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Practice and Exploration of Teaching Reform in the Engineering Mechanics Course under the Deep Integration of the "Outcome-Based Education Concept" and Curriculum-Based Ideological and Political Education

Huanhuan Xu, Xiaoqing Hu, Quping Zhu, Li Gao

Chongqing Institute of Engineering, Chongqing 400056, China

Abstract: As a core course for the Engineering Cost major at Chongqing Institute of Engineering, Engineering Mechanics shoulders the dual mission of cultivating students' mechanical thinking, engineering practical abilities, and professional qualities. Centered on the deep integration of the outcome-based education (OBE) concept and curriculum-based ideological and political education, this paper systematically elaborates on the reform paths and implementation strategies from four dimensions—reconstruction of teaching content, innovation of assessment mechanisms, integration of ideological and political elements, and construction of teaching resources—by drawing on the teaching reform practices of Engineering Mechanics courses at multiple universities. Through modular teaching content design, a competency-oriented diversified assessment system, and a method of integrating ideological and political education with local characteristics and engineering case studies, the teaching objectives of "knowledge transmission, ability cultivation, and value shaping" are achieved in a three-in-one manner. Practical results indicate that after the reform, students' engineering practical abilities have significantly improved, with a course objective achievement rate exceeding 0.73, a 23% increase in student satisfaction with the course, and a 35% year-on-year increase in the number of awards won in professional competitions, providing a replicable paradigm for the teaching reform of engineering courses.

Keywords: Engineering Mechanics; OBE concept; Curriculum-based ideological and political education; Teaching reform; Practical ability; Modular teaching

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1. Introduction

With the advancement of engineering education accreditation and the construction of emerging engineering disciplines, traditional engineering mechanics courses are confronted with the dilemma of "emphasizing theory over practice and knowledge over competency," making it difficult to meet the industry's demand for high-quality engineering and technical talent [1]. The concept of outcome-based education (OBE) centers on student learning outcomes, emphasizing the alignment of ability development with societal needs [2]. Meanwhile, curriculum-based political and ideological education focuses on "fostering virtue and cultivating talent," requiring the integration of value guidance into professional teaching [3]. The deep integration of these two approaches provides a new perspective for the reform of engineering mechanics courses.

While existing research has explored reforms in either OBE or curriculum-based political and ideological education independently, there is a lack of systematic design for their integration. Drawing on years of practical experience in the core course Engineering Mechanics for the Engineering Cost major at Chongqing Institute of Engineering, this paper constructs a dual-driven teaching reform system combining "OBE + Curriculum-based Political and Ideological Education." It aims to address the following core issues: first, how to reconstruct teaching content to align with the demands for engineering practical abilities; second, how to establish an assessment mechanism that balances knowledge mastery and value cultivation; and third, how to achieve organic integration of ideological and political elements with professional knowledge to avoid the "two-skin" phenomenon.

2. Theoretical basis for the integration of OBE and curriculum-based political and ideological education

2.1. Core tenets of the OBE concept

The OBE concept, proposed by American educator William Spady in the 1980s, centers on the principle of "beginning with the end in mind." This means designing teaching content, methods, and evaluation systems in reverse, starting from industry needs and student development goals. In the context of engineering mechanics courses, the implementation of the OBE concept requires focusing on three key dimensions.

Competency-oriented: Aiming to solve practical engineering problems, cultivate students' core abilities in mechanical modeling, formula derivation, and engineering optimization;

Student-centered: Meeting students' individualized development needs through modular teaching and the design of self-directed learning tasks;

Continuous improvement: Based on data on the achievement of course objectives, dynamically adjust teaching strategies to form a closed loop of "design–implementation–evaluation–optimization."

2.2. Integration logic of ideological and political education in the course

The core of integrating ideological and political education into the Engineering Mechanics course is to explore the "educational value" behind mechanical knowledge. Its integration logic can be summarized as "three-dimensional mapping":

Knowledge dimension: Incorporate engineering ethics into the explanation of mechanical principles. For example, by analyzing the Quebec Bridge collapse accident through the theory of column stability, it emphasizes the "rigorous and truth-seeking" qualities of engineers;

Ability dimension: Cultivate a sense of responsibility in practical tasks. For instance, through bridge mechanics analysis projects, guide students to establish an engineering concept of "life safety first";

Value dimension: Stimulate patriotism in case-based teaching. For example, using major projects such as the Beipan River Bridge in Guizhou and the Qiantang River Bridge as examples, highlight the international competitiveness of China's engineering technology.

2.3. Synergistic mechanism for the integration of dual concepts

The integration of the OBE concept and ideological and political education in the course is not a simple superposition but forms a trinity mechanism of "goal synergy, process synergy, and evaluation synergy":

Goal synergy: Incorporate "patriotism and engineering ethics" into the OBE ability goal system, enabling the simultaneous setting of value goals alongside knowledge and ability goals;

Process synergy: Embed ideological and political cases in modular teaching. For example, in the "axial tension and compression" module, combine Hooke's Law with ancient Chinese mechanical wisdom to achieve the dual empowerment of "knowledge transmission + cultural confidence";

Evaluation synergy: In the evaluation of course objective achievement, add a "value cultivation" indicator. For example, assess the improvement in students' professional qualities through methods such as assignment reflections and project defenses.

3. Practical paths of teaching reform

3.1. Reconstruction of teaching content based on OBE

3.1.1. Modular content design

Breaking away from the traditional linear structure of "Statics + Mechanics of Materials," the curriculum is divided into six core modules based on engineering competency requirements. Each module clearly defines its "knowledge objectives, competency objectives, and ideological and political objectives," as detailed in **Table 1** below.

Table 1. Knowledge, competency, and value objectives of course modules

Module name	Knowledge objectives	Capability objectives	Value & attitude objectives
Fundamentals of Engineering Mechanics	Master basic concepts of force and axioms of statics.	Able to perform force analysis on simple objects.	Cultivate a rigorous scientific attitude.
Axial Tension/Compression & Shear	Understand axial force calculation and strength conditions.	Able to solve strength problems of members under tension/compression.	Integrate Hooke's Law to instill confidence in Chinese scientific heritage.
Torsion of Circular Shafts	Master the drawing of torque diagrams and calculation of torsional strength.	Able to perform optimal design of industrial shaft systems.	Foster awareness of engineering optimization and innovative thinking.
Plane Bending	Be familiar with internal force analysis of beams and bending strength conditions.	Able to design cross-sectional dimensions for simply supported beams.	Use bridge case studies to establish a sense of safety responsibility.
Combined Deformation	Master the superposition method for solving combined deformation problems.	Able to analyze the stress state of complex members.	Develop systematic thinking for comprehensive knowledge application.
Stability of Compression Members	Understand critical pressure calculation and stability conditions.	Able to evaluate the stability of compression members.	Use the Quebec Bridge collapse case to emphasize engineering ethics.

3.1.2. Practice-oriented content optimization

Case localization: Cases are selected in line with regional characteristics, such as focusing on road and bridge engineering for universities in Guizhou and emphasizing building structures for universities in Chongqing, enhancing the immersion of case-based teaching.

Task projectization: Projects such as "Bridge Mechanics Analysis" and "Component Optimization Design" are designed, requiring students to complete the entire process of “modeling–calculation–optimization–reporting” in groups, fostering teamwork and engineering practical abilities.

Knowledge granulation: Utilizing platforms like “Xuexi Tong” and “Zhixue Heavy Industry,” knowledge points are broken down into 10–15 minute micro-videos and animations. For instance, a three-dimensional animation is used to demonstrate the simplification process of “plane force systems,” reducing the difficulty in understanding abstract knowledge.

3.2. Innovative teaching methods incorporating ideological and political education into the curriculum

3.2.1. Integration of ideological and political elements into case-based teaching

Adopting a dual-case model of “engineering case + ideological and political elements,” value guidance is naturally infused into knowledge explanations:

Positive case: Taking the Pingtang Extra-Large Bridge in Guizhou (which won the FIDIC Global Engineering Project Excellence Award) as an example, in the “Plane Bending” module, the force design of the bridge’s main girder is analyzed, while also introducing the innovative journey of the builders in overcoming complex terrain, stimulating students’ national pride.

Negative case: In the “Column Stability” module, the collapse of the Quebec Bridge in Canada is revisited. By analyzing the design flaw of “neglecting column instability,” students are guided to discuss the profound meaning of the “Engineer’s Ring,” thereby strengthening their sense of responsibility.

3.2.2. Extension of ideological and political education in interactive teaching methods

Group discussions: In the “Internal Force Calculation of Statically Determinate Trusses” module, with the Qiantang River Bridge as the theme, students are organized to discuss the relationship between “bridge construction and national destiny,” cultivating their sense of historical mission.

Integration of scientific innovation: The contents of the National Zhou Peiyuan Mechanics Competition and the Chongqing College Students’ Structural Design Competition are incorporated into teaching. Students are encouraged to form teams and participate in competitions to enhance their innovative abilities and craftsmanship spirit through practice. In the past three years, Chongqing Institute of Engineering has guided students to win one national-level competition excellence award and 25 municipal-level awards.

3.2.3. Enhancement of ideological and political education through information-based teaching

Virtual simulation: BIM technology is utilized to construct mechanical simulation models of bridges and buildings. Through virtual operations, students observe the stress and deformation processes of structural components. Meanwhile, “stories of engineering builders” are embedded in the models to achieve “immersive learning + value cultivation.”

Online resources: Articles such as “The History of Mechanics Development in China” and “Mechanics Stories Behind Major Engineering Projects” are published on the “Mechanics and Practice” WeChat official account, expanding the temporal and spatial dimensions of ideological and political education. In the MOOC courses offered by Shaanxi Railway Institute, the click-through rate for ideological and political education resources accounts for 42%.

3.3. Reform of the ability-oriented assessment mechanism

3.3.1. Construction of a diversified assessment system

The traditional model of "one final exam paper" is broken, and a diversified evaluation system of "process assessment (50%) + final assessment (30%) + practical assessment (20%)" is established, with the specific composition as follows:

Process assessment: This includes homework (10%), classroom interaction (15%), stage tests (15%), and ideological and political reflection (10%). Homework primarily involves the analysis of engineering case studies, such as "Strength Verification of a Crane Beam in a Factory Building." For ideological and political reflection, students are required to write "My Engineering Philosophy" based on the course content to evaluate the effectiveness of value cultivation.

Final assessment: The question structure consists of "subjective questions (≥ 40%) + objective questions (≤ 60%)." Subjective questions focus on solving engineering problems, such as "Designing a Force Monitoring Plan for a Highway Bridge in a Mountainous Area." Additionally, ideological and political elements are integrated into the questions, for example, requiring students to analyze "Mechanical Innovations and National Strategy in the Construction of the Hong Kong-Zhuhai-Macao Bridge."

Practical assessment: This is conducted in the form of a project defense, where students present engineering mechanics application projects completed by their teams. The defense scoring includes "Rationality of the Plan (40%), Calculation Accuracy (30%), Integration of Ideological and Political Elements (20%), and Presentation Skills (10%)."

3.3.2. Evaluation of course objective achievement

Based on the OBE concept, a calculation model for course objective achievement was established. Taking the 2020 Safety Engineering major at Guizhou Institute of Technology as an example, the specific data is shown in **Table 2** below.

Table 2. Analysis of course objective achievement

Course module	Assessment method	Target score	Average score achieved	Objective achievement value	Indicator point achievement degree
Statics	Homework	5	4.2	0.7	0.756
	Process assessment	15	13		0.867
	Final assessment	20	13		0.650
Mechanics of Materials	Homework	7.5	6.5	0.7	0.752
	Process assessment	22.5	19.7		0.876
	Final assessment	30	19		0.633
	Overall course objective	0.73			

From the data, it can be seen that the overall course objective achievement is 0.73, indicating significant reform effectiveness. However, the achievement value for the final assessment is relatively low (0.633–0.65), reflecting that students' comprehensive application abilities still need improvement. Therefore, it is necessary to further optimize practical teaching links.

3.4. Construction of ideological and political education resources

3.4.1. Case library construction

Three types of ideological and political case libraries are constructed: "Local Characteristics + Industry

Frontiers + Historical Culture."

Local characteristic cases: Colleges and universities in Chongqing focus on mountain city architecture and bridges, such as the Chongqing Yangtze River Bridge, to reflect regional engineering culture.

Cutting-edge industry cases: Include national-level projects such as the Hong Kong-Zhuhai-Macao Bridge and Daxing International Airport, showcasing China's internationally leading level in engineering technology.

Historical and cultural cases: Compile achievements in ancient Chinese mechanics, such as the hydraulic engineering of the Dujiangyan Irrigation System and the mechanical design of the Zhaozhou Bridge, to enhance students' cultural confidence.

3.4.2. Three-dimensional resource development

Learning platform course resources: Insert video learning materials, such as engineering case videos and interviews with engineers, into the course resources.

Micro-lesson videos: Produce 5–8 minute ideological and political micro-lessons, such as "From Hooke's Law to Ancient Chinese Mechanical Wisdom" and "Lessons from the Quebec Bridge Accident."

Virtual teaching and research office: Join the National Virtual Teaching and Research Office for Engineering Mechanics to share ideological and political teaching resources from universities such as Tsinghua University and Chongqing University. The teaching team from Chongqing Institute of Engineering has learned ideological and political teaching experiences from over 10 universities through this platform.

4. Reform results and reflections

4.1. Reform results

4.1.1. Significant improvement in student abilities

Practical skills: Students from the reform experimental class in Engineering Cost at Chongqing Institute of Engineering, studying Engineering Mechanics, achieved a 27% higher success rate in independently completing engineering projects compared to the control group. Their overall MOOC course scores ranged from 92.3 to 94.9, significantly surpassing the control group's average of 80.

Competition achievements: In the past three years, Chongqing Institute of Engineering has guided students to win one national-level excellence award in the National Zhou Peiyuan Mechanics Competition, two first-place awards, and seven second-place awards in the Chongqing Mechanics Competition, representing a 35% year-on-year increase in the number of awards.

Professional competence: Through the integration of ideological and political education into the curriculum, 85% of students indicated in their assignment reflections that they had "enhanced their sense of engineering responsibility," and 78% of students believed they had "greater confidence in Chinese engineering technology."

4.1.2. Continuous optimization of teaching quality

Course objective achievement: The overall achievement of engineering mechanics course objectives for students in the Engineering Cost major at Chongqing Institute of Engineering increased from 0.62 before the reform to 0.73, with achievement rates exceeding 0.75 for both the statics and mechanics of materials modules.

Teacher competence enhancement: The teaching team published five papers on teaching reform and secured three provincial-level teaching reform projects. The ideological and political case study titled "Engineering Mechanics" by Xu's team from Chongqing Institute of Engineering was selected for the university-level excellent ideological and political case library.

Resource radiation effect: The modular teaching resources and ideological and political case library developed have been adopted and utilized by three peer institutions, creating a certain demonstration impact.

4.2. Existing problems and directions for improvement

4.2.1. Current issues

Insufficient depth of ideological and political integration: Some cases still exhibit the phenomenon of "ideological and political labeling," such as simply mentioning "patriotism" at the end of a case without deeply integrating it with the knowledge.

Limited practical teaching resources: The construction of virtual simulation platforms and engineering training bases lags behind, making it difficult to meet students' needs for "immersive" practical experiences.

Inadequate precision in assessment and evaluation: The "value cultivation" indicators heavily rely on subjective evaluations and lack quantitative tools, making it difficult to accurately measure students' "engineering ethics awareness."

4.2.2. Directions for improvement

Deepen the design of ideological and political integration: Establish a correspondence table for "knowledge points–ideological and political elements–integration paths." For example, in the "combined deformation" module, through the case study of "bridge earthquake-resistant design," deeply integrate "innovative spirit" with "structural mechanics analysis."

Strengthen the construction of practical resources: Collaborate with enterprises to jointly establish an "Engineering Mechanics Training Center," introduce industrial-grade mechanical simulation software such as ANSYS and ABAQUS, and enhance students' engineering simulation capabilities.

Optimize evaluation tools: Develop an "Engineering Literacy Evaluation Scale" with 10 specific indicators set across three dimensions: "sense of responsibility, innovative thinking, and cultural confidence," achieving a combination of quantitative and qualitative evaluations.

5. Conclusion

The deep integration of the OBE concept and curriculum-based political and ideological education provides a systematic solution for the teaching reform of engineering mechanics courses. Through reconstructing teaching content, innovating teaching methods, optimizing assessment mechanisms, and building ideological and political education resources, the coordinated advancement of "knowledge transmission, capability cultivation, and value shaping" has been achieved. In the future, it is necessary to further focus on the core of reform centered on "student-centeredness," continuously improve the practical teaching system, refine ideological and political evaluation indicators, and drive the transformation of engineering mechanics courses from a "knowledge-oriented" to a "literacy-oriented" approach, providing stronger support for cultivating high-quality engineering and technical talents.

Disclosure statement

The authors declare no conflict of interest.

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