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Research on the Ideological and Political Education Model for the "Fundamentals of Mechanical Design" Course

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Abstract: The "Fundamentals of Mechanical Design" course is a core course for mechanical engineering majors and a foundational required course for mechanical engineering students. In the process of imparting professional knowledge, ideological and political education must be given equal importance to achieve the coordinated development of professional skill cultivation and value guidance. In this paper, the ideological and political education model of the course is explored. First, a three-dimensional framework for identifying ideological and political education elements—history, technology, and ethics—is established, achieving the organic integration of the professional knowledge system and value guidance elements. Second, a comprehensive educational model is constructed, encompassing pre-class preparation stage, classroom teaching stage, practical teaching stage. Finally, an ideological and political quality assessment system is established, enabling scientific evaluation and dynamic monitoring of students' ideological and political qualities.

1. Introduction

As China's manufacturing industry undergoes transformation and upgrading and the innovation-driven development strategy is implemented in depth, higher engineering education is facing the important mission of cultivating new engineering and technical talents with both the morality and the ability. "Fundamentals of Mechanical Design" course is a required foundational course for second-year students in mechanical engineering programs in China. As an introductory course, it guides students into the field of mechanical engineering and lays the foundation for subsequent courses. In the current context of intensifying international competition, the traditional course model that focuses primarily on technical skill development is no longer sufficient to meet the nation's demand for innovative and multidisciplinary engineering talent [1]. To achieve the goal of cultivating well-rounded individuals, in addition to imparting professional knowledge, it is essential to strengthen students' ideological and political education [2]. Integrating ideological and political theory elements into the "Fundamentals of Mechanical Design" course not only enriches the teaching content, but also guides students to deeply reflect on the practical application value and social impact of mechanical science. In the current context of accelerating the construction of a manufacturing powerhouse and an innovative nation, thoroughly exploring the ideological and political elements of the "Fundamentals of Mechanical Design" course and achieving the organic unity of value shaping and knowledge transmission holds significant importance for cultivating high-quality engineering and technical talent in the new era.

A thorough analysis of the current state of teaching in the “Fundamentals of Mechanical Design” course reveals several pressing issues that require immediate attention. From the perspective of teaching content, most textbooks and course designs focus too much on imparting traditional design theories and calculation methods, while neglecting the cultivation of soft skills such as engineering ethics and innovative thinking; In terms of teaching methods, case-based teaching often remains at the technical level, failing to delve deeply into the ideological and political elements embedded within them; In terms of the evaluation system, current assessment methods primarily focus on students' mastery of technical details, neglecting the evaluation of professional ethics and value judgment capabilities. These issues result in students who have a solid professional foundation, but often lack systematic thinking that comprehensively considers technical feasibility, economic rationality, and social acceptance when facing complex engineering practice problems. Research indicates that achieving the organic integration of ideological and political education with professional knowledge is the core to enhancing teaching effectiveness [3,4]. A scientifically reasonable assessment system not only objectively reflects students' ideological and political learning outcomes but also provides important basis for teaching improvements [5]. Therefore, establishing a comprehensive ideological and political education assessment mechanism for the “Fundamentals of Mechanical Design” course has significant practical value.

This study is based on the characteristics of the "Fundamentals of Mechanical Design" course and proposes a systematic curriculum ideological and political construction plan. By constructing a framework for exploring ideological and political elements from three dimensions: historical dimension, technological dimension, and ethical dimension, developing a teaching method that combines pre-class stage, classroom stage, practical stage. Additionally, it establishes a full process, multi-dimensional ideological and political quality evaluation system. The structure of this paper is as follows: Chapter 1 is an introduction; Chapter 2 outlines the core content of the course; Chapter 3 explores ideological and political elements; Chapter 4 constructs a path for ideological and political teaching practices; Chapter 5 investigates assessment methods for ideological and political education; Chapter 6 summarizes the main conclusions.

2. Contents for the "Fundamentals of Mechanical Design" Course

"Fundamentals of Mechanical Design" serves as a core professional course within the field of mechanical engineering, with its knowledge framework centered on the fundamental principles, methods, and applications of mechanical design. The course aims to establish a solid professional foundation for students and cultivate technical competencies aligned with international engineering standards. Although the course itself belongs to the professional technical category and does not directly involve ideological content. However, in the process of teaching implementation, universal values education such as sense of responsibility and innovative spirit can be naturally integrated through engineering ethics, standard setting, and other links. This course is divided into thirteen chapters. Chapter 1 is an introduction; Chapter 2 introduces the structure and motion analysis of planar mechanisms; Chapter 3 introduces the planar link mechanisms; Chapter 4 introduces the design of cam mechanism; Chapter 5 introduces the gear mechanisms; Chapter 6 introduces the gear systems; Chapter 7 introduces the belt drives and chain drives; Chapter 8 introduces other types of drives; Chapter 9 introduces machine dynamics; Chapter 10 introduces the threaded connections and keyed connections; Chapter 11 introduces the bearings; Chapter 12 introduces the couplings, clutches, and brakes; Chapter 13 introduces the shafts. The core knowledge points of each chapter are summarized in Table 1.

Table 1: Knowledge points of the "Fundamentals of Mechanical Design" course

Chapter	Key knowledge Points
Chapter 1: Introduction	Components of machinery; Classification of motion pairs; Basic process of mechanical design
Chapter 2: Structural and Motion Analysis of Planar Mechanisms	Draw a schematic diagram of the mechanism's movement; Degree of freedom calculation; Instantaneous velocity method
Chapter 3: Planar Linkage Mechanisms	Four-bar linkage type; Rapid return characteristics; Dead point position analysis
Chapter 4: Design of Cam Mechanism	Motion characteristics of the follower; Relationship between pressure angle and base circle radius; Design methods of cam profile
Chapter 5: Gear Mechanisms	Principles of involute formation; Basic parameters of standard gears; Root cutting phenomenon and displacement correction
Chapter 6: Gear Systems	Calculation of the transmission ratios for the fixed-axis gear trains, planetary gear trains, and differential gear trains
Chapter 7: Belt Drives and Chain Drives	Belt drive elastic sliding principle; V-belt model selection; Chain drive polygon effect
Chapter 8: Other Transmission Types	Worm gear transmission efficiency calculation; Helical gear pitch angle selection; Friction wheel transmission clamping force design
Chapter 9: Machine Dynamics	Mechanical speed fluctuation adjustment; Flywheel rotational inertia calculation; Rotor balancing
Chapter 10: Threaded Connections and Key Connections	Thread pitch angle; Preload and anti-loosening measures; Flat key size selection
Chapter 11: Bearings	Rolling bearing designation; Life calculation; Oil film formation conditions for sliding bearings
Chapter 12: Couplings, Clutches, and Brakes	Differences between rigid and flexible couplings; Torque capacity of friction clutches; Brake thermal balance calculations
Chapter 13: The Axis	Shaft structural design; Bending and torsion combined strength verification; Critical speed estimation

3. Exploration of ideological and political elements in the course

Based on the characteristics of the "Fundamentals of Mechanical Design" course, this paper proposes a three-dimensional exploration method combining "history, technology, and ethics." Through a multi-perspective systematic review of the ideological and political elements in the course, this method achieves an organic integration of professional knowledge and value guidance. The framework design of the three-dimensional exploration method is shown in Figure 1.

3.1. Historical Dimension: Inheriting the Genes of Mechanical Civilization

From the primitive mechanical devices of the Neolithic Age, to the bronze gears of the Spring and Autumn and Warring States periods, and to the highly developed hydraulic machinery of the Tang and Song dynasties, the development trajectory of ancient Chinese mechanical civilization demonstrates the outstanding wisdom of the Chinese nation. Taking the Northern Song Dynasty Water Clock Observatory as an example, we can use three-dimensional dynamic simulation technology in teaching to recreate its working principles, guiding students to gain a deeper understanding of how Chinese craftsmen in the 11th century, without modern computational tools, achieved such a complex and precise design through accumulated practical experience and repeated adjustments. This historical exploration based on specific technological cases not only showcases the scientific and technological achievements of Chinese civilization, but also allows students to appreciate how the "pursuit of excellence" craftsmanship spirit has evolved over millennia. Additionally, we emphasize establishing a dialogue between ancient and modern technologies, enabling students to understand cultural inheritance in technological innovation and thereby enhance their engineering cultural confidence and national pride.

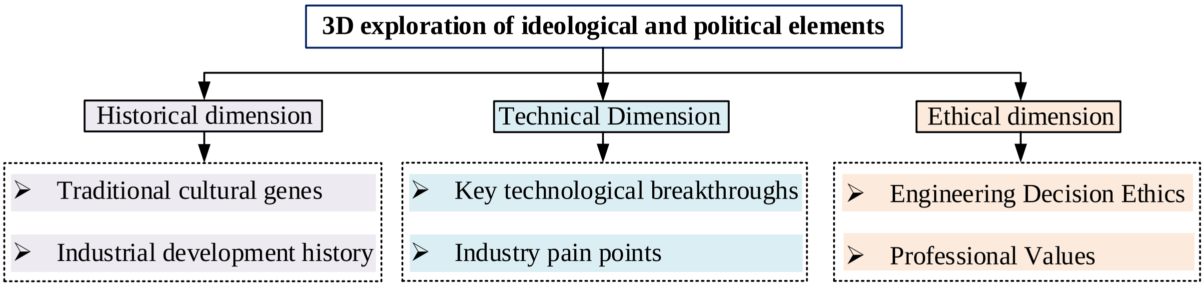

Figure 1: Framework design for "3D exploration of ideological and political elements"

3.2. Technical Dimension: Aligning with National Strategic Needs

In the exploration of ideological and political elements within the technical dimension, the focus is on the deep integration of national strategic needs with mechanical design technology. For example, by comparing and analyzing the key parameter differences between China's domestically developed "Fuxing" high-speed train gearbox and earlier imported technologies, and deeply interprets the breakthrough process of core technologies such as tooth profile optimization and material heat treatment. In classroom teaching, we have introduced a "key technology benchmarking" component: students are divided into research and development groups, given the technical specifications of a German-imported gearbox, and required to apply the design theories learned in the course to attempt to achieve equivalent performance through methods such as finite element analysis and parameter optimization. Additionally, in line with the "14th Five-Year Plan" for intelligent manufacturing development, the course design includes an "intelligent upgrading" module. This teaching design, which is in sync with national strategy, naturally establishes a sense of mission to "serve the country through science and technology" and a professional pursuit of "manufacturing power."

3.3. Ethical Dimension: Shaping Engineering Value Judgments

In the integration of ideological and political education elements within the ethical dimension, the focus is on cultivating students' engineering ethics awareness and professional sense of responsibility.

During the teaching process, we provide students with the operational parameters of a critical bolt in a crane, and require them to calculate the cost differences and failure probabilities corresponding to different safety factors in groups. They then assess the social impacts of various options through failure mode and effects analysis. This teaching method allows students to deeply understand that mechanical design is not merely cold numerical calculation, but also involves value judgments concerning life safety. In the course design phase, we have introduced an “end-of-life responsibility” assessment requirement, where students must explain the potential social and environmental impacts of their design works across manufacturing, use, and disposal phases, along with corresponding mitigation measures. Through this immersive ethical training, students gradually develop a professional mindset that “design is responsibility,” internalizing safety awareness and humanistic care as inherent engineering values.

4. Practical Pathways for Ideological and Political Education in the Course

Implementing ideological and political education in the “Fundamentals of Mechanical Design” course, it is essential to organically integrate three-dimensionally explored ideological elements throughout the professional teaching process via systematic instructional design and multifaceted teaching methods. The following are specific practical pathways:

4.1. Pre-class preparation stage: Building a resource library for political education

A comprehensive teaching support system has been established through the in-depth development and integration of multidimensional resources. Firstly, it is necessary to establish a case system of mechanical engineering that spans both ancient and modern times, including both traditional mechanical wisdom and detailed technical archives of major engineering breakthroughs in contemporary times. Additionally, through deep collaboration with enterprises, practical experience from the industrial frontlines should be transformed into teaching materials. These resources should not only include textual materials, but also be made into diverse forms such as micro lesson videos, interactive courseware, virtual reality scenes, etc., to meet the needs of different teaching stages. In addition, the latest engineering cases and research achievements should be regularly updated to ensure that teaching content remains aligned with industry development, thereby maintaining the timeliness and appeal of ideological and political education.

4.2. Classroom teaching stage: Innovative Teaching Methods

During the classroom teaching stage, it is essential to break away from traditional lecture-based teaching methods. Taking the "Gear Transmission Design" unit as an example, a documentary clip about the research and development of high-speed rail gearboxes in China is played first, creating a real-life scenario of "breaking through technological barriers". Student groups are then organised to discuss the fatigue life test data of imported and domestically produced gears, conducting a comparative analysis of the reliability through numerical calculations. This process naturally sparks reflection on the importance of independent innovation. For the cultivation of engineering ethics, students are required to conduct multi-objective optimization and elaborate on the value trade-offs in their design during the defense phase. This teaching method organically integrates case analysis, digital tools, and situational simulation, enabling students to achieve a sublimation from technical cognition to value recognition in the process of solving specific engineering problems.

4.3. Practical teaching stage: Deepening value experience

In the practical teaching process, an immersive educational model based on "real-world scenarios, multi-dimensional constraints, and collaborative evaluation" is established. Taking the "high-precision transmission system design" project as an example, students are required to immerse themselves in intelligent manufacturing enterprises through a two-week on-the-job training program on production lines, gaining a comprehensive understanding of the entire process from design requirements to production validation. During the project execution, the student teams must simultaneously meet multi-dimensional engineering technical indicators such as "transmission precision, service life, and maintenance costs." The project includes a "extreme condition simulation testing" phase to validate system reliability under harsh environments like vibration and temperature fluctuations. A review team composed of enterprise technical experts and frontline assembly personnel conducts a comprehensive evaluation from the technical feasibility, economic viability, and manufacturability perspectives.

5. Assessment Methods for the ideological and political Elements

The assessment of ideological and political elements employs a comprehensive evaluation method that is both process-oriented and multi-dimensional. Through three key components—classroom discussions, research reports, and report presentations—it systematically evaluates students' demonstrated values, engineering ethics awareness, and sense of social responsibility during their professional studies. This assessment approach emphasizes formative evaluation, seamlessly integrating the cultivation of ideological and political elements into all aspects of professional teaching, thereby achieving the organic unity of knowledge transmission and value guidance.

Note: This section focuses solely on the assessment methods for ideological and political education. The assessment results obtained can be combined with course knowledge assessment results to form the final assessment score.

5.1. Classroom Discussion

During classroom discussions, instructors assess students' value orientations as reflected in their professional discussions by observing their comments and discussion performance. Instructors evaluate whether students can consciously consider social benefits, environmental impacts, and other factors in their technical analyses, as well as the comprehensiveness of their arguments and the accuracy of their values. Classroom discussion scores account for 40% of the ideological and political theory assessment.

5.2. Research Reports

The evaluation of research reports adopts a "dual-mentor review system," with scores assigned jointly by professional faculty and ideological and political education faculty. Professional faculty members focus on evaluating the academic quality of the research, while ideological and political education faculty members emphasize assessing the alignment of the research topic with national needs, the dialectical consideration of technological development. The grade for the research report accounts for 30% of the ideological and political education assessment.

5.3. Report Presentation

During the report presentation session, a panel of judges composed of professional teachers, corporate engineers, and senior student representatives evaluates the presentations. The assessment not only evaluates the accuracy and innovation of the technical content but also places particular emphasis on assessing students' professional attitudes and sense of social responsibility. The judging panel evaluates students based on three dimensions: professional competence, communication skills, and professional ethics. The presentation score accounts for 30% of the ideological and political theory assessment.

6. Conclusion

This study explores in depth the ideological and political education elements of the course "Fundamentals of Mechanical Design". Through the three-dimensional fusion of ideological and political education paradigms, a paradigm shift has been achieved from "technology imparting" to "nurturing people and forging souls". In addition, a practical path for ideological and political education in the pre-class, in-class, and practical stages is constructed, and an evaluation system is designed that includes three dimensions: classroom discussions, research reports, and report presentation. The results of this study provide important reference for the ideological and political education of the "Fundamentals of Mechanical Design" course.

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