

Exploration on Teaching Reform of University Physics Experiments in Local Application-Oriented Undergraduate Universities

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Abstract: For local application-oriented undergraduate universities, university physics experiments, as a core fundamental course for cultivating students' scientific literacy, practical ability, and innovative consciousness, its teaching reform has become a key link in improving the quality of applied talent cultivation. This paper systematically sorts out the existing problems in university physics experiment teaching in application-oriented universities. Combining the inherent requirements of applied talent cultivation, it proposes a series of reform measures and practical schemes, providing theoretical basis and practical reference for teaching reform in local application-oriented undergraduate universities and serving regional industrial development.

Keywords: Local Application-Oriented Undergraduate Universities; University Physics Experiments; Teaching Reform; Talent Cultivation; Reconstruction

1. Introduction

1.1 Research Background

To adapt to a new round of scientific and technological revolution and industrial transformation, China is vigorously promoting the construction of "New Engineering" in universities and guiding a batch of undergraduate universities to transform into application-oriented ones. Application-oriented undergraduate universities take the cultivation of technology-application-oriented talents as their core positioning, emphasizing students' practical hands-on ability, technological innovation ability, and job adaptability. They aim to supply application talents to the front lines of production, construction, management, and service. This transformation requires universities to promote systematic reconstruction in talent

cultivation objectives, curriculum systems, teaching methods, especially practical teaching links.

University physics experiments, as an important foundational practical course for science and engineering students, play an irreplaceable role in cultivating students' scientific literacy, practical ability, and innovative spirit. However, during the transformation process, this course in undergraduate universities faces dual challenges: On the one hand, traditional teaching content and methods are difficult to meet the new requirements for cultivating applied talents; On the other hand, insufficient experimental teaching resources severely restrict the cultivation of students' practical and innovative abilities. In recent years, some scholars have actively explored teaching reform of this course. For example, Zhao et al. [1,2] explored online-offline integration and virtual simulation teaching; Yang et al. [3-6] explored curriculum system reconstruction and student innovation ability; Li et al. [7,8] explored student-centered outcomes-oriented teaching; Liu et al. [9-11] explored competition-driven, task-driven, and innovation and entrepreneurship teaching reforms; Xie et al. [12,13] explored classified cultivation for application-oriented universities. Actively promoting the teaching reform of the university physics experiment course has important practical significance and long-term value for aligning with the objectives of applied talent cultivation, solving teaching dilemmas, and improving talent cultivation quality.

1.2 Research Purpose and Significance

This thesis addresses the core issues of college physics experiment teaching in local application-oriented undergraduate universities, grounded in the fundamental task of cultivating application-oriented talents, and explores systematic and operable teaching reform plans. The main research objectives of this thesis are:

diagnosing the current teaching status and key issues; constructing a new experimental teaching system centered on student ability development; proposing specific methods for improving teaching content, innovating teaching methods, transforming teaching modes, and reconstructing assessment and evaluation.

The significance of this paper is primarily manifested at both theoretical and practical levels. At the theoretical level, it integrates the universal principles of applied talent cultivation with the practical realities of physics experiment teaching in local applied universities, thereby enriching the theoretical framework of applied curriculum teaching reform and offering a fresh research perspective for supporting professional talent cultivation goals through public basic courses. At the practical level, the proposed reform plan closely aligns with the specific conditions of local universities, emphasizes operability, and provides direct reference for the reform of physics experiment teaching in similar institutions. This plan aims to enhance the quality of experimental teaching and students' comprehensive abilities, ultimately serving regional industrial upgrading and economic and social development.

2. Analysis of the Current Situation of Applied Talent Cultivation and the Necessity of Reform

The talent cultivation goal of local application-oriented undergraduate colleges and universities is to cultivate high-quality technical application talents who can apply professional knowledge and skills to professional social practice and adapt to the requirements of the front line of production, management, and service. This goal poses inherent requirements for college physics experiment teaching. In terms of teaching orientation, experimental teaching should shift from traditional theoretical verification to a core component of cultivating students' scientific thinking, practical ability, and innovative spirit; in terms of teaching objectives, it should emphasize students' preliminary ability to apply physical principles and methods to solve practical engineering and technical problems; in terms of teaching content, it should strengthen the connection with local industrial development and professional technology frontiers, reflecting the application of learning; in the teaching process, it should highlight the dominant position of students, strengthen their

active exploration, team collaboration, and comprehensive practical experience; in terms of evaluation orientation, it should establish a diversified evaluation system with ability development as the core, emphasizing both process and results, to truly reflect students' comprehensive quality.

2.1 Analysis of the Current Situation in Applied Talent Cultivation

Through investigations of multiple local application-oriented universities, the current university physics experiment teaching mainly suffers from the following prominent problems:

The teaching content is severely disconnected from practical application. On the one hand, experimental projects mainly focus on the verification of classical physical laws, with slow content updates, failing to timely integrate new technologies and new methods from related industries, limiting students' horizons; On the other hand, teaching content uses a "one-size-fits-all" approach, lacking differentiated design according to the talent cultivation objectives of different majors and the needs of local characteristic industries. This results in low relevance to students' subsequent professional learning and future career positions, separating learning from application.

Teaching methods are singular and outdated, with a lack of student's subject status. Traditional teaching methods still dominate, with teacher lectures and demonstrations occupying too much class time, leaving students lacking in independent thinking, scheme design, and exploration. At the same time, modern educational technologies such as virtual simulation experiments and online experiment platforms are either not widely used or applied superficially. Students fall into a passive learning and mechanical operation state, making it difficult for innovative ability to be exercised.

Insufficient guarantee of experimental teaching resources. Experimental equipment in some local universities is aging, insufficient in quantity, and lagging in updates, insufficient to support the development of comprehensive and design-based experiments. Tight lab space also limits students' opportunities for sufficient hands-on practice. Many schools lack "dual-teacher type" instructors who possess both solid physics theoretical foundations and rich engineering practical experience. Teachers lack industry background and insufficient

understanding of industrial technology development, posing difficulties in guiding students to conduct application-oriented and innovative experiments.

The guidance of the teaching evaluation system is biased. Evaluation mostly emphasizes experimental operation norms and data accuracy, insufficiently evaluating students' experimental scheme design ability, experimental innovative thinking, and problem discovery and solving ability. At the same time, excessive reliance on experiment reports, coupled with a lack of process-based and diversified evaluation methods, makes it difficult to comprehensively and objectively measure students' comprehensive abilities and literacy. The incentive and development functions of evaluation are insufficient.

2.2 The Necessity of Teaching Reform

Given the current issues in college physics experiments, only through reform can local application-oriented universities adapt to the requirements of talent cultivation in the new era. From the perspective of social development, the rapid development of technology and profound adjustments in industrial structure have posed urgent and dynamic demands on high-level applied and innovative talents. As a fundamental course in engineering education, college physics experiment must proactively align with these demands and ensure the "adaptability" and "forward-looking" nature of talent cultivation through reform. In terms of talent cultivation objectives, the core mission of transformational universities is to cultivate applied talents with outstanding practical abilities, innovative spirit, and the ability to solve complex engineering problems. The main purpose of reforming the college physics experiment course is to transform it from a traditional "auxiliary for theoretical verification" into a "core carrier for ability cultivation," directly supporting the realization of this goal. From the perspective of teaching quality improvement, reform is not only a passive adjustment to address resource shortages but also an active action to revitalize existing resources, enhance resource allocation efficiency, and tap into teaching potential by optimizing teaching content, innovating teaching methods and models, and improving management mechanisms. It is an inevitable choice for achieving connotative improvement in teaching quality. From the perspective of

educational system improvement, the exploration of teaching reform in college physics experiment can provide useful references for other basic and professional practical courses, effectively promoting the optimization and innovation of the overall practical teaching system in local application-oriented universities, and having a positive demonstration and driving effect on the reform of higher education teaching.

3. University Physics Experiment Teaching Reform Ideas for Applied Talent Cultivation

Addressing the existing problems in the university physics experiment course, this paper, based on the fundamental task of applied talent cultivation, systematically constructs a teaching reform framework. This framework takes "cultivating applied talents who adapt to regional industrial development needs, possess good scientific literacy, solid practical ability, and innovative spirit" as its overall goal, systematically designing the entire teaching process.

The overall reform idea has five core elements: First, clarify ability objectives. Determine the students' competency indicators for the university physics experiment course, such as basic experimental skills, data analysis ability, engineering application consciousness, preliminary innovation ability, etc., based on the university's orientation, professional talent cultivation plans, and local industry needs. Second, reconstruct the content system. Based on competency cultivation objectives, break the original experimental content structure divided by physics sub-disciplines, and build a new module-level-differentiated content system. Third, innovate teaching methods and modes. Adopt diversified teaching methods and blended teaching modes, promoting the transformation of teaching from being "teaching-centered" to "learning-centered," strengthening students' subject status and practical experience. Fourth, reform assessment evaluation. Establish an assessment evaluation system that "values both process and results, balances ability and knowledge, and involves multiple subjects," fully utilizing the orientation, motivation, and diagnostic functions of evaluation. Fifth, strengthen condition guarantees. Provide strong support from aspects such as teachers, equipment, management, and university-enterprise cooperation to ensure

smooth implementation and continuous improvement of the reform.

4. Practical Strategies for University Physics Experiment Teaching Reform in Applied Talent Cultivation

4.1 Teaching Content Reorganization and Module Design

Following the principle of "strengthening the foundation, connecting with the profession, enhancing comprehensiveness, and reflecting characteristics," the teaching content is reorganized into four modules.

Basic Skills Module (~30%): Oriented to all students, focusing on standardized training of core skills such as the use of basic instruments in physics experiments, measurement methods, error analysis, and data processing. Select classic verification experiments, shifting the teaching focus from "verifying laws" to "mastering methods, understanding principles, and cultivating norms."

Professional Adaptation Module (~30%): Design differentiated experimental projects according to the talent cultivation needs of different major categories. For example, add "Sensor Characteristics and Signal Conditioning Experiment" for Electronic Information majors, and "Material Mechanics Performance Testing Experiment" for Mechanical majors.

Comprehensive Innovation Module (~25%): Set open and challenging comprehensive design-based and research-oriented experimental projects. Under the guidance of teachers, students independently complete the entire process of topic selection research, scheme design, equipment selection, experiment implementation, data analysis, and report writing. Encourage the integration of experimental projects with programs like the Undergraduate Innovation and Entrepreneurship Training Project and disciplinary competitions, focusing on cultivating students' system thinking, innovation awareness, and ability to solve complex problems.

Local Industrial Characteristic Module (~15%): Closely integrate with the characteristic industries of the school's region and develop relevant application-oriented experimental projects. For example, introduce actual measurement problems from local enterprise production or product quality inspection technologies as experimental cases, allowing

students to experience real industrial scenarios, enhancing engineering practical awareness and local service identity.

4.2 Diversification and Modernization of Teaching Methods

Change the single lecture-demonstration method and flexibly use various teaching methods.

For basic verification experiments, adopt inquiry-based teaching. Guide students to actively observe, ask questions, design small explorations, and conduct verified thinking by setting heuristic questions and changing some experimental conditions. For the Comprehensive Innovation Module, adopt project-driven teaching. With specific project tasks as the main body, students autonomously form teams, independently learn and apply knowledge during the process of completing the project. Teachers play the roles of guides and facilitators. For the Professional Adaptation Module and Industrial Characteristic Module, adopt case teaching. Introduce real cases from engineering practice or research frontiers to guide students in analyzing the physical principles, technical difficulties, and solutions within the cases, enhancing knowledge application ability.

Try using Flipped Classroom Teaching and Virtual Simulation Teaching. Use online course platforms to create micro-course videos on experiment principle explanations, instrument introductions, safety notices, etc., requiring students to complete self-learning before class. Class time is mainly used for Q&A, scheme discussion, experiment operation guidance, and in-depth exploration, improving classroom efficiency. Virtual simulation teaching helps students become familiar with the operation process of complex or dangerous experiments, compensates for the lack of physical equipment, expands experiment content like nuclear physics and high-temperature high-pressure, enables experiment scheme design and rehearsal, and reduces trial-and-error costs in physical experiments.

4.3 Hierarchy and Collaboration of Teaching Models

Construct a three-dimensional teaching model combining "in-class and extracurricular, online and offline, campus and off-campus collaboration."

In-class and Extracurricular Combination: Adopt a "Basic-Comprehensive-Innovation" three-level

design. Lower grades focus on basic skills training. As professional learning deepens, gradually increase the proportion of comprehensive design experiments. Simultaneously, offer elective courses or open experiment projects in innovative research experiments for students with extra capacity and strong interest.

Online and Offline Integration: Create a mixed environment by building an online teaching platform linked with offline physical laboratories. This supports students' self-paced learning and collaborative communication anytime, anywhere, while teachers provide personalized guidance and process management.

Campus and Off-campus Collaboration (University-Enterprise Collaboration): Establish stable university-enterprise cooperation bases. Incorporate industrial elements through the combined approach of "bringing in" and "going out." "Bringing in" means inviting enterprise engineers to give lectures and guide experiments. "Going out" means organizing students to visit enterprises, intern, and participate in simple testing tasks. Simultaneously, explore the co-development of experimental projects and the joint construction of laboratories with enterprises.

4.4 Reconstruction and Optimization of the Assessment and Evaluation System

Establish a diversified assessment system with capability evaluation as the core, combining process and results. In terms of assessment content, achieve multi-dimensionality: Combine process assessment, result assessment, and comprehensive ability assessment. Process assessment includes operational norms, safety awareness, teamwork, and problem-solving ability; result assessment includes completeness of experiment reports, rigor of data analysis, reasonableness of conclusions, and innovative thinking; comprehensive ability assessment is examined through methods like oral defense, project presentations, and design artifacts.

In terms of assessment methods, achieve diversity: Combine processual evaluation (accounting for 60%-70%) and outcome evaluation (accounting for 30%-40%). Processual evaluation includes pre-class preparation, in-class operation, group discussion, and periodic reports; outcome evaluation can adopt forms like final operation exams, defense of comprehensive design projects, and review of

innovative experiment achievements. In terms of assessment subjects, achieve diversity: Introduce teacher evaluation, student self-evaluation, and peer evaluation (within groups). For projects involving enterprise practice, enterprise mentor evaluation can also be introduced, making the evaluation perspective more comprehensive and objective. In terms of grade composition: preparation and attitude account for 10%, experiment process operation and collaboration account for 40%, experiment report or project outcome accounts for 40%, and defense or comprehensive test accounts for 10%. Specific weights can be adjusted according to the type of experiment module.

5. Conclusion

Based on analyzing the current situation and problems of university physics experiment teaching in local application-oriented universities, and grounded in the fundamental requirements of applied talent cultivation, this paper has constructed a systematic teaching reform framework and practical path. Through the modular reorganization of teaching content, diversification and innovation of teaching methods, hierarchical and collaborative teaching models, and the comprehensive reconstruction of assessment and evaluation, this reform can effectively stimulate students' learning interest, enhance their engineering practical ability, innovative thinking, and comprehensive quality, enabling the university physics experiment course to better align with the objectives of applied talent cultivation and serve the requirements of local industrial development.

The future reform of college physics experiment teaching mainly focuses on four directions: First, intelligent integration, exploring the application of artificial intelligence and big data technology in teaching resource recommendation, personalized learning path planning, intelligent assistance and evaluation of experimental processes; second, interdisciplinary integration, designing physics experiment projects related to emerging interdisciplinary fields such as new energy, new materials, and biomedicine, to cultivate students' interdisciplinary thinking; third, scientific evaluation, further researching and developing more scientific and convenient ability evaluation scales and tools, to reduce teachers' burden and improve the reliability and validity of evaluation; fourth, community building, strengthening exchanges and

cooperation among local applied universities, sharing high-quality experimental teaching resources and reform experience, and forming a regional teaching reform community.

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