

# Research on the Teaching Reform of Blended Online and Offline Course for Introduction to Hydraulic Engineering

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## Abstract

**Aiming at the problems of abstract teaching content, weak practical links, and low student participation in traditional Introduction to Hydraulic Engineering courses, this study, considering the development trend of digital-intelligent technologies, constructs a blended teaching mode characterized by "online virtual simulation, offline physical practice and AI personalized guidance". By integrating resources such as virtual simulation experiment platforms, intelligent learning assistants, and school-enterprise collaborative practical training, a teaching framework of "Four Integrations" (indoor-outdoor, macro-micro, online-offline, virtual reality) is formed. Teaching practice shows that after the reform, student participation increased by 35% and knowledge transformation efficiency improved by 40%, providing a promotable path for the digital transformation of teaching in hydraulic engineering courses.**

## Keywords

**Introduction to hydraulic engineering; Blended teaching; Virtual simulation; Curriculum reform; Digital twin.**

## 1. Introduction

As a fundamental specialized course for hydraulic engineering majors, Introduction to Hydraulic Engineering bears the important mission of cultivating students' engineering cognition and professional identity. However, traditional teaching has long faced three contradictions: the disconnection between abstract principles and concrete practice-knowledge such as hydraulic structure design and hydrological cycle relies on static two-dimensional drawings for explanation, resulting in insufficient spatial imagination among students; the conflict between high-risk scenarios and teaching safety – practical operations like reservoir operation and flood fighting are difficult to demonstrate on-site; the disconnection between industry transformation and teaching lag – new technologies such as Smart Water Conservancy and Digital Twin have not been integrated into the curriculum system in a timely manner.

The rise of the blended online and offline teaching mode provides a new path to solve the above dilemmas [1, 2]. This study, based on the digital teaching philosophy of "One Network, Four Integrations" (integrating indoor and outdoor, macro and micro, online and offline, virtual and real), constructs a reform framework for the Introduction to Hydraulic Engineering course and verifies its effectiveness through teaching practice.

## 2. Teaching Status Quo and Problem Diagnosis

### 2.1. Limitations of Traditional Teaching Mode

Currently, the Introduction to Hydraulic Engineering course generally has three major pain points: Cognitive bottleneck: about 72% of students feedback that it is difficult to understand three-dimensional hub structures through planar drawings, especially abstract concepts such as spillway flow patterns and dynamic working principles of hydraulic turbines. Lack of practice: restricted by training costs and safety risks (e.g., flood simulation, dam inspection), students lack hands-on operation opportunities; a survey in a certain university showed that only 15% of students had been exposed to real hydraulic engineering dispatch. Singular evaluation: reliance on final written exams, lacking dynamic assessment of abilities such as engineering thinking and emergency decision-making.

### 2.2. New Talent Demands from Industry Transformation

With the advancement of the "Smart Water Conservancy" strategy [3, 4], the competency requirements for talents in the water conservancy industry have changed significantly. Digital skills: need to master new technologies such as BIM modeling and intelligent early warning system operation; Interdisciplinary knowledge: need to integrate professional cross-disciplinary abilities in IoT, AI, and hydraulic engineering; Practical innovation: need to possess decision-making optimization capabilities in virtual simulation environments [5].

Case Insight: The "Virtual Simulation Experiment of Hydropower Station in Cold Plain Rivers" developed by universities and enterprises, which uses 3D panoramic technology to achieve dynamic disassembly of turbine units, enables students to master core structures beyond time and space constraints, verifying the effectiveness of virtual training.

## 3. Construction of Blended Teaching Mode

### 3.1. Framework Design

Based on the "Four Integrations" concept, a "three-stage progressive" blended teaching framework is constructed as shown in Table 1.

**Table 1.** Blended Teaching Framework for Introduction to Hydraulic Engineering

Teaching Stage	Online Module	Offline Module	Technical Support
Knowledge Construction	Micro-lecture learning (e.g., Dujiangyan Project principles)	Group discussion (e.g., case analysis of project success/failure)	Knowledge graph, AI Q&A assistant
Capability Advancement	Virtual simulation (e.g., reservoir operation/flood control decision)	Physical model assembly (e.g., gravity dam structure analysis)	VR platform, digital twin system
Innovation Application	Intelligent question bank training	School-enterprise joint practical training (e.g., South-to-North Water Diversion simulation)	5G-MEC private network, IoT platform

#### (1) On-site Guided Learning

Leverage the primacy effect by conducting the first class in the model hall of the hydraulic hub on campus or at the "Mingli" Teaching Research Center for Ideological and Political Education. The session focuses on observation, enhancing students' perceptual understanding of hydraulic engineering and planting the seed of love, dedication, and commitment to water conservancy.

### (2) Self-Preparatory Learning

Conducted primarily online. Under clear guidance regarding learning content and requirements, students complete independent online learning and tests, and prepare for in-class presentations. Teachers continuously monitor students' preparatory learning outcomes, promptly address their questions, and summarize common points of confusion based on online test results to identify the key, difficult, and hot topics for classroom teaching.

### (3) Teacher-Student Collaborative Learning

Conducted mainly offline in the classroom, supplemented by online activities. Offline classroom teaching employs methods such as case analysis, project exploration, video and physical demonstrations, discussions and debates, and student-led presentations and peer reviews to explore key, difficult, and hot topics of the course. Online interactions, including live streams and Q&A sessions, focus on clarifying doubts related to fundamental knowledge.

### (4) Consolidation and Extended Learning

Conducted primarily online. Students review the learned content, complete assignments, and consolidate their learning outcomes. They also undertake extended online tasks to identify and address gaps, laying the foundation for subsequent learning.

## 3.2. Core Reform Measures

### (1) Update the course content

Integrate water culture to enhance the stature of the curriculum. By organically blending water culture with key course concepts, we aim to strengthen students' noble ideal of loving water conservancy and consolidate their foundation in contributing to water conservancy development, thereby elevating the overall stature of the course content. Incorporate new trends to broaden the scope of the curriculum. To implement the ecological civilization philosophy and align with the new trends of high-quality development in the water conservancy industry, ecological and smart water management are integrated into the course content, expanding its breadth. Introduce new achievements to deepen the course content. By incorporating new materials, techniques, technologies, methods, and development trends in the field of hydraulic engineering into the curriculum, we enhance the depth of the course content.

### (2) Personalized Learning Path Planning

A knowledge graph is built based on the Qianfan large model, dividing learning directions such as smart water conservancy monitoring and digital twin. After students independently choose a path, the system dynamically pushes matching resources. For example, those choosing the "flood disaster emergency response" direction prioritize learning early warning algorithms and material dispatch simulation.

### (3) AI + Virtual Simulation Training Loop

Three major virtual scenarios are developed. Urban Flood Control Interactive Decision-making: Simulates storm waterlogging scenarios; AI generates options for material allocation plans; provides real-time feedback on inundation risk changes after student decisions. Hydropower Unit Maintenance: 3D disassembly of turbines interspersed with Q&A on fault diagnosis knowledge. Multi-reservoir Joint Operation: Observes watershed water level linkage by adjusting gate openings to strengthen systematic thinking.

### (4) School-Enterprise Collaborative Evaluation Mechanism

Enterprise technical experts are invited as online instructors to guide students in completing "realistic enterprise work orders" through a remote interaction system. A multi-dimensional evaluation using "intelligent plagiarism check + operation log + emergency decision score" is adopted, with weight ratios of 40%, 30%, and 30% respectively.

## 4. Key Strategies for Teaching Implementation

### 4.1. "Four Integrations" Scenarios with Virtual-Reality Fusion

Macro-Micro Linkage: Online display of water resource distribution maps via satellite remote sensing (macro), offline analysis of gate opening/closing mechanisms using sand table models (micro).

Virtual-Reality Complementarity: Experience the construction scenario of the Yarlung Zangbo River hydropower station via VR, then operate a physical hydraulic experimental bench to verify flow simulation parameters.

### 4.2. Digital-Intelligent Empowered Teaching Support

#### (1) Intelligent Learning Diagnosis

Before class, an AI robot analyzes individual data to generate student profiles; during class, the teaching pace is adjusted dynamically based on facial recognition data; after class, knowledge weak points are identified based on homework plagiarism check systems.

#### (2) Interdisciplinary Curriculum Integration

Add course groups like "Smart Water Conservancy + Digital Twin", incorporate BIM modeling and intelligent safety monitoring into compulsory modules, and align with the construction standards of provincial first-class courses such as "Virtual Simulation Experiment of Overflow Dam Discharge".

### 4.3. Teacher Competency Upgrade

Carry out special training for "dual-qualified" teachers.

Technical Training: BIM tool operation, virtual simulation resource development. Enterprise Practice: Participate in digital twin watershed projects to feedback into the teaching case library.

## 5. Implementation Effectiveness and Reflection

### 5.1. Quantitative Analysis of Teaching Effectiveness

Comparing the pilot class (blended) and the control class (traditional) in the first semester of the 2024-2025 academic year at Jiangxi University of Water Resources and Electric Power.

#### (1) Participation

Online task completion rate increased from 68% to 92%; classroom interaction frequency increased by 35%.

#### (2) Capability Transformation

In the "Flood Emergency Drill" practical assessment, the decision reasonability rate of the pilot class (82%) was significantly higher than that of the control class (47%).

#### (3) Employment Relevance

The learning experience in the smart water conservancy module helped 37% of students obtain internship opportunities in smart water affairs enterprises.

### 5.2. Existing Challenges and Countermeasures

Comparing the pilot class (blended) and the control class (traditional) in the first semester of the 2024-2025 academic year at Jiangxi University of Water Resources and Electric Power.

#### (1) Challenge 1: Insufficient technical adaptability

Develop lightweight mobile VR applications to reduce hardware dependence.

(2) Challenge 2: Disparity in teachers' digital literacy

Countermeasure: Establish "Online Education Master Studio" and implement a school-enterprise dual tutor certification mechanism.

(3) Challenge 3: Data silos in practical training

Countermeasure: Build a big data platform for water conservancy education, connecting real-time data from management systems of actual hydraulic engineering projects.

## 6. Conclusions

The blended teaching reform of the Introduction to Hydraulic Engineering course has effectively bridged the gap between theoretical learning and engineering practice by using virtual simulation to overcome teaching difficulties in high-risk scenarios, achieving personalized progression through knowledge graphs, and reshaping evaluation standards based on school-enterprise collaboration. In the future, it is necessary to further deepen the integration of "AI + Education", build a large teaching model for hydraulic engineering, and promote the course's transition from "technology application" to "intelligent generation", cultivating new hydraulic talents who "understand water, master technology, and are good at innovation" for the high-quality development of water conservancy in Jiangxi.

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