RESEARCH ARTICLE

Case Library Teaching Research on the Integration of Ideological and Political Education and Digitalization

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Abstract

Engineering ethics holds a crucial position in the cultivation of new engineering talents, as it fosters essential values of integrity, responsibility, and sustainability that guide their professional conduct and decision-making processes throughout their careers. In response to persistent challenges within contemporary curricula, such as the inadequate integration of ideological and political education elements and the being outdated of teaching models, this research strategically employs landmark national infrastructure projects, namely, the Hong Kong-Zhuhai-Macao Bridge and the Sichuan-Tibet Railway, as comprehensive case studies. It delves deeply into the ideological and political dimensions inherent in these projects, thoroughly examining core aspects including patriotism, the spirit of innovation, and ecological responsibility. By integrating advanced digital technologies, such as 3D modeling, VR panoramic visualization, and AR augmented reality, the study meticulously formulates detailed content for the case library and develops robust teaching implementation plans to enhance pedagogical effectiveness and foster a more engaging learning environment. The reformed teaching practice indicates that this case library substantially improves students' comprehension of engineering ethics by fostering critical analysis and discussion, and effectively internalizes core value orientations through experiential learning, thereby offering a practical and replicable paradigm for analogous courses in engineering and related disciplines.

Keywords: engineering ethics, case library, ideological and political education, teaching reform.

1 Introduction

With the rapid development of China's engineering construction industry, engineering activities have evolved beyond mere technical practices to involve substantial consumption of social and natural resources. These activities inherently involve social equity and justice, inevitably giving rise to numerous ethical issues in engineering. Consequently, engineers bear significant social and environmental responsibilities while frequently confronting rigorous ethical challenges [1]. Concurrently, the nation has established new educational objectives for engineering disciplines in higher education in response to the Fourth Industrial Revolution, aiming to cultivate high-caliber, interdisciplinary,

Submitted: 24 October 2025
Accepted: 02 November 2025
Published: 30 December 2025

Vol. 1, **No.** 3, 2025.
10.62762/FEIR.2025.461424

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Citation
Dong, Y., Wei, N., & Lu, H. (2025). Case Library Teaching Research on the Integration of Ideological and Political Education and Digitalization. *Frontiers in Educational Innovation and Research*, 1(3), 110–115.

Table 1. Overview of the case library module.

Module	Key Points
Case Background	Explain the background, scale, technical difficulties and strategic significance of the project.
Ethical Analysis	Addressing ethical challenges in engineering, including ecological conservation, cultural preservation, and social responsibility.
Integrate ideological and political elements	Examine the ideological and political values embedded in the case, including patriotism, innovative spirit, and ecological responsibility.
Solution Seminar	Guide students to propose solutions that take into account both engineering goals and ethical responsibilities.
Digital-assisted teaching	Enhance teaching effectiveness through 3D modeling, VR, AR and other technologies to improve visual and interactive learning.
Expand your thinking	Guide students to transfer case experience to other engineering scenarios to deepen ethical awareness.

and application-oriented engineers with strong professional competencies, ethical awareness, and moral integrity to drive technological advancement and social progress [2]. As a crucial engineering discipline, engineering ethics courses play a vital role in fostering students' ethical consciousness, value judgment capabilities, and social responsibility. The teaching quality of these courses directly impacts the effectiveness of cultivating new engineering talent.

However, there are currently widespread issues in the teaching process of engineering ethics courses at our university. Firstly, the case teaching resources are not sufficiently diverse. The current course cases mainly consist of engineering cases from outside China, lacking typical cases that highlight Chinese characteristics and engineering practices. Secondly, the deep integration of ideological and political elements with engineering ethics teaching is insufficient, and the introduction of ideological and political elements is not systematic enough, appearing somewhat rigid. Thirdly, the teaching methods remain stuck in traditional approaches, failing to stimulate students' interest in learning and unable to meet the requirements for cultivating new engineering talents. It is necessary to reform the teaching model and introduce more innovative digital technologies to enhance students' learning interest. Therefore, our university has completely rebuilt the case library for this course and reformed the teaching model, introducing new teaching methods such as blended online-offline teaching and discussion methods. At the same time, ideological and political elements and advanced digital technologies have been integrated into the design of the case library to improve teaching effectiveness and achieve the goal of cultivating new engineering talents.

2 Design concept and architecture of engineering ethics case library

2.1 Design concept

The innovative case library framework is designed to achieve the core mission of cultivating new engineering talents. By aligning with the specific objectives of engineering ethics education, it curates authentic, representative, and timely engineering cases. These cases systematically integrate ideological education elements (including patriotism, legal awareness, cultural confidence, and ecological responsibility) into every aspect of engineering ethics instruction. Leveraging advanced yet user-friendly digital technologies, the platform enhances students' intuitive understanding of engineering practices, boosts learning engagement, and helps establish proper engineering values. Ultimately, this approach fosters new engineering professionals who combine ethical integrity with technical expertise and demonstrate strong social responsibility.

2.2 Architecture Design

2.2.1 Case library domain design

Try to cover the core areas of engineering, such as construction, transportation and water conservancy. Select 3-4 typical cases in each field that can reflect the characteristics of the times to ensure the system, diversity and timeliness of the cases.

2.2.2 Case library teaching module design

Each case includes case background, ethical problem analysis, ideological and political elements integration, solution discussion, digital teaching assistance, and

expanded thinking modules. The modules are interrelated to form a complete teaching logic chain. The specific content of each module is shown in Table 1.

3 Typical case design

3.1 Construction engineering

The Hong Kong-Zhuhai-Macao Bridge, a landmark project in the Guangdong-Hong Kong-Macao Greater Bay Area development, spans 55 kilometers and integrates bridge, island, and tunnel structures, making it the world's longest sea-crossing bridge with significant engineering significance. During construction, Chinese engineering teams faced multiple world-class challenges, including crossing the China National Nature Reserve for Baiji Dolphins and overcoming foreign technological barriers in immersed tube tunneling [3]. The case study design requires in-depth analysis of the conflict between ecological conservation and project timelines, guiding students to explore the balance between economic development and environmental protection in engineering projects.

Integration of Ideological and Political Elements: Analyzing the pivotal role of bridges in China's economic development, this section highlights how bridge construction supports national strategies while fostering students' patriotic sentiments. It recounts the arduous journey of construction teams achieving technological breakthroughs through independent innovation, inspiring students to pursue self-improvement and innovation. The text also examines various ecological conservation measures implemented during engineering projects, reinforcing students' ecological responsibility and sustainable development awareness. For instance, when explaining the breakthrough in immersed tube tunnel technology, the narrative details how Chinese engineers pioneered this innovation from scratch through rigorous research. This vivid account allows students to deeply appreciate the significance of technological advancement for national progress, thereby strengthening their sense of national pride.

3.2 Transportation engineering

Stretching 1,543 kilometers across the Qinghai-Tibet Plateau and other challenging terrains, the Sichuan-Tibet Railway is hailed as "the world's most difficult railway to build" [4]. The case study framework enables in-depth analysis of the project's ecological impacts and cultural preservation challenges, guiding students to explore how to balance infrastructure development with environmental conservation and the preservation of ethnic cultural heritage.

Integration of Ideological and Political Elements: By analyzing the significant impact of railway construction on local economies, students develop awareness of ethnic unity and the importance of economic development in strengthening national cohesion. Through stories of builders working under extreme conditions, students cultivate perseverance and resilience. Discussions on preserving ethnic cultural heritage during project implementation enhance students' sense of responsibility for cultural continuity. For example, when evaluating railway station designs, students are guided to incorporate ethnic cultural elements, achieving a harmonious balance between modern transportation needs and cultural preservation. This approach helps students recognize that engineering projects are not merely technical endeavors but vital vehicles for cultural inheritance.

3.3 Water conservancy projects

Established in 256 BC, Dujiangyan is the world's oldest, only surviving, and still operational gambles water diversion project [5]. By comparing Dujiangyan's ecological wisdom of 'harmony between heaven and humanity' with modern water conservancy projects' environmental challenges, this case study encourages students to re-examine the relationship between humans and nature, and explore sustainable development pathways for modern water conservancy engineering.

Integration of Ideological and Political Elements: Highlighting Dujiangyan's profound historical and cultural significance, we analyze its modern engineering implications to strengthen cultural confidence. By examining the ecological wisdom embedded in Dujiangyan's engineering, students are guided to develop a proper ecological civilization perspective. Exploring its innovative structural design and construction process cultivates students' innovative thinking. For instance, when explaining Dujiangyan's structural composition, we emphasize the sustainable development philosophy demonstrated by ancient engineers in maintenance practices. This approach helps students recognize the enlightening role of traditional cultural wisdom in modern engineering, thereby reinforcing their cultural confidence.

4 Case library teaching design and implementation

4.1 Teaching plan before class

Before commencing the course, teachers should complete preparatory tasks including material integration, digital tool configuration, and task guidance. For instance, they should collect resources such as the CCTV documentary on the Hong Kong-Zhuhai-Macao Bridge construction and the "Outline of the Guangdong-Hong Kong-Macao Greater Bay Area Development Plan", categorize them, and upload them to the Learning Hub platform. Pre-testing should be conducted to ensure smooth access to digital resources like 3D models and VR panoramas. For the Sichuan-Tibet Railway case study, teachers should design pre-class task sheets requiring students to observe the surrounding environment through VR platforms, analyze the impacts of different engineering designs and construction processes on the environment and ethnic minority cultures, and share their perspectives in the discussion section.

Students watch case videos, study uploaded materials, and access digital resources through platforms such as Xuetong. They think about the ethical issues corresponding to each case, exchange preliminary opinions in groups, and organize them with mind maps and other methods. They enter the classroom with questions.

4.2 In-class teaching plan (designed for 90 minutes)

Contextual Introduction (15 minutes): Begin by showing multimedia materials such as aerial footage of Dujiangyan and work records of Sichuan-Tibet Railway builders. Design a teaching scenario with thought-provoking questions like 'How to balance project progress with white dolphin conservation during the Hong Kong-Zhuhai-Macao Bridge construction?' to guide students' critical thinking.

Case Analysis (30 minutes): After grouping students, each group will discuss the ethical issues in the case. The teacher will distribute discussion outlines, providing guidance on dimensions such as technical feasibility, economic costs, and ecological impacts. The teacher will patrol and guide the discussion, asking timely questions to encourage deeper thinking.

Outcome Presentation and Feedback (35 minutes): Each group selects representatives to present their findings through PowerPoint slides or online collaboration platforms, showcasing data analysis charts and solution mind maps. Other groups may raise questions and suggestions during discussions. Finally, the instructor will provide feedback by integrating fundamental engineering ethics principles, incorporating ideological and political elements, evaluating solution feasibility, and supplementing key knowledge points to deepen students' understanding of engineering practice challenges.

Political Education Enhancement (10 minutes): During the summarization and elevation phase, instructors can conduct in-depth analysis of ideological elements such as patriotism and innovative spirit in case studies. By comparing similar engineering projects from China and abroad, they can further highlight the value orientation of China's construction engineering. For example, guiding students to reflect on the relationship between personal career development and national strategies, and fostering the professional philosophy of "engineering for the people".

4.3 Post-class teaching plan

Homework assignments: Teachers can enhance classroom learning effectiveness through various methods, including written assignments (such as case analysis reports covering ethical issues, solution optimization, and ideological insights), practical assignments (like conducting ethical analyses of local engineering cases), and extended reading tasks (recommending academic papers, websites, and related books).

Learning Feedback and Tutoring: When teachers grade assignments on the Learning Hub platform, they can provide comments to evaluate students' work, highlighting strengths and areas for improvement. Additionally, they may organize regular online Q&A sessions via Tencent Meeting to address common questions collectively.

Teaching Evaluation: To better stimulate students' learning motivation, we can adopt a combination of process evaluation (recording group discussions, classroom participation, etc.), summative evaluation (case analysis questions in final exams), and diversified evaluation (self-assessment by students, peer assessment within groups) to comprehensively, deeply, and effectively assess learning outcomes. This approach promotes students' self-reflection and mutual learning.

5 Teaching reform results and reflection

5.1 Teaching effectiveness

The implementation of the "Engineering Ethics" case library in classroom teaching has significantly enhanced instructional effectiveness. Compared to previous cohorts, students demonstrate markedly increased learning engagement and classroom participation. A comparative analysis of pre-and post-introduction case study reports reveals substantial improvements in quality, particularly evident in the enhanced comprehensive analytical capabilities of engineering practices among most students, along with notable advancements in ethical awareness and value judgment. Post-course scenario-based assessments indicate that students now approach complex engineering ethics issues through multidimensional analysis encompassing technical, economic, ecological, and social dimensions. Their proposed solutions exhibit greater comprehensiveness and rationality, demonstrating strengthened social responsibility and ethical consciousness.

5.2 Teaching reflection

Further analysis of curriculum design, teaching methodologies, and instructional outcomes reveals areas for improvement in the educational process. For instance, while the case library covers major fields such as architecture, transportation, water conservancy, and municipal engineering, both the number of cases and the breadth of coverage require expansion to enhance comprehensiveness. This would enable deeper exploration of ethical characteristics across different engineering disciplines. Although the integration of ideological and political education elements has shown initial success, there remains a need for refined exploration in identifying optimal integration points and depth of these elements within specific cases. These improvements will significantly enhance the ideological education effectiveness of the case library.

6 Conclusion

This study develops a case library for engineering ethics, which revolutionizes teaching methodologies. This is achieved by deeply integrating ideological and political education elements with advanced digital technologies. Teaching practices demonstrate that this case-based approach has significantly enhanced students' learning engagement and participation, while strengthening their ethical awareness and value judgment capabilities in engineering. Looking ahead, as information technology advances and ideological education initiatives progress, the engineering ethics case library will be further optimized to play a more proactive role in cultivating new engineering talents.

Data Availability Statement

Data will be made available on request.

Funding

This work was supported by the Graduate Case Library Project of Wuhan Polytechnic University under Grant 2025ALK04.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

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