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Exploration and Practice of College Physics Teaching for Non-Physics Majors

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Abstract**—***College physics is not only a core foundational course for non-physics majors but also a crucial avenue for cultivating scientific literacy and logical thinking abilities. However, many students encounter significant challenges in mastering the content and developing innovative thinking skills. Thus, reforming the traditional teaching model of college physics is essential. This paper proposes a series of specific measures, including optimizing teaching content and methods to enhance student interest and engagement, as well as improving assessment mechanisms. Through the implementation of these reforms in classroom teaching, students demonstrated a more solid theoretical foundation and superior applied innovation capabilities compared to those in traditional teaching settings. Significant improvements were observed in overall exam performance, classroom engagement, and applied innovation skills.*

Keywords— *College physics; Teaching optimization; Applied innovative thinking.*

I. INTRODUCTION

Facing the new opportunities brought by the new industrial revolution, it is essential to focus on the latest demands of national development and carefully plan for the new direction of engineering education[1]. The core spirit advocated by Emerging Engineering Education (3E) emphasizes moral cultivation as the foremost goal, aiming to cultivate talents capable of adapting to change and possessing applied abilities. By integrating tradition and innovation, promoting interdisciplinary fusion, and facilitating coordinated resource sharing, 3E is committed to nurturing outstanding engineers with diversified and innovative capabilities[2]. The proposal of the 3E concept reflects the challenges currently faced by higher education, particularly in the field of engineering education: an urgent need for adjustment and reform[3] to meet the new requirements for application-oriented talents in the context of China's economic development in the new era. Therefore, it is imperative to transform higher education in applied disciplines, with the key lying in the innovation and practice of classroom teaching models[4].

Under the framework of the 3E education strategy, the college physics course, as a core foundational discipline for non-physics engineering students, undertakes the critical mission of cultivating students' scientific thinking and problem-solving abilities[5]. Through the study of physics, students not only acquire essential scientific knowledge but also develop rigorous logical reasoning, experimental inquiry, and innovative thinking skills—all of which are indispensable qualities for future engineers and researchers[6].

To effectively enhance the core status and role of college physics within the 3E education system, teaching practitioners have explored a series of teaching models through practice, such as flipped classrooms, blended online-offline teaching, and comprehensive practical teaching[7-8]. These models have, to some extent, promoted the development of students' physical thinking abilities. However, in the specific implementation of teaching, students still face many challenges, including a disconnection between learning content and their majors, a lack of learning motivation, and weak links between theory and practical application[9]. In light of these issues, it becomes imperative to closely integrate college physics courses with students' majors and implement more comprehensive and in-depth curriculum reforms. This involves a holistic optimization of teaching content, methods, and tools, as well as the design of diversified assessment mechanisms. The core objective is to construct a teaching model driven by professional needs, making the learning process engaging, internalizing knowledge, and thereby stimulating students' practical enthusiasm and applied innovation capabilities.

II. ANALYSIS OF THE CURRENT STATE OF COLLEGE PHYSICS TEACHING

A. Uniform "One-Size-Fits-All" Teaching Approach

As a core general education course, physics caters to students from diverse academic majors. With the increasing prevalence of major specialization and transfer policies, student backgrounds have become increasingly varied, including a significant number from humanities disciplines. However, current teaching syllabi and plans adopt a "one-size-fits-all" approach, demonstrating high uniformity in teaching content, learning requirements, and examination formats[10]. This model overlooks the differences among various disciplines, resulting in a disconnect between the physics knowledge acquired and students' respective major fields. Furthermore, as the number of specialized courses continues to grow, the allocated teaching hours for college physics have been compressed—some majors offer only 36 class hours—making it particularly challenging to provide in-depth coverage of mechanics, thermodynamics, optics, and electromagnetism.

B. Lack of Student Interest in College Physics

In current college physics education, instruction often focuses heavily on elaborating complex theories and interpreting specialized physics formulas, adhering to a traditional exam-oriented approach. This type of content is not only difficult but is also rarely connected to students' professional practice. As a result, many students perceive college physics as non-essential within their major studies, leading to a lack of interest in the course[11]. Since "interest is the best teacher," it is essential to first foster strong student engagement in college physics. Encouraging students to proactively apply the knowledge gained to their major studies is crucial for achieving optimal teaching outcomes[12].

C. *Insufficient Integration with Majors*

In current university teaching practices, there is inadequate emphasis on cultivating students' scientific thinking abilities. Some instructors continue to prioritize textbook knowledge, leading students to focus merely on completing assignments and investing considerable effort in problem-solving and calculations, while paying insufficient attention to the practical applications of physics[13]. This teaching approach prevents students from fully recognizing the importance of physics in their professional domains and diminishes their motivation to actively explore physical principles or apply physical methods to solve real-world problems in their fields.

III. TEACHING OPTIMIZATION METHODS

To address the existing issues in college physics teaching, Figure 1 illustrates the overall reform and research framework proposed in this paper. Specific measures are as follows:

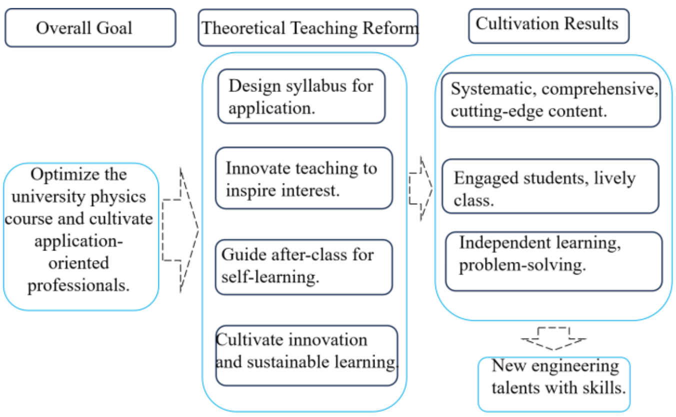

Figure 1. Overall Framework for College Physics Teaching Reform and Research.

A. *Integrating Teaching Content with Professional Practical Applications*

In college physics teaching, it is crucial to develop syllabi that are closely aligned with the practical applications of various majors. This customized approach ensures that physics content effectively connects with students' major-specific knowledge, enhancing the practicality and relevance of learning. This will break the current "one-size-fits-all" model, forging organic links between physics knowledge and students' disciplines. Therefore, a key teaching focus is to help students understand the application contexts and future career directions of their majors early on, clarifying learning objectives. This improves student motivation and focus, serving as a critical step in cultivating application-oriented professionals. Syllabi should be jointly developed by college physics instructors and major-specific faculty to ensure comprehensiveness and practicality.

Given the conflict between extensive teaching content and limited class hours, interdisciplinary collaborative teaching can be adopted. This approach not only better cultivates students' physical thinking but also incorporates professional perspectives. Topics closely related to professional needs should be emphasized in class, while other content can be treated more briefly. This arrangement also effectively addresses the challenge of extensive content within limited hours. For example, in electronic information majors, physics content can be integrated with professional knowledge, emphasizing the physical foundations underlying the field. In today's rapidly evolving technological landscape, understanding the physical principles supporting new technologies and advancements is crucial for students. Integrating these principles into physics teaching deepens students' comprehension of their field's development and innovation, sparking interest in scientific exploration and insight into future technological trends.

B. *Optimizing Classroom Teaching*

Students are at the core of the educational process. To effectively stimulate learning enthusiasm and autonomy, discussion-based teaching has proven to be a highly effective strategy. This model not only engages students actively in class but also enhances their focus and interactivity, thereby honing their analytical and problem-solving skills and fostering innovative thinking.

This teaching model places higher demands on instructors. Teachers must prepare thoroughly before class, designing discussion topics and questions that align with students' cognitive levels and course objectives. In class, the teacher's role shifts from traditional information transmitter to facilitator and guide. Instructors should create an inquiry-friendly environment, encouraging students to ask questions, communicate, and collaborate. Through these interactions, students actively acquire knowledge, enhancing critical and innovative thinking abilities. Furthermore, teachers should encourage students to seek answers, think independently, and engage actively with peers during discussions. This approach cultivates the qualities essential for application-oriented talent.

C. *Incorporating Online Teaching Resources*

To further optimize teaching effectiveness, building a comprehensive online teaching resource repository is particularly important (utilizing smart teaching platforms such as Learning Express or Rain Classroom). This repository should include all necessary course materials as well as major-specific extended knowledge, enabling students to engage in self-paced learning and knowledge deepening after class. Given the abundance of online teaching resources, instructors should create customized online learning platforms tailored to their majors, helping students better grasp the physics knowledge and application skills required for their fields.

On smart teaching platforms, students can share their insights in discussion forums, instructors can provide timely feedback and guidance, and assignment submission and

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evaluation can be efficiently conducted online. This blended approach effectively addresses the limitations of traditional large-class teaching in attending to all students and reduces the burden of manual grading, allowing teachers to focus more on improving teaching quality and developing student capabilities, with greater emphasis on instructional design itself. Figure 2 illustrates the basic process of blended online-offline teaching.

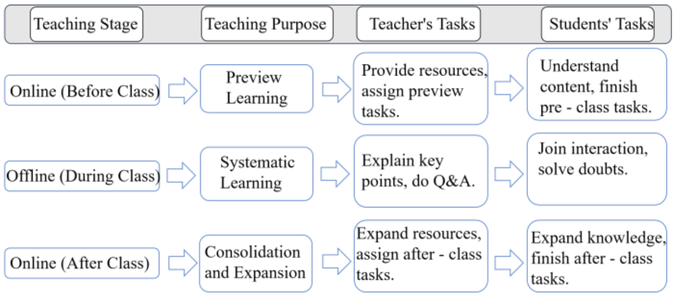

Figure 2. Basic Process of Blended Online-Offline Teaching.

IV. Cultivation of Innovative Thinking Skills

While imparting theoretical knowledge, college physics instruction should place greater emphasis on fostering students' scientific and innovative thinking—essential qualities for applied talents. In physics courses, instructors should prioritize guiding students' thought processes, helping them uncover the essence of problems, form concepts, grasp principles, and apply acquired knowledge to solve practical issues, rather than merely focusing on problem-solving and passive listening.

V. Optimization of Assessment Methods

To more comprehensively reflect students' learning outcomes, it is crucial to adjust the grading system by increasing the weight of usual performance. In traditional evaluation systems, overreliance on final exam scores often leads to student complacency during the semester, with last-minute cramming becoming commonplace. This approach results in short-term memory that quickly fades after exams, hindering the achievement of ideal teaching effects.

To address this, it is recommended to adopt suitable smart education platform software to establish multiple assessment points, strengthening the monitoring and evaluation of students' regular learning. Such measures help shift students' focus from solely the final exam to continuous learning and understanding, encouraging sustained and active engagement throughout the semester. Furthermore, increasing the proportion of usual performance more accurately reflects students' overall learning process, including classroom participation, homework completion, and group collaboration. This comprehensive evaluation method not only assesses learning outcomes more precisely but also promotes deeper understanding and long-term retention of knowledge, thereby achieving more effective teaching results.

VI. Implementation Results

A teaching reform study based on the proposals of this paper was conducted within the Department of Electronic Information at Anhui University of Finance and Economics, targeting sophomore students from the class of 2022. Two classes from the same discipline were selected as subjects, with one class exposed to the traditional teaching model and the other to the reformed teaching model. These two classes shared similar academic performance and learning backgrounds within the same field, thereby providing a fair basis for comparing the effectiveness of the two teaching approaches.

The results showed that the reformed teaching model, which combined carefully optimized content and diversified teaching methods, significantly enhanced students' learning interest. This innovative approach effectively reduced the student failure rate, achieving a breakthrough of zero failures. More importantly, compared with traditional teaching, the number of students achieving good (scores above 70) and excellent (scores above 90) grades increased markedly. In terms of classroom performance, students exposed to the reformed teaching demonstrated a stronger grasp of fundamental physics knowledge and were able to apply this knowledge more effectively in the field of electronic information. This teaching model not only strengthened students' theoretical understanding but also improved their practical skills, laying a solid foundation for their future specialized courses.

In summary, this teaching reform study demonstrates the effectiveness of innovative teaching methods in enhancing student learning outcomes, particularly in stimulating interest, improving academic performance, and strengthening practical application abilities. These advantages highlight the potential of such approaches in elevating the overall quality of education."

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