

Case Design Research on Curriculum Ideological and Political Education Based on OBE Concept in Pipeline Engineering Principles

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Abstract: Curriculum ideological and political education is a crucial measure for implementing the fundamental task of fostering virtue and cultivating talents. The Outcome-Based Education (OBE) concept, being student-centered and outcome-oriented, highly aligns with the educational logic of curriculum ideological and political education, which is student-centered and literacy-goal-oriented. This paper takes the Pipeline Engineering Principles course for the Municipal Engineering Technology major in a higher vocational college as an example. Based on the backward design principle of the OBE concept, it effectively unifies the curriculum ideological and political education goals with the index points of graduation requirements, constructing a three-in-one course objective system integrating knowledge, ability, and values. By deeply exploring the ideological and political elements embedded in municipal water supply, drainage, and comprehensive pipeline projects, typical teaching cases are designed to integrate these elements, organically merging teaching objectives with ideological and political goals. This model achieves the organic integration of professional knowledge instruction and curriculum ideological and political construction, effectively enhancing students' professional skills, engineering literacy, and sense of patriotism and social responsibility. It provides a replicable practical paradigm for the ideological and political education reform of engineering courses in higher vocational education.

1. Introduction

Outcome-Based Education (OBE) is the core concept in the current international professional accreditation of undergraduate engineering education. It emphasizes being oriented towards students' expected learning outcomes, using a backward design approach for teaching objectives, content, and evaluation systems[1-3]. Compared with traditional teaching models, it is a quintessential student-centered, outcome-oriented educational philosophy[2]. OBE is a transformative educational model whose core lies in shifting from traditional knowledge indoctrination to focusing on students' ultimate learning outcomes. It emphasizes that education should be closely aligned with industry and societal needs, encompassing not only macro issues such as moral responsibility, environmental sustainability, and regulatory compliance but also

focusing on cultivating students' comprehensive skills including technical proficiency, critical thinking, communication, collaboration, and lifelong learning. Through systematic curriculum design, delivery, and assessment, OBE aims to shape graduates capable of solving complex problems and meeting new challenges, ensuring the education system achieves continuous improvement in a rapidly changing world and adequately prepares students for their future societal roles[3, 4].

Since China joined the Washington Accord, it has gradually promoted the integration of engineering education with international standards. Currently, the OBE model has become a core pathway for reform in domestic higher education institutions[5]. Gradually initiating and comprehensively promoting engineering education reform guided by the OBE concept holds significant practical importance for improving the quality of engineering talent cultivation[2]. The Guiding Outline for Curriculum Ideological and Political Construction in Higher Education Institutions pointed out that the ideological and political dimension of courses is a core measure, and ideological and political education must permeate the entire talent cultivation process[6]. It further proposes that comprehensively advancing curriculum ideological and political construction is a strategic initiative to implement the fundamental task of fostering virtue and cultivating talents[7].

The core spirit of the OBE concept is to cultivate student abilities; educational activities must shift from teacher-centered to student-centered. Supported by this educational philosophy, the transmission of professional knowledge constitutes explicit education, while the integration of ideological and political content such as worldview, values, humanistic literacy, and professional ethics should be implicit education. What is cultivated is not only students' professional capabilities but also their applied ability to achieve higher personal and social value through the reasonable application of professional knowledge[8].

Pipeline Engineering Principles is a compulsory course for the Municipal Engineering Technology major at a higher vocational college in Shanghai. It primarily covers the composition, structure, technical principles, design calculations, construction, operation, and management of urban infrastructure such as municipal water supply pipeline networks, drainage pipeline networks, and utility tunnels. This course possesses both theoretical and practical characteristics, involving technical knowledge like hydraulic calculations and pipe material selection, while being closely related to social value dimensions such as urban safety, public welfare, and ecological protection. It naturally contains rich ideological and political education resources. However, current teaching practices commonly exhibit a tendency to emphasize technology over values and emphasize theory over practice. The integration of ideological and political elements with professional knowledge is insufficiently deep, and there is a lack of systematic case design and implementation pathways.

In view of this, guided by the OBE concept and taking the Pipeline Engineering Principles course as the research object, this paper explores a systematic design method for curriculum ideological and political education teaching cases. It aims to achieve the organic unity of knowledge transmission, ability cultivation, and value shaping, providing theoretical reference and practical guidance for the ideological and political education reform of engineering courses in higher vocational education.

2. Teaching Design of Curriculum Ideological and Political Education Based on the OBE Concept

2.1. Inherent Alignment between OBE Concept and Curriculum Ideological and Political Education

OBE uses backward design—defining expected graduate abilities first to shape the curriculum [9,

10]. It aligns seamlessly with curriculum ideological and political education: OBE provides the systematic methodology, while ideological education injects the "value soul" [11]. Guided by this approach [12], this study follows a backward design logic to construct a "knowledge-ability-value" teaching system.

2.2. Alignment of Course Objectives and Ideological and Political Goals

Based on the characteristics of professional talent cultivation, and the demands of industry enterprises, through full investigation and demonstration, the three major teaching objectives of the Pipeline Engineering Principles course and their corresponding ideological and political education goals are determined based on the OBE concept, as shown in Table 1.

Table 1: Alignment Matrix of Course Objectives and Ideological and Political Goals for Pipeline Engineering Principles

Course Objective Dimension	Professional Knowledge Objectives	Engineering Ability Objectives	Ideological and Political Education Goals
Water Supply System	Master the composition, structure, and hydraulic calculation principles of municipal water supply networks; understand differences between gravity and pressure flow systems.	Grasp principles of water supply network modeling and optimization design; preliminarily perform water supply system design optimization.	Craftsmanship spirit, national consciousness, internalizing the professional pursuit of excellence.
Drainage System	Understand principles of drainage system selection, rainwater runoff calculation methods, and LID facility design key points.	Grasp principles of sewage and stormwater network modeling and optimization design; preliminarily perform drainage system design optimization.	Ecological civilization, social responsibility, life first. Establish ecological concepts, strengthen safety responsibility of engineering personnel.
Gas, Power, and Other Systems	Understand installation specifications for gas, electricity, communication pipelines.	Master utility tunnel cross-section design and pipeline integration methods.	Collaborative spirit, innovation awareness, specification consciousness. Cultivate an engineering community concept of co-construction and sharing.

3. Exploration of Ideological and Political Elements and Case Design Principles

3.1. Pathways for Exploring Ideological and Political Elements

Deeply exploring the ideological and political elements within specialized courses and their carried educational functions is key to realizing curriculum ideological and political education construction[13]. This course explores ideological and political elements from the following three dimensions:

3.1.1. Dimension of Major National Strategies

Using national strategic projects such as the South-to-North Water Diversion, Sponge City, and utility tunnels as carriers, explore ideological and political elements like patriotism and craftsmanship spirit.

3.1.2. Dimension of Engineering Ethics and Professional Norms

Using engineering accidents like urban waterlogging, pipeline bursts, and gas leaks as mirrors, explore ideological and political elements such as social responsibility, life first, and specification consciousness.

3.1.3. Dimension of Ecological Civilization and Sustainable Development

Using water resource protection, low-carbon cities, and green infrastructure as entry points, explore ideological and political elements like ecological civilization, sustainable development, and harmonious coexistence between humans and nature.

3.2. Case Design Principles

The course's case design follows three principles: Backward Design (structuring teaching based on expected outcomes), Problem-Oriented (using real engineering problems to drive learning), and Implicit Integration (subtly embedding ideological education into practice)[14].

4. Teaching Case Design Based on the OBE Concept

This chapter relies on the core knowledge modules of Pipeline Engineering Principles course to design typical teaching cases, presenting the systematic design pathway of curriculum ideological and political education cases under the OBE concept.

4.1. Case 1: Water Supply Pipeline Network System

4.1.1. Case Teaching Objectives

Based on the graduation requirements, the three-dimensional teaching objectives for this case are determined in Table 2.

Table 2: Case 1 Teaching Objectives

Objectives	Objective Contents	Corresponding Graduation Requirements
Knowledge Objective	Master the composition, pipe material characteristics, and hydraulic calculation principles of municipal water supply networks; understand design differences between gravity and pressure flow systems.	Engineering Knowledge
Ability Objective	Be able to initially establish a water transmission network model, conduct hydraulic simulation, and perform scheme optimization.	Application of Modern Tools
Ideological Objective	Recognize the institutional advantage of concentrating efforts to accomplish large undertakings, internalize the pursuit of excellence in craftsmanship, and enhance national pride and the belief in serving the country through engineering.	Professional Norms, Engineering and Society

4.1.2. Integration Design of Ideological and Political Elements

This case study integrates the Yellow River Crossing Project of the Middle Route of the South-to-North Water Diversion Project into the Water Supply Pipeline Network System module, using a major national strategic project to enrich the teaching context. The instructional objectives focus on helping students master the principles of gravity and pressure flow transmission, as well as the hydraulic calculation methods for pipeline networks. The lesson begins with an introductory overview of the South-to-North Water Diversion Project's overall layout and its socioeconomic benefits following completion, prompting students to reflect on the national strategic significance embedded in such large-scale infrastructure.

The session then delves into the technical challenges encountered during the construction of the crossing tunnel, including high water pressure, complex geological conditions, and millimeter-level precision requirements. By interspersing stories of technical personnel tackling boulder clusters and advancing shield tunneling techniques, students come to appreciate the craftsmanship spirit of pursuing excellence and confronting difficulties fearlessly.

On this foundation, the teacher further enriches the ideological and political dimensions of the lesson through the lens of dialectical thinking. By examining the relationship between the whole and the part, students gain insight into the systems-level thinking behind the South-to-North Water Diversion Project, a nationally coordinated effort involving multiple provinces, municipalities, and the collective sacrifice of reservoir-area migrants. Through the dialectical relationship between humanity and nature, the teacher analyzes the project's guiding principles, water conservation before diversion, pollution control before water delivery, and environmental protection before water use, helping students cultivate an ecological mindset rooted in respect for nature and harmonious coexistence.

The discussion then turns to the balance between the present and the long term, guiding students to reflect on the life-cycle awareness and intergenerational responsibility embodied in this century-spanning project. Finally, through the teacher's synthesis, the engineering achievement is elevated

to a broader understanding of institutional confidence, professional ethics, and patriotic commitment.

4.2. Case 2: Drainage Pipeline Network System

4.2.1. Case Teaching Objectives

Based on the graduation requirements, the three-dimensional teaching objectives for Case 2 are determined in Table 3.

Table 3: Case 2 Teaching Objectives

Objectives	Objective Contents	Corresponding Graduation Requirements
Knowledge Objective	Master rainwater runoff calculation methods, principles of drainage system selection, and key points of LID facility design.	Engineering Knowledge
Ability Objective	Understand hydrological models for hydrological simulation and optimize drainage scheme design.	Problem Analysis, Research Capability
Ideological Objective	Establish the ecological concept, strengthen the engineer's social responsibility and life-first awareness.	Engineering and Society, Environmental Awareness

4.2.2. Integration Design of Ideological and Political Elements

Guided by the Outcome-Based Education (OBE) concept, this case centers the instructional design of the drainage pipeline network system on cultivating students' capacity to solve complex urban waterlogging problems. The teaching objectives are set to equip students with core skills such as stormwater runoff calculation, drainage system selection, and Low Impact Development (LID) facility design, while fostering essential qualities including dialectical thinking, social responsibility, and cultural confidence throughout the learning process.

Drawing on the event of the extreme rainstorm disaster in Zhengzhou, the lesson serves as an entry point for guiding students to grasp the engineering ethics of putting life first through quantitative analysis of extreme rainfall events. By tracing the historical evolution of drainage systems in cities such as Paris and London, students develop the ability to examine the rationale behind combined and separate sewer systems from both dialectical and historical perspectives, thereby understanding the broader social implications of engineering decisions.

The core of this section lies in the dynamic interplay between gray and green infrastructure. Through a comparative analysis of urban waterlogging challenges and Sponge City principles, students are prompted to reflect on the dialectical relationship between the traditional rapid drainage approach and the eco-priority pathway. Subsequent case studies, including the drainage system of the Forbidden City, decode the ancient wisdom of stormwater management, reinforcing students' cultural confidence. These are further juxtaposed with policy practices in Berlin to deepen their systems thinking and understanding of sustainable development.

Building on this foundation, the ideological and political dimensions are further enriched through

the lens of materialist dialectics. By applying the materialist dialectic approach, students are guided to view gray and green infrastructure not as opposing alternatives but as complementary systems. The relationship between humanity and nature reveals how low impact development (LID) facilities embody respect for ecological principles, while the dialogue between historical and contemporary practices showcases the enduring relevance and innovation of ancient engineering wisdom. Through teacher-led synthesis, the design of drainage systems is ultimately elevated to a form of patriotic responsibility that is grounded in safeguarding urban safety and honoring the ecological environment. This integrated approach aligns professional knowledge with value-oriented education, fostering in students the comprehensive capabilities needed to address urban water challenges in the future.

5. Teaching Reflection and Improvement Directions

This course establishes a continuous improvement mechanism by integrating the quantitative attainment calculation of course objectives with multi-dimensional qualitative feedback. Based on these comprehensive data reports, the course group conducts regular teaching seminars to reflect on instructional deviations and formulate targeted improvement measures. During the teaching practice, the course identified several areas requiring further improvement:

(1) Systematic development of ideological and political education resources needs to be strengthened. Future efforts will involve systematically organizing the ideological and political elements by chapter, drawing on the experience of model courses, and developing a digital resource platform to support teaching.

(2) The reliability and validity of value internalization assessment require enhancement. At present, the evaluation of educational goal attainment relies heavily on teachers' subjective judgment and lacks quantifiable indicators. In the next stage, a curriculum-based ideological and political education attainment scale will be developed to enable a multi-dimensional evaluation, encompassing the dimensions of cognitive recognition, affective identification, and behavioral tendency.

(3) The balance between technological empowerment and the cultivation of critical thinking needs closer attention. A tendency toward over-reliance on AI-assisted tools has been observed among some students, who prefer to seek answers from AI rather than engaging in independent problem-solving. In subsequent teaching, it will be necessary to reinforce the principle that "tools serve thinking" and to establish clearer boundaries for the appropriate use of AI tools in the learning process.

6. Conclusion

This paper details a systematic approach to embedding ideological and political education into the Pipeline Engineering Principles course using the Outcome-Based Education (OBE) framework. By deeply exploring the educational elements embedded in municipal pipeline engineering, this study develops representative teaching cases that organically merge professional instruction with value-based education. This synergy not only enhances students' technical competencies, engineering ethics, and social responsibility, but also enriches the competency-driven OBE model with a deeper value orientation. Future initiatives will focus on deepening industry-education integration through real-world cases, expanding smart teaching resources, and developing interdisciplinary evaluation mechanisms. Ultimately, these efforts are dedicated to cultivating a new generation of municipal engineering professionals equipped with a spirit of craftsmanship, ecological awareness, innovative thinking, and robust social responsibility.

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