, process mechanisms, assessment and monitoring, and the psycho-individual traits of learners – ensures the enhancement of teaching quality.

3. The proposed methodical system promotes student-centred learning approaches and self-directed learning skills among lyceum students, encourages autonomous regulation of cognitive activity, and supports the development of 21st-century competencies.

4. Implementing non-standard lesson models – such as problem-based, inquiry, and project-based learning sessions, debate lessons, the

case method, and virtual and traditional laboratory practices – encourages the development of students' heuristic and research-oriented skills.

5. Applying a standards package based on Bloom's taxonomy and relevant assessment criteria makes the internal evaluation process (both formative and summative) in physics education purposeful and objective.

Scientific novelty of the research

1. A conceptual methodical system customised for the lyceum context has been developed based on ideas of modernising the instructional process, student-centred learning, developing self-directed learning skills, and organising and effectively managing independent cognitive activity. Six principal theoretical provisions underpin this system.

2. It has been scientifically proven that using generalised schematic representations of physical phenomena, quantities, laws, and theories is essential for modernising the instructional process in lyceums.

3. A theoretical model has been developed to facilitate the practical application of the proposed conceptual framework. This model comprises five interconnected components: goals, content, processual mechanisms, assessment-monitoring, and the characterristics of instructional participants, and is presented within a systems-based approach.

4. A comprehensive scientific-methodical support package has been developed for lyceums, which includes:

- Generalised schematic representations of physical concepts, devices, and laws;
- Methodical guidelines for traditional and virtual laboratory practices;
- Structured application schemes and solution strategies for case-based physics tasks;
- Implementation mechanisms for problem-based, inquiry-based, project-based and debate-style lessons;
- A scientifically grounded professional development algorithm for physics teachers;
- A modular-block structure of the lyceum physics curriculum;

• A standards package encompassing all levels of Bloom's taxonomy;

• Planning models based on the developed standards;

• Rubrics for formative assessment and self-evaluation tables aligned with the standards.

5. The conceptual provisions of the developed methodical system were empirically validated through pedagogical experiments, demonstrating its effectiveness in promoting self-directed learning and research-oriented activities among lyceum students.

6. The methodical system developed for lyceums enhances student motivation for autonomous learning, supports their holistic development, and guarantees active participation of all stakeholders in the teaching process.

Theoretical significance of the research

• Enables the development of more effective teaching resources and materials for lyceum teachers, thereby contributing to the formation of student-centred learning and self-directed learning skills by considering students' interests.

• Supports improving the structure, format, and content of lyceum-level physics textbooks, thus facilitating the implementation of new pedagogical approaches to enhance independent cognitive activity.

• Stimulates the application of innovative methodical approaches in physics instruction, enhancing student engagement and increasing instructional effectiveness.

• Provides a theoretical foundation for physics teachers to design contemporary teaching strategies to improve students' academic achievement.

Practical significance of the research

• The perspective plans, case-based tasks, and implementtation mechanisms for traditional and virtual laboratory work developed according to the new standards make teaching physics more engaging and effective.

• The application of the 7E model and examples of problem-, inquiry-, project-, and debate-based lessons enable teachers to benefit from modern educational technologies.

• The modular-block structure of the lyceum physics curriculum ensures the systematic and staged delivery of instructional content.

• The competencies and professional development algorithms prepared for teachers help to organise lessons more effectively and boost student motivation.

Approval and implementation. The scientific findings have been published in reputable international journals such as Physics Education, Jurnal Pendidikan Fisika Indonesia, Revista Mexicana de Física E, Advanced Physical Research, and the International Journal on Technical and Physical Problems of Engineering.

Practical aspects of the research have been published in local journals such as Azərbaycan məktəbi, Kurikulum, Pedaqoji Universitet Xəbərləri, Təhsildə İKT, Fizika, Riyaziyyat və İnformatika Tədrisi, as well as in Russian journals such as Современное педагогическое образование, Современный учёный, and Школьные технологии.

The dissertation was presented at 24 conferences of international and national importance. The practical components of the study were introduced to the academic community at international events held at ADA University (2023), in Turkey (Kars and Erzurum, 2025), Denmark (Copenhagen, 2018), Poland (Warsaw, 2024), Spain (Madrid, 2025), the United Kingdom (London, 2025), and Singapore (Singapore, 2025).

The institution where the research was conducted. The dissertation was completed at the Department of Physics Teaching Technology, Azerbaijan State Pedagogical University.

The volume of the dissertation. The dissertation comprises six chapters, a conclusion, recommendations, a bibliography, and appendices. It includes 48 figures, 25 schemes, 56 tables, and 22 appendices. The bibliography contains 318 references to both local and international sources. The character count by section is as follows: introduction – 21,587 characters, chapter 1 – 92,273 characters, chapter 2 – 30,602 characters, chapter 3 – 79,087 characters, chapter 4 – 87,309 characters, chapter 5 – 70,309 characters, chapter 6 – 48,482 characters, conclusion and recommendations – 6,750 characters.

The dissertation is 404 pages long, which amounts to 440,807 characters.

THE MAIN CONTENT OF THE RESEARCH

The Introduction section demonstrates the importance of the research topic. Additionally, the object, subject, purpose, research objectives, methodical basis, employed research methods, scientific novelties gained, the theoretical and practical relevance of the study, the main theses for defence, and the research's validation are explained in detail.

The first chapter is titled "**Problem statement and the research context in the lyceums of Azerbaijan and developed countries**". In the first paragraph, "***The Methodical system, structural components and functions of physics training in lyceums***", the conceptual foundations of "system," "training system," and "methodical system of physics training" are explained. The pedagogical system developed by N.V. Kuzmina, which includes structural and functional components, is analysed, and its differences from I.P. Podlasy's instructional system are examined. N.Y.Safarov proposed a unified instructional system based on the analogy between topics within higher education. He conceptualises a "system" as a unity of components interacting with and influencing one another. P.I.Pidkasisty's instructional model is characterised by its integrative nature, adherence to pedagogical regularities, and dynamic coherence among interconnected components; this structure is also presented schematically[5,6].

In the literature, the term "methodical system of physics training" is generally understood as a comprehensive system that includes the aims of instruction, the content of physics education, teaching methods,

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[5]Səfərov N.Y. Texniki ali məktəblərdə ümumi fizika kursunun təlimində vahid yanaşmanın sistemi. Ped. üzrə Elm. Dok. diss., Bakı, 2016. s. 370.

[6]Подласый И.П. Педагогика. Повый курс: Учебник. В 2-х кн. Кн.1: Общие основы. Процесс обучения.Москва: Владос, 1999. 574 с.

tools, and organisational forms – all of which are interconnected[7]. The methodical system comprises five essential components: goal, content, procedural, methodical-technological, and criteria. These should be regarded as a unified and interdependent system. As a result, the need to design a specialised methodical system of physics training specifically for lyceums has become increasingly urgent.

The second paragraph, titled "***Lyceums in Azerbaijan and abroad***", examines the nature and organisation of lyceums both within Azerbaijan and internationally. Although educational institutions operate under different names in various countries, many share conceptual similarities with Azerbaijan's lyceum model. For example, schools called "Magnet Schools" in the USA, "Specialist Schools" in the UK, "Gymnasium" in Germany, "Selective Schools" in Australia, and "Lycée" in France function with comparable aims.

Due to Azerbaijan's longstanding integration into the Soviet Union for seventy years, the structure and operational principles of its lyceums were primarily modelled on Russian prototypes. In pre-revolutionary Russia, six notable lyceums were established: the Imperial Lyceum, the Demidov Lyceum, the Richelieu Lyceum, the Kremenets Lyceum, the Nizhyn Lyceum, and the Katkov Imperial Lyceum.

"Magnet Schools" refers to specialised institutions for high-potential students in the USA. Admission to these schools is competitive and based on specific criteria, and the curriculum is tailored to support gifted learners. By the early 1990s, over 232 such programmes were implemented, with the number increasing to approximately 1400 by 2000[8].

Magnet schools in the United States specialise in STEM (Science, Technology, Engineering, Mathematics), fine and performing arts, International Baccalaureate (IB), international studies,

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[7]Каменецкий С.Е., Пурышева Н.С., Важеевская Н.Е. Теория и методика обучения физике в школе. Общие вопросы, 2000. 368 с.

[8]U.S. Department of Education, Office of Innovation and Improvement. Innovations in Education: Creating Successful Magnet Schools Programs. Washington, D.C., 2004.

technical education, and world languages. As of 2021, the top 10 magnet schools in the U.S. included[9]:

1. Thomas Jefferson High School for Science and Technology
2. Academic Magnet High School
3. Peyton College Preparatory Academy
4. Sumner Academy of Arts and Science
5. Merrol Hyde Magnet School
6. School for the Talented and Gifted
7. Academic Magnet Program High School
8. Irma Lerma Rangel Young Women's Leadership School
9. Tesla STEM High School
10. Julia R. Masterman Laboratory and Demonstration School

In the United Kingdom, specialised schools focus on ten main areas: fine arts, business and entrepreneurship, engineering, humanities, languages, mathematics and computing, music, natural sciences, physical education, and technology.

In Azerbaijan, lyceums typically specialise in three broad areas: humanities, natural sciences, and technical disciplines.

The third paragraph, titled "***Problem Statement in Azerbaijan and Developed Countries***", offers a comparative analysis of physics education in Azerbaijan, Singapore, the USA, Canada, Japan, Italy, China, Australia, India, Russia, France, Germany, and the United Kingdom. It stresses that laboratory work and experiments are essential to physics teaching, greatly enhancing students' scientific outlook, technological understanding, and research skills.

The analysis indicates that countries like the USA, France, and the UK allocate considerable instructional time to experimental work. In the USA, nearly half of the content in physics textbooks is dedicated to experiments. In Eastern European nations, 15-18% of classroom time is spent on laboratory activities, whereas in French lycées, this constitutes up to 50%. In the UK, students undertake

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[9]Wang J., Herman J. Magnet Schools. The Wiley Handbook of School Choice, 2017, p. 158-179.

around 260 laboratory experiments and nearly 300 demonstration activities over five years[10,11].

In Azerbaijan, physics training followed the Russian model until 2003. Subsequent curriculum reforms significantly reduced laboratory activities. Although the 5E instructional model aimed to encourage independent experimentation, it has not been widely adopted in practice due to teachers' challenges in effectively implementing its sequential structure stages.

This paragraph also compares the Cambridge curriculum in the UK with Azerbaijan's national curriculum. Observations show that Azerbaijan's lyceums were initially modelled on the Russian system. However, the national curriculum introduced in 2013 shares similarities with the British National Curriculum, which has been developed and refined since 1988. In the UK, compulsory secondary education is organised into four Key Stages, each delivered with developmentally appropriate psychological and pedagogical methods. Although both systems acknowledge Bloom's taxonomy, Azerbaijan has yet to fully incorporate its levels into a comprehensive assessment framework.

The international PISA results are an essential indicator of the quality of physics education. In the 2018 PISA assessment, Russia ranked 33rd, while Azerbaijan was 68th, revealing significant methodical and structural differences. Azerbaijan's ongoing underperformance, especially in mathematics, reading, and science, highlights the urgent need to modernise its educational system.

Countries such as China, Singapore, Japan, Finland, the UK, Poland, and Germany are among the top performers in PISA. Their

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[10]Goldberg F.M., McDermott L.C. An investigation of student understanding of the real image formation formed by a converging lens or concave mirror. American Journal of Physics, 1987. №55, s.108-119.

[11]McDermott L.C., Rosenquist E.H., van Zee J. Students' difficulties in connecting graphs and physics: Examples from kinematics. American Journal of Physics, 1987. №55, s. 503-513.

curriculum development, assessment methods, teacher training, and technology-based instructional models are exemplary standards.

Studying and adapting best practices from other countries to suit the local context is advisable to improve physics education in Azerbaijan's lyceums. This approach could enhance educational results and foster critical, creative thinking and problem-solving skills. Instructional methods based on problem-based, inquiry-based, and project-based learning – commonly used in Western countries – make physics lessons more engaging and effective. Research from Finland indicates that problem-based learning (PBL) helps intellectually gifted students grasp complex subject matter[12].

Within this framework, students develop research skills, address real-world problems, and apply their knowledge practically.

Y.Karakuyu emphasises that students show greater interest in physics lessons when engaged in real-life projects, thereby necessitating the professional development of teachers[13]. According to Ryzhikov, the research potential of gifted students in physics is closely connected to the development of both convergent and divergent thinking, systematic inquiry skills, and a creative learning environment. He particularly emphasises the role of problem-based and inquiry-based learning instruction[14].

Finally, it is noted that educating gifted students requires a differentiated approach. These students need advanced knowledge and research-oriented activities. Customised instructional programmes and the application of modern teaching methodologies are essential for unlocking their full intellectual potential.

According to the National Association for Gifted Children (USA), effective education of gifted students requires providing them

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[12]Makkonen T., Tirri K., Lavonen J. Engagement in Learning Physics Through Project-Based Learning: A Case Study of Gifted Finnish Upper-Secondary-Level Students. Journal of Advanced Academics, 2021. 32. 1932202X2110186.

[13]Karakuyu Y. Gifted students' opinion about physics education in science and art centers. Abuja: Scientific Research and Essay, 2009, 4, p. 799-805.

[14]Рыжиков С.Б. Развитие исследовательских способностей одаренных школьников при обучении физике. Дис.докт.пед. наук. Москва, 2014. 470 с.

with broad opportunities for cognitive development. Similarly, comprehensive studies conducted in the UK have identified key characteristics of talented students in physics[15]. These include rich imagination, enjoyment of scientific theories, a deep interest in causal explanations, the ability to formulate hypotheses, the capacity to present creative ideas with objective arguments, conducting fair investigations, manipulating variables, proposing alternative strategies, analysing data, drawing connections between broad concepts, engaging in abstract thinking, self-criticism, and a particular interest in specialised scientific domains such as astrophysics.

In conclusion, it is emphasised that the instructional technologies used in foreign lyceums for gifted students in physics training have not been systematically analysed, nor have their implementation prospects in Azerbaijani lyceums been fully explored.

The fourth paragraph is titled "The State and contemporary problems of physics education in Republican lyceums from the perspective of the national concept." In this paragraph, curriculum models implemented at the lyceum level worldwide have been compared with those used in the Azerbaijani education system. Notably, widespread adoption of models proposed by Tyler, Taba, Taba-Tyler, and Wolf-Shoe has been observed in the United States. The Tyler model is deductive, while the Taba model relies on an inductive strategy. The combination of these two – known as the Taba-Tyler model (or "Conscious Planning") – began to be adopted in the U.S. during the 1950s. According to this model, if learning outcomes are unsatisfactory, the steps taken must be critically analysed, and if necessary, the objectives should be redefined.

The "Systematic Approach" model, introduced by Wolf and Shoehave in 1984, emphasises a phased and structured curriculum content design. The model prioritises the development of individual learning programmes and the effective organisation of group activities. It includes core stages such as determining learning objectives,

[15]National Association for Gifted Children Position Statement. Creating contexts for individualized learning in early childhood education. 2006. Retrieved April 1, 2013.

formulating content, lesson planning, selecting teaching materials, and arranging the learning environment. The final stage involves assessment and analysis of outcomes.

In the 21st century, integrating Bloom's taxonomy into physics curriculum, approved by the Ministry of Education of the Republic of Azerbaijan under Order No. F-238, dated 28 April 2022, was designed to systematise students' knowledge, enhance their ability to identify creative and practical solutions, and foster a learning environment to solve real-world problems. One of the key features of the new curriculum is its application of Bloom's taxonomy across different grade levels, integration of multidisciplinary approaches, and inclusion of self-development components. These elements distinguish the revised curriculum from its predecessor and improve its effectiveness in the educational process. However, the lack of comprehensive coverage of all cognitive levels outlined by Bloom's taxonomy within the assessment system may be considered a significant shortcoming.

Although there has been noticeable progress in global physics education systems, several contradictions still adversely impact the quality of physics teaching. These issues can be generally categorised into three types: contradictions of inconsistency, contradictions of perception, and contradictions of resource provision.

The following major issues have been identified in the physics teaching process in lyceums:

- Poor integration of practical components and limited experimentation;
- Gaps in organising group work methodology;
- Limited use of modern instructional technologies and methods;
- Overemphasis on homework at the expense of situational tasks;
- Uneven difficulty levels in summative assessments.

In the second chapter, titled "**The role of the teacher and the psychophysiological characteristics of students in the optimal organisation of physics training in lyceums**", various pedagogical and methodical issues are examined in detail. In the first paragraph, "***The role and competence of the teacher in the optimal teaching of physics in lyceums***", the role of the physics teacher in the instructtional process and the conceptual foundations of professional competence are analysed. Moreover, approaches shaped by the experiences of various countries are critically assessed. Scholars have interpreted the term "competence" from different perspectives: for instance, J.C.Raven relates it to practical activity, whereas L.I.Fishman presents it in the context of professional values and behavioural stereotypes.

Several international models are referenced for classifying professional competencies for physics teachers. These include A.V.Khutorskoy's seven-dimensional model, Hongcun Xin's approach, which emphasises practical and methodical skills in physics[16], and the 21 core competencies outlined by the European Education Structures Organisation, covering areas such as teaching, assessment, interdisciplinary integration, and modelling[17].

State standards govern teacher competencies in the Azerbaijani education system, encompassing knowledge, communication, ethics, and methodical preparedness. In Australia, professional competencies are evaluated across three areas: subject-specific theoretical knowledge, pedagogical practice, and engagement in professional development[18]. I.N.Rogova categorises the competencies of physics teachers into three main areas: cognitive, behavioural-performance, and personal[19].

As a result of this analysis, a five-stage algorithm for the professional development of physics teachers in lyceums is proposed

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[16]Hongjun X. Key compentences of Physics: Perspective, Discussion and Reconstruction. Educational Science Research, 2018. №11, s. 5-14.

[17]Gonzalez J., Wagenaar R. Tuning Educational Structures in Europe. Final Report. Phase 1. University of Deusto, Bilbao, 2003. 317 p.

[18]Australian Institute for Teaching and School Leadership. Australian Professional Standards for Teachers, AITSL. Melbourne, 2011. pp. 32.

[19]Рогова И.Н. Оценка сформированности методической компетентности учителей физики. Волгоград: Известия ВГПУ. 017. №4 (117), с. 40-46.

(see Figure 1). Additionally, competencies for lyceum physics teachers are categorised into four pedagogical areas: cognitive, personal, instructional-performance, and analytical-reflective.

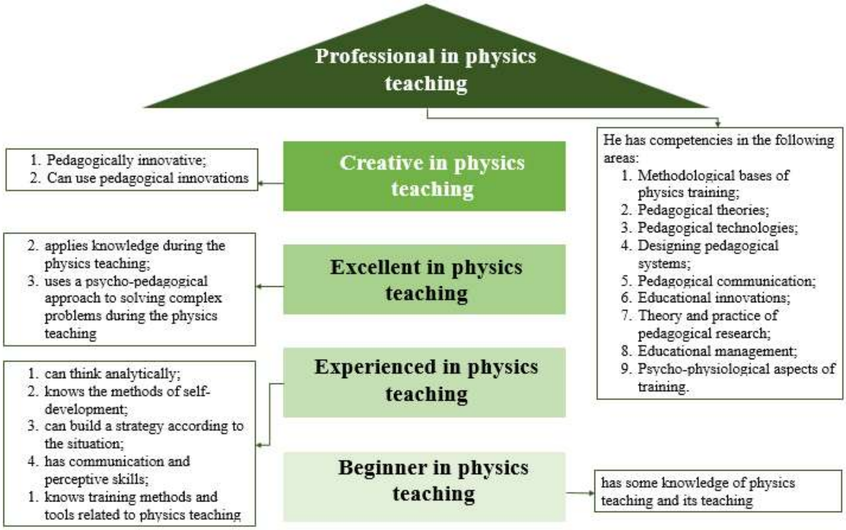

Figure 1. Lyceum physics teacher's professional development algorithm

The second paragraph, "**Psychodiagnostic Analysis of the Individual Characteristics of Gifted Students**", discusses the concept of “giftedness” and the specific principles for organising work with gifted children. Research shows that in European and Asian educational settings, activities with talented students in lyceums are carried out at four primary levels:

1. Level 1: identifying and nurturing giftedness within regular classroom lessons;
2. Level 2: encouraging giftedness through school competitions, projects, and academic contests;
3. Level 3: developing gifted students’ skills within creative and research laboratories, often in small project-based groups;
4. Level 4: targeted individualised efforts to support and enhance the capabilities of gifted students.

In the post-Soviet space, four primary pedagogical strategies have been used to educate gifted students[20]: accelerating learning, deepening instructional content, enriching the content with supplementary materials and activities, and applying problem-based learning strategies.

Structured programmes for gifted students in most schools across Europe and the United States have been developed. Accordingly, professional development programmes for teachers working with gifted learners have undergone significant revisions and improvements.

J.P. Guilford identified six key abilities crucial for recognising creativity and giftedness in students[21]:

1. The ability to identify problems and formulate solutions systematically;
2. The ability to generate multiple and diverse ideas;
3. The ability to organise and structure different ideas;
4. The ability to produce unconventional answers and propose non-standard solutions;
5. The ability to enhance objects by adding further details;
6. The ability to solve non-standard and complex problems effectively.

Additionally, Guilford emphasised the significance of involving students in practical activities during lessons with gifted learners.

Experts identify several key psychological signs to diagnose giftedness in children[22,23,24]. These include psychological portrait

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[20]Министерство образования и науки Российской Федерации. Технологии работы с одарёнными детьми. Елабуга, 2017. 112 с.

[21]Guilford J.P. Intellect and the Gifted. Washington: Gifted Child Quarterly, – 1972, 16 (3), p. 175-184.

[22]Большаков В.Ю. Педагогические основы развития лидерской одаренности у старших школьников: Дис. д-ра пед. наук: 13.00.01, 19.00.07. Москва, 2000. 459 с.

[23]Боровикова О.Н., Дежникова Н.С., Ришар Е.Н. Зарубежная школа: авторский поиск, эксперименты, находки. М., 1993.

[24]Брюно Ж. и др. Одаренные дети: психолого-педагогические исследования и практика. Психологический журнал. 1995. № 4. с. 73.

(appearance), self-esteem, negative attitudes towards lessons resulting from curriculum simplicity, and the level of socialisation. These include psychological portrait (appearance), self-esteem, negative attitudes towards lessons resulting from curriculum simplicity, and the level of socialisation.

Ultimately, three main areas of gifted students' development need focused cultivation, each involving nurturing vital skills: 1) Cognitive abilities and intellectual skills; 2) Creative capacity; 3) Emotional characteristics.

The third paragraph, "**Characteristics of Students' Intellectual Abilities**", provides a detailed analysis of the complex nature of intellect. Psychologists have understood "intelligence" and "intellect-tual abilities" differently. According to M.A.Kholodnaya, intelligence involves organising an individual's cognitive experience, while intellectual ability is regarded as a psychological trait. L.S.Vygotsky noted that the development of thinking is central to adolescents' intellectual growth.

K.A.Jakob examined the challenges faced during physics lessons and highlighted teachers' difficulties explaining certain concepts. Using Gardner's theory of multiple intelligences, Jakob suggested that physics teaching can incorporate various modalities—verbal-linguistic, logical-mathematical, spatial-visual, bodily-kinesthetic, interpersonal, and intrapersonal intelligences.

Psychological research highlights the importance of intellectual faculties such as thinking, memory, imagination, and attention. Studies on developing these abilities in lyceum students show that the contemporary teacher must prioritise consistent support for these skills throughout all lesson stages.

The third chapter, "**Analysis of the content and instructional components of physics from the perspective of constructing a methodical system of physics training in lyceums**", discusses the structural foundations and pedagogical design of physics education.

The first paragraph, "***Forms and methods of physics training in lyceums***", systematically examines the theoretical foundations of instructional forms and methods used in physics training within lyceums. Research evidence shows that in the education systems of developed countries, special emphasis is placed on group-based instructional formats, which promote collaboration, responsibility, critical thinking, and creative reasoning among students. The effecttiveness of these instructional forms and the coherence among their components are considered essential criteria for success implementtation[25].

Several pedagogical conditions are emphasised for effectively organising group work in Lyceum physics classrooms: structuring group composition based on methodological principles, assigning clear roles, encouraging student participation in decision-making, implementing peer assessment, and ensuring teacher supervision.

The theoretical core of the term "method" and its practical importance in physics education are critically examined based on the works of I.ya. Lerner, M.I.Makhmutov, and M.M.Mekhdizadeh.

The research classifies physics teaching methods in lyceums along three functional axes:

1. Heuristic and research-oriented methods, such as PBL, IBL, and PjBL tasks, all aimed at fostering students' research skills.
2. Methods aimed at developing critical thinking, including the Question Formulation Technique (QFT), debate-based methods, Bloom's Taxonomy, SOLO (Structure of Observed Learning Outcomes), TeachThought frameworks, Socratic and Paideia seminars, and the "Question Game" technique.
3. STEM-based instructional methods that incorporate STEM elements into physics teaching and encourage interdisciplinary and applied learning experiences.

The second paragraph, "***Instructional tools for physics training in lyceums***", emphasises the importance of verbal, visual, specialised, and technological tools in lyceum-level physics education. The use of LAB Discs, Promethean Boards, 3D animations, virtual laboratories, infographics, concept maps, and technological flowcharts is parti-

[25]Чередов И.М. О принципе оптимального сочетания фронтальной, групповой и индивидуальной работы с учащимися на уроках. Омск, 1973. 136 с.

cularly highlighted. These tools are crucial for enhancing understanding and engagement in physics lessons in the United States and the United Kingdom. Incorporating educational technologies into the learning environment boosts student interest and modernises traditional teaching methods, creating a more cohesive and effective learning environment.

The third paragraph, "***Instructional techniques in lyceum physics education***", concentrates on differentiated methods for gifted students. These include Brainstorming, Jigsaw, Auction, Cluster, Fishbone, Case Method, Cinquain, INSERT, KWL (Know–Want to know–Learned), Cubing, Bloom's Flower, Thin and Thick Questions, Essay Writing, Reciprocal Q&A, and the IDEAL Model (Identify – Define – Explore – Action – Learn). Examples are provided for each technique, and their pedagogical applications are thoroughly analysed.

The fourth paragraph, "Content of the physics subject", categorises activities to enhance lyceum-level physics content into three main subsections.

In the first subsection, "Epistemological and methodological knowledge in physics training," these components are vital for fostering scientific understanding. Analytical reasoning techniques – such as induction, deduction, analogy, synthesis, and abstraction – play a crucial role in developing learners' systematic and creative thinking skills. Notably, in internationally recognised "Magnet" schools, these cognitive strategies are systematically incorporated into independent learning tasks, enriching physics's instructional depth and conceptual significance.

The proper use of cognitive strategies is recommended in the following areas: inductive-deductive approaches in explaining phenomena and solving problems; the use of analogies and modelling to understand complex concepts such as gravitation, wave phenomena, and atomic structure; comparative analysis for systematisation and causal reasoning; and the integration of modern methodological principles such as relativity, symmetry, and superposition.

Internationally recognised models such as the Instructional Function Model, the Missouri Program, and Madeline Hunter's Instructional Theory exemplify frameworks for structuring physics instruction. In conclusion, models for teaching physical phenomena, devices, quantities, laws, and theories based on inductive and deductive reasoning, grounded in Bloom's Taxonomy, are presented.

In the second subsection, "*Formation of visual representations in physics education*", the principle of visual learning is recognised as a fundamental element in modern didactic theory. Empirical results from physiological studies show that around 80% of all human sensory information is gained through the visual channel. At the same time, psychological research highlights the central role of visual imagery and schematic representations in shaping internal speech structures. As a result, incorporating visual elements into physics education significantly enhances students' conceptual understanding and long-term retention of the subject matter.

Consequently, improving visual representation in lyceum physics should involve actively using photos, colour-coded diagrams, 3D animations, models, QR codes, and comparative illustrations found in international textbooks, strongly emphasising integrating ICT tools.

Integrating information and communication technologies (ICT) into learning is a key pedagogical approach in modern education. Prof. Isa Ismayilov's scientific-pedagogical research on applying ICT in teaching physics in general education schools is particularly significant in this context. These studies demonstrate that the deliberate use of ICT increases interactivity, encourages students' cognitive engagement, and aids in developing autonomous learning skills[26].

In the third subsection titled "Structure of the physics course and curriculum in lyceums", it is observed that in several developed countries – such as the United States, the United Kingdom, Finland, Germany, Japan, and France – physics is not offered as a separate subject at the 7-8 grade levels. Instead, it is integrated into an all-encompassing "Science" curriculum that covers physics, chemistry, and biology. For example, in the Japanese education system, physics is taught as a standalone subject for only one academic year, usually

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[26]İsmayılov İ.N. Ümumtəhsil məktəblərində fizikanın tədrisində yeni informasiya texnologiyalarından istifadənin nəzəri və praktik problemləri. Ped. üzrə Elm. Dok.diss. Bakı, 2010. 300 s.

at the upper secondary level. This curricular model reflects a broader pedagogical approach to foster interdisciplinary scientific literacy during the early stages of general education.

Prof. Isa Ismayilov suggests that the structure of physics textbooks should mirror the scientific regularities of nature, following the principles of directionality, recurrence, and continuity of natural phenomena. Psychological research indicates that organising instructtion from simple to complex promotes deeper learning, although presenting knowledge in overly fragmented units may prevent the formation of conceptual links[27].

Analysis of international curricula shows that programmes like IB and IGCSE demonstrate strong content coherence and step-by-step progression. The IB Physics 1 course covers modules such as vectors, dynamics, energy, waves, optics, thermodynamics, and the history of physics, and prepares students for the AP Physics C examination.

The curriculum should include complex topics such as non-inertial frames of reference, Bernoulli's equation, the Doppler effect, eddy currents, interference, and diffraction to promote a thorough understanding and application of physical phenomena among lyceum students.

The physics course's block-modular structure, designed for lyceums, is organised according to key instructional areas, topic types, and teaching units. This framework supports the optimal allocation of lesson formats (7E, PBL, IBL, PjBL, debate-based lessons, etc.) by class level and specialisation and encourages structured instructional organisation.

The fourth chapter, "**Systemic, theoretical, and methodical foundations of physics training in lyceums**", discusses instructional motivation and organising of student engagement in practical activities.

The first paragraph, *"Methodology of organising motivation"*, investigates current challenges related to student motivation and

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[27]İsmayılov İ.N. Fizikanın tədrisi metodikasının müasir problemləri. Bakı: ADPU-nəşriyyatı, 2019. 378 s.

proposes strategies for addressing them. A system and algorithm for generating motivation in lyceum-level physics instruction are presented. Significant motivational challenges are identified and analysed as follows:

- Improper formulation of the guiding question;
- Motivation limited to textual explanation;
- Poor quality of visual aids used for motivation;
- Inadequate allocation of time for motivational activities;
- Designing motivational elements around overly complex experiments.

The second paragraph, ***"Methodology of organising practical activities of lyceum students"***, explores the dynamics of student engagement in task-solving and laboratory activities during physics lessons.

The first subsection, "Methodology for organising student activities in solving physics problems," emphasises the role of mathematics, especially the application of the head-to-tail vector method, supported by numerous examples. Furthermore, relevant examples demonstrate the significance of the coordinate method in identifying the centre of gravity.

Instructional algorithms for problems commonly used in lyceums are developed and supported by illustrative examples. The use of situational issues in physics education is also examined in detail, emphasising their pedagogical value.

The second subsection, "*Methodology for organising student activities in laboratory work*", presents comparative models of laboratory instruction in various countries. Since the early 20th century, developed nations have systematically incorporated practical activities into education to cultivate hands-on skills among gifted students. In the United States, C.A.Dewey criticised formalist instruction and stressed teaching science as a way of thinking. In Japan, practical experiments are of particular importance.

This section offers a comparative analysis of traditional and virtual laboratories, the use of LAB Discs, a proposed list of school laboratory activities, and recommendations for instructional materials.

The findings show that students often make specific “mistakes” during laboratory activities, caused by external factors not considered.

In the third paragraph of the fourth chapter, titled "***Methodical forms of organising physics training in lyceums***", various lesson models used in developed countries have been examined, and those considered most suitable for lyceums have been designed accordingly. Specifically, lesson structures have been systematically elaborated based on the 7E model and non-traditional lesson formats, such as problem-based, inquiry-based, project-based, and debate lessons. The phased organisation of these lesson types has been thoroughly analysed. In addition to the structural framework of debate lessons, a sample format is presented for students’ four-part responses – statement, explanation, justification, and conclusion – based on a predetermined algorithm.

It was concluded that the following principles should systematically guide the organisation of physics training in lyceums:

1. Providing in-depth knowledge of subject-specific physics content (for lyceums specialising in technical and natural sciences);
2. Systematic teaching of interconnected physics topics;
3. Development of students' independent thinking and creative performance skills.

The fourth paragraph, “***Methodology for assessing students’ achievements in physics training at the lyceum level***”, examines approaches to student assessment in various countries. The findings are organised into three subsections.

The first subsection (*Methodology and technology of criterion-based assessment*) examines in detail research studies on assessment models widely used in lyceums of developed countries, such as IB, IGCSE, and AP Physics. It has been shown that approximately 75% of the IB Physics curriculum, 50% of IGCSE Physics, and about 80-90% of AP Physics focus on developing practical skills. The assessment criteria of these systems have been thoroughly analysed, revealing that knowledge and skills are assessed separately based on Bloom’s Taxonomy.

The author has established a set of evaluation standards for lyceums based on the aforementioned assessment systems, rooted in Bloom's Taxonomy (Table 1). As shown in the table, knowledge and skills are categorised separately. Additionally, student assessment in lyceums is carried out through low-level standards, marked with "L", and high-level standards, indicated with "H". According to Bloom's Taxonomy, the L-standards correspond to the stages of "remembering," "understanding," and "applying," whereas the H-standards refer to the stages of "analysing," "evaluating," and "creating." For example, in the substandard "L.III.3.1. Uses instruments or equipment relevant to the topic," the components are interpreted as follows:

- L indicates a lower cognitive level;
- III corresponds to the third level of Bloom's Taxonomy, i.e., "applying";
- 3 identifies the activity domain as "conducting experiments";
- 1 specifies the first substandard within this domain.

Table 1

Suggested assessment directions for lyceums

L-standards		H-standards
I. Knowledge, II. Understanding	III. Application	IV. Analysis, V. Synthesis, VI. Evaluation
1. Sign (2)	1. Modelling (2)	1. Modelling (5)
2. Quantity (2)	2. Problem-Solving (2)	2. Problem Solving (5)
3. Reason (2)	3. Practice (2)	3. Practice (4)
4. Property (6)	4. Data processing (1)	4. Data processing (3)
5. Coordinating(8)	5. Reasoning (1)	5. Reasoning (6)
	6. Coordinating (1)	6. Coordinating (6)
	7. Life and Technology (2)	7. Life and Technology (4)

The learning outcome derived from a given substandard is formulated by replacing the placeholder "relevant to the topic" with the specific lesson content. During assessment, a student's achievement level is expressed using the following structure: a negative construction is used at the first level; adverbs such as “partially,” “mostly,” and “fully” are employed at the second, third, and fourth levels respectively, to modify the corresponding verb forms.

The second subsection, "*Technology of school-based assessment in lyceums*", provides an analytical overview of rubrics used in the national curriculum and developed countries. It has been found that, similar to international practice, Azerbaijan uses three types of school-based assessment: formative, diagnostic, and summative. However, it is noted that rubrics employed in formative assessment of students’ understanding in physics do not systematically cover all cognitive stages of Bloom’s Taxonomy. Consequently, a criteria-based analytical rubric for formative evaluation in lyceums has been developed and presented (Table 2).

Table 2

Rubric assessment table for lyceums

<table>
<tr><td colspan="2">SUBJECT</td><td colspan="5"></td></tr>
<tr><td colspan="2">Standards</td><td colspan="2">Bloom's taxonomy</td><td colspan="3">Sub-standards</td></tr>
<tr><td colspan="2">L-standards</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="2">H-standards</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="7">EVALUATION</td></tr>
<tr><td>Learning outcomes</td><td colspan="2">I level</td><td colspan="2">Level II</td><td>Level III</td><td>Level IV</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td></tr>
</table>

The third subsection, "*Methodology and technology of implementing student self-assessment*", examines various research findings on self-assessment conducted by international scholars. At the end of each instructional unit, a four-level self-assessment table designed for lyceums and a student self-assessment form for reflective purposes are also presented.

The fifth paragraph of the fourth chapter, titled “***Organisational aspects of physics training planning in lyceums***”, examines prospective and current planning models used in developed countries. Specifically, it reviews planning models employed in AP Physics and IGCSE Physics curricula. Consequently, a structured model of current lesson planning has been identified as suitable for lyceums. This model includes lesson type, topic, standards, learning outcomes, methods, activity formats, resources, assessment tools, and lesson progression. Sample long-term plans are also presented for Natural Sciences, Humanities, and Technical lyceums, covering all grade levels.

Chapter five is titled "**The Concept, methodical system, and practical implementation of physics training in lyceums**". The first paragraph, "***The Concept of the methodical system of physics training in lyceums***", explains the main aims of physics training at the lyceum level and, based on these aims, discusses the key educational tasks of the subject.

It has been observed that there is a growing need for interactive teaching methods in physics training within Azerbaijani lyceums. However, several significant deficiencies remain in this area. In particular, insufficient emphasis is placed on research-oriented activities and the development of technological literacy. Shortcomings in scientific-methodical complexes, limited utilisation of virtual experiments, and restricted application of artificial intelligence tools present considerable obstacles to effective instruction.

In recent years, the growing inclusion of situational tasks in national examinations administered by the State Examination Centre reflects a shift from rote memorisation. The modernisation and digitalisation of assessment tools are also widely recognised. Moreover, the contemporary challenges discussed in earlier chapters have been systematised and categorised into the following categories:

1. Issues related to the content of the physics subject in lyceums;
2. Challenges associated with fostering student motivation in physics;
3. Methodical problems concerning instructional strategies in physics training at the lyceum level;
4. Issues about the professional competencies of physics teachers in lyceums.

In response to these challenges, a conceptual framework and a model for the methodical system of physics training in lyceums have been developed (Figure 2). The foundational principles and theoretical basis of this concept are described in detail.

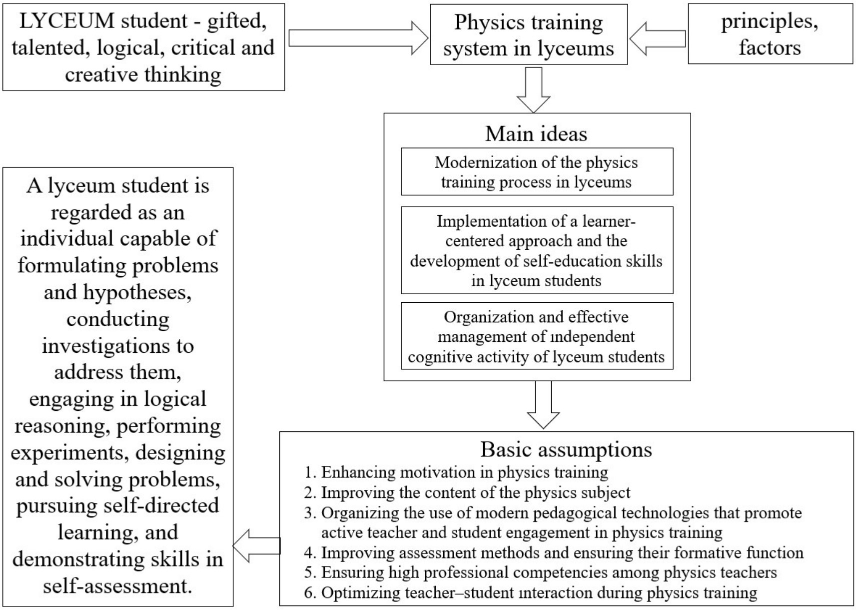

Figure 2. Conceptual framework of the methodological system of physics training in lyceums

While developing this concept, references were made to the theoretical and methodical works of Azerbaijani scholars, including M.I.Murquzov, A.O.Mehrabov, E.M.Gojayev, Z.I.Qaralov, S.Sh.Imanov, Sh.H.Alizade, I.N.Ismayilov, N.A.Aliyev, R.S.Adigozalov, S.S.Hamidov, A.M.Huseynov, A.G.Pelengov, R.R.Abdurazakov, and R.Y.Shukyurov, as well as prominent international didacticians such as F.A.Diesterweg, A.S.Makarenko, V.G.Razumovsky, I.F.Herbart, K.D.Ushinsky, M.T.Montessori, J.A.Dewey, I.H.Escobar, E.C.Panadero, I.D.Gonzalez, among others.

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The conceptual framework's foundation includes its sources, influencing factors, objectives, principles, criteria, a system of key propositions, and their implementation mechanisms.

The factors identified as contributing to the development of the conceptual propositions include:

- establishing a universal system for physics training in lyceums;
- students' understanding of independent, student-centred learning technologies;
- the acquisition of comprehensive professional competencies by educators;
- students' adaptation to modern instructional methodologies;
- effective organisation of teacher-student communication when applying contemporary teaching models;
- equipping classrooms with ICT tools;
- developing ICT skills among both students and educators;
- taking into account students' physiological characteristics and developmental needs;
- mastering the Physical Picture of the World through both theoretical and practical methods;
- enhancing laboratory resources.

As is well known, all conceptual frameworks are based on specific pedagogical principles. The concept of the methodical system of physics training in lyceums is built on the following principles: scientific orientation; accessibility; the unity of development, instruction, and upbringing; visual demonstration; sequence and systematicity; unity of theory and practice; polytechnic education; modularity; staged structure; generalisation; and cyclicity.

The main criterion for any model is its outcome-focused nature: how well the achieved results match the set goals. In other words, the knowledge, skills, and habits learners gain in physics training must meet normative standards and help develop social and personal competencies required by modern society.

The methodical system is an open, adaptable, and flexible structure. Its flexibility allows it to respond to changing pedagogical conditions and learning environments, and enables it to be enriched by individualised methodical approaches. Each methodical system is highly organised and includes subsystems that support the implementation of different stages of instruction in lyceums.

The conceptual framework of the methodical system of physics training in lyceums is based on the following ideas:

- modernisation of the physics training process in lyceums;
- implementation of a learner-centred approach and the development of self-education skills in lyceum students;
- organisation and effective management of ındependent cognitive activity of lyceum students.

Building on these ideas, the following key propositions have been formulated:

1. Enhancing motivation in physics training;
2. Improving the content of the physics subject;
3. Organising the use of modern pedagogical technologies that promote active teacher and student engagement in physics training;
4. Improving assessment methods and ensuring their formative function;
5. Ensuring high professional competencies among physics teachers;

6. Optimising teacher-student ınteraction during physics training.

Each of the above propositions is elaborated through specific pedagogical elements.

The second paragraph of chapter five, entitled "***Model of the methodical system of physics training in lyceums***", introduces the developed model for the methodical system of physics training tailored to lyceum settings (Figure 3). This model incorporates five key components: objectives, content, procedures, assessment-monitoring, and participant characteristics. Each component reflects the previous chapters' new models, structures, and proposals.

The objective component outlines the following:

- enhancement of the methodical system of physics training in lyceums;
- development of student-centred growth, self-directed learning capacity, 4C competencies (critical thinking, communication, collaboration, creativity), deep subject-matter knowledge in physics, experience-based learning, and independent research skills among lyceum students.

The content component includes refining physics content in lyceums through case-based assignments, visual representations, tasks aimed at developing critical thinking, in-depth knowledge, research-driven a block-modular structure based on specific subject domains in physics. One essential consideration in lyceum instruction is the role of homework. The content component also covers the scope of homework, which may include project work, essays, virtual laboratory investtigations, and analysis of animations on platforms such as YouTube.

The procedural component is divided into two parts: organisation and technology. The "Organisation" part includes motivation, lesson planning, and supporting students' scientific activities through laboratory and problem-solving tasks. This involves both traditional and virtual laboratory work. The "Technology" part covers methods, strategies, forms, and tools that foster heuristic thinking, research skills, and critical thinking abilities.

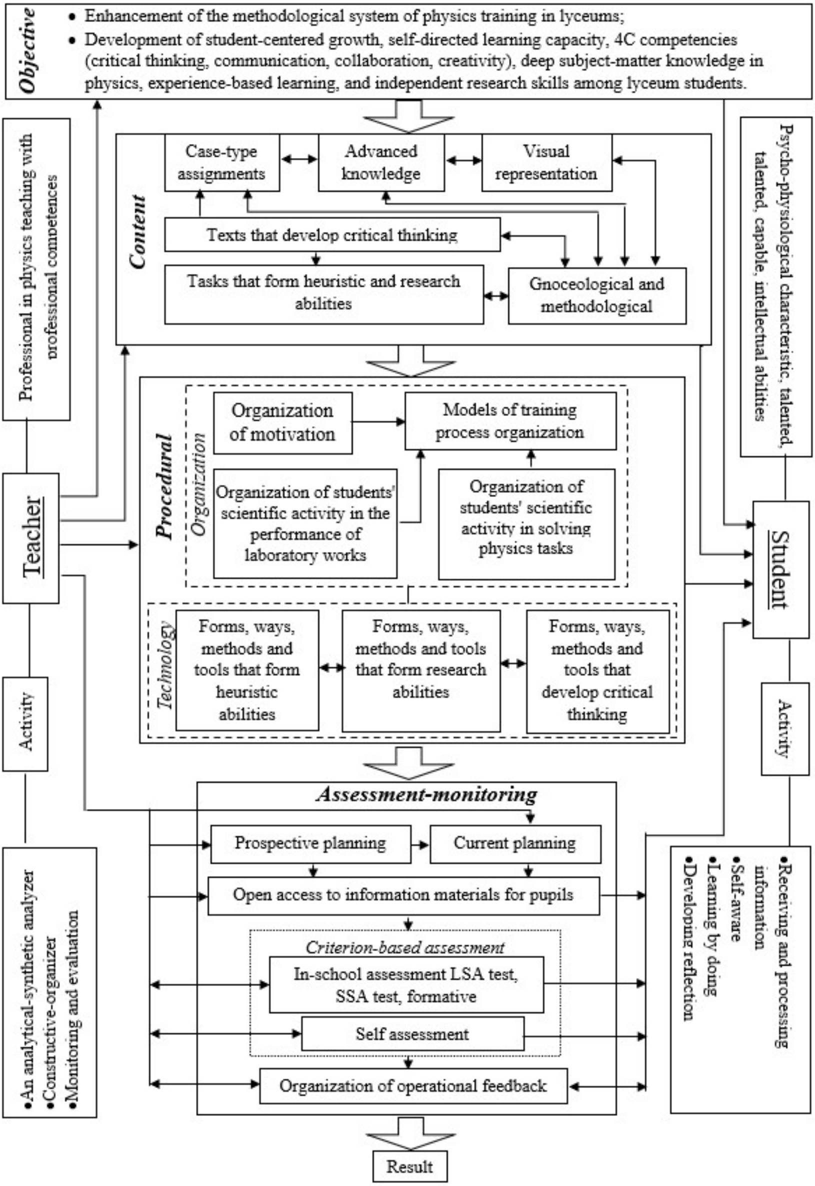

Figure 3. Model of the methodical system of physics training in lyceums

The assessment monitoring component includes long-term and daily planning, access to student information resources, facilitation of active feedback, and integration of Large Summative Assessment, Small Summative Assessment, formative and self-assessment, as well as criterion-based assessment approaches. Students should not be limited to practical tasks or topic-based tests alone; they should also have access to reference materials during oral examinations and final evaluations, such as instruments, physical constants, trigonometric functions, and core physics formulas. Such access enhances, rather than diminishes, the level of assessment in the lyceum context by creating opportunities for processing and applying knowledge. Active feedback involves providing students with corrective guidance or correct answers after reviewing their responses to physics tasks. It is recommended that some assessment activities be carried out during the creative application stage and linked to real-life situations. Situational tasks should be designed with progressively increasing complexity. Student performance may be evaluated through four control methods: frontal oral questioning, situational testing, self-assessment tests, and peer-assessment tests. It is also advisable to assign point values to each assessment task.

The participant characteristics component covers the teacher's professional competencies, the development algorithm of a qualified physics teacher, and students' psycho-physiological features and intellectual abilities.

Additionally, as part of this research, a sample lesson structure for a one-hour academic topic was created based on the 7E instructtional model.

The third paragraph of this chapter, titled "***Practical implementation models of the methodical system of physics training in lyceums***", introduces nine model lessons on "Fundamentals of Dynamics" for Grade 10 students in science-oriented lyceums. These lesson models were developed based on the standards, long-term and short-term planning strategies, and assessment rubrics for science-track Grade 10 lyceums. Each model is detailed in a separate subsection and analysed by instructional stages.

1. The subsection “Lesson model based on the 7E instructional framework”, Topic 2.19 – *“*Projectile motion*”,* is analysed according to the 7E stages.

2. The subsection *“*Problem-based learning model in lyceums” analyses Topic 2.24 – “Why doesn’t a ballpoint pen write in a spaceship?” following a structured PBL format.

3. The subsection “Inquiry-based learning model in lyceums” analyses Topic 2.21 – “How does air resistance affect objects moving through the atmosphere?” within an IBL framework.

4. The subsection “Project-based learning model in lyceums” presents Topic 2.44 – “Designing a Vacuum Dynamometer,” using the PjBL methodology.

5. The subsection “Debate-lesson model in lyceums”, Topic 2.35 – “Is frictional force beneficial?” is presented and analysed in debate format.

6. The subsection “Problem-solving and small-scale summative assessment model in lyceums” examines Topic 2.22, “Solving physics problems”, using situational tasks and a technological map.

7. The subsection “Experiment-based lesson model in lyceums” covers Topic 2.46 – “Measuring the coefficient of sliding friction on an inclined plane.”

8. The subsection “Virtual lab-based lesson model in lyceums” analyses Topic 2.39 – “Measuring buoyant force in liquids and gases” using a virtual experiment.

9. In the subsection “STEM-based physics lesson model in lyceums”, an integrative lesson on “Reaction Machines” is analysed according to STEM principles.

Chapter six is titled “**Technology for organising and conducting pedagogical experimentation**”. The first paragraph, “***Methodology for organising and conducting a pedagogical experiment***”, describes the principles and procedures guiding the implementation of pedagogical experimentation. The hypothesis of the study was based on the following assumptions:

• Applying the methodical system of physics training in lyceums can foster students' heuristic and inquiry skills while promoting the development of 21st-century competencies.

• Instruction based on the new conceptual framework enhances students' motivation and engagement by stimulating their self-directed learning and independent cognitive activity.

• Effective integration of the core components of the methodical system – objectives, content, procedural mechanisms, assessment, and participant characteristics – can increase the efficiency and quality of instruction.

In the second paragraph, "***The diagnostic stage of the pedagogical experiment***", this phase aimed to evaluate the current state of physics education in lyceums and identify key issues. The main objective was to scrutinise the instructional context and scientifically justify the necessity of implementing a new methodical system.

The research was conducted at the Baku Private Turkish Lyceum, the Chemistry-Biological Lyceum, and the Modern Education Complex after Heydar Aliyev. A sociological survey was conducted with 12 teachers and 210 students. Data analysis was performed using factorial analysis in SPSS software across 32 variables. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.871, and Bartlett's test of sphericity yielded a statistically significant result ($p < 0.001$), confirming the suitability and reliability of the factor analysis. Variables with factor loadings above 0.5 were grouped into five macrofactors: (1) pedagogical competencies of teachers; (2) organisation of the instructional process; (3) students' practical engagement; (4) learning environment and visual elements; (5) organisation of laboratory work.

The overall scientific and pedagogical analysis concluded that the methodical system of physics training in lyceums requires significant improvement. Current challenges include formalistic instructtional approaches, a lack of individualised learning materials, deficiencies in teachers' professional preparedness, and inadequate promotion of self-directed and inquiry-based student activities. The results also provide empirical and pedagogical validation for the necessity of a newly designed methodical system.

The third paragraph, "***The exploratory stage of the pedagogical experiment***", outlines the functions of this phase. It also mentions that during this stage, the conceptual framework of the methodical system – comprising its core ideas and propositions – was developed, and the five-component model (objectives, content, procedural, assessment-monitoring, and participant characteristics) was finalised.

The fourth paragraph, "***The formative stage of the pedagogical experiment***", outlines the main experimental intervention involving 546 students from various classes. Both control and experimental groups were established. Instruction in the experimental groups adhered to specific standards and long-term plans, with outcomes analysed comparatively. For example, in the topic "Dynamics," a total of 209 students from 7th and 10th Grades participated, including 61 from the European Lyceum, 107 from the Heydar Aliyev Modern Education Complex (7th Grade), and 72 (10th Grade). A 30-question test was administered, with results evaluated on a 100-point scale. The analysis employed the Independent t-test. Findings showed significantly higher performance in the experimental groups compared to controls: for 7th Grade, experimental ($M=60.1$, $SD=7.9$) versus control ($M=50.4$, $SD=7.95$), $p = 0.000$; for 10th Grade, experimental ($M=61$, $SD=7.7$) versus control ($M=54.7$, $SD=6.1$), $p = 0.000$. Boxplot diagrams in Figure 4 verified improved minimum and median values, with 7th Grade results being more concentrated and within a higher range. Conversely, 10th Grade results demonstrated greater consistency and overall performance (Table 3).

Subsequently, Pearson correlation (rather than Spearman, due to the normal distribution of variables) was used to determine the relationship between mastery percentage (based on scores) and self-assessment scores in the experimental groups (Table 4). Results indicated a strong positive correlation in both 7th Grade ($r(84) = 0.863$) and 10th Grade ($r(36) = 0.807$), both statistically significant at $p = 0.000$. This finding suggests that the purposeful implementation of the newly developed methodical system fostered a notable increase in students' academic self-confidence.

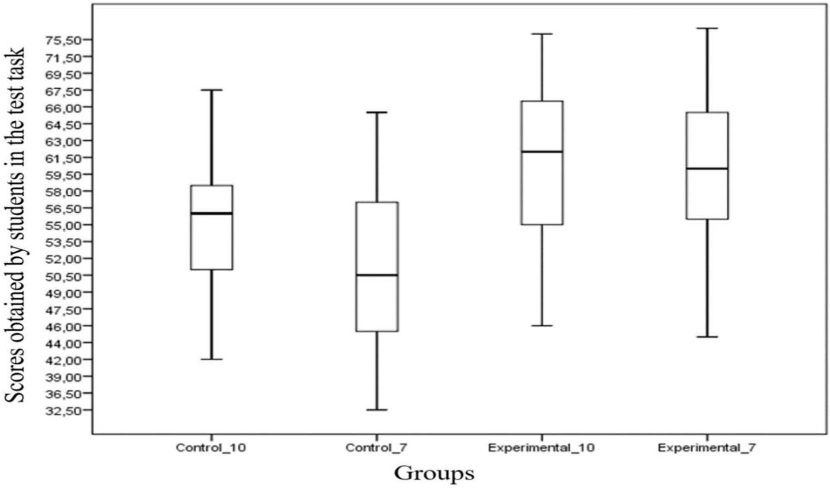

Figure 4. Test Results for Control and Experimental Groups

In the paragraph "***Pedagogical Experiments on the Role of Virtual Experiments in Physics Training***", the impact of incorporating virtual laboratories in Grades VII, VIII, and IX was examined. Independent t-test and boxplot analysis showed that students in the experimental group significantly outperformed their peers in the control group ($p < 0.05$). Median and quartile indicators indicated more stable and higher levels of content mastery among the experimental groups. These results provide empirical support for the conclusion that integrating virtual laboratories into instruction improves students' conceptual understanding and practical skills in physics.

The final paragraph of this chapter, "***Pedagogical experiments on the role of vector operations in physics training***", evaluates the effectiveness of using the "Head-to-Tail" method for vector addition in teaching. Experimental results revealed that this approach significantly improved students' problem-solving skills and practical ability in calculating resultant forces. Statistical analysis with SPSS confirmed a notable difference between pre-test and post-test scores for 10^{th}-grade students in the experimental group ($t(11) = 6.57$, $p < 0.001$), thereby empirically supporting the effectiveness of the instructional technology used.

Therefore, the experiments produce significant scientific and pedagogical findings related to modernising physics education at the lyceum level, improving its structural-methodical foundations, and consistently implementing student-centred and competency-based approaches.

Table 3

Independent t-test

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
7th Grade									
Equal variances assumed	0.137	0.712	-7.978	166	0.000	-9.77	1.23	-12.19	-7.36
Equal variances not assumed.			-7.978	166	0.000	-9.77	1.23	-12.19	-7.36

Continuation of Table 3

10th Grade									
Equal variances assumed	2.861	0.095	-3.803	70	0.000	-6.26	1.65	-9.55	-2.98
Equal variances not assumed.			-3.803	67	0.000	-6.26	1.65	-9.55	-2.98

Table 4
Pearson correlation

		Percentage of mastery according to accumulated points (7^{th} Grade)	Self-assessment score (7^{th} Grade)
Percentage of mastery according to accumulated points (7th Grade)	Pearson Correlation	1	0.863
	Sig. (2-tailed)		0,000
	N	84	84

Continuation of Table 4

Self-assessment score (7th Grade)	Pearson Correlation	0.863	1
	Sig. (2-tailed)	,000	
	N	84	84
		Percentage of mastery according to the accumulated points (10th Grade)	Self-Assessment Score (10th Grade)
Percentage of mastery according to accumulated points (10th Grade)	Pearson Correlation	1	0.807
	Sig. (2-tailed)		0.000
	N	36	36
Self-assessment score (10th Grade)	Pearson Correlation	0.807	1
	Sig. (2-tailed)	0.000	
	N	36	36

Results

As a result of the research conducted, the following conclusions were drawn based on the analysis and generalisation of the invest-tigated data issues:

1. It was identified that the existing problems of physics training in lyceums could be classified into four major categories: the subject's content, the formation of motivation, the applied methods and techniques, and the professional competencies of physics teachers.

2. A scientifically grounded concept of the methodical system of physics training in lyceums was developed based on pedagogical ideas such as modernising the educational process, implementing student-centred approaches, developing self-directed learning skills, and effectively organising independent cognitive activity.

3. Based on the aforementioned concept, a model was developed comprising the following components: objectives, content, procedural structure, assessment-monitoring, and participant character-ristics. This model improved the instructional process and supported the development of self-education and independent inquiry among lyceum students.

4. An algorithm for teacher' professional development that promotes the formation of professional competencies and supports the ongoing professional growth of lyceum teachers was elaborated.

5. A block-modular structure of the physics subject enriched with advanced and supplementary topics was proposed for lyceums, which provided broad opportunities for improving subject content and instructional effectiveness.

6. A package of standards based on Bloom's taxonomy, current and long-term plans, internal assessment, and self-evaluation tools was created, significantly refining physics teaching content and instructional processes.

7. In lyceums, the system for assessing learning outcomes in physics has been refined scientifically and methodically through a standards package developed according to Bloom's taxonomy within the framework of physics training.

8. Argumentation, analysis, and reasoning-based approaches were implemented to support students' development of 4C skills. Based on these approaches, non-standard lesson models – such as problem-based, inquiry-based, project-based, and debate-format lessons – were designed with clear structures and execution stages.

9. The use of innovative formats, methods, and cognitive strategies in physics training was systematised, and a scientific-pedagogical classification was provided, demonstrating both theoretical and practical value for improving the methodical instruction system.

10. Deductive and inductive instructional models based on Bloom's taxonomy were designed to optimise students' understanding of physical phenomena, laws, theories, and quantities.

11. Generalised schematic plans, technological maps, and virtual and traditional laboratory activities were prepared for lyceum students, stimulating the development of their research and heuristic competencies and increasing their engagement in independent scientific inquiry.

12. The case method was used to develop physics-related tasks in lyceums, and a comprehensive set of recommendations and sample tasks was created, establishing favourable conditions for organising physics training more innovatively.

13. The importance of using interactive technologies to improve physics training in lyceums was justified, and relevant instructional-methodical materials were elaborated for teachers.

14. The experiment's results proved that the proposed methodical instructional system effectively facilitated the development of students' self-education skills, supported their independent cognitive activity, and created favourable conditions for holistic personal growth. Furthermore, it actively involved all participants in the pedagogical process in meaningful instructional engagement.

Based on the findings of the dissertation, the following recommendations and proposals have been formulated:

1. It is considered appropriate to incorporate selected elements of the theory of general relativity and the theoretical foundations of modern methodological principles, such as symmetry and super-

position, into the content of the physics subject in lyceums within the framework of relevant topics. This integration may expand students' scientific worldview and facilitate their acquaintance with fundamental concepts of modern physics.

2. To enhance students' research and heuristic skills in the physics training process, it is recommended that the number of problem-based, research-oriented, and project-based lessons, including debate-driven sessions, be increased. This approach may create favourable conditions for developing analytical thinking, creative engagement, and scientific reasoning skills among students.

3. In physics, paying special attention to organising virtual and traditional laboratory experiments, research, and project activities is advisable. The systematic implementation of such activities may reinforce the link between students' theoretical knowledge and practical competencies, thereby promoting the development of application-oriented thinking.

4. The systematic application of standards developed based on Bloom's Taxonomy in school-level assessment – covering both formative and summative forms – is encouraged to enhance the efficiency of the teaching process in lyceums. This approach will enable a more objective and goal-oriented student achievement evaluation.

5. The scope of systematic implementation of Bloom's Taxonomy-based standard packages in evaluating outcomes in physics training should be expanded. Such an approach aligns assessment criteria with students' cognitive levels and facilitates purposeful reflection during the teaching process.

6. To improve the quality of physics training in lyceums, it is recommended to develop situational tasks systematically – based on the experience of developed countries – and to pay special attention to creating methodical guides encompassing such tasks. These resources may support the development of students' thinking abilities and enhance the practical application of theoretical knowledge in real-life contexts.

7. Modernising materials and resources used in physics training in lyceums, aligned with contemporary requirements and technological advancements, and developing and implementing relevant methodical guidelines to foster students' self-directed learning skills are deemed necessary. This strategy may strengthen learner-centred approaches in physics education and provide a favourable environment for instruction tailored to students' individual developmental needs.

8. To ensure the continuous professional development of physics teachers in lyceums, it is necessary to regularly design training and professional enhancement programs and organise internships and in-service training courses based on these programs. This systematic approach may significantly improve teachers' pedagogical competencies and methodical preparedness.

The author has published the following scientific works related to the dissertation:

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