Global Research in Higher Education
ISSN 2576-196X (Print) ISSN 2576-1951 (Online)
Vol. 8, No. 3, 2025
www.scholink.org/ojs/index.php/grhe

Original Paper

Research on the Reform and Practice of the "Bridge Engineering" Course in the Digital and Intelligent Era

Aihong Qin[1], Sai Zhang[1], Wenting Hua[1], Liya Han[1], Linlin Ma[1] & Shouling Luan[1]
[1] Qingdao City University, Qingdao, Shandong Province, China

Received: September 7, 2025 Accepted: September 26, 2025 Online Published: October 8, 2025
doi:10.22158/grhe.v8n3p43 URL:http://dx.doi.org/10.22158/grhe.v8n3p43

Abstract

In the digital and intelligent era, the traditional "Bridge Engineering" course is confronted with practical dilemmas such as outdated knowledge systems and disconnection between practical teaching and real-world needs. This study integrates cutting-edge technologies like BIM and knowledge graphs, establishes a dedicated WeChat official account platform for the "Bridge Engineering" course, and builds an intelligent construction workshop with virtual-real interaction. Through these efforts, it systematically reorganizes the course content, constructs a digital platform, and implements industry-education integration practices. By adopting the three-stage progressive teaching model of "Exploring Bridges-Investigating Bridges-Creating Bridges", a trinity course system of "Culture-Technology-Innovation" is built. Ultimately, an engaging course centered on the core concept of "Discovering Your Beauty Through Bridges" is realized.

Keywords

digitalization and Intelligence, bridge Engineering, course Reconstruction, intelligent Construction

1. Introduction

With the advent of the digital and intelligent era, a new generation of information technologies such as artificial intelligence, big data, cloud computing, and the Internet of Things is profoundly transforming the design, construction, and operation and maintenance modes of the bridge engineering industry. The "Bridge Engineering" course is a core course for the road and bridge engineering direction in the civil engineering major. The traditional "Bridge Engineering" course system takes structural mechanics, material science, and construction technology as its core. However, its teaching content and methods are relatively rigid, making it difficult to meet the demand for interdisciplinary and innovative talents in the digital and intelligent era. Currently, universities at home and abroad tend to focus on theoretical knowledge in the teaching philosophy of the bridge engineering course, while paying insufficient attention to the cultivation of practical abilities and innovative thinking.

Against this background, this paper proposes an innovative exploration based on the teaching philosophy of "Discovering Your Beauty Through Bridges". It constructs this teaching philosophy through three integrations: discipline integration, technology integration, and industry-education integration.

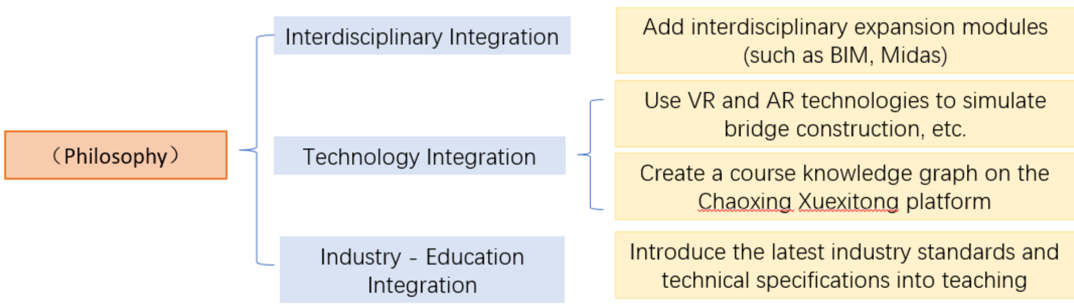

Figure 1. Teaching Philosophy

1.1 Underlying Logic of Discipline Integration and Support for Smart Courses

The core concept of discipline integration lies in breaking down disciplinary barriers, constructing an interdisciplinary knowledge system, and cultivating students' ability to analyze and solve complex bridge engineering problems from a multi-disciplinary perspective. By using AI-driven knowledge graphs to demonstrate the internal connections between disciplines such as mechanics, materials, and environmental protection in bridge engineering, the underlying logic of discipline integration is established. Meanwhile, interdisciplinary expansion modules are added to the "Bridge Engineering" course to realize the support of discipline integration for smart courses. For example, a computer science module is added to the bridge engineering course, teaching bridge modeling, simulation analysis, and optimization design (such as finite element analysis, BIM technology, MIDAS CIVIL technology, etc.).

1.2 Teaching Philosophy of the "Bridge Engineering" Course Based On Technology Integration

Modern bridge engineering is developing towards intelligence, digitalization, and sustainability. Emerging technologies (such as BIM, the Internet of Things, artificial intelligence, and big data analysis) are playing an increasingly important role in bridge design, construction, and operation and maintenance. The core concept of technology integration is to deeply integrate modern technologies with traditional bridge engineering teaching, enhance students' technology application capabilities and innovative abilities, and enable them to adapt to the technological development trend of future bridge engineering. For example, virtual reality (VR) and augmented reality (AR) technologies are used to simulate bridge construction processes or disaster scenarios (such as earthquakes and floods). Through VR simulation of the entire bridge construction process (such as construction safety scenarios and structural load tests), students can intuitively understand mechanical principles and environmental impacts; AR technology can overlay the internal structure of bridges (such as the layout of prestressed steel bars) onto real scenes. By introducing digital and intelligent technologies, a knowledge graph for the “Bridge Engineering” course is created on the Chaoxing Learning Platform, which systematically sorts out and displays the complex knowledge points and their relationships in the course.

1.3 Teaching Philosophy of the “Bridge Engineering” Course Based On Industry-Education Integration

Bridge engineering is a highly practical discipline, and industry demands and technological development are changing with each passing day. The core concept of industry-education integration is to integrate industry needs, engineering practices, and industry standards into course teaching through school-enterprise cooperation. This ensures that the teaching content keeps pace with industry development, enhances students’ practical abilities and professional literacy, and enables them to quickly adapt to industry job requirements after graduation. For example, the latest industry standards and technical specifications (such as bridge design specifications and construction safety standards) are introduced into the teaching of bridge engineering.

2. Reform Philosophy

Based on the constructivist learning theory and the CDIO engineering education model, a teaching framework of “three integrations” is constructed:

Interdisciplinary Integration: By integrating the knowledge graphs of civil engineering, computer science, and industrial design, an interdisciplinary course system is built. In the bridge shape design module, the structural mechanics knowledge of civil engineering, the parametric modeling technology of computer science, and the aesthetic evaluation system of industrial design are integrated to form a progressive teaching design of “structural performance-digital modeling-shape optimization”. For instance, parametric modeling is incorporated into bridge shape design.

Virtual-Real Scene Integration: A dual-track platform combining virtual and real scenes is adopted. Virtual scenes are used for scheme verification, and physical workshops are used to produce 1:10 scale models.

Value-Ability Integration: The course assessment system not only focuses on technical abilities but also emphasizes professional literacy and engineering ethics. The craftsman spirit is evaluated through quantitative indicators such as model production accuracy and node craftsmanship; engineering ethics is integrated into the review of design schemes to examine students’ consideration of safety, sustainability, and social impact. In addition, soft indicators such as teamwork and innovative thinking are set up. Combined with evaluations from industry experts and public hearings, it is ensured that students not only master professional skills but also have a sense of social responsibility, realizing the all-round development of “technology + humanities”.

3. Course System Reconstruction: A Three-Dimensional Progressive Teaching Model

Against the backdrop of the rapid development of digital and intelligent technologies, the "Bridge Engineering" course urgently needs to break through the traditional teaching framework and build a teaching system that meets the needs of engineering talent cultivation in the new era. This course adopts a three-dimensional progressive teaching model of "Journey of Exploring Bridges-Secret of Investigating Bridges-Joy of Creating Bridges". Combined with technologies such as virtual simulation, big data analysis, and intelligent interaction, it realizes multi-dimensional innovative reconstruction of course content and teaching methods. Through this model, the course will transform from "knowledge imparting" to "ability construction" and cultivate a new generation of bridge engineers with digital thinking and cross-boundary collaboration capabilities.

3.1 Journey of Exploring Bridges-Cultural Origin Module

In the "Journey of Exploring Bridges", teachers and students enter the world of "bridges" together. This part mainly covers the overview of bridges, the history of bridge development, the basic composition and classification of bridges, etc.

(1) Typical ethical conflict scenarios in bridge construction are set up. For example, the site selection of mountain bridges needs to balance ecological protection and economic development. Students conduct decision-making deduction through multi-role play (engineers, villagers, environmental protection organizations).

(2) Measures such as warm-up videos of domestic and foreign bridges, small bridge demonstration experiments (with human participation in bridge construction), and bridge-related games are used to lead students into the "Journey of Exploring Bridges".

(3) Students can collect materials, give presentations titled "Let Me Talk About Bridges", and complete the first assignment that is not related to mechanical analysis.

3.2 Secret of Investigating Bridges-Technology Decoding Module

Students are guided to study various types of bridges together. This part mainly covers the structure, force transmission characteristics, and design of various bridge types. In addition, special sections for famous bridge appreciation, bridge aesthetics, red bridges, bridge construction, and bridge accidents are established; resource libraries such as MIDAS CIVIL, micro-bridge experiments, bridge competition database, bridge standard drawing database, and bridge specification database are built to lead students to explore the secrets of bridges.

3.3 Joy of Creating Bridges-Practical Innovation Module

Students are encouraged to make bridges by themselves to enhance the practicality of the course. This teaching model not only cultivates students' comprehensive abilities with both "hard technology" and "soft literacy" but also fosters an innovative ecosystem of "education feeding back the industry" in the integration of industry and education. It provides a replicable practical paradigm for the cultivation of bridge engineers in the era of intelligent construction.

4. Three Major Reform Implementation Plans

4.1 Strategy for Course Content Reorganization

In this reform of the “Bridge Engineering” course, the course content is redesigned, and a modular knowledge system is built, including a basic module, five expansion module sections (famous bridge appreciation section, bridge aesthetics section, red bridge section, bridge construction section, bridge accident section), and a resource library module.

(1) The original 8 chapters of teaching content in the basic module are reconstructed into four modules, namely, Overview of Bridges, Beam Bridge Structure, Beam Bridge Design, and Other Types of Bridges. The Overview of Bridges includes the basic composition and classification of bridges, planning and design procedures, and the functions of bridge structures. The Beam Bridge Structure covers slab bridges, beam bridges, bridge deck structures, supports, and piers. The Beam Bridge Design includes the design of main beams, bridge decks, and diaphragms. Other Types of Bridges include arch bridges, cable-stayed bridges, and suspension bridges.

(2) The five expansion module sections include: Famous Bridge Appreciation Section, Bridge Aesthetics Section, Red Bridge Section, Bridge Construction Section, and Bridge Accident Section.

(3) The resource library module includes: bridge software module, micro-bridge experiment database, bridge competition database, bridge standard drawing database, bridge specification database, and other resources.

4.2 Practical Model of “Course Entering Workshop”

By integrating the “Bridge Engineering” course into the workshop, project-based teaching is realized, and an intelligent workshop with “coexistence of virtual and real” is built. This closely combines theoretical knowledge with engineering practice, enhances students’ practical abilities and their ability to solve practical problems. For example, the teaching of the “Bridge Engineering” course is divided into two parts: classroom teaching and workshop teaching. In classroom teaching, students are guided to use MIDAS CIVIL, finite element analysis, and other tools for bridge analysis; in workshop teaching, students are required to complete the experimental design and construction tasks of a reinforced concrete micro-bridge analyzed in classroom teaching in groups, so as to cultivate their teamwork and communication skills. Students are required to complete the whole process from design to construction, which stimulates their innovative thinking and practical abilities.

4.3 Construction of Wechat Official Account

A dedicated WeChat official account for the “Bridge Engineering” course is established and applied to the interactive teaching of bridge engineering professional courses, so as to improve the shortcomings of traditional course teaching.

The unique value of this official account is as follows:

(1) Breaking the constraints of time and space: Students can obtain resources anytime and anywhere for fragmented learning. Through various interactive forms, students’ participation is enhanced, making

the official account an extension of the classroom.

(2) Stimulating learning interest: Cases, interactions, and stories are used to reduce the dullness of professional knowledge. This official account records images and shares stories to make the learning process more vivid. For example, it posts on-site photos and short videos of students conducting “bridge load tests” and “model making”; selects excellent bridge models, calculation reports, and CAD drawings, and attaches teachers’ comments.

(3) Connecting the classroom with the industry: It not only consolidates the theoretical foundation but also broadens the professional horizon. This official account is committed to providing cutting-edge, practical, and systematic knowledge content for bridge engineering students and enthusiasts, covering industry frontiers and technological innovations; it also provides past real exam questions, key points for the Registered Road Engineer examination, and guidelines for the National University Student Structural Design Competition.

5. Evaluation Plan

An evaluation method centered on the combination of diversification, process orientation, and timeliness is constructed. In the teaching evaluation reform of bridge engineering, this evaluation method, which combines diversification, process orientation, and timeliness, is taken as the core, aiming to comprehensively and scientifically evaluate students’ learning effects and ability development.

5.1 Diversified Evaluation Method

A variety of evaluation methods and indicators are adopted to comprehensively evaluate students’ mastery of knowledge, application of skills, and comprehensive quality, avoiding the limitations of a single test score. For example, multiple evaluation methods such as examinations, assignments, quizzes, group micro-bridge experiment project tasks, and PPT reports are used.

5.2 Process-oriented Evaluation Method

Emphasis is placed on the evaluation of the learning process. Through phased feedback and continuous improvement, students are helped to discover and solve problems in a timely manner, and their ability development is promoted. For example, real-time feedback on quiz scores and assignment evaluations is provided through the online learning platform. One-on-one tutoring or group discussions are used to help students solve problems in the learning process.

5.3 Timely Evaluation Method

Real-time or near-real-time evaluation methods are adopted to quickly feed back students’ learning effects and improve the timeliness and effectiveness of evaluation. For example, students receive their scores and explanations immediately after completing a quiz. A real-time question-and-answer system is used to collect students’ in-class feedback. The learning progress and knowledge mastery of students are analyzed through the data of the learning platform.

6. Conclusion

By using the above reform plans and adopting the three-stage progressive teaching model of "Exploring Bridges-Investigating Bridges-Creating Bridges", a trinity course system of "Culture-Technology-Innovation" is constructed. Ultimately, an engaging course centered on the core concept of "Discovering Your Beauty Through Bridges" is realized.

Funding

This paper sponsored by Teaching Research Project of Qingdao City University. Research on the Reform and Practice of the "Bridge Engineering" Course in the Digital and Intelligent Era. Project Number: 2025007B.

References

Liu, S. M., & Zhong, W. (2024). Exploration and Reform of the Teaching Model of the "Bridge Engineering" Course. *Technology Wind*, (25), 7-9.

Wu, A. J., & Wu, Y. (2024). Discussion on the Teaching Reform of the "Bridge Engineering" Course Based on Knowledge Graphs—Taking Guizhou Institute of Technology as an Example. *Education Observation*, *13*(30), 40-43.

Yang, Y. H. (2024). Research on the Reform of "Smart" Courses and Talent Cultivation Under the Background of Digitalization. Henan Private Education Association. In *Proceedings of the 2024 Higher Education Development Forum* (Volume 1, pp. 223-224). Chongqing Public Transportation Vocational College.

Ye, Y. F. (2018). Reform and Practice of the "Bridge Engineering" Course Based on the CDIO Concept. *Fujian Architecture and Construction*, (12), 106-108.