Teaching Design and Practice of Ideological and Political Education in the "University Physics" Course within the Context of Industry-Education Integration

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Abstract: *Against the backdrop of deepening industry-education integration and advancing ideological and political education within curricula, this paper systematically constructs a four-dimensional ideological and political teaching framework for university physics courses-encompassing objectives, content, methodology, and assessment-from the perspective of industry-education collaboration. Addressing current challenges such as insufficient integration of ideological and political elements and disconnect from industrial realities, this paper proposes a core philosophy of 'value-led, competency-based' education. By leveraging ideological and political resources, innovating teaching methodologies, and refining multi-dimensional assessment, it explores effective pathways to unify knowledge transmission, competency development, and value formation. This framework offers practical guidance for advancing ideological and political education within science and engineering curricula.*

Keywords： *Industry-education integration; Ideological and political education in courses; University physics; Instructional design*

1. Introduction

University physics, as a foundational course for science and engineering disciplines, not only establishes the theoretical groundwork for students' subsequent specialized studies but also plays an irreplaceable role in cultivating scientific literacy, logical thinking, and innovative capabilities. However, for a long time, university physics teaching has exhibited tendencies to 'prioritize knowledge over values' and 'emphasize theory over practice', with ideological and political education often marginalized, struggling to achieve synergistic effects with professional instruction. With the progressive implementation of the Guidelines for Ideological and Political Education in Higher Education Institutions' Curriculum Development[1], integrating ideological and political elements naturally and effectively into specialized courses has become a key challenge in university teaching reform.

Industry-education integration, as a vital mechanism for aligning higher education with industrial demands, provides new practical arenas for course-based ideological and political education[2]. Through university-enterprise collaboration, real-world project integration, and the development of dual-qualified teaching staff, course-based ideological and political education is implemented in authentic contexts, enhancing students' professional identity, social responsibility, and sense of national mission. Drawing upon multidisciplinary experiences in curriculum-based ideological and political education and considering the characteristics of university physics courses, this paper explores systematic design and implementation pathways for curriculum-based ideological and political education within the context of industry-education integration.

2. The Practical Demands and Problem Analysis of Ideological and Political Education in the "University Physics" Course

2.1 The Practical Demands and Problem Analysis of Ideological and Political Education in the 'University Physics' Course

The integration of ideological and political education within contemporary university physics curricula is frequently superficial, with most approaches remaining confined to brief introductions to scientists' biographies or national scientific achievements, failing to achieve an organic fusion with physical principles. The primary cause of this phenomenon lies in educators' insufficient depth of understanding and exploration of ideological elements, resulting in teaching methods that mechanically graft such content in a "labeling" fashion. Taking the teaching of "electromagnetic induction" as an example, lecturers often merely mention Faraday's discovery without connecting it to China's cutting-edge innovations in fields such as ultra-high voltage transmission technology and new energy equipment manufacturing. This disconnect renders the ideological content lacking in contemporary relevance and persuasive power. A deeper-seated issue lies in some teachers' perception of ideological and political education remaining confined to 'political indoctrination.' They fail to integrate value guidance throughout the entire process of knowledge construction and competency development, resulting in a disconnect between professional education and ideological and political education, creating a phenomenon of 'two separate entities'[3].

2.2 Disconnect between teaching content and industry requirements

The current university physics curriculum suffers from two major issues: a disconnect between theory and practice, and outdated content. On the one hand, teaching places excessive emphasis on formula derivation while failing to connect with contemporary technological and industrial applications. On the other hand, the curriculum does not adequately reflect cutting-edge technological developments such as quantum communication and quantum computing, nor their strategic importance to national development. This prevents students from establishing links between their physics knowledge and engineering practice, thereby diminishing their motivation to learn and their sense of mission to serve national strategic objectives.

2.3 Teaching methods are monotonous, and student engagement is low

The traditional teaching model of intensive instruction coupled with extensive practice demonstrates clear shortcomings in stimulating students' interest in learning, and proves even less effective in fostering the internalization of values. Concurrently, current teaching methods remain predominantly characterized by one-way lecturing from teachers, leaving students in a passive state of knowledge reception, lacking the process of active thinking and value construction. Due to the insufficient incorporation of modern teaching approaches such as contextualization, project-driven learning, and collaborative inquiry, ideological and political education struggles to genuinely achieve teaching outcomes that truly resonate with students' minds and hearts.

2.4 The evaluation mechanism places undue emphasis on knowledge assessment while neglecting value orientation

Currently, the assessment system for university physics courses remains predominantly reliant on end-of-term written examinations, with the focus centred on students' comprehension and memorization of formulas and concepts. Although some institutions have attempted to introduce formative assessment, these measures still revolve primarily around knowledge acquisition. No scientifically sound and effective evaluation tools or standards have yet been established to assess students' performance in soft skills such as scientific attitudes, teamwork, and innovative thinking. Furthermore, course assessments lack systematic formative evaluation of comprehensive qualities such as scientific spirit, innovative thinking, and professional ethics[4]. These limitations in the evaluation mechanism not only constrain the actual achievement of course-based ideological and political education outcomes but also hinder the holistic development of students' comprehensive qualities and professional competencies to a certain extent.

3. Theoretical Framework for Ideological and Political Education Design in University Physics Courses under the Context of Industry-Education Integration

3.1 Design Philosophy

Centred on the principles of 'value-driven, competency-based, and industry-academia collaboration', the university physics curriculum organically integrates ideological and political elements such as socialist core values, the spirit of scientists, engineering ethics, and cultural confidence. This approach achieves a tripartite teaching objective encompassing knowledge, competency, and values.

3.2 System Architecture

Establishing a four-pronged curriculum-based ideological and political education system encompassing objectives, content, methodology, and assessment:

Firstly, the objective framework comprises knowledge objectives, competency objectives, and value objectives, clearly defining the ideological and political education goals for each teaching unit. Secondly, the content framework reconstructs teaching modules based on the logical progression of physics disciplines while integrating cutting-edge industrial developments, thereby uncovering the ideological and political implications underlying each module. Thirdly, the methodology system employs diverse teaching approaches such as case-based learning, project-driven instruction, virtual simulation, and university-industry collaboration to enhance the impact and effectiveness of ideological and political education. Finally, the evaluation system establishes a multi-dimensional assessment mechanism incorporating value cognition, scientific attitudes, and teamwork into the assessment criteria.

4. Specific Practical Approaches to Ideological and Political Education in University Physics Courses

4.1 Deeply explore ideological and political elements to construct an integrated content system combining physics with ideological and political education

4.1.1 Scientific Spirit and Patriotic Education

In teaching the "Mechanics" chapter, it is recommended to use major national scientific and technological projects such as China's manned space programme as the central narrative framework, systematically integrating relevant theoretical concepts and ideological and political elements. For instance, when teaching Newton's laws of motion, practical examples such as thrust analysis and orbital calculations during rocket launches may be introduced to help students grasp the laws' engineering applications. When explaining universal gravitation and orbital mechanics, the construction and operation of China's space station may be used to elucidate the underlying scientific principles, emphasizing the independent innovation and systems engineering mindset embodied in such projects.

4.1.2 Engineering Ethics and Sense of Responsibility

In teaching the course on electromagnetism, real-world issues such as high-voltage transmission and electromagnetic radiation may be integrated to elucidate the physical principles underlying Maxwell's equations and electromagnetic wave propagation. Appropriate engineering case studies of China's ultra-high voltage transmission technology should be introduced to guide students in considering potential safety and ethical concerns arising from technological applications, thereby fostering their sense of social responsibility and engineering ethics[5]. To reinforce this educational objective, online platforms may host thematic discussions on 'The Societal Impact of Electromagnetic Technologies'. This encourages students to examine the dual effects of technological advancement from multiple perspectives, thereby enhancing their critical thinking and sense of social responsibility through deliberative engagement.

4.1.3 Cultural Confidence and Philosophical Thinking

In teaching the "Optics" section, emphasis is placed on exploring the educational value of the subject matter in terms of cultural heritage and the cultivation of philosophical thinking. On the one hand, by systematically introducing ancient optical practices such as the pinhole imaging principle and "sun-fire" techniques from the Mo Jing, the scientific concepts embedded within-such as the rectilinear propagation and reflection laws of light-are elucidated. This demonstrates the early wisdom of the Chinese nation in the field of optics, thereby effectively enhancing students' cultural identity and national confidence. On the other hand, when teaching core modern optical concepts such as the wave-particle duality, conscious efforts are made to guide students beyond specific knowledge. This involves helping them grasp the fundamental dialectical materialist principle of 'unity of opposites,' thereby promoting the integration of scientific thinking with philosophical reasoning capabilities.

4.1.4 Green Development Concept and Ecological Civilization

In teaching the thermodynamics section, instruction should be closely aligned with China's dual carbon strategy objectives. Core concepts such as energy conversion efficiency and the principle of entropy increase should be systematically explained in relation to sustainable development, guiding students to establish a scientific foundation for understanding green development. Furthermore, nuclear energy systems may be introduced as a representative case study, detailing their operational principles and carbon emission characteristics. Emphasis should be placed on analyzing the strategic value and safety assurance requirements of nuclear energy in optimizing energy structures and supporting green development, thereby cultivating students' ecological awareness and sense of responsibility towards green technology[6].

4.2 Innovate teaching methods to enhance the effectiveness of ideological and political education

4.2.1 Case-based teaching method

Employing a tripartite case design approach integrating 'physical principles + national engineering projects + scientists' narratives', this methodology organically merges fundamental theories with national scientific achievements and the ethos of scientific endeavour. For instance, when teaching fluid mechanics, the aerodynamic design of the C919 large passenger aircraft serves as a paradigmatic case study. Instruction begins by outlining the national context and strategic significance of the C919 programme; students are then guided to apply principles such as Bernoulli's equation to analyse the aerodynamic characteristics of its wings. Subsequently, it delves into the perseverance and collaborative ingenuity demonstrated by the R&D team when confronting challenges in aerodynamics, materials science, and other domains. Through this progressive teaching approach-from engineering context to theoretical analysis to spiritual essence-students not only master professional knowledge but also gain profound insight into the national significance of scientific innovation. This fosters a sense of national pride and a mission to serve the nation through scientific advancement.

4.2.2 Project-Based Learning

To deepen industry-education integration, differentiated real-world project tasks may be designed according to students' disciplinary backgrounds. For instance, physics students could undertake a 'High-Precision Optical Temperature Measurement System' project, while engineering students might be assigned a 'Regional Energy Planning Analysis' task. Taking the 'Intelligent Energy-Efficient Building Design' project for architecture students as an example, participants must complete the assignment in teams. First, they conduct an analysis of building energy consumption requirements. Subsequently, they integrate knowledge of thermodynamics, optics, and electromagnetism to complete the system design. They then validate the scheme's energy efficiency using simulation software, ultimately presenting their findings through a report and defence.

4.2.3 Virtual Simulation and Digital Teaching

For certain high-risk, high-cost, or highly abstract physical concepts, virtual simulation experiments may be introduced as supplementary teaching tools. For instance, developing digital teaching modules such as 'Fundamentals and Safety Simulation of Nuclear Reactors' enables students to observe the basic processes of nuclear fission chain reactions within an interactive interface, learn fundamental radiation protection protocols, and simulate safety operating procedures under typical operational scenarios. Through such virtual tasks, students not only gain intuitive understanding of abstract physical mechanisms but also progressively develop awareness of safety standards and social responsibility through simulated practical operations[7].

4.2.4 University-Industry Collaborative Teaching

Explore collaborative teaching mechanisms between universities and enterprises by integrating cutting-edge industrial case studies into physics curricula through the involvement of corporate experts with extensive practical experience. For instance, when teaching semiconductor-related knowledge, collaborations with industry enterprises could establish a specialized module on 'Physical Principles in Chip Manufacturing'. Corporate engineers would then elucidate the underlying physical mechanisms and engineering implementation pathways associated with specific processes such as lithography and etching. Building upon this foundation, students could undertake field visits to enterprises or participate in simulated practical operations. This would enable them to comprehend the technological translation of physical knowledge within authentic contexts, thereby strengthening professional identity and enhancing vocational competence[8].

4.3 Establishing a 'Three-Classroom Synergy' Educational Mechanism

4.3.1 Primary Classroom: The Main Arena for Theoretical Instruction

Building upon systematic knowledge transmission, value guidance is organically integrated throughout the entire theoretical teaching process. In physics courses, the 'problem-inquiry-reflection' teaching approach may be employed, where carefully designed physics problems guide students in constructing their knowledge framework, naturally instilling scientific spirit and values during the inquiry process. For instance, when teaching the 'law of increasing entropy,' after explaining the fundamental physical principle, students should be guided to consider its broader implications for energy utilization and ecosystem expansion. This enables them to grasp the value of physical laws within sustainable development, thereby concurrently establishing scientific concepts and social responsibility during theoretical learning.

4.3.2 Second Classroom: Experimental and Practical Extension

The second classroom serves as a platform for translating theoretical instruction into practical application, with a focus on guiding students to apply their acquired physics knowledge to real-world scenarios, thereby deepening their understanding and honing their skills through hands-on experience. Through diverse formats such as open-access experiments, subject competitions, and research projects, it prioritises cultivating students' rigorous approach, collaborative abilities, and innovative mindset. For instance, in the open project 'Intelligent Sensing and Physical Measurement', students independently design sensors to measure environmental parameters. They then analyse the data in light of the 'dual carbon' goals and draft energy-saving recommendation reports. Such activities not only strengthen students' hands-on capabilities and systematic thinking but also heighten their sense of mission to apply specialized knowledge towards meeting national strategic needs.

4.3.3 Third Classroom: Enterprise and Social Practice

The Third Classroom programme aims to broaden students' learning horizons by organizing visits to high-tech enterprises, key laboratories and similar venues. This immerses them in real-world industrial settings, enhancing their appreciation of the practical value of physics knowledge. Where feasible, existing corporate partnerships may be leveraged to deliver appropriately scaled practical activities such as "Technology Observation Weeks" or "Engineer Face-to-Face" sessions. For instance, arranging visits to local laser technology enterprises enables students to observe the practical application of optical principles in precision machining and medical equipment. Through direct interaction with technical personnel, this reinforces their recognition of the discipline's professional value and fosters a sense of mission regarding future careers. Such activities emphasize alignment with specialized fields, helping students comprehend the relationship between technological advancement and societal needs within authentic contexts. This approach strengthens their social responsibility and cultivates the ability to apply knowledge effectively.

4.3.4 Refine the diversified comprehensive evaluation system

To comprehensively evaluate the effectiveness of implementing ideological and political education within the curriculum, the university physics course has established a multi-faceted, integrated assessment system guided by the principle of 'equal emphasis on process and outcome, integrating knowledge with values'. This framework encompasses three core dimensions: knowledge acquisition, competency demonstration, and value recognition. The knowledge acquisition dimension evaluates students' comprehension of physical concepts and principles through written examinations, unit tests, and assignments. The competency demonstration dimension systematically assesses students' practical skills and innovative aptitude via laboratory operations, project design, and collaborative tasks. The value recognition dimension employs ideological assignments, reflective practice, and corporate mentor evaluations to thoroughly gauge students' scientific attitudes and social responsibility. During implementation, the 'Student Comprehensive Quality Evaluation Form' consolidates feedback from teaching staff, industry partners, and students. At each semester's conclusion, this generates a report containing pedagogical improvement recommendations, thereby establishing a virtuous cycle where evaluation drives development and refinement.

Conclusion

The integration of industry and education provides a rich practical arena and resource support for the ideological and political education development of the University Physics course. Through the establishment of systematic teaching design, diversified teaching methods, and collaborative educational mechanisms, this course effectively fulfills its educational mission of value guidance while imparting scientific knowledge. As a foundational course in science and engineering disciplines, the ideological and political teaching reform of University Physics not only concerns the shaping of students' scientific literacy and value concepts but is also closely linked to the future of national scientific and technological innovation and industrial development. Within the framework of industry-education integration, the University Physics course should fully leverage its bridging role to organically connect theory with practice, science with humanities, and individual growth with national development. It should strive to cultivate new-era engineering talent equipped with scientific literacy, a craftsman's spirit, and a profound sense of national and civic responsibility.

Fund Projects

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