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Innovation of College Physics Teaching Models in the Context of the "New Engineering" Initiative

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Abstract: Amid the latest wave of scientific and industrial revolutions, the construction of "New Engineering" majors has become the core direction of higher-engineering-education reform. As a foundational course for engineering programs, college physics directly determines the quality of talent cultivation. At present, traditional physics instruction in universities shows several shortcomings in the New Engineering context: it is disconnected from cutting-edge technologies, weak in cultivating engineering-application competence, and insufficient in fostering innovative thinking—thus failing to meet the demand for high-caliber talent. This study systematically analyzes the fundamental role college physics plays in New Engineering talent training, including laying theoretical foundations for engineering technology and nurturing scientific and logical thinking. In response to existing problems, it proposes a series of innovative measures: reshaping teaching objectives to focus on engineering application and innovation, adopting project-based and inquiry-based pedagogies, expanding diversified practical activities, and employing multi-dimensional assessment systems. These suggestions provide theoretical and practical references for improving college physics teaching quality and cultivating innovative talent geared to New Engineering development. Ultimately, by aligning physics education with contemporary industry demands, higher education can evolve to nurture more adaptive, creative, and technically competent engineering professionals for the future.

1. The Foundational Role of College Physics in New Engineering Talent Training

1.1 Laying Theoretical Foundations for Engineering Technology

New Engineering focuses on emerging fields such as AI, intelligent manufacturing, and new energy—all of which fundamentally rely on deep physics knowledge. College physics establishes core theoretical frameworks in mechanics, electromagnetism, optics, and thermodynamics, forming the backbone of engineering R&D and application (see Table 1). For example, in aerospace engineering, aerodynamic theory guides the design of aircraft shapes; in the development of new-energy materials, thermodynamics and statistical physics explain energy-conversion mechanisms and stability. Through systematic physics study, engineering students grasp the laws of motion and energy conversion, enabling them to understand the essence of engineering phenomena. This foundation not only supports advanced coursework but also offers scientific references for analyzing problems and optimizing designs in practice, helping students solve engineering challenges from fundamental physical principles and drive technological innovation.

Furthermore, a solid grounding in physics empowers students to engage in interdisciplinary innovation, bridging gaps between science and engineering to produce novel technologies and problem-solving strategies with long-term social and economic impact[1-3]. In practical settings, understanding wave-particle duality, superconductivity, or fluid dynamics may directly influence the design and efficiency of intelligent control systems or renewable energy devices. By reinforcing physics as a theoretical backbone across engineering disciplines, universities can better cultivate problem solvers who combine analytical precision with creative insight, thereby accelerating scientific breakthroughs and technical advancements.

Table 1: The results of the application of physical theory in the field of engineering

Field of application	Theory of physics	Actual application effect data
Aerospace engineering	aerodynamics	The optimal design can improve the fuel efficiency of the aircraft by 15%-20%
New energy materials development	Thermodynamics and Statistical Physics	Optimizing electrode materials can improve the energy density of lithium-ion batteries by about 18%
Feedback from engineering graduates	mechanics	78% of the students think that it is significantly helpful to mechanical design

1.2 Cultivating Scientific Thinking and Logical Ability

Scientific thinking and logic are essential for tackling complex engineering problems. College physics covers the entire process of scientific inquiry—phenomenon observation, experimental design, law derivation, and application—highlighting rigorous research methods at every stage. Students abstract complex real-world scenes into physical models, stripping away secondary factors to focus on core variables—an effective exercise in abstraction. Quantitative analysis and logical deduction using mathematical tools further hone strict reasoning abilities. When solving dynamics problems, for instance, students combine force analysis with motion equations under Newton's laws, progressively deriving motion states. Such training teaches them to decompose problems and construct causal logic, fostering critical thinking[4-5].

Moreover, this scientific reasoning process enhances students' ability to formulate hypotheses, evaluate evidence, and iterate solutions—key competencies for engineering innovation. It also trains them in a systematic approach to uncertainty and error analysis, helping them make informed design decisions based on incomplete data or real-world constraints. This is especially important in modern interdisciplinary contexts such as smart city infrastructure or biomedical devices, where physics-based reasoning is often essential in modeling complex systems. Over time, consistent exposure to this rigorous thinking model shapes students' intellectual discipline, preparing them to meet future technical and societal challenges with clarity, precision, and resilience.

2. Problems in College Physics Teaching under the New Engineering Context

2.1 Lack of Connection with Frontier Technologies

New Engineering emphasizes rapidly developing frontiers—AI, quantum information, new energy—which demand broader knowledge. Yet physics curricula still revolve around classical topics such as Newtonian mechanics and Maxwellian electromagnetism, offering scant exposure to modern fields like condensed-matter or quantum physics and their applications. Quantum computing, for example, hinges on qubit properties; AI algorithms rely on statistical physics and information theory—topics rarely touched upon in traditional courses. This lag prevents students from linking physics with cutting-edge engineering technologies or appreciating physics' foundational role in solving complex problems.

Additionally, the absence of frontier content in textbooks and assessments makes it difficult for students to recognize physics as a dynamic and evolving discipline. Without exposure to real-world applications or state-of-the-art research, learners are likely to develop a narrow, outdated view of the discipline, which further impedes their motivation to pursue interdisciplinary innovation in engineering fields. Bridging this gap requires not only curricular reform but also active engagement with current research, such as integrating case studies on photonics in 6G communication or quantum sensors in medical diagnostics. These efforts would not only update content but also energize students' understanding of the relevance of physics in shaping future industries.

2.2 Insufficient Cultivation of Engineering-Application Competence

A long-standing gap between theory and practice hinders students' engineering-application abilities. Laboratory work is often secondary and mainly verification-oriented: objectives, procedures, and results are pre-set, leaving little room for independent thought and innovation. The integration of physics teaching with real engineering scenarios—mechanical design, electronic circuits, material development—is low, so students struggle to relate physics knowledge to engineering-design parameters or system optimization, limiting their future potential.

To compound this issue, current lab environments often lack updated instrumentation or industry-standard software, making it hard for students to simulate actual engineering workflows. As a result, students may gain theoretical understanding but fail to apply it effectively in prototyping, modeling, or optimization tasks. This disconnection weakens the pipeline between education and industry, diminishing graduates' readiness for real-world engineering challenges. Without sufficient training in practical simulations or interdisciplinary problem solving, students often feel unprepared for capstone projects or industry internships, where real-world complexity and fast-paced innovation are the norm[6].

2.3 Neglect of Innovative-Thinking Development

Traditional teacher-centered, one-way lecturing stifles students' creativity. With teachers controlling the process and emphasizing systematic exposition, students passively receive knowledge, lacking opportunities for active inquiry. Methods are monotonous and rarely create problem scenarios or guide exploratory learning. Students become accustomed to ready-made answers, lacking independent exploration and critical thinking. Graduates thus fail to meet New Engineering's demand for innovative talent, impeding breakthroughs in engineering technology.

Furthermore, innovation requires environments where students feel comfortable taking intellectual risks, experimenting with alternative solutions, and learning from failure—conditions rarely supported in rigid, exam-centric classrooms. Without developing a habit of questioning assumptions or imagining possibilities beyond textbook content, students remain confined to rote memorization and procedural routines, ultimately hindering their potential as future innovators. Encouraging divergent thinking, integrating peer collaboration, and incorporating reflective activities such as journals or maker challenges can help break this pattern and cultivate curiosity, adaptability, and entrepreneurial vision.

3. Concrete Measures for Innovating Physics Teaching Models under New Engineering

3.1 Reshaping Classroom Teaching Objectives

Teaching goals must shift from a traditional "knowledge-centered" framework to a more comprehensive approach that balances conceptual mastery with practical ability and scientific literacy. Engineering-application competence should become a core objective, requiring students to analyze real-world problems in mechanics, electromagnetism, and thermodynamics, and connect theory with engineering practice. This means students must not only understand the principles of motion or energy transfer but also apply them in tasks such as optimizing thermal systems or designing mechanical structures under dynamic loads.

Innovation should permeate the learning process: instructors must encourage students to question classical models, experiment with new interpretations, and explore unconventional solutions, thereby fostering independent thinking and creative problem-solving. Teaching objectives should be diversified based on major-specific needs: students in mechanical engineering may focus more on kinematic modeling, while those in electronics or automation should emphasize electromagnetic applications in system design and signal processing.

In addition, these objectives should align with broader national and global initiatives, such as sustainable development, low-carbon technology, and digital transformation. For example, students may be guided to explore how physics principles contribute to solar panel efficiency or smart sensor networks. By embedding physics within larger societal goals, educators can help students develop a clearer sense of academic purpose and professional identity. Teachers should also use performance-based descriptors to articulate learning outcomes, such as "quantifying thermal gradients in green building materials" or "interpreting magnetic field dynamics in electric vehicle systems," thereby linking course outcomes to job-ready competencies.

3.2 Adopting New Teaching Methods

Traditional teacher-centered lecturing, though effective for delivering foundational knowledge, no longer meets the dynamic demands of New Engineering talent cultivation. Instead, student-centered, interactive pedagogies should be widely adopted. Project-based learning (PBL) uses real engineering problems to break disciplinary silos and allow students to collaboratively explore physics applications in authentic design challenges. Students form teams, investigate issues, plan and execute solutions—experiencing the full engineering cycle while integrating physics with practical know-how and soft skills like communication and leadership[7-8].

Inquiry-based learning (IBL), on the other hand, stimulates deeper thinking by placing students in uncertain or complex problem situations where they must generate hypotheses, develop experimental frameworks, and validate outcomes. It mirrors the iterative process of scientific research, empowering learners to become knowledge producers, not just recipients (see Figure 1).

These methods are complemented by flipped classrooms, where students review instructional content at home through videos or simulations, then engage in in-class activities such as debates, concept-mapping, or problem-solving workshops. This reversal encourages active participation and allows differentiated instruction based on learner progress. Blended learning, combining online and offline platforms, extends learning beyond the classroom and provides flexibility for personalized engagement. Simulation-based virtual labs, integrated with adaptive learning platforms, further enable students to manipulate variables, run multi-scenario experiments, and receive instant feedback—enhancing both engagement and cognitive retention. Together, these innovative approaches make learning more immersive, inclusive, and aligned with the challenges of modern engineering practice.

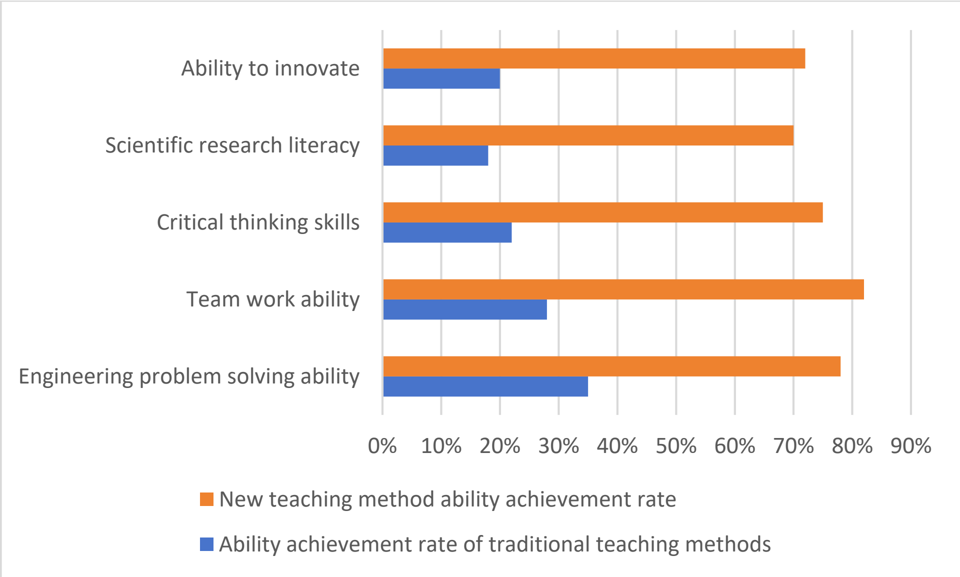

Figure 1: The effect of teaching method reform on the improvement of students 'ability

3.3 Innovating Practical-Activity Expansion

In the New Engineering context, hands-on learning and real-world practice are critical to bridging the gap between academic knowledge and industry demands. Traditional verification-based laboratory activities, where students follow predetermined procedures, must be replaced by comprehensive, exploratory, and design-oriented experiments that promote active learning and engineering innovation. Comprehensive experiments require students to draw from multiple disciplines to address complex, often ill-structured problems—such as optimizing heat exchange efficiency or modeling energy loss in electronic systems—thereby enhancing their ability to transfer knowledge across contexts.

Design-based experiments give students autonomy to select instruments, formulate hypotheses, develop experimental protocols, and interpret findings. This fosters creativity, scientific reasoning, and troubleshooting skills—traits indispensable in real-world engineering environments. Additionally, universities should expand access to virtual and remote laboratories, enabling students to engage in simulations of sophisticated experiments involving high-end equipment, even when resources or conditions are limited.

Extracurricular opportunities—such as physics innovation contests, STEM maker competitions, cross-university collaboration challenges, and industry-sponsored projects—should also be actively developed. These platforms give students firsthand experience with emerging technologies, such as sensor integration, embedded systems, or clean energy prototypes, allowing them to see how physics translates into engineering innovation. Furthermore, establishing partnerships with leading tech firms for internship and mentoring programs ensures that students not only learn technical skills but also develop workplace competencies and understand the evolving expectations of employers in a globalized industry landscape.

3.4 Employing Multi-Dimensional Assessment

Traditional assessment methods—primarily written exams—fail to capture the range of competencies required in modern engineering contexts. Thus, a multi-dimensional evaluation system must be constructed, integrating both formative and summative assessments across different learning domains. Formative assessments such as quizzes, classroom discussions, minute papers, and learning journals provide real-time feedback and help students track their own progress. Summative assessments should be diversified to include not only midterms and finals, but also open-ended problem sets, group projects, presentations, and lab portfolios.

Process evaluation plays a crucial role: assessing how students approach complex problems, work in teams, and reflect on their learning journey is just as important as evaluating final outcomes. Lab-report evaluation should focus on clarity of hypothesis, depth of analysis, and the ability to connect empirical findings to theoretical principles. Project evaluation should incorporate peer feedback, creativity, feasibility, and interdisciplinary integration[9].

Digital technologies also offer powerful tools for learning analytics and competence-based assessment. Platforms such as e-portfolios, concept-mapping software, and simulation tracking tools allow educators to visualize student development over time. Self- and peer-assessment practices foster metacognitive skills, encouraging students to reflect on how they learn, collaborate, and improve.

Moreover, assessment data should be aligned with industry expectations. Institutions can create a feedback loop by evaluating how students perform in internships, capstone projects, or graduate-level research. By mapping student learning outcomes to actual employment performance or professional competencies, universities can better align instructional and assessment strategies with workforce needs, thus ensuring sustainable, student-centered educational reform[10].

4. Conclusion

In the New Engineering era, innovating college physics teaching models is essential for enhancing the quality of engineering-talent cultivation. Theoretically, physics underpins engineering technology; pedagogical reform consolidates knowledge foundations, shapes scientific thinking, and promotes interdisciplinary integration. Practically, measures such as goal reshaping and method innovation address disconnections with frontier technologies and weak application skills, providing robust support for students' professional growth and creative practice.

Yet innovation is ongoing: as engineering demands and educational concepts evolve, physics teaching must continue exploring and optimizing. Future efforts should deepen synergy with New Engineering majors, tighten links between teaching practice and industry frontiers, and refine multi-dimensional assessment, thereby advancing China's high-quality engineering education. Additionally, sustained collaboration among universities, enterprises, and research institutions will be vital in adapting curricula to real-world needs, ensuring that physics education remains dynamic, future-oriented, and capable of contributing to national scientific and technological rejuvenation. Only through such systemic and sustained efforts can college physics fully fulfill its strategic role in cultivating the next generation of engineers equipped for innovation, interdisciplinarity, and global impact.

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