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Exploration and Practice of Teaching Reform in Bilingual University Physics Courses in Local Application-Oriented Undergraduate Colleges—A Case Study of the Sino-Foreign Cooperative Program in Mechanical Manufacturing and Automation at Yulin University

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Abstract: *To address the pain points in bilingual teaching of University Physics and to meet the training objectives of local application-oriented undergraduate institutions, a three-dimensional modular curriculum system—centered on "English as the foundation, physics knowledge as the core, and application as the goal"—was developed. This paper elaborates on reforms involving curriculum content optimization, pedagogical innovation, ideological-political integration, and process-oriented assessment. The initiatives effectively tackle teaching challenges and significantly improve instructional outcomes.*

Keywords: *Bilingual Teaching of University Physics, Local Undergraduate Institutions, Modular Teaching, Ideological-Political Education*

1. Introduction to Course Background

Bilingual education refers to the practice of using at least two languages for instructional purposes in the classroom, with one of the languages being non-native to the learners. In the current stage of educational development in China, bilingual teaching primarily refers to courses delivered in both Chinese and English. With the acceleration of globalization and the increasing frequency of international exchange, bilingual instruction has attracted widespread attention as a significant educational reform initiative in Chinese higher education. The Ministry of Education has actively promoted and supported bilingual teaching through a series of policies and guidelines providing a solid foundation for its development across various levels of higher education institutions.

In particular, under the framework of the "Belt and Road Initiative," there has been a growing demand for professionals with both technical expertise and foreign language proficiency. This trend has further highlighted the strategic importance of bilingual education in cultivating talents who can participate in international collaboration and competition [1]. As a result, in recent years, university educators across China have actively explored and implemented bilingual teaching reforms in University Physics courses, achieving notable progress and accumulating valuable experience [2–5].

However, for local application-oriented undergraduate institutions, effectively implementing bilingual teaching and achieving substantive educational outcomes remains a challenging and worthwhile area of study. This paper takes the bilingual University Physics course offered to students in the Sino-foreign cooperative Mechanical Manufacturing and Automation program at Yulin University as a case study. It aims to investigate the practical challenges and difficulties encountered in the course of bilingual teaching and to propose corresponding strategies and implementation experiences. The ultimate goal is to provide constructive insights and references for the further development of bilingual University Physics education in local undergraduate institutions.

Yulin University is a local application-oriented undergraduate institution. In response to the Ministry of Education's directive to cultivate high-quality talents with international perspectives who can contribute to local economic and social development, the university launched a joint undergraduate program in Mechanical Manufacturing and Automation with the University of Wolverhampton, UK, in 2015. The program follows a “3 + 1” model: students complete three years at Yulin University and may undertake the final year in the UK, graduating with dual degrees from both institutions.

University Physics is a foundational course for science and engineering majors. It explores fundamental forms of matter, their motion, and the laws governing their transformation. Its theories underpin all natural sciences and have extensive applications in engineering and industry. Offering a bilingual University Physics course enables students to read scientific materials in English, broadens their knowledge base, and enhances their English listening, speaking, reading, and writing skills—laying the groundwork for English-medium professional courses.

2. Analysis of Key Teaching Challenges

Despite over two decades of policy support for bilingual education in Chinese universities, significant obstacles remain in the practical implementation of bilingual instruction in foundational science courses, especially at local application-oriented institutions. These challenges are multifaceted and stem from systemic, pedagogical, and resource-related factors. The following sections provide a detailed analysis of the main problems encountered during the bilingual teaching of University Physics at Yulin University.

2.1 Ambiguity in Teaching Objectives

A fundamental issue lies in the lack of consensus regarding the primary instructional objectives of bilingual physics courses. Is the core goal to enable students to master key physical concepts and problem-solving methods in English? Or is it to develop their scientific English literacy and communication abilities for future academic and professional use? The absence of clear prioritization leads to inconsistencies in teaching practices. Instructors often oscillate between focusing on physics content and emphasizing English comprehension, resulting in diluted outcomes in both domains. Without a unified objective framework, curriculum design, classroom activities, and assessment strategies may become fragmented and misaligned.

2.2 Weak Student Foundations

The student demographic at local application-oriented colleges is characterized by relatively modest academic backgrounds. Most students enter university with limited exposure to oral English training, as their previous education prioritized written examination performance over communicative competence. This leads to insufficient listening and speaking abilities, which significantly hinders comprehension in a bilingual physics class. Compounding this is the fact that many students also lack a solid grounding in high school physics, making it difficult for them to grasp abstract concepts such as vector decomposition, Newtonian mechanics, and thermodynamic principles. The confluence of weak English proficiency and insufficient physics foundation creates a dual burden that discourages student participation and undermines learning efficacy.

2.3 Difficulty in Textbook Selection

The selection of instructional materials is a persistent challenge in bilingual teaching. In theory, high-quality English textbooks offer a comprehensive and authentic source of knowledge. However, foreign originals—while rich in content and illustrations—often do not align well with the Chinese national syllabus. They are usually too lengthy and emphasize advanced topics that are not immediately relevant to the students' academic progression. Furthermore, they may introduce terminologies and conceptual structures unfamiliar to students and teachers alike. On the other hand, domestically produced English textbooks or bilingual editions, though more tailored to local curricula, often suffer from low authenticity, limited problem sets, and outdated examples. This mismatch between textbook design and pedagogical objectives makes it difficult for teachers to maintain instructional coherence while ensuring language immersion.

2.4 Scarcity of Bilingual Teaching Resources

Effective bilingual instruction requires a rich ecosystem of supporting materials—including bilingual problem sets, annotated slides, video lectures, interactive simulations, and English-language readings. However, such resources are notably scarce in most local institutions. Teachers often struggle to find or

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produce high-quality English materials that are both scientifically accurate and pedagogically effective. As a result, classroom delivery becomes overly reliant on traditional lecturing, with limited opportunities for active engagement, self-directed learning, or multimodal comprehension. Students, in turn, lack access to meaningful English-language review materials outside the classroom, limiting their ability to consolidate knowledge or prepare for assessments.

2.5 Insufficient Class Hours

University Physics is inherently a demanding subject. It involves both abstract theoretical reasoning and complex mathematical operations. In the context of bilingual instruction, teachers must allocate additional time to explain terminology, scaffold English reading comprehension, and address linguistic barriers. However, due to institutional constraints, the contact hours allocated to bilingual courses are often identical to those of regular Chinese-medium courses. This discrepancy between the increased instructional demands and static time allocation leads to compressed content delivery, superficial treatment of key concepts, and a lack of time for interactive learning or formative feedback. Consequently, students may fall behind, and the intended bilingual learning outcomes cannot be fully realized.

3. Exploration of Teaching Reforms

In response to the complex challenges encountered in the bilingual teaching of University Physics, Yulin University initiated a series of comprehensive teaching reforms aimed at optimizing content delivery, enhancing instructional methods, integrating ideological and political elements, and establishing an adaptable curriculum system. The reforms were guided by the principles of modularization, student-centered learning, interdisciplinary integration, and outcome-based education. Through iterative design and implementation, a set of innovative strategies was formed to improve both the quality and effectiveness of bilingual physics instruction in the context of a local application-oriented undergraduate institution.

3.1 Establishing a Modular Curriculum System

The core reform initiative was the development of a three-dimensional modular curriculum system. This model restructures traditional linear course content into interrelated yet independently functional modules, each with specific learning objectives, teaching strategies, and assessment methods. The modular approach offers flexibility, scalability, and contextual adaptability—enabling instructors to cater to diverse learner needs while ensuring coherent progression across the course.

The modular framework is based on three pedagogical pillars: “English as the foundation, physics knowledge as the core, and application as the goal.” This structure reflects a balanced integration of language acquisition, conceptual understanding, and real-world relevance.

3.1.1 English Module

Each The English module serves as the linguistic foundation of the entire bilingual course. Recognizing the difficulties students face in engaging with scientific English, this module focuses on developing technical vocabulary, improving pronunciation, and enhancing reading and listening comprehension.

Each chapter begins with a curated list of 20–30 key technical terms, including both general scientific vocabulary and discipline-specific expressions. These terms are not only introduced in written form but also accompanied by phonetic transcription and usage examples in physics contexts. Instructors provide pronunciation models and facilitate in-class oral drills. Students are required to record short video readings and engage in peer evaluations via social media platforms such as WeChat.

Additionally, the English module integrates authentic scientific texts sourced from reputable media (e.g., Nature News, CGTN, China Daily, BBC Science Focus) to cultivate reading strategies such as skimming, scanning, and contextual guessing. Pre-reading tasks, vocabulary mapping, and reading journals are employed to scaffold comprehension and critical engagement.

The learning objective of this module is to enable students to confidently recognize and interpret physics-related terminology, follow English-medium lectures, and develop foundational competence in scientific communication.

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3.1.2 Physics Knowledge Module

This module constitutes the academic core of the course and focuses on systematically delivering the fundamental theories and principles of classical physics, including Newtonian mechanics, thermodynamics, electromagnetism, waves, and optics. The selection and sequencing of topics are informed by the major requirements of the Mechanical Manufacturing and Automation program.

To address curriculum alignment issues, content was restructured based on both the Chinese national syllabus and selected international textbooks (e.g., Fundamentals of Physics by Halliday & Resnick, University Physics by Young & Freedman). Customized bilingual slides and English handouts were developed to ensure consistency in terminology and conceptual clarity.

Each sub-topic is introduced through real-world phenomena or industrial applications to increase relevance and student motivation. For instance, when teaching the laws of motion, examples related to mechanical gears, industrial conveyor belts, and vehicle crash analysis are employed. Visual aids, animations, and physics simulations are incorporated to facilitate understanding of abstract concepts.

In addition, problem-solving sessions are conducted bilingually, with a gradual shift from Chinese-supported instruction to fully English-based analysis. Students are encouraged to use English to explain reasoning processes, draw free-body diagrams, and write solution steps, thereby reinforcing both conceptual mastery and language output.

3.1.3 Application Module

The third module aims to connect theoretical physics knowledge with real-world engineering and scientific applications. Drawing on the principles of project-based learning and inquiry-driven pedagogy, this module incorporates current events, national scientific achievements, and hands-on exploration.

Students engage with authentic English-language articles reporting China's advances in aerospace, renewable energy, artificial intelligence, and climate science. Each article is linked to a corresponding physics concept—such as using the Chang'e lunar missions to explain gravitational potential, or wind turbine design to analyze rotational dynamics.

Assignments include reading comprehension questions, technical summaries, oral presentations, and cross-disciplinary group projects. Students work collaboratively to model real-life problems, perform basic simulations or calculations, and present their findings in English using slides and diagrams.

This module aims to develop students' interdisciplinary thinking, scientific curiosity, communication skills, and global awareness—qualities essential for future engineers in a competitive international environment.

3.2 Optimizing Teaching Content Based on Disciplinary Characteristics

Given the limitations in total teaching hours and the heavy cognitive load of bilingual instruction, the content of the University Physics course was carefully adjusted. Emphasis was placed on core topics most relevant to mechanical engineering—namely Newtonian mechanics, thermodynamics, and electromagnetism—while topics such as optics and wave theory were simplified to conceptual overviews.

This prioritization ensures depth over breadth and aligns with the principle of "content modularization with contextual integration." Each topic is connected to its practical application within the student's major to enhance perceived utility and facilitate knowledge transfer.

For instance, in the unit on energy conservation, the course delves deeply into thermodynamic cycles and the operation of heat engines, which are directly related to the design of mechanical systems. Similarly, in electromagnetism, topics such as magnetic field generation, electromagnetic induction, and circuit analysis are contextualized within motor control and sensor technology.

Such content optimization reduces extraneous cognitive load, allowing students to focus on high-yield learning while progressively building confidence in both physics and English.

3.3 Constructing Ideological and Political Elements with Professional Relevance

The goal of teaching University Physics is not only to build students' knowledge and critical thinking skills, but also to foster scientific spirit, innovation, and integrity. By integrating ideological and political education into the physics curriculum, values-based learning can be made more natural and effective.

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In this course, the ideological and political goal is: "To cultivate students' awareness of national scientific and societal developments and enhance their capacity to communicate China's achievements to the world. "This is realized through English-language reading assignments and related reflective tasks, such as: After teaching momentum conservation, students read China's first rocket launch in the South China Sea (China Daily) and write an English summary. They then research and present either the history of China's rocket development or the features of a specific Chinese rocket model. After the thermodynamics unit, students read Chinese scientists convert CO_2 into glucose and fatty acids (CGTN) and then investigate China's efforts to mitigate climate change. After electromagnetism, students read Shanxi breaks record in wind power generation (China Daily) and write about the history and status of China's electricity industry or ultra-high-voltage (UHV) transmission technology.

These tasks integrate ideological themes in a seamless and measurable way, boosting student engagement and partially addressing low motivation.

3.4 Reforming Teaching Methods

Traditional "cramming" and "spoon-feeding" approaches were replaced with more interactive methods: heuristic questioning, problem-based learning (PBL), project analysis, and group discussions. This cultivates students' self-directed learning, problem-solving, and collaboration skills.

Digital and traditional teaching tools were combined: platforms like WeChat and Chaoxing (Learning Pass) were used alongside multimedia and physical tools (e.g., pointers). Real-time feedback and monitoring further enhanced engagement. Course delivery was structured into three phases for each module—pre-class, in-class, and post-class.

3.4.1 English Module

The instructional process is divided into three stages: pre-class activities include assignments on the pronunciation and translation of technical terms, student-recorded video readings, and daily vocabulary check-ins via WeChat, in-class sessions feature random oral translation exercises facilitated through the Chaoxing platform, and post-class tasks consist of chapter-based English vocabulary quizzes.

3.4.2 Physics Knowledge Module

The teaching process is structured into three phases: pre-class preparation involves preview assignments delivered through the Chaoxing platform, in-class activities focus on Q&A sessions and guided inquiry-based learning supported by digital slides, and post-class tasks include homework, mind-map assignments, and quizzes targeting key concepts.

3.4.3 Application Module

After each chapter, students are assigned science reading tasks, reflective writing, and group projects. Projects culminate in English presentations with peer feedback and teacher evaluation. The use of rubrics ensures transparency and consistency in assessment.

3.5 Emphasizing Formative Assessment

Assessment is continuous: 30 % regular performance (attendance, homework, vocabulary, translations, ideological tasks), 20 % quizzes (physics concepts and vocabulary), and 50 % final English-medium exam on physics knowledge.

4. Outcomes and Reflections on the Reform

4.1 Reform Outcomes

The outcomes of the reform were evaluated based on three main criteria: student satisfaction with the course, peer recognition of the course and instructional design, diversity and richness of teaching resources.

4.1.1 Student Satisfaction

As shown in Table 1, evaluations from students enrolled in the 2022 and 2023 cohorts of the Sino-foreign cooperative mechanical program indicated that average satisfaction scores across all indicators exceeded 85%. Among them, indicators 1, 5, and 6 surpassed 90%, demonstrating that more than 85%

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of students were satisfied with the current approach to bilingual teaching in University Physics.

Table 1: Teaching Evaluation of the Bilingual College Physics Course – Mechanical Joint Program Students, Yulin University (Past Two Cohorts).

Evaluation No.	Evaluation Criteria	Satisfaction (%) 2022 Cohort	Satisfaction (%) 2023 Cohort
1	Instructor responsibility and positive value dissemination	91.1	96.8
2	Clear objectives and assessment promoting learning	88.9	95.0
3	Content clarity with disciplinary updates	89.5	97.4
4	Modern methods, ample resources, engaging delivery	89.5	96.3
5	Timely tutoring and feedback, prompt grading	92.5	96.9
6	Effective management and lively atmosphere	91.9	96.6
7	Ability to apply theory after course completion	85.2	85.8

4.1.2 Peer Recognition

The teaching reform received institutional acknowledgment and peer validation. The lead instructor was awarded first prize in Yulin University's Online Teaching Competition (Science & Engineering category) and second prize in the university-level Innovation in Teaching Contest. Furthermore, the overall bilingual course plan was assessed as "Excellent" in departmental and school-wide reviews, reflecting its alignment with curriculum reform trends and institutional development goals.

More importantly, the reform experience has been shared at regional teaching forums and has attracted interest from other academic departments seeking to replicate the modular, bilingual, and value-integrated approach.

4.1.3 Diversity of Teaching Resources

During the reform process, the teaching team created a well-rounded suite of instructional materials—including a technical vocabulary booklet, bilingual slides, English handouts, scientific English readings, a problem set booklet, and 27 self-recorded instructional videos—which substantially enhanced the bilingual course and facilitated the application of varied and effective teaching strategies.

4.2 Reflections

Future work will focus on strengthening the teaching team through training and competitions, enriching resources—such as micro-videos and application-oriented assignment banks—and gradually adopting a SPOC model for blended learning.

5. Conclusion

This paper, based on the bilingual teaching practices of University Physics in the Sino-foreign cooperative program at Yulin University, analyzes the key challenges in bilingual instruction and proposes targeted reform strategies. These include the construction of a modular curriculum system, optimization of content based on disciplinary needs, integration of ideological and political education, interactive teaching methods, and formative assessments. The reforms have achieved significant results and may serve as a valuable reference for similar teaching innovations in other local application-oriented undergraduate institutions.

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