



Approaches and Practical Exploration: Integrating Curriculum-based Ideological and Political Education into *Introduction to Road and Bridge Engineering*

Qinghua Ding

School of Architectural Engineering, Oxbridge College, Kunming University of Science and Technology, Kunming, Yunnan, 650106, China

E-mail: 1012493695@qq.com

Abstract. Curriculum-based ideological and political education constitutes a pivotal initiative in the new-era reform of higher education. Its essence lies in systematically integrating ideological and political elements into discipline-specific curricula, thereby achieving a synergistic alignment between knowledge impartation and value-oriented guidance. As a core curriculum in road and bridge engineering technology programs, *Introduction to Road and Bridge Engineering* not only cultivates students' professional competencies but also fulfills the pedagogical mission of enhancing engineering ethics awareness, social responsibility, and national identity. Based on the curriculum characteristics, this study systematically identifies key ideological and political elements, including engineering ethics, professional accountability, safety awareness, sustainable construction, and national identity, and explores their integration pathways within instructional content, pedagogical methods, and assessment frameworks. Through innovative teaching strategies such as case studies, virtual simulation experiments, and project-based learning, students are guided to comprehend the societal value of engineering technologies through practical engagement, thereby strengthening their sense of responsibility and professional ethics. Empirical evidence demonstrates that the in-depth integration of curriculum-based ideological and political education (CIPE) significantly elevates students' professional competencies, teamwork skills, and social responsibility awareness. Future efforts should focus on optimizing pedagogical models and deepening CIPE reforms to cultivate high-caliber engineering professionals with innovative spirit, global perspectives, and societal accountability.

Keywords: Curriculum-based ideological and political education (CIPE), road and bridge engineering, engineering ethics, social responsibility, teaching reform

1 Introduction

Curriculum-based ideological and political education (CIPE) represents a critical orientation for higher education reform in the new era, with its fundamental objective being

the integration of ideological and political education into discipline-specific curricula to achieve the unification of knowledge transmission and value cultivation. The *Guidelines for the Development of Curriculum-based Ideological and Political Education in Higher Education Institutions* explicitly mandates that all courses undertake educational responsibilities by fully leveraging ideological and political pedagogical resources, thereby cultivating high-caliber professionals with both moral integrity and professional competence. Against this backdrop, the effective integration of ideological-political elements into engineering curricula, specifically to enhance students' social responsibility, engineering ethics awareness, and national identity, has emerged as a pivotal challenge in contemporary engineering education.[1]

Introduction to Road and Bridge Engineering, a foundational curriculum for Civil Engineering and Transportation Engineering programs, serves as a specialized curriculum within road and bridge engineering disciplines. It aims to equip students with structural characteristics and construction methodologies of road and bridge engineering, along with fundamental knowledge and technical competencies required for professional practice in this field, while cultivating innovative thinking, problem-solving capabilities, and professional ethics. The effective integration of ideological and political education into such discipline-specific curricula, particularly to foster students' cultural literacy, social responsibility, and professional ethics, has emerged as a critical challenge in contemporary engineering education.[2]

Based on this, this study takes the curriculum *Introduction to Road and Bridge Engineering* as its research object, conducting an in-depth investigation into three core dimensions: the identification of CIPE elements, pedagogical integration pathways, and practical implementation strategies. Specifically, it explores methodologies for embedding CIPE within road and bridge engineering education to cultivate “master craftsmen with national responsibility”—professionals who integrate technical expertise with cultural literacy—thereby providing transferable ideological education models for application-oriented undergraduate engineering curricula.

2 Mining CIPE Elements in Introduction to Road and Bridge Engineering

2.1 Curriculum Features

Introduction to Road and Bridge Engineering, a core curriculum of road and bridge engineering technology programs, is designed to equip students with systematic professional knowledge and comprehensive engineering perspectives. Its content encompasses fundamental concepts, structural configurations, and construction methodologies in road and bridge engineering, establishing a foundation for subsequent specialized curricula. Its key characteristics include:

First, Foundational Nature: this curriculum covers essential concepts, structural systems, and construction techniques in road and bridge engineering, providing the theoretical basis for advanced coursework; second, Interdisciplinary Nature: it integrates

multiple disciplines including material mechanics, structural engineering, and transportation planning to cultivate cross-disciplinary thinking and holistic analytical capabilities; third, Practical Orientation: this curriculum enhances hands-on competencies and engineering application skills through case analysis of engineering projects, field investigations, construction simulations, and virtual prototyping applications. Building upon these curriculum characteristics and accumulated pedagogical experience, this study identifies core dimensions for embedding ideological-political education elements and systematically integrates them into instructional processes.[3]

2.2 Core Dimensions of CIPE Elements

Based on the curriculum content, this section systematically identifies key ideological-political elements in *Introduction to Road and Bridge Engineering* and integrates them into instructional design through the following approaches:

(1) Engineering ethics and professional responsibility

In road and bridge engineering projects, engineers not only possess solid technical expertise but also uphold social responsibilities and adhere to engineering ethics. The curriculum *Introduction to Road and Bridge Engineering* integrates engineering ethics education through three methods. First, **case analysis**: examination of typical engineering failures (e.g., bridge collapse incidents) to identify flaws in design, construction, and supervision, guiding students to reflect on engineers' responsibilities in ensuring public safety. Second, **legal interpretation**: introduction of regulations such as the *Regulations on Construction Engineering Quality Management* to clarify engineers' statutory obligations under legal frameworks. Third, **sharing of instructors' experience**: instructors share field experiences to demonstrate adherence to professional ethics in engineering practice, fostering students' accountability and dedication.[4][5]

(2) National identity and national self-confidence

As a critical pillar of national infrastructure, road and bridge engineering, directly mirrors a nation's technological capabilities and developmental progress. Within the pedagogical framework, the curriculum enhances students' national pride through case studies of mega-projects, such as **Hong Kong-Zhuhai-Macao Bridge, Hangzhou Bay Cross-Sea Bridge, Sichuan-Tibet Railway**, to showcase China's engineering advancements. Students are recognized to watch screening episodes of the documentary *Super Engineering* to visually demonstrate China's infrastructure accomplishments, inspiring students to contribute to national development. After that, **reflective writing** begins. This assignment "My Vision of Mega-Projects" requires students to articulate their perspectives on China's transportation development.

(3) Safety awareness cultivation

Safety education is systematically implemented through engineering case studies involving **bridge girder installation, elevated works, and road construction safety management**, where safety incidents are analyzed to identify root causes and formulate preventive measures. For instance, a detailed analysis of bridge collapse incidents demonstrates how design deficiencies, construction non-compliance, and safety management loopholes collectively compromise engineering safety. The curriculum introduces the domestic and international road and bridge engineering construction safety

management system, including China's *Management Measures for Work Safety in Highway and Waterway Engineering Projects* and international leading safety management practices, to guide students in developing optimized safety management protocols.

(4) Sustainable development and green construction

The curriculum enhances students' environmental awareness, equipping them to prioritize sustainability objectives—including green construction practices, energy conservation, and emission reduction—during engineering budgeting processes. China's Dual Carbon Policy (Carbon Peaking and Carbon Neutrality Goals) is systematically introduced to guide students in integrating **energy efficiency, environmental protection, and material circularity** principles into construction planning. Technical analyses of green road construction techniques, such as **permeable concrete pavement applications and energy-efficient bridge designs**, are conducted to demonstrate **cost-effective pathways for achieving green construction while maintaining budgetary viability**.

(5) Emergency management and engineering safety accountability

The curriculum elevates students' safety awareness and crisis response capabilities while cultivating their accountability in engineering management. Through such case studies as bridge collapses during the Wenchuan Earthquake, highway tunnel cave-ins, and flood-induced bridge scour, students explore strategies for enhancing disaster resilience via rational structural design, durable materials, and robust emergency response plans.[6]

Post-disaster rehabilitation analyses of highway bridges, exemplified by the 72-hour emergency restoration of critical lifelines following the Lushan Earthquake in Sichuan Province, are systematically integrated to cultivate students' sense of responsibility and professional mission. The curriculum emphasizes construction safety management systems and extreme weather contingency planning protocols to elevate students' prioritization of construction safety standards.

(6) Teamwork and communication skills

Road and bridge engineering construction necessitates multidisciplinary collaboration, with team collaboration competencies being a critical professional attribute for engineering practitioners. Through practical instructional modules, the curriculum guides students in developing collaborative spirit and communication skills via:

Pedagogical integration approach: implementing a team-based learning (TBL) framework where students assume professional roles (design engineers, contractors, supervision consultants) to conduct project planning, experiencing full-cycle engineering collaboration processes.

Engineering project roadshows are organized to train students in delivering layperson-accessible presentations of design proposals to "investors" (faculty/peers), enhancing technical communication proficiency. Furthermore, case analyses of multi-stakeholder bridge construction projects, involving designers, contractors, regulators, and governmental authorities, are conducted to deconstruct role-specific responsibilities, fostering professional teamwork awareness and cross-disciplinary negotiation capabilities.

(7) Engineering culture and craftsmanship ethos

The curriculum cultivates students' professional dedication and relentless pursuit of excellence while instilling lifelong learning awareness. Through technical analyses of ancient bridges such as Zhaozhou Bridge, Lugou Bridge, and Anji Bridge, students gain insights into the structural innovations, construction techniques, and cultural heritage of Chinese engineering wisdom.[7] The pedagogy explicates the spirit of the "master craftsmen with national responsibility", which is exemplified by the millimeter-level precision in Hong Kong-Zhuhai-Macao Bridge construction and breakthrough innovations in high-speed railway bridge engineering, demonstrating the enduring value of craftsmanship in modern mega-projects. Integration of emerging technologies including intelligent construction, digital twins, and AI-assisted building processes underscores the imperative for engineers to embrace continuous upskilling, thereby reinforcing the necessity of lifelong learning in technological evolution.

(8) Global perspectives and cross-cultural communication skills

With the advancement of the Belt and Road Initiative (BRI), Chinese enterprises have assumed pivotal roles in global infrastructure development, necessitating future engineers to cultivate global perspectives. The curriculum examines China's infrastructure projects—including highways, bridges, and ports along BRI corridors—to demonstrate how such initiatives foster international collaboration. Comparative analyses of diverse national engineering management systems are conducted to enhance students' adaptability to global engineering practices. Engineers engaged in international projects are invited to share field experiences, strengthening students' global mindset and career planning competencies. Concurrently, discussions on China's infrastructure contributions to international partnerships reinforce students' national pride in these achievements.

The curriculum *Introduction to Road and Bridge Engineering* inherently embodies profound opportunities for ideological-political education. Through systematic exploration and pedagogical integration, it enhances students' professional competencies while cultivating their social responsibility, safety awareness, national identity, teamwork ethos, and global perspectives. Future engineering education must prioritize curriculum-based ideological-political education development, achieving organic unity between knowledge impartation and value cultivation, thereby nurturing new-era engineering professionals equipped with both technical expertise and societal accountability.

3 The Integration Approaches of CIPE

The *Introduction to Road and Bridge Engineering* curriculum serves not only as a foundational course for road and bridge engineering technology programs but also as a vehicle for ideological and political education, namely cultivating students' professional ethics, safety awareness, and social responsibility. To achieve organic integration of disciplinary knowledge and ideological-political education, this curriculum constructs CIPE integration approaches through systematic **goal realignment, content optimization, pedagogical innovation, and assessment reform.**

(1) Reconstruction of curriculum objectives

Traditional curriculum objectives primarily focus on fundamental concepts, design principles, and construction methodologies in road and bridge engineering. CIPE integration necessitates expanding curriculum objectives to establish a dual-objective pedagogical framework that combines knowledge acquisition with value cultivation, simultaneously strengthening students' sense of accountability while delivering disciplinary content.[8]

Knowledge dimension: Enables students to master core theories, design approaches, and construction techniques in road and bridge engineering.

CIPE dimension: Cultivates students' social responsibility, engineering ethics awareness, safety consciousness, environmental stewardship, and collaborative ethos.

This dual-objective restructuring ensures the curriculum not only emphasizes technical proficiency but also integrates value-oriented guidance, thereby actualizing the educational paradigm of "cultivating virtue through pedagogy."

(2) Optimized design of teaching content

In curriculum content design, the curriculum emphasizes the organic integration of disciplinary knowledge with ideological-political elements to enhance students' recognition of engineering professionalism and social accountability.

Embedding CIPE case analysis: the curriculum embeds CIPE case studies with bridge collapse accident analysis, national key project construction, green construction practices, etc., guiding students to emphasize the social impacts of the project.

Strengthening interpretation of laws and regulations: legal framework integration is reinforced through the incorporation of regulations such as the *Regulations on Construction Engineering Quality Management* and *Management Measures for Work Safety in Highway and Waterway Engineering Projects*, enabling students to comprehend industry standards and statutory obligations.

Expanding global engineering perspectives: global engineering perspectives are expanded by introducing infrastructure developments along the Belt and Road Initiative corridors, strengthening students' global consciousness and cross-cultural communication competencies.

(3) Innovation of pedagogy and teaching methods

The curriculum adopts diversified pedagogical methods to enhance interactivity and practical engagement, rendering ideological-political education more dynamic and cultivating its profound resonance among students.

Case-based pedagogy: the curriculum employs engineering case analyses of the Hong Kong-Zhuhai-Macao Bridge construction, highway planning complexities, and challenges in mountainous road construction to demonstrate the intrinsic connections between engineering practice and social accountability. Analysis of bridge collapse incidents prompts students to critically assess the importance of construction quality and professional ethics. Ecological conservation strategies are integrated into discussions on mountainous road development, exploring methodologies to minimize ecological disruption during construction processes.

Virtual simulation experiments: the curriculum implements virtual simulation experiments leveraging Building Information Modeling (BIM), digital twins, and smart transportation systems, enabling students to experience the complete lifecycle of road

and bridge construction in immersive digital environments. Scenarios such as working at height and construction safety protection are rehearsed in the simulation system to improve safety awareness. Comparative analyses of construction scenarios' environmental impacts through virtual experimentation cultivate students' sustainable development awareness.[9]

Project-based learning (PBL): the curriculum develops a simulated highway and bridge project planning task, requiring students to holistically evaluate multiple factors including safety protocols, environmental sustainability, cost-effectiveness, and societal benefits, thereby cultivating teamwork ethos and integrated decision-making competencies through problem-solving processes. For instance, student teams collaboratively design highway alignments while analyzing cost optimization strategies and ecological impact mitigation measures as shown in fig. 1.



Fig. 1. Construction site diagram

Interdisciplinary team collaboration: Students assume professional roles as design engineers, contractors, and supervision consultants to conduct engineering project planning, experiencing the criticality of multi-stakeholder coordination. Students present design proposals to “investors” such as teachers or peers, refining technical communication proficiency and negotiation competencies.

(4) Improvement of curriculum assessment and evaluation system

To ensure the attainment of CIPE objectives, the assessment framework adopts a blended model combining formative assessment (40%) and summative assessment (60%), explicitly prioritizing dual evaluation of both disciplinary knowledge mastery and ideological-political competency development.

(1) Formative assessment (40%):

Classroom Discussion (10%): the curriculum conducts interactive discussions centered on ideological and political case analyses, including topics such as engineering ethics, reflections on safety incidents, and sustainable development.

Group Assignment (10%): students need to complete the “Highway Bridge Estimation Preparation” task to cultivate their awareness of engineering economics and teamwork skills.

Practical Report (10%): students should write a “Social Responsibility Analysis” report to explore the social responsibilities of engineers in infrastructure construction.

Documentary Reflection (10%): students are required to watch the documentary *Super Engineering* and compose a reflective piece to enhance students' national pride and professional identity.

(2) Summative assessment (60%)

Engineering project outcome presentation (30%): students are required to complete a design for a bridge or highway project, demonstrating considerations for safety, environmental protection, and economic efficiency.

Thematic paper (30%): students are to write a paper on topics such as professional ethics, sustainable development, and intelligent construction, reflecting their comprehensive critical thinking abilities.

Through the restructuring of objectives, content optimization, pedagogical innovation, and improvements in assessment, the course *Introduction to Road and Bridge Engineering* has achieved a deep integration of professional education and ideological and political education. This integration not only enhances students' professional competence but also cultivates their sense of social responsibility, teamwork skills, and international perspective, providing robust support for nurturing high-quality engineering talents in China's transportation infrastructure sector.

4 Outcomes of Ideological and Political Education Reform

In the practice of integrating ideological and political education into the *Introduction to Road and Bridge Engineering* curriculum, the **optimization of teaching content, innovation in teaching methods, and enhancement of case-based instruction** not only improved students' professional understanding of road and bridge engineering but also stimulated their attention to and sense of responsibility for engineering construction. The course reform has achieved significant results, as manifested in the following aspects:

(1) Student feedback and cognitive transformation

Post-curriculum evaluations reveal heightened student engagement with road and bridge engineering in daily contexts. Numerous students demonstrate increased observational acuity, proactively sharing field observations and analytical insights with instructors when encountering highway structures or bridges, evidencing connections between acquired knowledge and real-world applications. This behavioral shift substantiates that CIPE integration not only assists students in mastering professional knowledge but also encourages them to connect classroom learning with the real world, thereby fostering a deeper understanding of the engineering industry.

Case evidence: students traversing infrastructure landmarks such as the **Hong Kong-Zhuhai-Macao Bridge, expressway service zones, or mountainous slope stabilization sites** proactively photograph structural elements and share analytical observations with instructors, accompanied by annotations like: "This pier utilizes the seismic-resistant design methodology covered in lectures" and "The tunnel portal support system matches classroom instruction for collapse prevention." This behavioral pattern demonstrates how curricular content has subconsciously reshaped students' cognitive patterns, heightening their concerns with proximate road and bridge engineering works.

(2) The penetration and influence of ideological and political education

The ideological and political elements such as engineering ethics, safety responsibilities, and national identity integrated into the curriculum have also had a positive impact on students' cognition and behavior. For example, post-curriculum evaluations reveal that some students are more aware of the importance of engineering safety, and prioritize responsibility sharing in collaborative teamwork. Some students even express a greater focus on the infrastructure construction sector and a desire to contribute to the nation's transportation development in their future career choices.

Vocational perception shift: post-curricular reflections indicate that students now conceptualize **road and bridge engineering not merely as a technical practice but as a societal mission impacting national welfare and social betterment**. This paradigm shift has engendered profound reconsideration of career trajectories.

Enhanced national identity and technological pride: Pedagogical analyses of China's bridge and highway milestones, such as the **Hong Kong-Zhuhai-Macao Bridge, Sichuan-Tibet Highway, and Qinghai-Tibet Railway**, have given students a deep impression of China's rapid development in engineering and technology, and enhanced their national self-confidence and pride. After the study, some students stated, "Previously, I only thought that bridges were buildings, now I recognize them as critical nexuses connecting people to the world after the study."

(3) Enhanced learning experience due to pedagogical innovation

The integration of CIPE elements has not only enriched the curricular depth but also amplified student engagement and participatory learning. Case-based instruction, PBL (Project-Based Learning), virtual simulation experiments, and other pedagogical innovations enable students to comprehend engineering technologies within authentic contexts while internalizing the criticality of engineering ethics and social responsibility through applied practice.

Case-based pedagogy enhances learning engagement: students consistently report that real-world case analyses, field investigations, and engineer interviews provide a more tangible understanding of engineering applications compared to purely theoretical instruction, while also revealing the societal value embedded in technical solutions.

Practice-oriented instruction strengthens accountability: during simulated road and bridge project planning, students must holistically evaluate safety protocols, environmental sustainability, cost-benefit ratios, and social impacts—a process that fosters comprehensive decision-making capabilities and heightens their awareness of professional accountability as future engineers.

Through deepened CIPE integration, the *Introduction to Road and Bridge Engineering* curriculum equips students with both technical mastery and habitual critical observation of infrastructure significance in daily contexts, solidifying vocational diligence, societal commitment, and national identity. Future iterations will refine CIPE implementation strategies to cultivate engineering professionals with global perspectives, social consciousness, and innovative capacities alongside technical excellence.

5 Conclusion and Outlook

The exploration and implementation of CIPE in the *Introduction to Road and Bridge Engineering* curriculum demonstrate that integrating ideological-political education with disciplinary content is not only feasible but also significantly enhances students' professional competencies, social accountability, and national identity. Through systematic goal realignment, content optimization, pedagogical innovation, and assessment reform, the curriculum achieves organic unity between knowledge impartation and value cultivation, yielding the following outcomes:

Students exhibit heightened cognitive engagement and learning motivation, and proactively bridge classroom knowledge with real-world engineering contexts, deepening their comprehension of and commitment to road and bridge engineering.

CIPE integration fosters students' ethical professional outlook and social responsibility, elevating safety consciousness, engineering ethics literacy, and mission-driven dedication to infrastructure development.

Case-based instruction, PBL, virtual simulations, and other pedagogical innovations create immersive learning environments where students understand the societal value of engineering technologies, simultaneously advancing practical skills and collaborative capacities.

This practice validates that ideological-political education should transcend didactic indoctrination, instead achieving subtle and pervasive integration within disciplinary teaching to guide students in establishing vocationally aligned values and societal responsibilities, and truly actualizing the "education through curriculum" paradigm.

Future directions will optimize integration strategies for ideological-political elements through: deepened adoption of intelligent teaching technologies, strengthened practice-oriented instructional modules, expanded global collaboration initiatives, and enhanced multidimensional assessment frameworks. Through continuous innovation, the curriculum will cultivate high-caliber engineering professionals equipped with technical excellence, social consciousness, and global perspectives, thereby contributing to national transportation infrastructure advancement and sustainable development.

References

1. Ministry of Education of the People's Republic of China. Guidelines for the Development of Curriculum-based Ideological and Political Education in Higher Education Institutions [Z]. 2020.
2. YAN Shouxuan, Ni Jingtian, Zhao Xiankui. Value implications of middle and primary school education integration, realistic situation and the practice to the road [J]. Journal of education science, 2024, 40 (1) : 50-56, DOI: 10.3969 / j.i SSN. 1002-8064.2024.01.008.
3. Jiang Lanbo. Integration Path Selection for Improving Curriculum Implementation Ability of Ideological and Political Course teachers [J]. Ideological and Political Teaching, 2024(1):13-16.
4. Zhou Yuehua, Hao Xiaoqi. The logic and path of the Development of new quality Productive Forces enabled by Ideological and Political Education in colleges and universities [J]. Educational Theory and Practice, 2025(6).

5. ZHANG Yaocan, Sun Qinghua. Historical experience in the study of the principles of ideological and political pedagogy [J]. Teaching and Research, 2025(2).
6. Jin Hui, Guo Fanbo, Shao Guotao. Roads and Bridges to cross a river engineering practice teaching research and exploration [J]. Journal of experimental technology and management, 2015, 32 (7) : 5. DOI: 10.3969 / j.i SSN. 1002-4956.2015.07.045.
7. Cheng Lichun. A Practical Exploration of the Reform of Teaching methods based on the concept of Unit Teaching [C]// Proceedings of the 2024 Cultural Information Development Forum (2).2024.
8. Wang Lingqi, Zuo Jianmin, Wang Mulan. The view of engineering and practice-oriented teaching reform [J]. Journal of institute of higher education research, 2009 (2) : 3. DOI: 10.3963 / j.i SSN. 1671-606 - x. 2009.02.034.
9. Li Heping, Xiao Zhongyue, Luo Shuping, et al. Exploration on Improving Engineering Teaching Quality through industry-University-research Cooperation Innovation Education [J]. Journal of Jinggangshan University: Comprehensive Edition, 2009.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

