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Practice of Progressive Ideological and Political Reform in Experimental Courses under the Background of "New Engineering": A Case Study of An Engineering Finite Element Course

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Abstract: Under the background of "comprehensive ideological and political education", experimental teaching, as an important link connecting theory and practice in new engineering majors, plays an irreplaceable role in professional education and the construction of ideological and political elements in courses. Taking "Engineering Finite Element and Numerical Calculation," a core course for undergraduates majoring in mechanical engineering, as an example, this paper focuses on the course training objectives and the fundamental task of fostering virtue through education. It organically integrates theoretical knowledge, practical engineering problems, cutting-edge technological development and ideological and political elements, and constructs a reform of the "learning-practice-research" progressive ideological and political teaching mode in experimental courses. The reform of the "combination of learning and thinking" experimental teaching mode integrates value guidance into knowledge imparting; the design of the "integration of practice and thinking" experimental links cultivates students' engineering practice ability while enhancing their sense of engineering ethics and professional responsibility; the reform of the "integration of research and thinking" experimental content guides students to be brave in innovation and continuous exploration through scientific research project training. Through the analysis of the achievement degree of course and ideological and political objectives, as well as teaching evaluation, the effectiveness of the teaching reform is verified, which provides a referential implementation path and practical experience for the construction of ideological and political elements in "new engineering" experimental courses.

Keywords: Ideological and political elements in courses; Experimental teaching; Learning-practice-research; Engineering finite element

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1. Introduction

In 2020, the Guidelines for the Construction of Curriculum Ideology and Politics in Colleges and Universities issued by the Ministry of Education pointed out that "the construction of curriculum ideology and politics

is an important task for comprehensively improving the quality of talent training" [1], and emphasized that engineering professional courses should focus on strengthening engineering ethics education, cultivating students' craftsmanship spirit of excellence, and inspiring students' feelings of family and country as well as sense of mission and responsibility to serve the country through science and technology [2]. In recent years, China has attached great importance to curriculum ideology and politics education, and has successively issued a series of policy documents to promote its implementation, while actively exploring its theoretical basis and practical paths [3]. Under the background of the "new engineering" reform [4], experimental teaching, as an important means to cultivate students' innovative spirit, practical ability and the integration of knowledge and practice, has become one of the key positions in the construction of curriculum ideology and politics [5]. East China University of Science and Technology, taking the "Electrical and Electronic" experimental course as an example, has carried out the reform of the "multi-line co-learning" curriculum ideology and politics model [6]. The course team of "Finite Element Method and Software Application" in Changzhou Institute of Technology has carried out the practice and teaching design of "three-module spiral progression" for curriculum ideology and politics education [7]; Tsinghua University, adhering to the educational concept of combining value shaping, ability training and knowledge imparting, has deeply integrated classroom teaching with innovative practice [8]. Chongqing University has deeply explored the connotation of curriculum ideology and politics, integrated the core socialist values, the ideal and responsibility of realizing the great rejuvenation of the Chinese nation with the content of the mechanical precision design experimental course, which has reference value for professional experimental courses [9]. Although the above-mentioned universities have achieved certain research results in the practice of curriculum ideology and politics construction, the current construction of experimental curriculum ideology and politics is still in the exploration stage, and a systematic and standardized teaching model and system have not yet been formed [10]. How to give full play to the characteristics of experimental teaching and realize the organic integration of professional education and ideological and political education has become an important research direction in the reform of ideological and political teaching in colleges and universities [11].

In order to improve students' internal motivation for learning while cultivating their solid engineering practice ability [12], and to realize the role of ideological enlightenment and value guidance. Based on its own professional characteristics and disciplinary advantages, the Mechanical Engineering major of Xi'an Jiaotong University, relying on the experiments of the "Engineering Finite Element and Numerical Calculation" course, has deeply explored the ideological and political elements in experimental teaching, and explored the construction of a "learning-practice-research" progressive reform in experimental curriculum ideology and politics teaching. It organically combines professional practice with value shaping in a subtle way, providing ideas and implementation paths for the construction of experimental curriculum ideology and politics.

2. Experimental design of the "Learning-Practice-Research-Thinking" four-element integration course

Against the backdrop of the rapid development of intelligent manufacturing, the engineering finite element method has emerged as a crucial tool for solving complex engineering problems [13]. Mastering finite element technology to design and develop mechanical products has become one of the core competency requirements for students majoring in mechanical engineering [14]. Currently, numerous domestic universities offer related courses in mechanical disciplines to meet the industry's demand for high-quality engineering talent [15]. Xi'an Jiaotong University's mechanical engineering program lists "Engineering Finite Elements and Numerical Computation" as

a core undergraduate course. Through its experimental component, the course guides students to apply theoretical knowledge to real-world engineering scenarios through project practice [16], characterized by strong theoretical depth, high practical demands, and extensive engineering applications. The teaching team, aligning with the graduation requirements, course objectives, and disciplinary strengths of the mechanical engineering program, has deeply explored ideological and political elements in experimental teaching, integrating value cultivation with knowledge transmission. Drawing on Bloom's cognitive law—from learning to practice to innovation—they have designed and constructed a progressive "Learning-Practice-Research" ideological and political experimental teaching framework for the finite element course. This framework forms an experimental ideological and political teaching plan where theoretical learning serves as the foundation, engineering project practice as the core, and scientific research innovation as the culmination, with the three elements advancing in synergy.

The experiment comprises three main modules:

(1) Integration of learning and thinking: Based on the finite element calculation formulas for rod and beam structures in theoretical courses, students conduct programming simulations using industrial finite element software. They learn the stories of scientists behind industrial software, discuss the "bottleneck" issues faced by domestic industrial software, and inspire a sense of mission to contribute to the country through technological innovation.

(2) Integration of practice and thinking: Using engineering cases behind current political hotspots as entry points, students simulate the full process of designing and testing related mechanical products. This module closely integrates engineering design standards, a sense of responsibility, and experimental tasks.

(3) Integration of research and thinking: Research projects from the academic team are transformed into undergraduate experimental content, and a comprehensive experimental platform with digital twin characteristics is developed. This guides students to combine cutting-edge technologies with experiments, encouraging them to innovate and explore continuously.

3. Practice of ideological and political integration in finite element experiment courses

3.1. Hybrid teaching mode of "Integration of Learning and Thinking"

Relying on the online teaching platform, the teaching team has explored a hybrid experimental teaching mode of "integration of learning and thinking". Before class, students can review the theoretical knowledge of finite elements, compare the development of Chinese and foreign industrial software, and learn about the scientific research stories of Chinese scholars behind the finite element theory through online platform resources such as video micro-lectures and teaching materials, thus establishing a perceptual understanding of the experimental course content and tools. During class, online resources such as electronic interactive textbooks, AI-assisted programming, and engineering case introductions assist students in conducting simulation analysis and experiments on classroom practice cases. After class, through the online platform's communication community and supplementary database, students can carry out extended exercises and innovative explorations. Meanwhile, the tracking and statistics of learning data on the online platform provide directions for the dynamic adjustment and continuous feedback of the course. Through the online-offline hybrid teaching mode, elements of ideological and political education are integrated into experimental teaching, giving full play to students' subjective initiative and achieving the student-centered education goal.

3.2. Design of project-based experimental links with "Integration of Practice and Thinking"

The teaching team takes current political hot issues as the starting point, designs and develops several experimental cases transformed from real enterprise engineering projects, forming an experimental process of "current politics - problem - simulation - experiment - analysis", which mainly includes:

(1) Current politics introduction: Combining current political hotspots, while attracting students' learning interest, relevant engineering analysis cases are introduced. Through case analysis, students understand the important role of finite element technology in engineering design, guides them to establish a sense of engineering responsibility and stimulates their feelings of serving the country through science and technology.

(2) Problem orientation: Guide students to master the ability to analyze and describe engineering problems in accordance with relevant industry design specifications. At the same time, by introducing real projects of national independent brand product development, students' national confidence is enhanced.

(3) Modeling and simulation: Based on previous case studies and problem analysis, students conduct finite element modeling and simulation analysis of engineering projects to master the basic methods of finite element analysis and solution.

(4) Experimental testing: Students conduct experimental tests on the platform and compare them with simulation data. To illustrate the mutual support between finite element simulation and experiments in engineering, the Apollo space accident case is introduced to enhance students' sense of responsibility and standardize the experimental process.

(5) Analysis and expression: Using enterprise analysis reports as templates, students are required to sort out experimental results and propose engineering design optimization schemes in line with national industry standards. Through the whole-process project practice, students' awareness of engineering standards is improved, and their theoretical knowledge foundation and engineering practice ability are consolidated.

3.3. Reform of experimental content based on "Integration of Research and Thinking"

The scientific research projects undertaken by the course team teachers have been transformed into high-level experimental content suitable for undergraduates. Several high-level innovative exploration projects with strong interest, advanced nature and challenging degrees have been designed, such as "Design of Origami Core Can and Its Impact on Carbon Emissions", "Design of Lunar Soil Collection Manipulator Inspired by Tape Measures", and "Stress Evaluation of Aeroengine Blades". Students are required to form groups, choose their own topics, and use industrial software to conduct research. This allows students to truly apply their knowledge to innovative exploration in scientific research projects, helping them understand cutting-edge finite element technologies while inspiring their enthusiasm for innovation, exploration, and contributing to the country through science and technology.

4. Course evaluation and effectiveness

The course adopts a diversified evaluation model including group competitions, classroom interactions, teacher evaluations, and peer evaluations to comprehensively assess experimental teaching and ideological and political education in the curriculum. According to the output-oriented calculation formula for course achievement indicators, the achievement of each ideological and political goal in the course has reached over 84% in the past

three years. The course has carried out three rounds of reform practices, with a total of 870 students participating. A survey on teaching effectiveness conducted through the online teaching platform shows that 99.7% of students believe the experimental sessions are of great help to theoretical learning and engineering application, and 89% of students think the introduced scientific research analysis projects have enhanced their interest in scientific research exploration.

5. Conclusion

As an important channel for applying theories to practical engineering, experimental teaching plays an increasingly significant role in the construction of "new engineering" and also serves as a key position for the ideological and political development in courses. The Mechanical Engineering program at Xi'an Jiaotong University has long adhered to the educational philosophy of "cultivating people with virtue". It has deeply explored the ideological and political elements in experimental teaching and developed a progressive "learning-practice-research" educational scheme for ideological and political education in experimental courses. Taking the experiment of "Engineering Finite Element and Numerical Calculation" as an example, it has carried out teaching reform practices. Through the coordinated positioning of course objectives and ideological and political objectives, the integrated design of teaching links and ideological and political content, and the development of a digital twin comprehensive experimental platform based on scientific research transformation, it has organically integrated ideological and political education with practical teaching. From the perspective of teaching evaluation and feedback, the reform has achieved good results. The teaching design, methods, and models of ideological and political education in experimental courses, which integrate learning with thinking, practice with thinking, and research with thinking, provide a reference for the reform of ideological and political education in engineering practical courses.

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