Research on the Reform of Ideological and Political Education in the Course of Mechanical Design Based on the Theory of TRIZ

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Abstract: This article explores the innovative path of ideological and political education reform in the course of Mechanical Design, guided by the methodology of contradiction matrix and invention principle in TRIZ theory. By analyzing the correlation between technical contradictions and ideological and political education goals in mechanical design courses, a strategy of integrating ideological and political education with "contradiction transformation" as the core is proposed. Combining case teaching, project driven, and interdisciplinary integration methods, the organic integration of professional knowledge and core values is achieved. The research aims to provide theoretical basis and practical examples for the ideological and political reform of engineering courses, and to help cultivate high-quality mechanical engineering talents with both innovation ability and social responsibility.

Keywords: **Mechanical Design Course; TRIZ; Contradiction Matrix; Invention Principle; Ideological and Political Education; Teaching Reform**

1. Background and Significance of the Topic Selection

The course of Mechanical Design is a compulsory course for mechanical majors in engineering colleges and is a core foundational course for the major [1,2]. The main goal is to cultivate composite talents who meet the needs of modernization construction, adapt to the development of equipment manufacturing and other industries in the 21st century, possess comprehensive development in morality, intelligence, physical fitness, aesthetics, and other aspects, as well as comprehensive technical application and engineering practice abilities. Mechanical engineering students are the core force of national industrial development and the implementation of the major strategy of "Intelligent Manufacturing 2025". As the "engineering" in the field of engineering, emphasizing its professional foundation and practical skills is certainly important. However, important positions in the country require not only work ability, but often value talents with noble character and both moral integrity and talent. Therefore, the cultivation of correct patriotism, professional ethics, humanistic values, and dedication in moral education is particularly important for mechanical students.

In recent years, the country has put forward requirements for the construction of "curriculum ideology and politics", emphasizing that all courses should undertake the function of educating people and achieve the unity of knowledge transmission and value guidance. Curriculum ideological and political education is an educational practice activity that dissolves the" salt "of ideological and political education into the" water "of professional courses and general education courses, and is a specific measure to implement the fundamental task of cultivating morality and talents [3,4]. Mechanical design, as a core course in mechanical engineering, involves teaching content such as mechanical system design, component selection, and innovative practice, and has natural potential for cultivating engineering ethics and professional ethics. However, in traditional teaching, ideological and political elements are often presented in an "additional" manner, lacking systematic and methodological support, resulting in a prominent phenomenon of "two skins" between ideological and political education and professional teaching.

The TRIZ theory (Theory of Invention Problem Solving) [5,6] uses the contradiction matrix and 40 principles of invention as its core tools,

emphasizing the use of systematic thinking to solve technical contradictions. Introducing it into the curriculum ideological and political reform can construct a bidirectional mapping model of "technical issues ideological and political goals", achieving a transformation from "passive integration" to "active design". For example, in gear transmission design, by analyzing the technical contradiction between "transmission efficiency and manufacturing cost", it extends to the ideological and political theme of "technological innovation and sustainable development", cultivating students' global perspective and sense of responsibility.

This article aims to expand the application scenarios of TRIZ theory in the field of education and teaching, and provide methodological innovation for curriculum ideological and political education. By constructing a case library, reforming teaching models, and optimizing evaluation systems, we aim to enhance the educational effectiveness of mechanical design courses.

2. Current Research Status at Home and Abroad

Domestic curriculum ideological and political research mostly focuses on case development and innovative teaching models. For example, Yang and Ding [7] proposed incorporating elements of "patriotism" and "teamwork" into the course design of "Mechanical Design", and driving ideological and political education through real enterprise projects. Liu [8] focused on the difficulties in applying TRIZ, and specialized in the field of mechanical engineering, streamlined and revised TRIZ to make it more suitable for mechanical engineering. They also proposed new methods for using TRIZ to solve innovative problems. Shi et al. [9] closely integrated TRIZ theory with the graduation design of mechanical engineering majors, applying TRIZ theory to the entire process of topic formulation, proposal, implementation, and defense evaluation. They guided teachers and students to carry out activities such as topic formulation, research objectives and content determination, technical scheme formulation and practice, feedback and evaluation, and provided specific implementation cases. Southwest University of Science and Technology has established a "interdisciplinary + industry education integration" course group, which combines mechanical design with national strategies such as intelligent manufacturing and green manufacturing, and strengthens students' awareness of social responsibility. However, existing research lacks systematic methodological guidance and the depth of integration between ideological and political elements and professional knowledge is insufficient.

Foreign engineering education emphasizes the infiltration of ethical education and sustainable development concepts [10-12]. For example, the ABET certification system in the United States requires engineering courses to include "engineering ethics" and "social impact analysis"; The "dual system" education in Germany emphasizes the collaborative cultivation of professional competence and corporate culture. However, foreign research has paid less attention to the integration path of ideological and political education with professional knowledge, especially the curriculum ideological and political practice guided by TRIZ theory is still blank.

The research idea of this article is to systematically introduce the core tools of TRIZ theory - contradiction matrix and invention principle - into the ideological and political teaching reform of the course "Mechanical Design" for the first time, and construct an innovative path of "promoting value guidance by resolving contradictions". Unlike previous simple and superficial "grafting" or "labeling" of ideological and political elements with professional knowledge, the innovative feature of this article lies in achieving deep integration from a methodological perspective. We do not directly teach values, but rather analyze the correlation between the technical difficulties encountered in the teaching process (such as the contradiction between structural strength and lightweight, the contradiction between accuracy and cost) and the educational goals (such as the spirit of craftsmanship for excellence, the enterprising consciousness for innovation, and the team spirit for collaborative cooperation), accurately identifying the inherent relationship between "technical contradictions" and "ideological and political education goals". On this basis, we propose the core strategy of "contradiction transformation", which guides students to apply the principles of invention to solve engineering and technical contradictions, while

subtly understanding and practicing the dialectical thinking, innovative consciousness, and sense of responsibility contained therein, thus achieving the organic unity and resonance of knowledge transmission, ability cultivation, and value shaping.

The significance and value of this study are mainly reflected in three aspects: at the theoretical level, it broadens the application boundaries of TRIZ theory, successfully transferring it from the pure field of engineering technology innovation to the field of education, providing a new theoretical model with solid methodological support for curriculum ideological and political construction, and enriching the theoretical connotation of ideological and political education under the background of "new engineering". At the practical level, the specific methods proposed in this study, such as case-based teaching and project driven teaching, provide frontline teachers with an operable, replicable, and assessable teaching reform toolbox, effectively solving the problem of "hard integration" and "two skins" of ideological and political education, and significantly enhancing the affinity, pertinence, and effectiveness of ideological and political education. At the value level, the ultimate goal of this study is to cultivate outstanding engineers who not only master advanced design techniques, but also deeply understand and consciously practice the core values. This has profound and significant practical value for implementing the fundamental task of "cultivating morality and talents", serving the national innovation driven development strategy, and cultivating new generations who shoulder the great responsibility of national rejuvenation.

3. Design of Course Ideological and Political Methods Based on TRIZ Theory

3.1 Construction of Contradiction Matrix: Mapping of Technical Issues and Ideological and Political Goals

Using the TRIZ contradiction matrix as a tool, correspond the technical parameters in mechanical design with the parameters of ideological and political education goals, and form a "physics ideological" two-dimensional contradiction table (see Table 1). For example:

Technical parameters: Part strength (improvement) vs material cost (deterioration)

Ideological and political parameters: striving for excellence (improvement) vs resource conservation (deterioration).

The above content proposes an innovative method of integrating engineering technology issues with ideological and political education goals. Specifically, by introducing the contradiction matrix tool in TRIZ theory, a "physics ideological and political" two-dimensional mapping model is constructed. This model associates technical parameters in mechanical design (such as part strength, accuracy, etc.) with ideological and political education goal parameters (such as craftsmanship spirit, scientific spirit, etc.), forming a contradictory pair with educational significance. For example, pursuing higher strength at the technical level may lead to an increase in material costs, while at the ideological and political level, it is reflected in the tension between promoting the craftsmanship spirit of "striving for excellence" and advocating the sustainable development concept of "resource conservation".

Table 1. Typical Contradiction Matrix in Mechanical Design Course

echnical parameters (improvement/deterioration)	ideological and political parameters (improvement/deterioration)	Recommended invention principles
Strength vs Cost	Craftsmanship vs Sustainable Development Segmentation Principle	Segmentation Principle, Dynamics Principle
Precision vs Manufacturing Cycle	Scientific Spirit vs Efficiency Priority	Pre Action Principle, Feedback Principle

Through this mapping, traditional engineering technology problems are endowed with a dimension of value based thinking, enabling students to not only solve specific design problems, but also recognize the ethics, responsibilities, and value orientations behind them. In addition, the contradiction matrix also provides corresponding invention principles (such as segmentation principle, feedback principle, etc.) as a way to solve such "technology ideological and political" composite contradictions, thereby promoting interdisciplinary thinking cultivation and comprehensive quality improvement. This

method not only expands the application scope of TRIZ theory, but also provides an operational theoretical framework and teaching path for ideological and political practice in engineering education.

3.2 Innovative Principles Driven Ideological and Political Education Strategies

Design the following teaching method based on the principle of invention recommended by the contradiction matrix:

Using the dynamic principle in TRIZ theory, a case study of the development of the domestically produced C919 aircraft is introduced in gear transmission teaching. The optimization process of the gear system is demonstrated through dynamic simulation, while emphasizing the perseverance of the research team in "sharpening a sword in ten years". By using the segmentation principle, the mechanical system design is decomposed into modular tasks, which guide students to complete in groups and cultivate a sense of team cooperation (such as the ideological and political mapping of transnational technical cooperation in the "the Belt and Road" project). By applying the principle of prevention in advance and combining safety production accident cases in mechanical safety design, we strengthen the professional ethics concept of "life first".

Based on the principle of invention recommended by the contradiction matrix, this article aims to construct a set of ideological and political teaching methods for courses driven by specific invention principles. This method organically integrates mechanical professional knowledge with value guidance, for example, by combining the dynamic principle with the C919 case to promote the spirit of perseverance in science, using the segmentation principle to design modular tasks to cultivate students' teamwork awareness, and using the principle of pre prevention to introduce safety cases to strengthen the professional ethics of "life first".

The core significance of this teaching strategy lies in its systematic integration of engineering technology education and ideological and political education at the methodological level. Its value is mainly reflected in three aspects: firstly, at the cognitive level, it transforms abstract values into operable and experiential teaching activities, enhancing the affinity and effectiveness of ideological and political education; Secondly, at the practical level, through real cases and project tasks, guide students to form responsible technical ethics and engineering system thinking; The third is to embed core values such as excellence, teamwork, and life care into professional practice at the level of education, truly achieving the educational goal of "knowledge imparting ability cultivation value shaping", and providing a systematic and principled implementation path for curriculum ideological and political construction in engineering education in the new era.

3.3 Teaching Case Design

Based on the knowledge points of gear transmission and heavy machinery in mechanical design, the following teaching cases are designed.

Technical contradiction: transmission smoothness (improvement) vs structural complexity (deterioration)

Ideological and political mapping: By analyzing the localization process of high-speed rail gearboxes, guide students to understand the strategic significance of "independent and controllable core technology", propose structural optimization plans based on TRIZ's "nested principle", and synchronously integrate the values of "science and technology serving the country".

3.3.1 Analysis of technical contradictions

In the research and development process of high-speed rail gearboxes, the smoothness of transmission and the complexity of structure constitute a typical technical contradiction. In traditional design schemes, improving gear meshing accuracy (improving transmission stability) often requires increasing the number of gear sets or adopting complex lubrication systems (leading to a deterioration in structural complexity). Taking the CR400AF "Fuxing" gearbox as an example, early imported products achieved a meshing accuracy of ± 1 μ m through a 7-stage gear transmission, but there were defects such as a large volume (2.3m long) and a high failure rate of 0.8 times per 10000 kilometers. The negative correlation between precision and complexity has become a key technological bottleneck restricting the autonomy of high-speed rail.

3.3.2 TRIZ innovation solution

The CRRC Research Institute team has

successfully achieved a disruptive breakthrough in gearbox technology through the "nesting principle" in TRIZ theory. The core value of its innovative solution is reflected in three aspects:

Structural optimization: By replacing traditional parallel shaft systems with planetary gear systems, the number of transmission stages has been reduced from 7 to 4, significantly improving system compactness and transmission efficiency;

Material Innovation: Adopting nanocrystalline 18CrNiMo7-6 alloy steel, the fatigue life of gears has been increased by 300%, significantly extending the service life of equipment;

Lightweight design: Based on ANSYS topology optimization, the box reduces weight by 15% while maintaining stiffness, reducing energy consumption and manufacturing costs.

This solution controls the transmission error of domestic gearboxes within ± 0.8 μ m (internationally leading level), reduces the failure rate to 0.2 times per 10000 kilometers, and perfectly solves the technical contradiction between "strength and lightweight". Its significance lies not only in the breakthrough of technical indicators, but also in providing reusable innovative methodologies for high-end equipment manufacturing, promoting the industry's transformation from "experience driven" to "theory driven".

3.3.3 Exploration of ideological and political value

In terms of strategic dimension, the localization of gearboxes has reduced the procurement cost from 120000 euros per unit to 280000 yuan per unit, confirming the important statement that "key core technologies cannot be obtained, bought, or obtained". In terms of spiritual inheritance, the R&D team has spent 5 years conquering more than 200 patents, reflecting the scientific spirit of "sharpening a sword in ten years". In terms of methodological inspiration, the localization and application of TRIZ theory can cultivate students' innovative consciousness of "breaking through thinking patterns".

The teaching implementation process is based on the TRIZ theoretical framework, and a systematic teaching method of "case comparison virtual simulation value sublimation" is constructed. Firstly, by comparing the cross-sectional models of imported and domestically produced gearboxes, students are guided to establish intuitive cognition from structural differences; Then, with the help of ADAMS virtual simulation technology, quantitative analysis of the dynamic performance of different transmission schemes is carried out to cultivate students' scientific and rigorous engineering analysis ability; Finally, a debate was held on the theme of "Made in China 2025 from the Perspective of Gear Accuracy", elevating technical issues to the level of national strategy and industry development, and promoting students' understanding of the significance of technological self-improvement behind high-precision manufacturing. This progressive teaching design not only strengthens the practical application of professional knowledge, but also achieves the organic integration of values, reflecting the curriculum ideological and political innovation path of "knowledge ability values" collaborative cultivation.

4. Conclusion and Prospect

This study constructs an ideological and political teaching framework for mechanical design courses through TRIZ theory, which solves the problems of rigid integration of ideological and political elements and single methods. In the future, the "Mechanical Design Ideological and Political Case Library" and loose leaf textbooks can be developed, integrating TRIZ tools and ideological and political elements. Relying on virtual simulation experiments and the integration of industry and education base, achieve multi scenario education in "classroom-enterprise-society". And further explore the use of artificial intelligence technology to assist in optimizing the contradiction matrix, and expand the scope of cross school application verification, providing a universal paradigm for ideological and political reform in engineering education.

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