Research and Practice on the Reform of Practical Teaching in the High-Speed Boat Maneuvering Course

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Abstract: The high-speed boat handling course is one of the core curricula in maritime technology, playing a pivotal role in cultivating students operational skills and professional competencies. To address current challenges such as insufficient practical teaching resources, lack of qualified instructors, and misalignment with job requirements, this paper proposes competency-oriented practical teaching reform strategies. By reconstructing the practical teaching system, innovating a virtual-physical integration teaching model, deepening real-world training reforms, and refining a multidimensional assessment mechanism, a "theory-simulation-practice" trinity practical teaching system is established. Empirical results demonstrate that the reforms significantly enhance students operational skills and comprehensive abilities, offering a new pathway for high-speed boat handling talent development.
***Keywords*:** high-speed boat maneuvering; practical teaching; combination of virtual and real; scenario-based simulation

1. Introduction

A high-speed boat refers to a small sized ship that achieves a significantly higher speed than conventional vessels through optimized design, the use of high-performance power systems, and lightweight materials. The International Maritime Organization (IMO) defines a high-speed ship as a vessel with a designed speed exceeding 25 knots and meeting specific safety standards [1]. Due to its excellent mobility and speed, it is often used in maritime law enforcement and emergency rescue missions. The maneuvering skills of high-speed boats are one of the core capabilities of navigation technology students.

The high-speed boat maneuvering course is based on boat driving theory and focuses on cultivating students abilities in boat maneuvering under complex working conditions, emergency decision making, and team collaboration. However, traditional teaching has problems such as an unstructured practical teaching content system, unclear teaching levels, single teaching methods, and insufficient integration of teaching with job requirements [2,3]. Practical teaching mainly emphasizes basic maneuvering training, such as starting, turning, berthing and unberthing from the dock, and approaching and leaving a drifting ship for high-speed boats. There is a lack of comprehensive training in complex scenarios such as emergency rescue in severe weather and sea conditions, and maritime law enforcement boarding operations. It relies too much on classroom lectures by instructors and insufficiently utilizes modern technologies such as virtual reality (VR) and high-speed boat maneuvering simulators. The embedding of practical teaching scenarios in real world job scenarios is inadequate, resulting in a lag in the cultivation of students professional qualities. In response to the above problems, this paper combines the characteristics of the high-speed boat maneuvering course and the job requirements of high-speed boat operations to explore practical teaching reforms, aiming to cultivate high quality technical and skilled talents who are proficient in maneuvering, strong in emergency response, and good at collaboration.

2. Analysis of the Current Situation of Practical Teaching in the High-speed Boat Maneuvering Course

2.1 Inadequate Matching between Teaching Objectives and Job Requirements

High-speed boat drivers generally need to possess three core capabilities. First, high-speed boat maneuvering skills, which require precise control of speed and course, and the ability to adapt to the maneuverable and highly sensitive characteristics of high-speed boats. Second, situational decision-making ability, which means quickly formulating the optimal maneuvering plan in case of sudden working conditions such as mechanical failures and severe weather. Third, strong team-collaboration ability, which is necessary to cooperate with personnel in positions such as electromechanics and rigging to complete tasks. Traditional teaching focuses on single skill training and is insufficient in cultivating comprehensive abilities, resulting in students being able to operate but having difficulties in adapting to changes and lacking collaboration skills after taking up their posts.

2.2 Insufficient Allocation of Practical Teaching Resources

Firstly, there are many difficulties in using actual high-speed boats for practical teaching. On one hand, the purchase cost of high-speed boats is high, and they also require supporting dock facilities, maintenance equipment, etc. On the other hand, the costs of fuel, equipment wear and tear, maintenance, and repair during actual boat training are also high. At the same time, due to the high speed and difficult maneuverability of high-speed boats, high requirements are placed on safety protection facilities during the training process. Restricted by site, safety, and cost factors, students have few opportunities for practical operation, and it is difficult to simulate extreme risk scenarios.

Secondly, the development and optimization of high-speed boat simulators are challenging. Developing a high-speed boat dynamics simulation model is the key to virtual scene teaching. To accurately simulate the movement of high-speed boats under various working conditions, complex physical factors need to be considered, such as splash resistance, aerodynamic effects, and changes in lift during high-speed planing. The establishment and verification of these physical models require profound knowledge of ship dynamics and a large amount of experimental data support. Simulator teaching needs to ensure the real time nature of the simulation while guaranteeing the sense of reality of the scene. For example, when simulating complex sea crossing scenarios, it is necessary to simultaneously handle the movement, communication of multiple boats, and changes in various environmental factors, which poses high requirements for the computing power and optimization level of the software [4]. If the scene is too complex, it may cause the simulation to lag, affecting the teaching effect.

Thirdly, the teaching staff structure is unreasonable, and teaching abilities need to be improved. Most instructors are "academics" and lack practical experience in high-speed boat maneuvering. They do not explain the maneuvering characteristics of new type high-speed boats in depth. There are many restrictive factors for instructors to improve their practical experience. Using actual high-speed boats for teaching often requires multiple instructors to conduct group teaching simultaneously to meet the training needs of 40 students. School teaching usually has a fixed semester and course arrangement, making it difficult for instructors to be away from their posts for a long time to accumulate practical experience. Firstly, each instructor undertakes the teaching of multiple courses, and it is difficult to concentrate time for unified training. Secondly, it is difficult to coordinate and arrange centralized training for instructors because the work arrangements of employers are usually full.

2.3 High Difficulty in Implementing the Multidimensional and Three Dimensional Assessment System

It is difficult to quantify assessment indicators. Some of the assessment indicators designed from the three dimensions of "knowledge, skills, and qualities" are hard to quantify. For example, when assessing students team-collaboration abilities and professional qualities, it is difficult to use a specific numerical value to measure their performance in aspects such as communication efficiency and sense of responsibility.

Ensuring the fairness of the assessment process is a challenge. The comprehensive assessment involves multiple assessment forms, such as simulator operation assessment and actual boat collaborative maneuvering project assessment. It is difficult to ensure the fairness of these assessment forms among different students. For example, in the actual boat collaborative maneuvering project assessment, external factors such as different weather conditions and boat states may affect students assessment results.

3. Ideas and Implementation Paths of Practical Teaching Reform

3.1 Constructing a "Theory-Simulation-Combat" Trinity Practical Teaching System

Based on the law of "cognition-skill-comprehensive" ability generation, the practical teaching is divided into three modules, as shown in Figure 1.

Basic skill training In the basic skill training module of high-speed boat maneuvering practice, items such as high-speed boat structure recognition, propulsion system startup, telegraph and rudder coordinated operation, and instrument data interpretation are set. On the basis of theoretical knowledge, emphasis is placed on route design, radar target recognition and positioning, AIS target recognition and communication, etc. The knowledge of six degrees of freedom hydrodynamic analysis of high-speed boats is applied to basic maneuvering training to lay a solid foundation of theoretical knowledge for students.

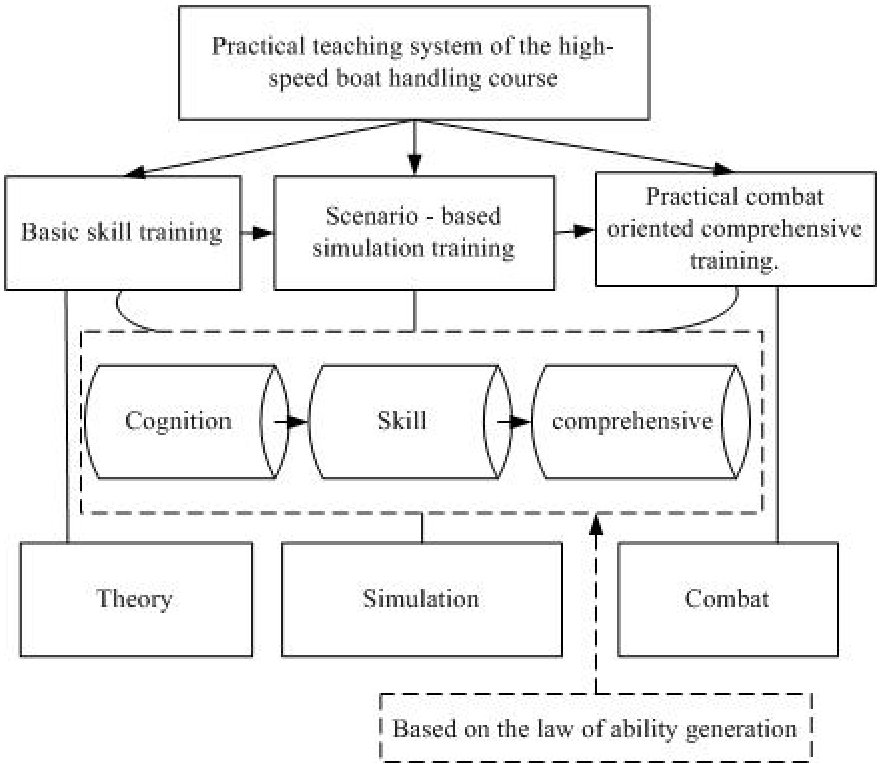

Figure 1. The Practical Teaching System of the High-Speed Boat Maneuvering Course

Scenario based simulation training. A virtual scene with the coupling of multiple elements such as "hydrology-meteorology-navigation" is constructed. Regular scenarios such as overtaking in narrow channels, navigation, and night navigation are set, as well as emergency scenarios such as main engine failure, steering gear failure, and collision avoidance [5]. A high-speed boat dynamics simulation model is developed to calculate parameters such as speed, drift angle, and heel angle in real time, enhancing the sense of simulation reality.

Practical combat oriented comprehensive training. Job-Cufficulum Alignment training is carried out on actual high-speed boats, and typical work tasks are set. The law enforcement and duty performing scenarios such as intercepting target ships, boarding target ships, rescuing drowning persons, and towing distressed boats, operations such as approaching and leaving drifting ships under different environmental conditions, and safe navigation in extreme weather [6]. Training bases are jointly built with employers. Team leaders act as "tutors" to guide students in the ability transfer from simulated maneuvering to actual boat operation.

3.2 Innovating the Combination of Virtual and Real Teaching Method

Task-Driven Teaching taking tasks as the carrier, progressive projects are designed. First, a primary task is set to complete the turning of a high-speed boat in the port, focusing on the telegraph and rudder coordination ability [7-9]. Second, an intermediate task is set. The team collaborates to complete navigation in complex waters, such as passing through fishing net areas and sea areas with high ship traffic, incorporating boat communication and lookout division of labor. Third, an advanced task is set. Emergency scenarios such as main engine failure, steering gear failure, boat grounding, and collision are set to assess students emergency response and handling abilities. A scenario of a high-speed boat overtaking, controlling, and boarding a target ship in a law enforcement context is set, and students high-speed boat maneuvering abilities are trained in the boat comprehensive simulation system. Figure 2 shows a high-speed boat overtaking and berthing alongside a target ship, Figure 3 shows the training track of multiple overtaking and berthing maneuvers of a high-speed boat alongside a target ship. In the constructed virtual scene, students seem to be in a fierce law enforcement confrontation, which greatly mobilizes students training enthusiasm. Figure 4 shows the training of rescuing drowning persons with an actual high-speed boat, which further improves students practical combat ability in high-speed boat maneuvering through actual equipment training.

Figure 2. A High-Speed Boat Overtaking and Berthing Alongside a Target Ship

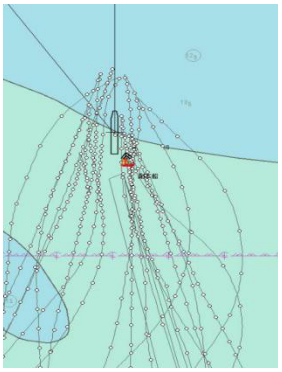

Figure 3. Training Track of Multiple Overtaking and Berthing Maneuvers of a High-Speed Boat Alongside a Target Ship

Figure 4. Training of Rescuing Drowning Persons with an Actual High-Speed Boat

Case Review Teaching Method During the teaching process of the high-speed boat maneuvering course, typical navigation accident cases are collected in advance, such as high-speed boat collision accidents and out of control drifting incidents. Through the three step process of case analysis-simulation reproduction-plan optimization, students risk prediction abilities are cultivated. For example, when analyzing an accident where a high-speed boat had excessive heel due to a high-speed sharp turn, students are guided to analyze the relationship between speed and rudder angle, and the changes in the bow and stern drift and heel of the high-speed boat under full rudder angle are analyzed in detail, as shown in Figure 5, Figure 6, and Figure 7. The accident scene is reproduced in the boat comprehensive simulation system, and students are required to develop corrective plans, such as staged deceleration and progressive rudder angle adjustment, to ensure the safety of high-speed boat maneuvering training.

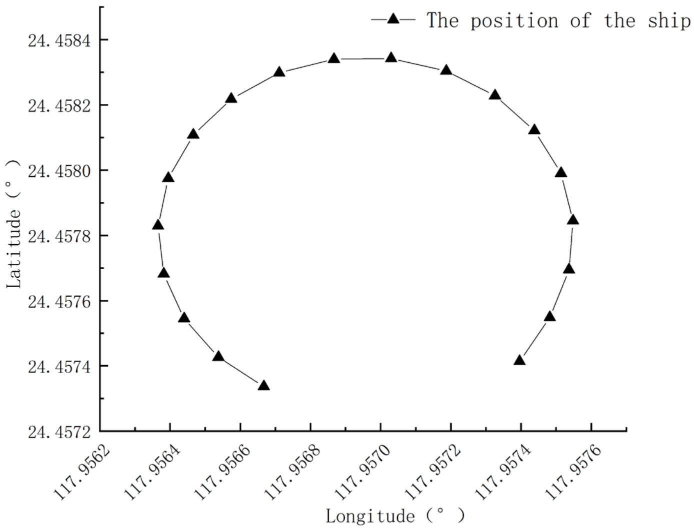

Figure 5. High-Speed Boat Sharp-Turn Training

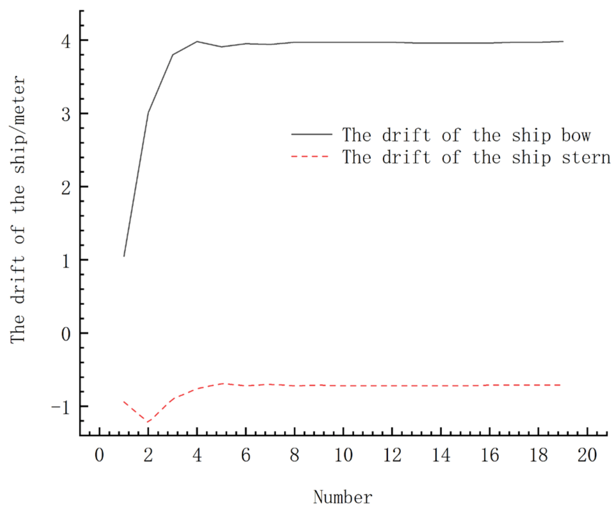

Figure 6. Changes in the Bow and Stern Drift of a High-Speed Boat during a Sharp Turn

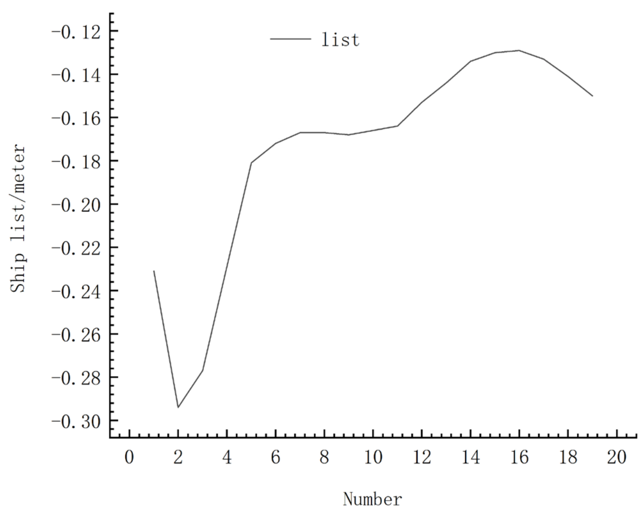

Figure 7. Heel Changes of a High-Speed Boat during a Sharp Turn

3.3 Building a Dual-Qualified Teaching Team

Based on the shortcomings of instructors teaching in the current high-speed boat maneuvering course, active measures are taken to improve teaching abilities. According to the annual training plan, instructors are required to reserve time in advance to participate in high-speed boat patrol and law enforcement tasks at employers units. During the task-completion process, their high-speed boat maneuvering skills are improved, and if necessary, they can take the high-speed boat driving license exam to obtain the high-speed boat maneuvering qualification certificate. Tutors are deeply involved in high-speed boat maneuvering teaching [10]. High-speed boat commanders and senior drivers from employers are invited to serve as part-time instructors to hold the Captains Lecture Hall, sharing practical experience in high-speed boat maneuvering, such as techniques for maintaining course and turning in swell waves, and maneuvering skills for overtaking and controlling suspect ships during law enforcement operations.

3.4 Constructing a Multidimensional and Three-Dimensional Assessment System

Assessment indicators are designed from the three dimensions of knowledge, skills, and qualities, as shown in Table 1.

Table 1. Multidimensional Assessment System

Assessment Dimension	Assessment Form	Specific Content	Weight
Basic Skills	Simulator Operation Assessment	Accuracy and Efficiency of Standardized Operation Processes such as Startup, Acceleration,Stopping, Navigation, Course-Keeping Maneuvering,Turning Maneuvering.	30%
Situational Decision-Making	Emergency Handling in Virtual Scenarios	Fault Response Time, Rationality of the Plan, Application of Collision Avoidance Rules	30%
Team Collaboration	Actual Ship Collaborative Maneuvering Projects	Rationality of Task Division such as Overtaking and Controlling, Towing Operations, Approaching and Leaving Drifting Ships, Rescuing Drowning Persons, etc., Communication Efficiency, Degree of Collaborative Completion	25%
Professional Qualities	Training Report + Employer Evaluation	Safety Awareness, Sense of Responsibility, Problem-Solving Ability	15%

4. Implementation Effects and Reflections on the Practical Teaching Reform

4.1 Implementation Achievements

To test the effectiveness of the practical teaching reform of the High-Speed Boat Maneuvering course, a teaching reform pilot was first carried out among junior college students majoring in navigation technology. The maneuvering skills of 40 students for high-speed boats were significantly improved. They had a solid and thorough understanding of maneuvering theoretical knowledge, and their proficiency in the maneuvering processes and contents of each module of high-speed boats was also significantly enhanced. By comparing the simulator operation data of students before and after the reform, the error in the full-rudder turning time of high-speed boats decreased from ±15% before the reform to ±5%, and the emergency stopping distance deviation was reduced by 40%. Students comprehensive qualities were comprehensively developed. In the comprehensive internship of navigation technology, the scores of students team collaboration projects increased by 20%, and the compliance rate of emergency response plans increased from 70% to 90%. Through follow-up visits to employers evaluations of graduated students, the feedback from employers showed that the adaptation period for graduates after taking up their posts was shortened by 30%, and their maneuvering confidence and decision-making abilities under complex working conditions were significantly enhanced.

4.2 Existing Problems and Improvement Directions

When using the boat comprehensive simulation system for high-speed boat maneuvering practical teaching, there is a significant difference in the hydrodynamic effect between the simulated high-speed boat and the actual boat. Some projects, such as mooring and unmooring operations when berthing at the dock, are quite different from actual operations in this system. It is necessary to continuously improve the teaching functions of the simulator in details to improve the effectiveness of practical teaching.

5. Conclusion

The practical teaching reform of the high-speed boat maneuvering course needs to closely adhere to “job-related ability requirements”. By breaking through the bottlenecks of traditional teaching through the combination of virtual and real, and integration of teaching and jobs, a practical teaching system that meets the job requirements of high-speed boat maneuvering is constructed, providing a reference paradigm for the reform of similar courses. In the future, intelligent technologies and intelligent sensing devices can be further applied to achieve precise and intelligent maneuvering training, cultivating high-speed boat maneuvering talents with a solid theoretical foundation and outstanding practical combat abilities.

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