

Research on the Teaching Reform of High School Physics Curriculum under the Top-Talent Training Model

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Abstract: Against the backdrop of China's strong emphasis on cultivating top innovative talents, the high school physics curriculum, as a core component of scientific education, bears the crucial mission of fostering students' scientific thinking, creativity, and practical ability. However, current physics teaching still faces issues such as fragmented content systems, weak experimental and inquiry components, and single evaluation methods, which fail to align with the objectives of top-talent cultivation [1]. Guided by the top-talent training model, this study systematically explores reform paths for the high school physics curriculum in terms of educational philosophy, course content, teaching methods, and evaluation mechanisms. The research proposes reconstructing the curriculum system around the main thread of "core concepts–inquiry practice–innovative application," strengthening interdisciplinary integration and the inclusion of frontier modern physics topics. In teaching methodology, it advocates for a shift toward problem-driven, project-based, and self-directed learning models, leveraging information and intelligent technologies to enhance classroom effectiveness. In evaluation, it suggests building a comprehensive system centered on formative assessment and innovation capability evaluation. Based on the reform practice of a key high school's top-talent experimental class, the findings show significant improvements in students' scientific inquiry skills and creative thinking, as well as optimization of teaching philosophy and classroom ecology. The results provide theoretical and practical references for high school physics curriculum reform in the new era and offer insights into the construction of top-talent cultivation systems.

Keywords: Top-talent cultivation; High school physics; Curriculum reform; Inquiry-based teaching; Innovation ability

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1. Introduction

With the advancement of educational modernization, cultivating top innovative talents has become a key goal of basic education. National documents such as *Education Modernization 2035* and the *General High School Curriculum Plan (2020 Revision)* emphasize innovation in curriculum and teaching to nurture students

with a scientific spirit, creativity, and practical competence. As a core subject in science education, physics plays an essential role in developing students' logical reasoning and scientific thinking. However, the current exam-oriented approach prioritizes knowledge transmission over inquiry and innovation, while evaluation systems remain overly simplistic. The top-talent training model emphasizes active learning, inquiry-based exploration, and individualized development. Teachers should evolve from knowledge transmitters to learning facilitators. Physics education should therefore shift from “mastering formulas and laws” to “understanding principles, building models, and solving real-world problems.” In recent years, both domestic and international explorations—such as project-based curricula in Tsinghua University High School and Beijing No.11 School, as well as research-oriented learning in A-level and IB programs—have provided valuable reference models. Guided by this context, this study explores reform pathways for high school physics education in philosophy, curriculum design, teaching methods, and evaluation systems, aiming to offer practical and theoretical guidance for talent-oriented curriculum innovation ^[2].

2. The connotation and characteristics of the top-talent training model

2.1. Educational philosophy and objectives of top-talent cultivation

The core philosophy of top-talent cultivation originates from China's national strategy for innovation-driven development. In the 21st century, the rapid pace of knowledge renewal and the increasing integration of science and technology across disciplines have reshaped educational goals. Education is no longer limited to the transmission of knowledge but is instead focused on cultivating versatile talents with independent innovation awareness and lifelong learning ability. Policy documents such as *Education Modernization 2035* and the *Guidelines for Cultivating Top Innovative Talents in the New Era* issued by the Ministry of Education emphasize building a forward-looking cultivation system that promotes the comprehensive development of morality, intelligence, physical fitness, aesthetics, and labor. These policies provide both institutional and theoretical foundations for the top-talent cultivation model and guide curriculum reform at the high school level ^[3].

At its core, this educational philosophy emphasizes “student-centered development and innovation-centered capability.” Unlike traditional education, which focuses on knowledge accumulation and exam performance, the top-talent cultivation model stresses autonomous learning and exploratory practice in authentic problem contexts. It advocates transforming the classroom from “knowledge delivery” to “ability generation,” and from “passive reception” to “active exploration.” The growth of top talents should not be viewed merely as academic excellence but as a comprehensive enhancement of scientific, creative, and humanistic qualities. The cultivation goals can be understood at three levels:

- (1) Cultivating scientific spirit: through inquiry, experimentation, and logical reasoning, students develop a truth-seeking, questioning, and innovative attitude.
- (2) Developing innovative thinking: encouraging critical thinking, problem awareness, and the ability to propose creative solutions in complex tasks.
- (3) Enhancing comprehensive competence: helping students integrate a solid disciplinary foundation with interdisciplinary perspectives and social responsibility, linking scientific research with real-world applications to achieve the unity of knowledge and value creation.

In practice, the aim of top-talent cultivation is not for every student to become a scientist or inventor but to inspire potential and foster independent thinking and continuous learning abilities. This requires educators to shift from “knowledge indoctrination” to a “guidance–exploration–innovation” learning pathway.

Teachers should act as facilitators, designing challenging learning tasks that stimulate curiosity and creativity. Meanwhile, the curriculum should evolve from linear knowledge transmission toward modular, open, and research-oriented learning structures that allow students to discover their interests and potential through diverse experiences. International experience demonstrates that successful top-talent cultivation depends on “clear goals, flexible pathways, and multidimensional evaluation.” For instance, the U.S. STEM education model emphasizes scientific inquiry through interdisciplinary projects; Finland’s thematic learning approach fosters critical thinking and social participation; and the U.K.’s A-level curriculum integrates open-ended experiments and research-based tasks in subjects such as physics and mathematics to deepen students’ understanding through exploration. These approaches share common characteristics: innovation as the central objective, student autonomy as the main learning pathway, and multidimensional evaluation as the mechanism for holistic development. In China’s educational context, the establishment of top-talent cultivation goals must align both with national innovation strategies and with students’ individual developmental patterns. The high school stage represents a critical period for forming scientific thinking and awakening creativity. Therefore, high school education should consolidate disciplinary foundations while providing opportunities for independent inquiry and innovation practice. Through the collision of ideas and the experience of discovery, students should develop the core competencies of “learning, thinking, and creating.”

In summary, the educational philosophy and objectives of top-talent cultivation embody the essence of educational modernization—innovation-oriented, competency-based, and development-focused. It calls for a transformation from knowledge-based to ability-based education, from result-oriented to process-oriented learning, and from closed classrooms to open learning environments. For high school physics, implementing this philosophy means not only optimizing curriculum content but also deeply reforming teaching methods and evaluation systems, thereby laying a solid foundation for cultivating innovative scientific talents.

2.2. Requirements for high school physics under the top-talent training model

Within the overall framework of the top-talent training model, high school physics plays a vital role in developing students’ scientific literacy, logical reasoning, and creativity. Physics is not only a fundamental discipline of natural science but also a key pathway for understanding the world, exploring natural laws, and driving technological innovation. The model requires physics education to transcend mere knowledge transmission and focus instead on cultivating scientific thinking, inquiry practice, and innovative application—shifting from “learning physics knowledge” to “thinking with physics.”

First, the model sets higher expectations for teaching objectives. Traditional goals focus mainly on knowledge acquisition and skill mastery, whereas top-talent cultivation emphasizes the development of scientific reasoning and creative awareness. Students should not only understand the core theories of mechanics, electromagnetism, thermodynamics, and optics but also grasp the underlying scientific methods—such as modeling, conservation principles, systems thinking, and experimental validation—to cultivate independent inquiry and logical reasoning abilities. Second, it demands innovation in curriculum structure. Current textbooks, though systematic, tend to overemphasize theoretical derivations and formula memorization, while neglecting the connection to modern scientific developments. The reformed curriculum should integrate modern physics and frontier technologies, such as quantum physics, relativity, the physics of artificial intelligence, and energy sustainability. These expansions broaden students’ perspectives and stimulate curiosity and research potential. At the same time, the curriculum should strengthen interdisciplinarity, creating a “Physics + X”^[4] framework that connects physics with mathematics, information technology, and engineering, thereby helping

students develop integrated problem-solving and innovation skills. Third, in teaching methodology, the model calls for a transition from “lecture-based” to “inquiry-based” learning. As an experimental science, physics should adopt problem-driven, project-based, and research-oriented approaches that encourage students to explore real-world problems independently. For instance, tasks such as “designing a small electromagnetic generator,” “creating an optimal energy conversion experiment,” or “analyzing mechanics in traffic safety” guide students to learn through experimentation and data analysis. Modern tools like virtual laboratories, AI-based assessment platforms, and visualization software should also be used to foster interactive and creative learning environments. Fourth, it raises new requirements for teachers’ professional competence. Teachers must become facilitators of learning and promoters of scientific inquiry, possessing strong research literacy and innovative teaching abilities. They should design differentiated learning tasks according to students’ abilities, guide them to abstract physical models from experiments, and inspire discovery through reasoning. Teachers also need curriculum development and interdisciplinary integration skills, linking physics with real-world engineering and social problems to build meaningful learning contexts. Finally, the evaluation system must evolve toward a competency-based and comprehensive model. Traditional assessments relying on multiple-choice and calculation questions fail to capture students’ reasoning quality and creative potential. A new evaluation framework combining formative assessment, process documentation, and achievement display should focus on inquiry skills, experimental competence, logical expression, and teamwork. For example, students could be evaluated through lab reports, research projects, and academic presentations, reflecting their learning progress and practical innovation ^[5].

In summary, high school physics education under the top-talent training model represents not only a reform of content and methods but also a redefinition of educational philosophy and talent development. Physics curricula should be grounded in scientific spirit, driven by innovative thinking, and realized through inquiry practice—establishing an open, interactive, and interdisciplinary system that cultivates scientifically literate, creative, and socially responsible talents for the new era. This transformation marks a crucial step toward the high-quality development of physics education.

3. Analysis of the current situation of high school physics teaching

3.1. Status of teaching content and curriculum structure

The current high school physics curriculum in China is designed to cultivate students’ scientific literacy through the integration of knowledge, methods, and values. However, in practice, there remains a considerable gap between the existing curriculum and the objectives of top-talent cultivation. The curriculum still focuses primarily on classical physics—mechanics, electromagnetism, thermodynamics, and optics—while giving insufficient attention to modern physics and interdisciplinary knowledge ^[6]. Topics such as quantum mechanics, relativity, semiconductors, energy transformation, and physical principles underlying artificial intelligence are briefly mentioned rather than systematically taught, leaving students with limited exposure to the scientific frontiers that shape contemporary technological innovation. As a result, many students develop a fragmented understanding of physics, with weak connections between theoretical knowledge and real-world application. Another prominent issue lies in the imbalance between theoretical instruction and experimental practice. Although educational guidelines advocate inquiry-based learning, classroom practice tends to remain verification-oriented. Experiments are often pre-designed with fixed procedures and expected results, providing little room for students to design, question, or explore independently. Consequently, learners seldom experience

the genuine process of scientific discovery, and their ability to conduct data-driven analysis and problem-solving remains underdeveloped. Compounding this issue, many schools face constraints such as outdated laboratory facilities, limited access to modern experimental tools, and insufficient integration of digital technologies such as simulation and data modeling platforms. Furthermore, the curriculum structure largely follows a linear, chapter-based organization, progressing from one topic to another without strong conceptual linkage or thematic cohesion. Students frequently focus on formula memorization and problem-solving drills instead of conceptual reasoning and model construction. The lack of modular or project-based content restricts the opportunity for deeper learning and cross-topic synthesis. Additionally, the difficulty gradient of the curriculum is relatively uniform, offering few enrichment pathways for high-achieving students who demonstrate exceptional curiosity or potential for innovation. To address these challenges, the curriculum needs to be restructured around a progressive framework emphasizing “core concepts–scientific inquiry–innovative application.” This approach should strengthen the coherence among key physical ideas, integrate modern physics and technological contexts, and encourage interdisciplinary connections such as physics with mathematics, engineering, and computer science. By introducing research-oriented and project-based learning modules, students can be guided to apply theoretical understanding to authentic problems, fostering creativity, critical thinking, and a genuine appreciation for the beauty and utility of physics in the real world ^[7].

3.2. Status of teaching methods and learning evaluation

Lecture-based instruction continues to dominate the teaching of high school physics, with teachers largely acting as knowledge transmitters and problem-solving demonstrators. While this approach can improve short-term examination performance, it fails to cultivate students’ curiosity, inquiry skills, and creative thinking. Classroom interactions tend to be one-directional, with limited opportunities for students to ask questions, design experiments, or explore ideas independently. Although some teachers attempt to incorporate inquiry-based, situational, or project-oriented learning, these efforts often remain superficial due to tight teaching schedules, large class sizes, and the persistent pressure of exam-oriented assessment systems. Moreover, the application of information technology in physics teaching remains underdeveloped. Multimedia resources and virtual experiments are mostly used as visual aids rather than as platforms for interactive exploration or data analysis. Students seldom engage in authentic research activities such as experimental design, hypothesis formulation, or result validation, which weakens their ability to think scientifically and critically. Digital learning tools, simulation software, and AI-assisted assessment systems have not yet been fully integrated into classroom practice, resulting in missed opportunities to enhance personalized learning and improve engagement. In terms of assessment, most schools still rely heavily on exam scores as the primary criterion for evaluating student performance. Such test-oriented systems prioritize accuracy and efficiency in problem-solving but neglect to assess inquiry competence, experimental skills, communication, and teamwork. Formative assessment methods—such as process evaluation, reflective journals, and project-based performance records—remain underutilized. This single-dimensional evaluation model fails to provide comprehensive feedback on students’ learning progress and potential for innovation. Similarly, the evaluation mechanisms for teachers do not adequately recognize curriculum design, teaching innovation, or mentoring in scientific inquiry, which reduces teachers’ motivation to engage in pedagogical reform. In summary, current high school physics instruction remains heavily constrained by traditional, exam-driven practices. The lack of exploratory, creative, and integrative teaching approaches hinders the development of top-talent competencies such as scientific inquiry, independent thinking, and problem-solving. To achieve meaningful transformation, schools must adopt

student-centered pedagogies, promote active and collaborative learning, and establish a multidimensional evaluation system that values ability growth and innovation practice, thereby laying a sustainable foundation for cultivating future scientific innovators ^[8].

4. Thoughts on the reform of high school physics teaching under the orientation of cultivating top-notch talents

4.1. Reconstruction and expansion of course content

Under the top-talent training model, the high school physics curriculum should move from knowledge accumulation to inquiry and innovation. The key reform direction is to reconstruct the content system around core concepts, inquiry modules, and application practice. Traditional linear teaching of “knowledge → exercises → exams” cannot meet the needs of cultivating creativity and scientific thinking. Therefore, the curriculum should highlight concept-based learning, integrate modern physics frontiers such as quantum mechanics and relativity, and encourage students to explore interdisciplinary themes like “Physics + Engineering” or “Physics + Information Technology.” As shown in **Figure 1**, the restructured curriculum follows a three-tier framework: the Core Concept Layer builds students’ fundamental understanding of physical laws and principles; the Exploration Layer encourages students to conduct experiments, simulations, and model-building through project-based tasks; and the Innovation Layer links physics knowledge with real-world applications and research projects. This hierarchical structure enables students to gradually progress from understanding to discovery, and finally to innovation.

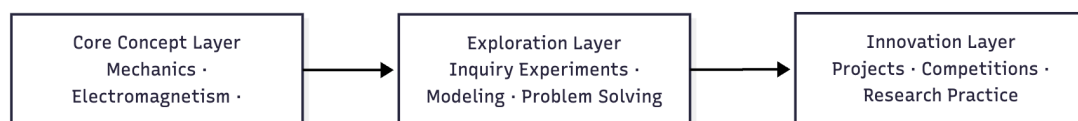


Figure 1. Simplified framework of physics curriculum reconstruction under the top-talent training model

This modular and progressive approach not only enhances students’ scientific literacy but also cultivates their ability to integrate knowledge, explore independently, and solve real-world problems—forming a solid foundation for the development of future scientific innovators ^[9].

4.2. Innovation of teaching methods and reconstruction of teaching models

In the context of top-talent training, the innovation of teaching methods in high school physics should emphasize student-centered, inquiry-driven, and technology-assisted learning. Traditional lecture-based approaches are no longer sufficient to cultivate creativity and scientific reasoning. Teachers should act as facilitators, guiding students to question, hypothesize, and experiment through project-based and problem-oriented learning. As shown in **Figure 2**, the new model builds a dynamic cycle of Question–Exploration–Application–Reflection. Students first identify problems from real phenomena, then design experiments or simulations to explore solutions. The process encourages collaboration, critical thinking, and data-based reasoning. Digital tools such as virtual labs and AI-assisted simulations provide richer and safer environments for scientific inquiry.

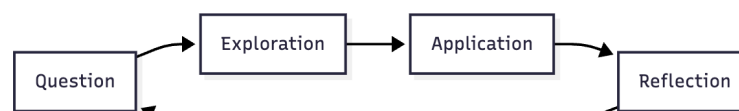


Figure 2. Innovative physics teaching model based on inquiry and reflection

This iterative model transforms classrooms into active laboratories of thinking, enabling students to connect theory with practice, develop sustained curiosity, and grow into independent learners capable of scientific innovation ^[10].

5. Practical case and analysis of teaching reform implementation

5.1. Implementation target and reform design

To verify the feasibility of high school physics curriculum reform under the top-talent training model, this study selected the “Innovative Experimental Class” of a key provincial high school as the research subject. The class consisted of 48 students with solid academic foundations but relatively weak abilities in scientific inquiry and innovation practice. The school established an overall reform framework guided by the principles of “problem-oriented, inquiry-centered, and innovation-driven,” focusing on three dimensions: curriculum restructuring, teaching method innovation, and the development of a diversified evaluation system. In terms of curriculum content, the reform group transformed traditional chapter-based teaching into a modular structure consisting of “Core Concept Modules,” “Inquiry Experiment Modules,” and “Innovation Practice Modules.” For example, when studying electromagnetic induction, students were required not only to master formula derivations but also to design miniature generators, explore the law of magnetic flux variation through experiments, and propose improvement plans. This design strengthened the connection between theoretical knowledge and practical application. Regarding instructional organization, teachers adopted a “group collaboration + project research” model, forming research teams of four to five students who independently selected inquiry topics, such as “Energy Conversion in Daily Life” or “Improving the Light Interference Experiment.” Digital teaching tools and virtual laboratories were introduced to expand experimental space and improve data analysis accuracy. Furthermore, the evaluation system shifted from a single score-based assessment to a combined “formative + summative” approach. Teachers evaluated students comprehensively based on experimental reports, project presentations, and innovation outcomes. The reform significantly enhanced students’ learning interest and classroom participation, while teachers transitioned from knowledge transmitters to facilitators, creating a more interactive and innovative classroom environment.

5.2. Implementation results and data analysis

After one semester of reform, the project team conducted a comprehensive evaluation using questionnaires, classroom observations, and performance comparisons. The results showed notable improvements in students’ scientific inquiry awareness, experimental operation skills, and creative thinking. According to the survey, more than 85% of students agreed that the reformed curriculum “stimulated their learning interest,” and 78% reported that they were “more willing to ask questions and conduct experiments.” Classroom observations confirmed a significant increase in participation during discussions and presentations, fostering a more dynamic and engaging learning atmosphere. Quantitative data indicated that the average score for experimental design and analysis increased by 22% compared to before the reform, and the participation rate in innovation competitions rose from below 30% to 70%. Teachers also reported clear improvement in students’ logical reasoning and expression abilities during problem-solving, as shown in **Table 1**.

Table 1. Comparison of students' abilities and participation before and after the teaching reform

Indicator	Before reform	After reform	Improvement
Learning interest (%)	60	85	+25
Inquiry ability (score)	68	83	+22%
Classroom participation (%)	55	80	+25
Innovation competition participation (%)	28	70	+42

Overall, the reform effectively achieved the transition from knowledge transmission to competence development. Students' autonomous learning and inquiry capabilities improved significantly, meeting the expected outcomes of the top-talent training model.

6. Conclusion

Guided by the top-talent cultivation concept, this study conducted a systematic reform and practical exploration of the content structure, teaching methods, and evaluation system of the high school physics curriculum. The results demonstrate that a curriculum framework centered on core concepts, inquiry, and innovation effectively stimulates students' learning interest and research potential. Through project-based learning and diversified assessment, students' scientific thinking, experimental skills, and creativity improved markedly. Teachers also shifted from being knowledge transmitters to learning facilitators, creating a more open and interactive classroom environment. The practice proves that the top-talent training model brings new vitality and direction to high school physics education. In the future, such reforms should be promoted more widely, supported by enhanced resources and teacher training, to establish a sustainable innovative teaching system that nurtures a new generation of youth with a scientific spirit and creative capacity.

Disclosure statement

The author declares no conflict of interest.

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