

Reconstruction of the “New Horizons in Ship and Ocean Engineering” Course under the Dual Integration of Industry–Education and Science–Education: A Case Study of Jiangsu Ocean University

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Abstract: In the context of New Engineering education, talent cultivation in Ship and Ocean Engineering requires stronger engineering competence and practical ability. To address the limitations of traditional introductory courses, this study proposes a curriculum reconstruction approach based on the dual integration of industry–education and science–education. Using the course “New Horizons in Ship and Ocean Engineering” as a case study, the curriculum is reorganized into three modules: intelligent ship manufacturing, unmanned surface vehicles, and autonomous underwater vehicles. Industry–education integration introduces engineering scenarios and tasks, while science–education integration incorporates research problems and technological evolution. The results show that this approach improves students’ professional cognition, learning motivation, and engineering awareness, providing a reference for application-oriented universities.

1. Introduction

Under the multiple backgrounds of the maritime power strategy, the construction of New Engineering disciplines, and the connotative development of higher education, the cultivation of talents in Ship and Ocean Engineering is undergoing a paradigm shift from “knowledge transmission” to “capability generation.” With the rapid advancement of electrification transformation in the shipbuilding industry and the continuous deepening of industrial transformation, higher requirements have been put forward for practitioners’ engineering practice ability, interdisciplinary thinking, and innovative quality. Meanwhile, curriculum reform at home and abroad shows a trend toward systematization, project-based organization, and digitalization, increasingly emphasizing outcome-based teaching and addressing the structural contradiction between the supply side of talent cultivation and the demand side of industry through university–enterprise collaboration. In this context, the integration of industry and education and the integration of science and education have become key pathways for deepening teaching reform and responding to new demands in talent

cultivation [1]. As a provincial first-class application-oriented undergraduate university, Jiangsu Ocean University urgently needs to base itself on regional industrial demands and its own institutional positioning to actively explore curriculum reform practices that align with the characteristics of application-oriented talent cultivation.

Industry–education integration focuses on addressing the practical concerns of “how to use knowledge” and “where to use knowledge.” By introducing job tasks, engineering cases, and enterprise scenarios, it precisely aligns teaching content with industrial needs, aiming to clarify how knowledge is applied and where it can be utilized [2]. Science–education integration, on the other hand, focuses on answering the logical questions of “why knowledge should be learned” and “where knowledge comes from.” By leveraging research projects, cutting-edge technologies, and research platforms, and relying on disciplinary frontiers and the development of knowledge systems, it reveals the formation background and development logic of knowledge, aiming to respond to the value of learning and the origin of knowledge [3].

The dual-path logic of industry–education integration and science–education integration is illustrated in Figure 1.

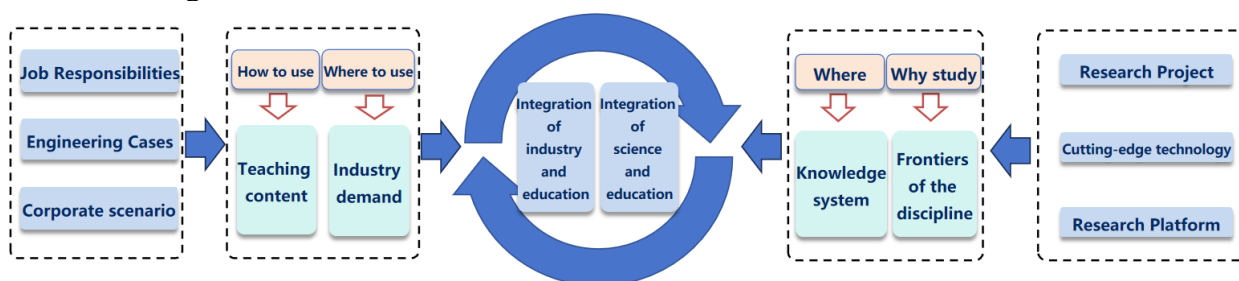


Figure 1: Dual-Engine Talent Cultivation through Integration of Industry and Education and Integration of Science and Education

Based on the above analysis, for local undergraduate institutions, promoting industry–education integration and science–education integration requires a clear understanding of differences in institutional foundations and student characteristics, avoiding the simple transplantation of training models from research-oriented universities. In the construction of Ship and Ocean Engineering programs, if institutions deviate from their own positioning and mechanically adopt models emphasizing theoretical deduction and high-threshold scientific research, students are likely to fall into the dilemma of “weak theoretical foundation and insufficient engineering practice,” making it difficult to effectively stimulate intrinsic learning motivation [4]. Therefore, application-oriented undergraduate institutions must base themselves on students’ cognitive starting points and adaptively transform industry–education integration and science–education integration: decomposing frontier scientific achievements into understandable knowledge maps. Only in this way can the effective connection between application-oriented talent cultivation goals and the teaching reality of local institutions be achieved.

For introductory courses such as “New Horizons in Ship and Ocean Engineering,” which undertake the function of professional cognition introduction, this paper takes the School of Ocean Engineering of Jiangsu Ocean University as an example to explore a learning outcome-oriented curriculum content reconstruction scheme. The reform adopts industry–education integration and science–education integration as dual implementation paths. The former breaks through the boundary between industrial scenarios and classroom teaching, while the latter connects research achievements with teaching content. The two work collaboratively to support the achievement of course objectives. Industrial demands and research progress are organically integrated into the teaching design of each module. The reform aims to bring industrial scenarios into classrooms, incorporate research

achievements into teaching materials, and embed engineering awareness into students' cognition, thereby effectively enhancing students' professional identity, learning interest, and preliminary engineering practice awareness, and providing a practical reference for curriculum reform of Ship and Ocean Engineering introductory courses in local universities[5].

The overall structure of the course content reconstruction plan is shown in Figure 2.

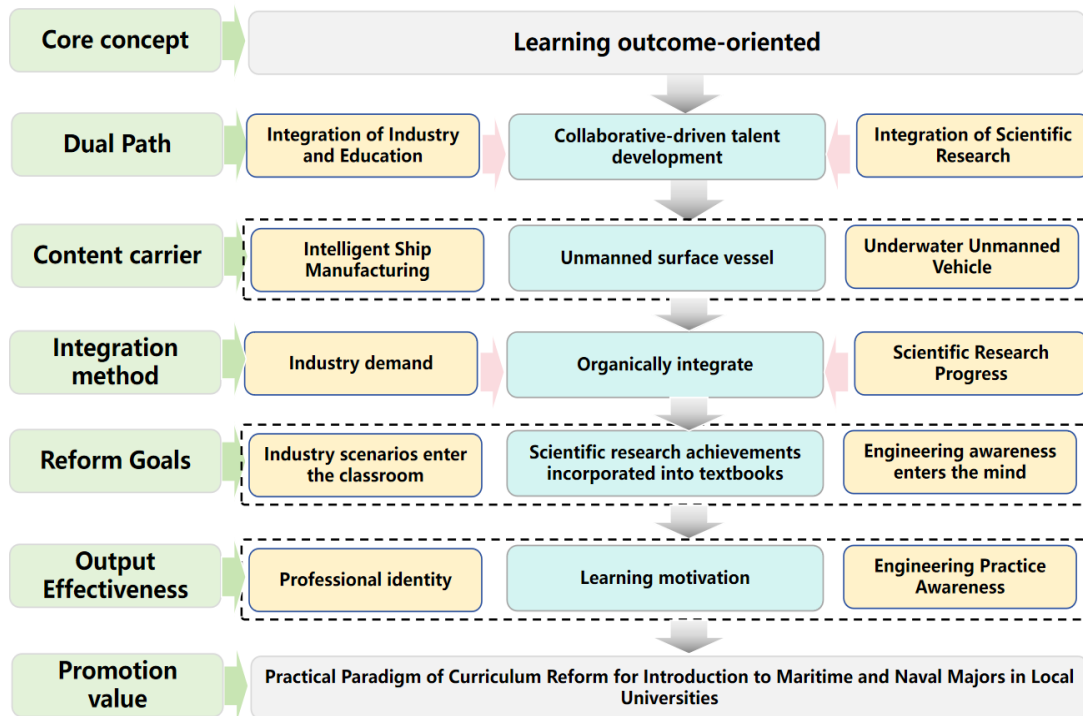


Figure 2: Structure of the Course Content Reconstruction Plan for 'New Horizons in Shipping and Maritime'

2. Current Situation and Main Problems of the Course

2.1. Practical Difficulties in Original Teaching

As an introductory course for the Ship and Ocean Engineering major, “New Horizons in Ship and Ocean Engineering” plays an important role in helping students establish professional cognition, stimulate learning interest, and initially understand the industry landscape. However, upon reviewing traditional teaching practices, the following three prominent problems generally exist:

The teaching content is broad but not in-depth, and professional cognition remains superficial. Traditional introductory courses mostly adopt a “general overview” arrangement, pursuing breadth of knowledge coverage while neglecting deep connections with industrial practice. Course content is often presented in parallel according to disciplinary branches. Although students gain a rough impression of ship types and marine structures after completing the course, they find it difficult to answer practical career-related questions such as “where this knowledge will be used in the future” and “how it will be applied,” resulting in professional cognition remaining at a superficial level.

Knowledge presentation emphasizes conclusions over processes, making it difficult to stimulate learning interest. Existing teaching methods directly present mature knowledge conclusions, lacking explanations of the background and development process of knowledge formation. Students know the results but not the underlying reasons, and find it difficult to understand “why these knowledge should be learned” and “how these knowledge are generated.” As a result, the inspirational function

of the course is not fully realized, and students' learning motivation mainly stems from credit requirements rather than intrinsic interest.

There is a mismatch between course positioning and institutional characteristics, and the application orientation is not sufficiently prominent. When offering such courses, institutions often directly adopt the standards and content frameworks of research-oriented universities, ignoring differences in institutional positioning and student cognitive foundations. Excessive theoretical teaching, insufficient engineering scenarios, and high-threshold research cases that are far removed from undergraduate cognition result in a mismatch between course content and students' "zone of proximal development," leading to unsatisfactory teaching outcomes.

2.2. Reconstruction Based on the Dual Path of Industry–Education Integration and Science–Education Integration

To address the above problems, this course proposes a reconstruction approach based on the dual path of industry–education integration and science–education integration, aiming to break the separation between teaching content and industrial demand, as well as between knowledge transmission and knowledge generation, and to construct a new curriculum content system characterized by "application-oriented and logically coherent" features.

The industry–education integration path emphasizes anchoring teaching content in real industrial needs. By sorting out typical job task systems in the field of Ship and Ocean Engineering, extracting corresponding knowledge points and competency requirements, transforming job tasks into teaching tasks, and converting engineering scenarios into learning contexts, students are enabled to clearly perceive the application scenarios and value orientation of knowledge before entering core professional courses.

The science–education integration path emphasizes injecting logical depth into teaching content. By introducing frontier developments in the discipline, technological evolution processes, and real research problems from teachers' scientific research projects, static knowledge conclusions are transformed into dynamic exploration processes, guiding students to understand "why knowledge is generated" and "where it will develop," thereby establishing a sense of historical depth and future direction of professional knowledge.

These two paths are not parallel but mutually integrated. Industry–education integration provides an "application outlet" for knowledge, answering the question of where knowledge is applied, while science–education integration provides a "logical source," answering where knowledge originates. Through their collaborative effect, students are expected to establish an organic connection among professional knowledge, industrial application, and disciplinary development at the initial stage of learning.

2.3. Construction of a Modular Curriculum Framework

Based on the above reconstruction ideas, the course team focused on the cutting-edge development directions in the field of ship and ocean engineering and established three major content modules: intelligent ship manufacturing, surface unmanned ships, and underwater unmanned vehicles. Each module organizes teaching content according to the dual clues of "integration of industry and education to anchor application scenarios, integration of science and education to connect knowledge logic".

The corresponding framework is shown in Table 1.

Table 1: Correspondence between Course Content Modules of 'New Horizons in Maritime Studies' and Dual Pathways

Serial Number	Content Module	Integration of industry and education	Integration of science and education
1	Intelligent Ship Manufacturing	Hull Designer: hull form lofting, structural specification verification, and section division; General Arrangement Engineer: compartment division, equipment layout, and passage planning; Marine Engineer: main engine selection, shaft line arrangement, and engine room equipment configuration; Digital Process Simulation Engineer: sectional hoisting simulation, virtual production line debugging, and process optimization.	Research Progress: The evolution of ship digital twins from geometric modeling to multi-physics simulation; process simulation and virtual commissioning technology in intelligent shipyards; AI-based ship design optimization and performance prediction methods. Knowledge Logic: The paradigm shift in ship design from 2D drawings to 3D digital prototypes; the driving mechanism of modular design on construction efficiency.
2	Unmanned water surface vessel	Unmanned Surface Vehicle System Integration Engineer: Overall integration and debugging of the hull platform and mission payload; Autonomous Navigation Algorithm Engineer: Integration and testing of perception-planning-control algorithms and verification on actual vessels; Sensor Fusion Engineer: Selection, matching, and layout optimization of navigation radar, vision, and inertial navigation; Shore-Based Monitoring Operator: Mission planning, real-time monitoring, and data return operations.	Research Progress: Motion modeling and high-precision state estimation methods under surface water environmental disturbances; autonomous decision-making and planning technologies oriented towards international maritime collision avoidance rules. Knowledge Logic: The logical progression of autonomous navigation capabilities from trajectory keeping to intelligent collision avoidance; the impact mechanism of surface communication availability on collaborative control strategies of unmanned boats.
3	Underwater unmanned vehicle	Pressure-resistant Structural Engineer: Strength verification of pressure-resistant housings and key sealing process points; Propulsion System Engineer: Selection of propulsion motors, propeller matching, and vector propulsion layout; Deployment and Recovery Operator: Surface deployment, underwater docking, and emergency recovery operations.	Research Progress: Integrated navigation and simultaneous localization and mapping technology under underwater conditions without GPS; collaborative control and information interaction strategies in acoustically constrained underwater communication environments Knowledge Logic: The technological generational leap from manned submersibles to unmanned autonomous vehicles; the scientific question tracing of multi-source information fusion and intelligent compensation methods arising from underwater navigation challenges.

The three major modules, from near to far, from shallow to deep, respectively correspond to the digital upgrade of the shipbuilding industry, the intelligent evolution of surface unmanned systems, and the cutting-edge exploration of deep-sea equipment. They not only cover the mainstream direction of industry development, but are also highly consistent with the location advantages and scientific research characteristics of Jiangsu Ocean University.

3. Path to Integration of Industry and Education

The core of the integration of production and education lies in transforming industrial demand into teaching content and transferring engineering scene into learning situation. Around the three modules, the course team selects typical post tasks and engineering scenes respectively, and reduces them to perceptual and participatory learning tasks, so that students can touch the pulse of the industry at the beginning of enrollment.

3.1. Building Modules: Taking the Design Position as the Traction, Perceive the Whole Process of Design and Construction

This module selects core positions such as hull designers, general arrangement engineers, and marine engineers as the entry point, and introduces typical design documents such as line drawings, general arrangement drawings, and engine room layout drawings, as well as segmented construction process image data of cooperative shipyards. The course takes "New Concept Bulk Carrier Concept Plan Design" as the overall task, and guides students through the four progressive links of demand interpretation, general arrangement drawing recognition, profile line reading, and engine matching, and initially perceives the evolution process of the ship from concept to drawings through role play and scheme comparison.

3.2. Boat Module: Taking System Integration as the Main Line, Experience from Components to Complete Machine

This module focuses on two key scenarios: system integration and autonomous navigation debugging, and corresponds to three typical positions: system integration engineer, sensor fusion engineer, and autonomous navigation algorithm engineer. The course introduces industrial elements such as the unmanned boat assembly and joint debugging process, sea trial measured data and shore-based monitoring interface, and designs three progressive tasks: first, component recognition and matching; second, system composition puzzle; third, sea trial data analysis.

3.3. Traveler Module: Focusing on Pressure Resistance and Deployment, Understanding the Special Constraints of the Deep Sea

This module selects the two most recognizable deep-sea equipment scenarios, pressure-resistant structure design and deployment and recovery operations, and corresponds to three typical positions: pressure-resistant structure engineer, deployment and recovery operator, and propulsion system engineer. The course introduces the pressure-resistant housing drawings, cross-sectional diagrams of sealing structures, and AUV lake and sea trial video materials. Learning tasks are designed around the two themes of 'pressure resistance' and 'deployment': pressure experience, identifying sealing defects, and deployment scenario simulation.

The logic chain of industry–education integration across the three modules is summarized in Table 2.

Table 2: Logic Chain of Industry-Education Integration

Content Module	Industrial elements	Corresponding position	Learning task	Teaching Objectives
Intelligent Ship Manufacturing	Profile drawing, general arrangement drawing, engine room arrangement drawing Segmented construction process images	Hull Designer General Arrangement Engineer Marine Engineer	① Requirement Interpretation ② General Layout Reading ③ Profile Line Reading ④ Engine Matching	Perceiving Ship Design and Construction Full Process
Unmanned Surface Vehicle	Final Assembly Integration Process Sea Trial Measured Data Shore-Based Monitoring Interface	System Integration Engineer Sensor Fusion Engineer Autonomous Navigation Algorithm Engineer	① Component recognition and matching ② System composition puzzle ③ Test flight data analysis	Understanding Unmanned Surface Vehicle Systems: Composition and Closed-Loop Control
Underwater unmanned vehicle	Pressure-resistant housing drawings Sealed structure sectional drawings Autonomous vehicle lake test and sea test footage	Pressure-Resistant Structural Engineer Deployment and Recovery Operator Propulsion System Engineer	① Pressure experience ② Sealed spot-the-difference ③ Cloth placement scenario simulation	Understanding Deep-Sea Equipment Special Engineering Constraints

4. Paths to the Integration of Science and Education

The core of integrating scientific research and education lies in transforming research advantages into teaching resources and restoring the process of knowledge production to the logic of knowledge transmission. The course team centers around three major modules, selecting topics from faculty research projects that highly match the teaching content, and breaking them down into a three-link teaching logic chain of 'research problem → knowledge principle → technical application,' as shown in Table 3. The Intelligent Ship Manufacturing module uses the topic 'Hull Form Optimization and Resistance Prediction' as a prototype, guiding students to start from the question 'how to make ships more fuel-efficient,' understand the composition of ship resistance and the principle of bulbous bow resistance reduction, and then compare the resistance prediction results of different hull form schemes. The Surface Unmanned Vessel module uses the topic 'Autonomous Berthing and Unberthing Control of Unmanned Boats' as a prototype, focusing on the scenario 'how an unmanned boat docks smoothly,' introducing the basic idea of feedback control, and demonstrating the engineering implementation of control strategies through experimental test trajectories. The Underwater Unmanned Vehicle module uses the topic 'AUV Wave-Compensated Deployment and Recovery' as a prototype, addressing the problem 'how to safely recover an AUV in wind and waves,' explaining the principles of relative motion compensation and hydraulic servo control, and showing the structural scheme of the wave-compensation device and the results of sea trials. Through this transformation, scientific research results are no longer a 'black box' beyond undergraduate understanding, but teaching stories that can be deconstructed, narrated, and understood, realizing the integration of scientific research and education from concept to classroom, as summarized in Table 3.

Table 3: Logic Chain of Integration of Science and Education

Content Module	Research question	Principles of Knowledge	Learning task
Intelligent Ship Manufacturing	How to make ships more fuel-efficient?	Components of ship resistance; Principle of bulbous bow drag reduction	Hull Form Optimization Scheme Comparison and Resistance Prediction
A boat without water or people	How does an unmanned boat dock smoothly?	Feedback control concept; Deviation detection and correction	Berthing Trajectory Planning and Real-Ship Control Verification
Underwater unmanned vehicle	How to safely recover an autonomous vehicle in rough seas?	Relative motion compensation; Hydraulic servo control	Design and Sea Trial Verification of Wave Compensation Device

5. Learning Output-Oriented Course Evaluation Design

This article takes Jiangsu Ocean University's "New Vision of Ships and Seas" course as an example and proposes a course content reconstruction plan driven by the dual path of "integration of industry and education + integration of science and education". The integration of industry and education responds to "how to use it and where to use it" and reduces industrial scenarios to learning tasks; the integration of science and education responds to "why to learn and where to use it" and disassembles scientific research results into teaching cases. The course focuses on the three modules of intelligent ship manufacturing, surface unmanned vessels, and underwater unmanned vehicles, and builds a three-ring logical chain of "scientific research issues → knowledge principles → technology applications" to promote industrial scenarios into classrooms, scientific research results into teaching materials, and engineering awareness into minds, providing a practical paradigm that can be used as a reference for the reform of the introductory courses of shipbuilding and marine majors in local universities.

6. Conclusions

This study proposes a curriculum reconstruction approach based on the dual integration of industry–education and science–education. By organizing course content into three modules, the approach effectively links industrial scenarios with knowledge logic. The results show that it improves students’ professional cognition, learning motivation, and engineering awareness, providing a practical reference for curriculum reform in application-oriented universities.

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