Received: 30 Oct. 2025 | Revised: 05 Nov. 2025 | Accepted: 08 Nov. 2025 | Published online: 25 Nov. 2025

RESEARCH ARTICLE

Contemporary Education and Teaching Research
2025, Vol. 6 (11)502-511
DOI: 10.61360/BoniCETR252019281106

Talent Development Strategies for Maritime Education under the Dual Challenges of Enrollment Stability and Green Transformation

Anqi Wang[1,*], Zhengrong Sha[1] & Qunpeng Wang[1]
[1]Guangzhou Maritime University, Guangzhou, China

Abstract: By 2025, the global shipping industry is facing a dual transformation toward digital intelligence and green development. According to the 2024 China Seafarer Development Report, enrollment in maritime education programs has shown significant fluctuations, revealing a gap between traditional maritime majors and the rapid evolution of emerging maritime technologies. This mismatch has made it difficult to meet the industry's urgent demand for interdisciplinary and high-quality professionals. Meanwhile, the rapid advancement of new-energy vessels has posed new challenges for maritime education, such as insufficient faculty reserves, outdated training facilities, and a lack of green technology content in curricula. Drawing on statistical data from China's shipping industry and the International Maritime Organization (IMO)'s carbon net-zero framework, this study analyzes the structural contradictions of maritime education under the pressures of enrollment instability and industrial transformation. It further proposes systematic strategies from five dimensions—optimizing student source allocation, improving curriculum systems, establishing tiered training mechanisms, deepening industry–academia collaboration, and strengthening policy support—to provide references for talent cultivation and the sustainable development of the maritime sector.

Keywords: maritime education, green transformation, talent cultivation strategies, carbon net-zero framework

1. Introduction

Maritime education, as the foundation of talent cultivation for the shipping industry, directly influences the sector's talent supply and overall competitiveness. The 2024 China Seafarer Development Report reveals a noteworthy trend: the enrollment scale of maritime degree programs has shown significant fluctuations. At the same time, the Chinese government has intensively introduced policies to support the training of seafarers for new-energy vessels (Maritime Safety Administration of China, 2025). This mismatch highlights structural issues in maritime education, particularly regarding the stability of student enrollment and its adaptability to industrial transformation.

According to data from the International Maritime Organization (IMO), global shipping accounts for nearly 3% of total worldwide carbon emissions, posing significant challenges to both the direction of maritime development and the global environment (Deng & Mi, 2023). In response to climate change, the IMO's Marine Environment Protection Committee (MEPC) adopted an initial strategy for greenhouse gas (GHG) reduction at its 72nd session in 2018. In April 2025, the MEPC, at its 83rd session, finalized a draft of the Net-Zero Framework, aiming to achieve net-zero GHG emissions from international shipping around 2050 (Nalupa, 2022).

Amid this urgent transformation, orders for alternative-fuel vessels have increased rapidly.

Corresponding Author: Anqi Wang
Guangzhou Maritime University, Guangzhou, China

Furthermore, according to data from the 2024 China Seafarer Development Report, the proportion of green-powered ships in newbuilding orders continues to rise. Dual-fuel vessels powered by liquefied natural gas (LNG) and methanol, as well as ships using battery or hydrogen fuel cell propulsion systems, have become the mainstream trend in shipbuilding development.

However, the traditional maritime education system has shown evident lag in responding to this technological revolution. The curriculum remains dominated by conventional fuel-powered vessels; faculty members generally lack backgrounds in new-energy technologies; and training facilities are inadequate for meeting the operational requirements of green ships. More complex still, maritime education faces dual pressures concerning enrollment stability. On one hand, societal perceptions of seafaring careers are often biased, leading to a continuous decline in young people's willingness to pursue maritime professions. On the other hand, there is a severe mismatch between traditional academic programs and the demand for emerging technical positions, resulting in enrollment difficulties in some majors and an undersupply of professionals in high-demand areas. This structural contradiction has placed maritime education in a dilemma between "quantitative stability" and "qualitative enhancement."

Therefore, China's maritime education must undergo a strategic transformation. It should not only ensure stable enrollment through innovative mechanisms to maintain a solid talent base for the shipping industry but also rapidly upgrade its training capacity so that talent cultivation can evolve in step with the green shipping technological revolution. This transformation is vital not only for the sustainable development of China's maritime sector but also for safeguarding the nation's strategic position in the global competition for green shipping. Based on detailed data from the 2024 Industry Report and the new development requirements of 2025, this paper conducts an in-depth analysis of the two core challenges—enrollment stability and green transformation—exploring their intrinsic connections and interaction mechanisms. It further proposes forward-looking and practical systemic countermeasures aimed at providing theoretical support and practical guidance for the reform of maritime education and the high-quality development of the shipping industry.

2. Causes of Enrollment Instability in Maritime Education

2.1 Fluctuations in enrollment scale and structural issues: evidence from industry reports

According to data from the 2024 China Seafarer Development Report, a total of 23,812 students were enrolled in accredited maritime-related degree programs across China in 2024, representing a year-on-year decline of 1.4%. However, when examined over a longer time horizon, deeper structural issues become evident. Over the past five years, maritime education enrollment has displayed clear volatility, not only in total numbers but also in the balance among disciplines.

As shown in Figure 1, total enrollment in maritime education was 24,567 students in 2020, increased to 25,234 in 2021, then dropped to 24,156 in 2022, further declined to 24,117 in 2023, and continued a slight downward trend to 23,812 in 2024. This pattern of gradual decline reflects mounting structural pressures of stagnation within maritime education. Particularly noteworthy is that, despite the global shipping market maintaining steady demand growth, domestic maritime education enrollment has continued to fall. This suggests that the root cause lies not on the demand side of the market but rather on the supply side of the education system.

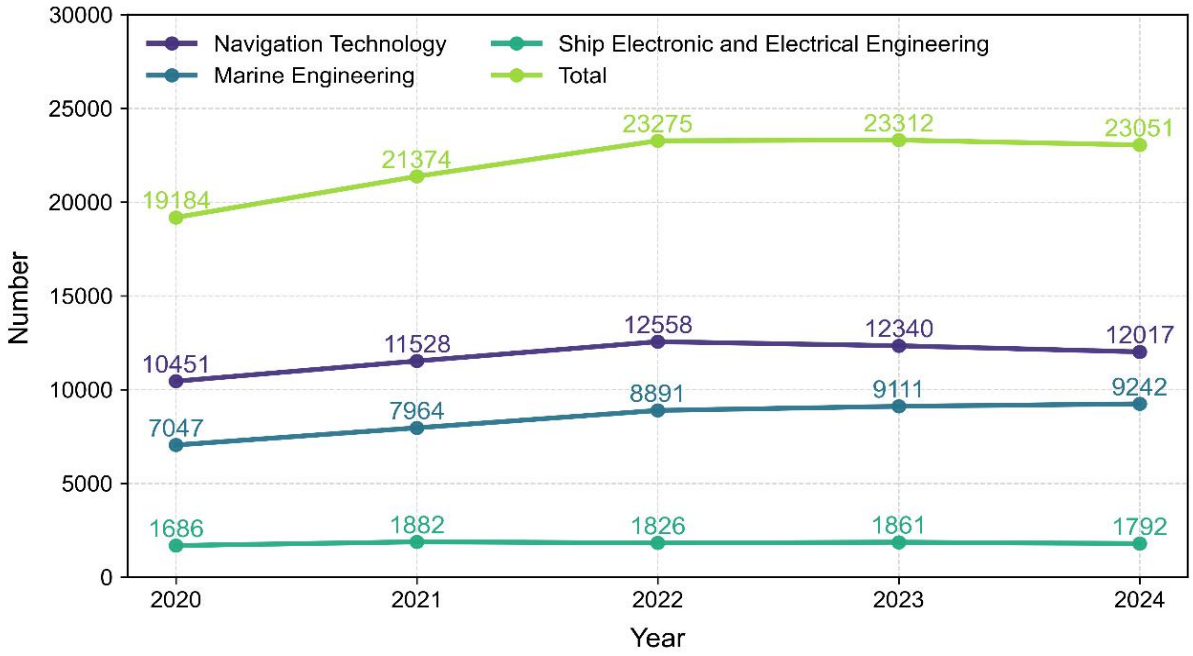

Figure 1 Enrollment Trends in Maritime-Related Programs at National Seafarer Training Institutions, 2020–2024

As illustrated in Figure 2, maritime training institutions for ocean-going seafarers enrolled 23,051 students in 2024. Among them, 12,017 students majored in navigation (52.1%), 9,242 in marine engineering (40.1%), and only 1,792 in electro-technical studies (7.8%). This reveals a clear imbalance among disciplines, with the training scale for electro-technical officers falling far short of market needs. Such disproportionality has become a critical bottleneck limiting the ability of China's maritime education to adapt to industrial upgrading.

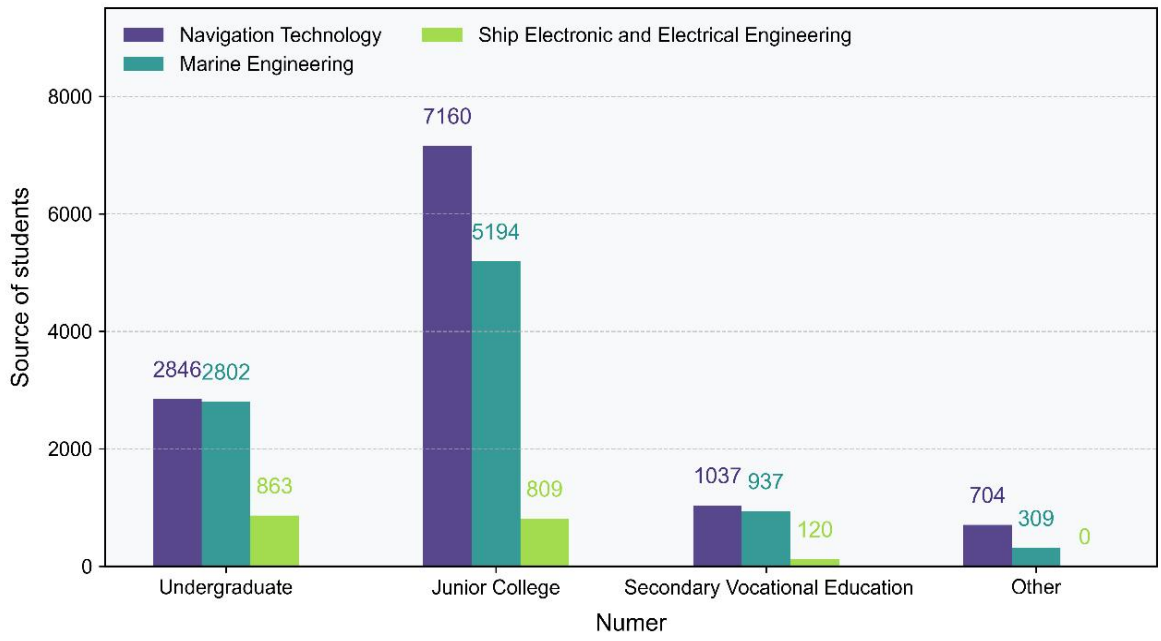

Figure 2 Enrollment in Maritime-Related Programs at Seafarer Training Institutions in 2024

The data in Figure 3 further highlight this problem through the lens of job-oriented talent supply. The case of Electro-Technical Officers (ETOs) is particularly striking: in 2020, 32 trainees completed training in this specialization, but there were no trainees at all from 2021 to 2023, with the number only recovering to 10 in 2024 (too small to be visible on the chart). This "zeroing-out" phenomenon suggests that during this period, the occupational appeal of high-tech positions in ship electrification dropped to its lowest point. The causes may include a persistent undervaluation of electronic systems' roles in the maritime sector or uncertainty about long-term demand, both of which dampened trainees' career intentions. The modest rebound in 2024 may signal the initial effects of new regulatory requirements—such as crewing standards for advanced electronic ships—or the industry's ongoing digitization trend, which is finally translating into tangible labor demand and attracting a small number of early entrants.

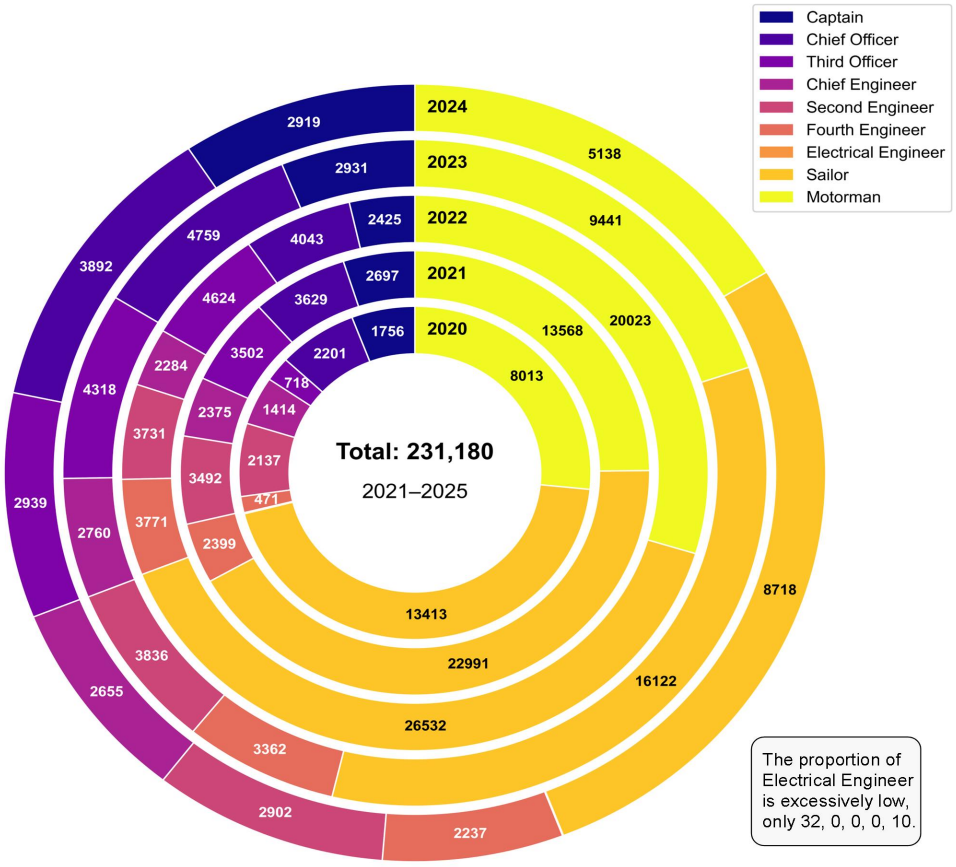

Figure 3 Number of Trainees Participating in Seafarer Competency Training, 2020–2024

2.2 In-Depth analysis of structural imbalances

Another key issue lies in the weak linkage between enrollment promotion and basic education. Maritime majors receive very limited exposure in secondary school career planning, and examples related to maritime applications are rarely incorporated into high school physics and mathematics teaching. As a result, students struggle to develop a sense of professional identity during adolescence. Many institutions still rely on traditional methods such as education fairs and on-campus recruitment events, while underutilizing emerging channels such as social media and short-form videos. Since Generation Z students primarily obtain information through digital platforms, this communication gap has led to an intergenerational mismatch in information dissemination (Lau et al., 2021). In addition, most

maritime students come from coastal regions, inland areas with developed waterways, or less-developed inland regions, while the appeal to students from other areas remains limited—further constraining the overall expansion of the student base.

The instability in enrollment is the result of multiple interacting factors. First, there is the issue of low social recognition and weak occupational attractiveness (Weng, 2023; Andresen et al., 2007). Although the 2024 Report mentions organizing "Day of the Seafarer" events to enhance professional prestige, the seafaring profession itself faces structural challenges (Nielsen et al., 2013). Prolonged absence from home is the most direct obstacle—international seafarers typically spend 8–10 months per year at sea—deterring many young workers. The demanding working environment, discrepancies between expected and actual income, and Generation Z's increasing emphasis on quality of life all further diminish the attractiveness of maritime careers to high-caliber students (Zhao et al., 2019).

2.3 Weak linkage between education, training, and the employment market

Although the 2024 Report indicates that 165,827 Chinese seafarers were deployed overseas throughout the year—a 15.5% year-on-year increase—reflecting strong international demand, this has not effectively translated into stable enrollment growth. The fundamental reason lies in the disconnect between the existing talent cultivation system and the profound transformation currently underway in the shipping industry. Many maritime universities still structure their curricula around traditional vessel types, whereas new-energy and intelligent ships now account for over 45% of global newbuilding orders. This discrepancy implies that graduates may face a mismatch between their academic training and actual market demand. Such expectation gaps further undermine the attractiveness of maritime education (Malau et al., 2025).

3. Systemic Challenges of Green Transformation to the Maritime Education System

3.1 Dual drivers: policy guidance and industry transformation

Green transformation has become an inevitable trend in the development of the shipping industry, driven by both international policy frameworks and market demand, jointly catalyzing profound changes in global shipping.

At the level of international policy, the IMO's Net-Zero Framework has established clear and stringent decarbonization targets for the global shipping sector. The framework aims to achieve a peak in carbon emissions as soon as possible, reduce emissions by 20% (aspiring to 30%) by 2030 relative to 2008 levels, 70% (aspiring to 80%) by 2040, and ultimately achieve net-zero greenhouse gas emissions by 2050 (Manuel et al., 2019). These binding targets have gradually been transformed into mandatory national regulations, forming hard requirements that the shipping industry must comply with. The implementation of these international policy frameworks implies that seafarers trained to operate new-energy vessels are increasingly indispensable (Borromeo et al., 2024). The 2024 Report clearly reflects the Chinese government's recognition of and response to this trend, highlighting policies such as "supporting the training of seafarers for dual-fuel vessels, issuing training guidelines for battery-powered ships, and promoting LNG crew order-class training models." These policies indicate that China has incorporated the cultivation of green skills for seafarers into national strategic priorities, recognizing it not only as a requirement for industry advancement but also as a marker of national competitiveness.

From the market perspective, green transformation has become an irreversible trend (Felício et al., 2021). Natural fleet renewal cycles, combined with the shift toward green shipping, will generate significant demand for green financing of

vessels. According to data from Clarkson Research, 552 new alternative-fuel vessels were ordered globally in 2023, accounting for 45% of newbuilding orders by gross tonnage (China Shipping Industry Green Finance Analysis Task Force, 2025). As the world's largest shipbuilding nation and seafarer exporter, China must seize the talent high ground in this transformation; otherwise, it risks falling behind in the emerging international competitive landscape.

3.2 Lagging education resources and capacity building

Facing the urgent requirements of green transformation, the maritime education system has exposed significant structural shortcomings, which not only limit enrollment momentum but also hinder the improvement of talent quality.

At the faculty level, teachers with practical experience and theoretical knowledge in new-energy vessels are extremely scarce. Most maritime educators were trained in the era of traditional fuel-powered ships, and they often have knowledge gaps in the theory and practice of new-energy systems, such as liquefied natural gas (LNG), methanol, and hydrogen fuel cells. This shortage makes it difficult to offer new courses effectively and ensures limited teaching quality (Wang, 2019).

In terms of practical training conditions, this is the most prominent limiting factor. Most maritime training facilities were designed around traditional shipping operations and fail to meet the requirements of modern green education. For example, ship maneuvering simulators were originally developed to replicate the handling characteristics of conventional fuel-powered vessels under standard navigation conditions. They are insufficient for simulating the propulsion characteristics of new-energy ships, such as LNG or hydrogen fuel cell vessels. Key operational aspects—energy conversion under different operating conditions, changes in endurance, and special maneuvering requirements—cannot be accurately represented with current simulators. At the same time, highly automated intelligent ships, featuring functions like automatic collision avoidance and smart berthing, are also difficult to replicate fully in existing training facilities. This creates a significant gap between students' practical training experiences and the requirements of actual low-carbon, intelligent maritime operations (Jiang, 2025).

Regarding program structure, the traditional "navigation–engineering–electrical" framework is increasingly inadequate for meeting green transformation demands. As shown in Figure 2, students enrolled in electro-technical programs account for only 7.8% of total maritime enrollment, far below the market demand for positions in new-energy ship electrical management and energy system maintenance. This structural mismatch means that even if total enrollment remains stable, an imbalance in talent composition will still result in structural shortages. According to the 2024 China Seafarer Development Report, as of the end of 2024, among 418,568 seafarers holding valid certificates of competency for international navigation, 310,000 had qualifications for navigation and engineering watchkeeping, including 90,321 senior officers. This structure indicates that the proportion of high-level technical talent still has room for improvement, while demand for such highly skilled personnel is particularly urgent for new-energy vessels.

4. Systematic Solutions Facing Dual Challenges

The future of maritime education lies in proactively shaping change. The dual challenges of enrollment stability and green transformation are not necessarily opposing forces, on the contrary, they can mutually reinforce each other. Through precise reform strategies and innovative practices, these pressures can be transformed into opportunities.

4.1 Strategies for optimizing the quality of student intake

Maritime education faces a paradox: enrollment must remain stable, yet traditional "extensive" recruitment approaches are no longer sustainable. The real solution is to shift the focus from quantity to quality and professional alignment. Data from the 2024 Report highlights a reality: navigation and engineering programs dominate the landscape, which

no longer matches the industry ecosystem. Emerging positions, such as electro-technical officers, are experiencing rising demand, but the scale of training lags behind. Therefore, it is necessary to establish a dynamic mechanism for adjusting program offerings, maintain regular communication with industry enterprises, and adjust enrollment plans promptly according to market feedback. In particular, increasing enrollment in high-demand programs, such as electro-technical officer training, ensures that educational investment aligns closely with industry needs. This adjustment should be gradual, allowing sufficient time and resources for schools and faculty to adapt.

To improve student quality, a diversified admissions evaluation system should be established, considering not only academic performance but also practical skills, innovative thinking, and career adaptability. Partnerships with key secondary schools can promote maritime science education, cultivating students' interest and awareness of maritime careers early. Additionally, differentiated enrollment strategies should be formulated based on regional characteristics, ensuring both the rationality and stability of the student population structure.

4.2 Enhancing curriculum development

Implementing modular teaching reform is crucial. Traditional courses should be organically integrated with knowledge of new energy and emerging technologies to form a three-dimensional curriculum system: foundation modules + specialized direction modules + extension modules (Li et al., 2024). Students can choose directions such as conventional fuel vessel operations, new-energy ship operations, or digital shipping management. Extension modules cover cutting-edge topics such as international maritime regulations, emergency management, and environmental protection skills. This design not only enhances the specificity of training but also fosters autonomous learning, which often attracts high-quality students more effectively than traditional recruitment campaigns.

Curriculum development should also incorporate international elements, introducing the latest IMO standards and advanced teaching resources to ensure that graduates are internationally competitive. A regular curriculum update mechanism should be established to revise teaching content annually based on technological developments and industry changes, maintaining forward-looking and practical relevance. Furthermore, interdisciplinary integration should be strengthened, incorporating emerging technologies such as artificial intelligence, big data, and the Internet of Things into traditional maritime courses, thereby cultivating multi-skilled professionals (Cicek et al., 2019).

4.3 Establishing tiered training mechanisms

Green transformation must translate into the operational skills, management awareness, and emergency competence of each seafarer. A "one-size-fits-all" approach is inadequate; differentiated training systems must be built according to specific job requirements.

Operational-level seafarers need to master practical skills such as operating new-energy ship equipment, daily maintenance, and troubleshooting. Management-level personnel should focus on system management principles, emergency response, and personnel management. Virtual simulation technology is key to achieving these goals. Investment should be increased in new-energy ship simulator training facilities capable of replicating real operational conditions, such as LNG cryogenic tank systems, battery-powered ship energy management, and multi-energy switching on hybrid vessels. High-fidelity virtual environments allow students to repeatedly practice operations and emergency scenarios without risk. This not only reduces training costs but also deeply integrates theory and practice, enabling immersive, proactive learning far superior to traditional methods.

Tiered training should establish a complete pathway from beginner to mastery. The initial stage emphasizes foundational theory and safety awareness; the intermediate stage strengthens professional skills and practical competence; the advanced stage cultivates innovative thinking and management capabilities. A skills certification system allows

trainees to clearly understand their competence levels and development directions, motivating continuous learning.

4.4 Deepening school–enterprise collaboration

True integration of industry and education requires enterprises to actively participate throughout the talent cultivation process: from program design and course development to training base construction. Promoting an "order-based" training model, where shipping companies partner with educational institutions to train targeted talent, resolves enrollment challenges and ensures enterprise talent supply, forming a virtuous cycle.

Deepening school–enterprise collaboration requires innovative cooperation models, such as establishing an enterprise mentorship system, where industry experts directly participate in teaching. Joint training bases should be promoted, with enterprises providing real working environments and advanced equipment while schools supply teaching resources and faculty. A talent-sharing mechanism should be implemented, allowing enterprise technicians to teach part-time at schools and teachers to gain practical experience in companies, fostering bi-directional talent flow. Additionally, a school–enterprise cooperation evaluation system should be established to periodically assess the effectiveness of collaborations, ensuring quality and sustainability.

4.5 Strengthening policy support

Reform requires a supportive policy environment. Well-designed teaching and training facilities must be backed by systemic and policy frameworks. Special support funds should be established to subsidize institutions conducting new-energy ship training or investing in virtual simulation facilities. Green shipping talent incentives should link reform outcomes to teaching evaluations, faculty funding, and enrollment targets. A green skills certification system should be developed to ensure international recognition of certificates, motivating students and enhancing China's maritime education competitiveness.

Policy support should also focus on faculty development, including establishing specialized talent recruitment programs for green shipping education to attract outstanding domestic and international instructors. A long-term teacher training mechanism should be implemented, regularly organizing professional development and international exchanges to improve faculty expertise and global perspectives. Furthermore, an education quality supervision system with third-party evaluation mechanisms should be established to ensure effective outcomes. These five reform dimensions mutually reinforce each other, forming a coherent system that enables maritime education to meet dual challenges and provide sustained talent support for China's green shipping transition.

5. Conclusions and Outlook

Faced with the dual challenges of enrollment stability and green transformation, China's maritime education must adopt systematic solutions. On one hand, a combination of deepened educational reform, faculty development, optimized training resources, and innovative institutional mechanisms is required to build a maritime education system that meets future development needs. On the other hand, international best practices should be referenced. For example, next-generation training vessels such as Norway's Skulebas at Måløy Fisheries School and France's Alba at Bastia Maritime School demonstrate that multi-energy teaching represents the future direction.

These international practices indicate that only by tightly integrating traditional maritime education with the demands of green, low-carbon, and intelligent shipping can truly modern seafarers be cultivated, breaking the enrollment bottleneck and achieving strategic breakthroughs in maritime education.

Looking forward, China's maritime education should:

1. Emphasize quality development, continuously improving talent cultivation while closely monitoring technological trends and adjusting training programs promptly;

2. Leverage international cooperation via platforms such as the "Belt and Road" blue partnerships, introducing foreign faculty and curricula to jointly develop green shipping education systems and achieve internationalized learning;

3. Develop internationally recognized green skills certification, in collaboration with the Ministry of Transport and the IMO Asia-Pacific Regional Center, ensuring domestic graduates' qualifications are globally recognized.

4. Only by implementing these strategies can China secure robust talent support for building a strong transportation nation and gain a competitive edge in the global green shipping transformation.

Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

Acknowledgement

This research received no funding.

References

Andresen, M., Domsch, M. E., & Cascorbi, A. H. (2007). Working unusual hours and its relationship to job satisfaction: a study of European maritime pilots. *Journal of Labor Research, 28*(4), 714-734.

Borromeo, G. A. (2024). Shaping the Future of Seafaring in an Age of Safer, Smarter, and Greener Shipping. *Maritime Digitalization and Decarbonization, 180.*

Cicek, K., Akyuz, E., & Celik, M. (2019). Future skills requirements analysis in maritime industry. *Procedia Computer Science, 158*, 270-274.

China Shipping Industry Green Financing Analysis Group. (2025). Green transformation of shipping industry: Blue ocean track for financial industry. *Financial Expo,* (10), 35-37. [In Chinese]

Deng, S., & Mi, Z. J. M. D. (2023). A review on carbon emissions of global shipping. *1*(1), 4.

Felício, J. A., Rodrigues, R., & Caldeirinha, V. (2021). Green shipping effect on sustainable economy and environmental performance. *Sustainability, 13*(8), 4256.

Jiang, M. (2025). Innovation and transformation of maritime vocational education under the background of green, low-carbon and intelligent development. *The Guide of Science & Education,* (5), 4-6. https://doi.org/10.16400/j.cnki.kjdk.2025.05.002 [In Chinese]

Lau, Y. Y., Dragomir, C., Tang, Y. M., & Ng, A. K. (2021). Maritime undergraduate students: career expectations and choices. *Sustainability, 13*(8), 4297.

Li, G., Tang, J., Liu, Y., Li, M., & Li, W. (2024, July). Cultivation of Innovative and Entrepreneurial Literacy of Maritime Talents. *In 2024 2nd International Conference on Language, Innovative Education and Cultural Communication (CLEC 2024)* (pp. 87-93). Atlantis Press.

Malau, A. G., Purnama, C., & Simanjuntak, M. B. (2025). Developing Competency-Based Maritime Education for the Digital Age. *Journal of Maritime Research, 22*(1), 100-106.

Manuel, M., Ghalwash, G., Elbawab, M. E., Ahvenjarvi, S., Nakazawa, T., Farag, Y. B., ... & Rowihil, M. (2019). *Global maritime professional book of knowledge (GMP-BoK).*

Maritime Safety Administration of China. (2025). *2024 China seafarer development report.* 2025-79384

Nalupa, H. D. V. (2022). Challenges and opportunities for maritime education and training in the 4th industrial revolution.

Nielsen, M. B., Bergheim, K., & Eid, J. (2013). Relationships between work environment factors and workers' well-being in the maritime industry. *International maritime health, 64*(2), 80-88.

Weng, S. G. (2023). Research on countermeasures for maritime talent cultivation in the new era. *Journal of Jiangsu Shipping College, 22*(2), 76-81. [In Chinese]

Wang, G., Yuan, J., Li, S., Ding, Z., & Deng, H.

(2019, June). Cultivation system of innovative talents in ship and ocean engineering complex engineering. *In International Conference on Applications and Techniques in Cyber Security and Intelligence (pp. 1-7)*. Cham: Springer International Publishing.

Zhao, S., Feng, D. D., Wang, X. J., Zhang, Y. P., & Feng, Z. J. (2019). Current situation and development ideas of semi-military management in maritime majors in the new era. *Maritime Education Research, 36*(1), 30-37. [In Chinese]

How to Cite: Wang, A., Sha, Z., & Wang, Q. (2025). Talent Development Strategies for Maritime Education under the Dual Challenges of Enrollment Stability and Green Transformation. *Contemporary Education and Teaching Research*, *06*(11), 502-511. https://doi.org/10.61360/BoniCETR252019281106