Research on the Virtual Practical Teaching System in Ocean Engineering Project Management Based on Digital Intelligence

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Abstract. This research focuses on the construction and application of a virtual practice teaching system for the course "Ocean Engineering Project Management," driven by digital intelligence empowerment. Against the backdrop of educational digitalization, the study addresses the limitations of existing teaching methods by integrating digital-intelligent technologies, such as digital twins, AI simulation, big data analytics, and cloud computing—into teaching practices. A project-based teaching system that deeply integrates workshop and digital-intelligent approaches is proposed, establishing a multi-level practical teaching platform. The system enhances the connection between professional knowledge and engineering practice, cultivates students' core competencies in intelligent management and collaborative decision-making, and strengthens their awareness of maritime power strategy and engineering ethics. Additionally, a data-driven, multi-stakeholder evaluation mechanism is introduced to comprehensively assess students' abilities. The study also develops digital teaching resources and supports faculty capacity building, providing a replicable model for the reform of engineering education in the digital intelligence era.

Keywords: Ocean Engineering Project Management, Digital Intelligence Empowerment, Virtual Practice Teaching, Digital Twin, Teaching Reform

1 Introduction

1.1 Analysis of the Current State of Research

Digital and intelligent empowerment in teaching research focuses on upgrading teaching environments and auxiliary tools. It applies technologies such as the Internet of Things, cloud computing, big data, artificial intelligence, and mobile Internet to the construction of smart teaching, connecting the entire process of teaching design, implementation, and evaluation. It promotes the variant transformation of disciplinary paradigms, effectively realizes the reform of teaching methods through the research and

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practice of new teaching models, enhances teachers' digital application capabilities in education, and facilitates students' deep learning and personalized learning.

With the advent of the digital and intelligent era, the teaching methods required for the course "Ocean Engineering Project Management" have undergone profound changes[1]. Relying on digital twin technology to build high-fidelity ocean engineering scenarios, the full-process immersive teaching method for ocean engineering project management is realized through dynamic data-driven (changes in progress, cost, and resources), multi-role collaborative interaction (online decision-making by owners, shipyards, and suppliers), and an AI risk simulation engine[2].

However, existing research is limited to the analysis of single links and does not cover the entire life cycle of ocean engineering projects[3]. Therefore, exploring the virtual practical teaching system of ocean engineering project management driven by digital and intelligent empowerment aims to provide theoretical support and practical paths for the digital and intelligent empowerment of university teaching services[4].

Current relevant teaching platforms fail to realize full-life-cycle collaborative management simulation from project initiation to delivery; lacking quantifiable risk random triggering function and data automatic collection for formative evaluation, which becomes the core motivation of this research.

1.2 Research Significance and Implications

1) It helps achieve the in-depth integration of curricula with digital and intelligent technologies, establish a closed-loop teaching model covering "theory-virtual deduction-management decision-making," and solve the practical dilemma that traditional offline teaching cannot launch large-scale full-cycle project training due to ultra-high construction cost and unpredictable safety risk of real marine projects deepen students' skill transfer in the full-cycle digital management and control of ocean engineering projects through dynamic twin platforms.

2) It helps cultivate students' core skills in intelligent management, trains them to master three key capabilities—data-driven resource coordination and optimization, multi-objective dynamic decision-making, and uncertain risk deduction—and strengthens their systematic management literacy in complex ocean engineering scenarios.

3) Establish a dedicated digital and intelligent resource hub for the course, and develop a parameterized ocean engineering management case library (covering offshore platform project planning and implementation, risk management, etc.).

4) Promote the capacity transformation of the teaching team, enable teachers to master new skills such as virtual project management training design, dynamic data teaching analysis, and intelligent evaluation tool development, and empower the continuous iteration of curriculum teaching reform.

2 Research Subjects and Content

2.1 Establish Reform Measures for Teaching Methods

Project-Based Teaching System Integrating Workshop and Digital-Intelligent Approaches.

To address the long-standing challenges in the teaching of the traditional Naval Architecture and Ocean Engineering program, such as the disconnect between theory and practice and the lag of technological application behind industrial development. This paper constructs a three-dimensional teaching system for the course "Ocean Engineering Project Management" featuring "workshop-based scenario carrying, digital-intelligent tool empowerment and project-driven task motivation." Relying on a cluster of high-fidelity practical workshops, including core scenarios such as the full-process simulation workshop for digital twin shipyards, the intelligent supply chain collaborative management training module, and the marine structure operation and maintenance simulation center, the system fully introduces an industrial-grade matrix of digital and intelligent tools. These tools encompass the ocean engineering structure parametric design platform, the full-lifecycle digital twin management system, the ocean engineering big data analysis platform, and the intelligent simulation analysis suite, creating a multi-level learning platform that ranges from basic training to comprehensive innovation[5].

Taking 12000TEU container ship newbuilding as standard teaching case, students are divided into 6-person groups with differentiated posts: shipowner, design institute, shipyard, component supplier, supervision bureau and maritime administration. The whole teaching task is split into six standardized phases: project approval, preliminary design, detailed design, site construction management, completion acceptance and post-project evaluation. During construction simulation, the built-in AI engine randomly inserts practical abnormal incidents including raw material price surge, typhoon shutdown and component unqualified defects, requiring groups to revise schedule and cost scheme within limited operation time; digital twin module synchronically feeds back the consequence of decision adjustment.

Through immersive teaching integrating virtual and physical elements, students master core theories such as structural mechanics of naval architecture and ocean engineering, and design principles of ships and offshore platforms. Simultaneously, basic operation training of digital-intelligent tools is conducted to ensure proficient use of design software for 3D modeling and parametric adjustment. Taking typical ocean engineering scenarios as carriers, the focus is on training student core skills, such as using intelligent design software for structural optimization, leveraging simulation analysis systems for wind and wave load simulation and performance verification, and conducting fault diagnosis and early warning through intelligent operation and maintenance platforms.

Through this system, students not only systematically grasp core knowledge in ocean engineering project management—including scope management, schedule control, cost accounting, and quality control—but also deeply practice the application logic of digital-intelligent technologies in engineering fields. They use big data analysis tools to mine fault patterns from operation and maintenance data, optimizing preventive maintenance strategies. Ultimately, the system achieves the in-depth integration of professional knowledge and digital-intelligent technologies, significantly enhancing the job adaptability in emerging industries such as intelligent ships, ocean engineering equipment manufacturing, and offshore wind power, as well as their ability to innovatively solve complex engineering problems.

In-Depth Integration of Curriculum Ideology and Politics Empowered by Digital-Intelligence.

Based on the industrial attribute of ocean engineering as a "national strategic pillar," we first clarify the three-dimensional value orientation in the teaching objective system: strengthening the awareness of building a maritime power at the national strategic level, implanting the concept of green and low-carbon development at the industrial development level, and consolidating the bottom line of engineering ethics at the professional literacy level. These value objectives are deeply coupled with digital-intelligent teaching links, forming a new paradigm of ideological and political teaching characterized by "intelligent scenario penetration, data-driven deduction and dynamic feedback enhancement."

For example, in the digital twin shipyard workshop, digital models of "national strategic pillars" such as China's independently developed large cruise ships and deep-sea drilling platforms are embedded, allowing students to intuitively perceive the development history and technological breakthroughs of China's ocean engineering industry through design comparisons. In the supply chain management module, simulation tasks such as logistics support for polar scientific research materials are set to guide students to reflect on the supporting role of ocean engineering technology in national strategies.

For instance, the big data analysis platform is used to present data on the impact of different ocean engineering schemes on the marine ecological environment, and students are organized to debate around "the balance between technological optimization and ecological protection". The intelligent decision-making system simulates scenarios of safety risk trade-offs in engineering construction, strengthening the engineering ethics awareness of safety of the students. By analyzing data such as students' scheme choices, team collaboration performance, and ethical debate speeches in project tasks, a personalized I&P literacy assessment report is generated. An online test question bank is designed for core values such as the awareness of building a maritime power and the concept of green development, and dynamic assessment is conducted in combination with project practice performance.

Through this integrated model, the integration of professional skill training and value guidance is achieved. In the process of using digital-intelligent technologies to solve practical ocean engineering problems, students not only improve their technical capabilities but also deeply understand the national mission and social responsibility of the ocean engineering major, and establish the professional belief of serving the country through technology and pursuing green development[6].

Data-Driven Diversified and Multi-Stakeholder Assessment System.

To break through the limitations of traditional teaching evaluation, such as "prioritizing results over processes" and "valuing knowledge over capabilities," a data-driven, multi-dimensional, and multi-stakeholder assessment system centered on "competency achievement" is constructed to achieve comprehensive and accurate evaluation of students' comprehensive literacy. Supported by a digital-intelligent assessment platform, the system integrates three core modules: process data collection, multi-dimensional competency analysis, and multi-evaluator participation, covering all process competency dimensions of ocean engineering project management.

The digital-intelligent platform automatically collects students' design scheme data, simulation result data, modification and iteration records, etc. By comparing industry standards and excellent cases through pre-set algorithm models, it generates competency achievement analysis reports. Quarterly phased scheme optimization tests based on the platform are conducted, setting complex scenarios such as "ocean engineering emergency fault handling" and "economic optimization of design schemes." The platform records real-time process data of students using digital-intelligent tools to solve problems, evaluating their emergency response capabilities and technical application abilities. For team collaboration tasks, a team collaboration behavior analysis module is developed to objectively assess students' teamwork and leadership skills by recording data such as task allocation, communication frequency, and contribution degree of team members.

To strengthen the feedback and improvement functions of evaluation, the digital-intelligent assessment platform generates personalized learning diagnosis reports and pushes targeted training resources for students' weaknesses in each link. A linkage mechanism between evaluation results and teaching improvement is established: by analyzing the competency achievement data of all students, teaching content and training scenarios are optimized. Through this system, a closed-loop management of "promoting learning through evaluation and improving teaching through evaluation" is realized, comprehensively enhancing students' comprehensive literacy and post competitiveness[7,8].

2.2 Establish Innovative Teaching Concepts

Digital-Intelligent Driven and Student-Centered Teaching Framework.

In the Ocean Engineering Project Management course, student development is taken as the core, and precise grasp of students' learning status and needs is achieved through digital-intelligent empowerment. By leveraging intelligent learning portfolios, online collaboration platforms, and AI teaching assistant tools, personalized learning path recommendations and dynamic feedback are realized. The teaching process deeply integrates project-oriented and engineering-based knowledge points. Through digital scenario simulation, virtual workshop practice, and intelligent interactive Q&A, students' ability to actively think, explore, and solve real ocean engineering project management problems is stimulated, significantly enhancing their autonomy and participation.

Curriculum Philosophy Integrating Digital-Intelligent and Workshop Approaches.

Based on the project experience accumulated by the research team, digital and intelligent elements are organically integrated into the course. In light of students' personalized competence characteristics, modern information technologies are fully applied in teaching practice. Through these means, students are encouraged to actively participate in classroom activities, their learning interest is boosted, and the all-round development of their comprehensive abilities is promoted[9].

Digital-Intelligent Empowered Mechanism for Integrating Curriculum Ideology and Politics into Talent Cultivation.

Ideological and political elements in ocean engineering project management are thoroughly explored and presented in a digital form, constructing an intelligent ideological and political case library and a standard database. Through intelligent matching, core ideological and political content—such as abiding by laws and regulations, industry standards, and promoting the craftsman spirit—is organically integrated into the entire chain of digital-intelligent teaching, including online learning, virtual simulation, and project collaboration. By utilizing intelligent analysis of digital engineering cases and standardized processes, students' patriotic feelings are effectively aroused, national confidence and engineering ethics awareness are strengthened, and their rigorous and dedicated professional qualities as well as awareness of abiding by laws and norms are cultivated in immersive digital-intelligent practices[10].

2.3 Establish Course Resources

First, establish a diversified digital teaching resource library, collect and organize various engineering cases to ensure students have access to a wide range of practical cases and enhance their practical application capabilities, as shown in Fig. 1.

Second, promote the development of digital-intelligent software and teaching platforms. Build a digital teaching platform to support students' independent operation and practice during the course. Develop or utilize existing online learning platforms to establish channels for course learning and resource sharing, providing functions such as online assignment submission, real-time interaction, and answering questions.

In addition, focus on improving digital-intelligent teaching capabilities and systematically carry out teaching team development. Conduct regular dynamic training for teachers on modern teaching technologies (such as AI-assisted design, data analysis tools, and the application of virtual simulation platforms) to effectively enhance their abilities in digital-intelligent curriculum design, intelligent resource development, and precise analysis of students' learning status. Simultaneously, leverage intelligent knowledge bases and sharing platforms to realize the collaborative evolution and efficient sharing of curriculum resources and teaching wisdom[11].

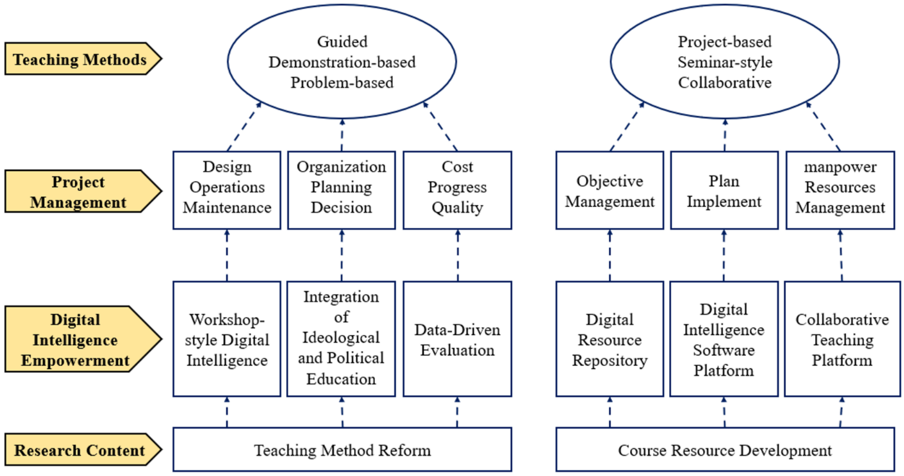

Fig. 1. Construction of Teaching Models Driven by Digital Intelligence Empowerment

3 Research Objectives

1) Form a Project-Based Teaching System with In-Depth Integration of "Workshop and Digital-Intelligent Approaches"

By integrating workshop environments such as virtual simulation laboratories and intelligent training bases with digital-intelligent tools including intelligent design platforms and digital twins, a multi-level practical teaching platform is established. The goal is to achieve seamless connection between professional knowledge, digital-intelligent technologies and engineering practice, and enhance students' comprehensive capabilities in solving complex problems in the field of intelligent ships and ocean engineering[12].

2) Form a Full-Chain Talent Cultivation Model of Curriculum Ideology and Politics Empowered by Digital-Intelligence

Ideological and political elements such as the awareness of building a maritime power and the concept of green and low-carbon development are systematically integrated into curriculum objectives, content design and teaching methods. Through case discussions, policy interpretation and other approaches, students' sense of social responsibility and professional norms are strengthened, realizing the organic unity of professional skill training and value shaping.

3) Form a Digital-Intelligent Driven Diversified and Dynamic Competence Evaluation Mechanism

Construct a process-oriented evaluation system covering multiple dimensions such as project design, digital-intelligent platform operation and team collaboration. Introduce self-evaluation and mutual evaluation mechanisms to comprehensively assess students' innovative thinking, technology application and ability to solve complex engineering problems, driving the improvement of their overall quality.

4) Form a Digital Teaching Resource and Faculty Support System

Develop a digital teaching resource library and intelligent software platforms to support students' independent practice. Meanwhile, through interdisciplinary faculty training and collaboration mechanisms, teachers' digital-intelligent technology application capabilities and curriculum development levels are improved, ensuring the sustainable advancement of teaching reform[13]. The research objectives are shown in Fig. 2.

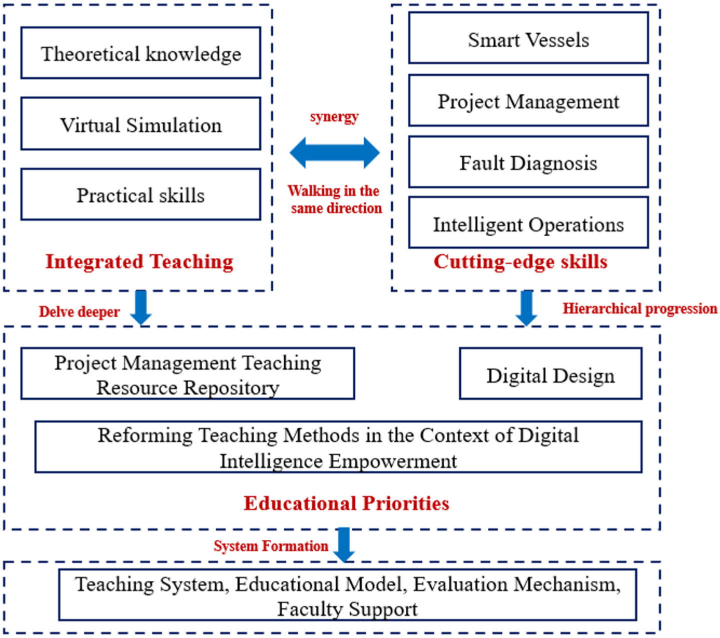

Fig. 2. Research Objectives

4 Primary Issues to be Addressed

First, address the issue of how to break through the disconnect between traditional teaching and digital-intelligent practice. Technologies such as intelligent design and digital twins in the marine equipment field require in-depth hands-on training, yet existing teaching lacks an effective integration path between real project carriers and digital-intelligent tools. Design workshop projects that combine virtual and physical elements to form a closed loop from principle cognition to intelligent decision-making, and develop digital-intelligent tools suitable for teaching scenarios.

Second, resolve the problem of how to establish dynamic competence evaluation standards and tools. Traditional evaluation systems fail to quantify the ability to solve complex engineering problems and the level of digital-intelligent technology application, and formative evaluation lacks an operable indicator system. It is necessary to construct a hierarchical competence evaluation model and develop embedded evaluation tools for digital-intelligent platforms.

5 Conclusion

In summary, this research systematically explores the construction and application of a virtual practice teaching system for "Ocean Engineering Project Management" driven by digital intelligence empowerment. The main findings and contributions can be summarized as follows:

1) A project-based teaching system that deeply integrates workshop approaches with digital-intelligent tools has been formed. It establishes a multi-level practical teaching platform, achieving a seamless connection between professional knowledge, digital-intelligent technology, and engineering practice, thereby enhancing students' comprehensive ability to solve complex problems.

2) A full-chain talent cultivation model for curriculum ideology and politics empowered by digital-intelligence has been constructed. It systematically integrates ideological and political elements into the teaching process, realizing the organic unity of professional skill training and value shaping.

3) A digital-intelligent driven, diversified and dynamic competency evaluation mechanism has been established. This process-oriented system covers multiple dimensions and introduces self- and peer-assessment, comprehensively assessing students' innovative thinking and practical abilities.

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