

ORIGINAL ARTICLE

Strategies for Leveraging the "Double High" Vocational Education Strategy to Empower Qingdao in Building a Modern Hub for Applied Education in Port and Maritime Transportation

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Building on Qingdao's strategic position as a "Belt and Road" dual node and its role as an international shipping hub in Northeast Asia, this study focuses on research aimed at establishing Qingdao as a leading center for modern port and maritime transportation applied education. Qingdao possesses advantages such as a robust port and maritime industry, support from institutions with "high-quality and high-level" characteristics, mature industry-education integration mechanisms, and advanced international standards; however, it also faces challenges, including misalignment between talent supply and demand, lagging professional programs and practical training, superficial integration of industry and education, and inadequate institutional mechanisms. To address these issues, this study proposes several countermeasures, such as establishing the Shandong Maritime Engineering University, constructing a three-pronged approach comprising "dynamic adjustment of academic programs + physical platform for industry-education integration + export of international standards," and improving the policy support system. These measures aim to build a national model and an internationally leading hub for port and maritime vocational education, thereby providing the "Qingdao experience" for building a maritime powerhouse and advancing the high-quality development of vocational education.

Keywords: Vocational Education, Double High-Level Project, Port and Shipping Logistics, Applied Education

INTRODUCTION

The report to the 20th National Congress of the Communist Party of China emphasized coordinating collaborative innovation in vocational education and other fields, optimizing the positioning of vocational education, and ushering in a strategic period of high-quality development opportunities for vocational education^[1,2]. As an important city serving as a dual node along the Belt and Road initiative, Qingdao bears the heavy responsibility of building an international shipping hub in

Northeast Asia. Against this backdrop, focusing on the national "Double High Strategy" for higher vocational education and accelerating the establishment of a modern, applied education hub for port and shipping transportation not only addresses the urgent need to serve the industrial upgrading of Qingdao's port and shipping sector but also serves as a strategic pivot for promoting innovative development of vocational education in Shandong Province and enhancing the international influence of China's vocational education system^[3].

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THE FOUNDATIONS AND ADVANTAGES OF QINGDAO AS A LEADING HUB FOR APPLIED EDUCATION IN MODERN PORT AND MARITIME TRANSPORTATION

The Port and Maritime Transportation Industry is Experiencing Robust Growth, With Its Strategic Positioning Becoming Increasingly Prominent

As a globally significant comprehensive hub port, Shandong Port achieved a cargo throughput exceeding 1.8 billion tons in 2024, with its container throughput surpassing 44 million TEUs, and its handling volume for bulk commodities such as crude oil ranking among the top in China^[4]. The Shandong Port Group, with Qingdao Port at its core, has established an integrated development framework characterized by "one central hub leading and three supporting wings collaborating," thereby enhancing its overall radiating influence. Currently, Qingdao Port is actively transforming toward becoming "intelligent, green, and a hub port." It has built the world's first intelligent air-rail transport system for cargo distribution and collection, achieving record-high operational efficiency at its automated terminals; it has pioneered the deployment of hydrogen fuel cell rail-mounted cranes and container trucks, setting a benchmark for a "hydrogen-powered port"; and it is leveraging its route network to establish a major international logistics corridor^[5]. Additionally, the cultivation of emerging business models—such as cruise tourism and Port Information Futures—is accelerating, while the integration of port operations with industry and urban development continues to deepen. This series of transformations not only sets higher standards for high-quality technical and skilled professionals but also opens up vast opportunities for the development of vocational education.

The leading role of the "Double High Plan" has become increasingly prominent, with core universities providing strong support.

In 2025, Qingdao Port & Shipping Vocational and Technical College was selected for the national "Double High Plan," becoming the only higher vocational college in Qingdao to be included in this initiative, marking a new stage of strategic national guidance for port and shipping education in Qingdao. As an industry-specific institution sponsored by Shandong Port Group, the college adheres to the "University–Port Integration" model, deeply integrates into the port and shipping industry chain, and plays a pivotal role in talent cultivation, technological R&D, and standard formulation. The college graduates more than 3,000 students annually, with an employment rate exceeding 98%, earning it the reputation as the "Whampoa Military Academy" of the port

and shipping sector. All nine core members of the "Li-angang Innovation Team" at the automated terminal of Shandong Port Group graduated from this college, demonstrating the deep integration of industry and education. The college has taken the lead in formulating 15 national vocational skill standards, established a national port-related assessment and certification station, and achieved an annual certification capacity of over 3,000 individuals, significantly enhancing Qingdao's voice in the field of smart ports^[6].

The Integration of Industry and Education Mechanism Has Begun to Take Shape, and the Outcomes of Collaborative Talent Cultivation Have Become Evident.

Leveraging its advantages as a college operating under a state-owned enterprise, the college has established a quadrilateral collaboration mechanism involving government, industry, enterprises, and educational institutions; it has taken the lead in establishing the National Port and Shipping Industry-Education Integration Community, collaborating with 124 port and shipping enterprises, research institutes, and industry associations to promote deep university-enterprise cooperation^[7]. Together, they have established 40 industry-education integration practical training bases and developed 17 smart port internship projects, thereby enabling immersive teaching where "classrooms connect directly with ports, and instruction extends into port zones." The college has implemented diverse talent cultivation models, such as "customized training classes," "craftsmanship-oriented classes," and the "modern apprenticeship system," with corporate mentors actively participating in course design and instructional implementation. Additionally, the college is actively exploring integrated pathways connecting secondary education, higher vocational education, and undergraduate studies, while developing "3+2" segmented training programs and pathways for advancing through vocational education examinations to break the "ceiling" limiting the growth of technical and skilled professionals, thereby providing practical experience for Shandong Province in building a modern vocational education system.

The Country is at the Forefront of Internationalization Efforts, With Initial Results Emerging in Standard Export Initiatives.

In line with Shandong Port's "Going Global" strategy, Qingdao Port Vocational and Technical College has proactively supported the Belt and Road Initiative by establishing overseas training bases such as the "Banmo College" at Pakistan's Gwadar Port and in Hungary, founding the International Port and Shipping School of Belarusian State University, and exporting professional standards and curriculum systems. The college has

trained over 2,000 local employees for overseas projects, including Egypt's Suez Canal Economic Zone and Chinalco's Guinea base, while developing 12 international training courses. Additionally, the college participates in the China-ASEAN Vocational Education Cooperation Alliance, promoting mutual recognition of academic qualifications and professional credentials, thereby vividly embodying the internationalization concept of vocational education—"where industry develops, education follows"—and contributing to Shandong's efforts to establish itself as a leading hub for vocational education cooperation with the Shanghai Cooperation Organization and countries along the Belt and Road.

MAJOR CHALLENGES IN THE DEVELOPMENT OF QINGDAO AS A LEADING HUB FOR APPLIED EDUCATION IN MODERN PORT AND MARITIME TRANSPORTATION

Structural Mismatch Between Talent Demand and Vocational Education Supply

Based on recruitment data analysis from 15 leading enterprises, including Shandong Port Group and COSCO Shipping for the period 2023–2025, the talent demand in Qingdao's port and shipping industry exhibits characteristics of "high interdisciplinary integration, high technical requirements, and high mobility." The intelligent transformation has reduced traditional loading and unloading positions by 32%, while demand for emerging roles such as smart equipment maintenance has surged dramatically, with a projected talent gap exceeding 60% over the next three years, and the local vocational education supply rate falling below 40%. In terms of competency standards, 76% of positions require mastery of interdisciplinary skills—for instance, in "hydrogen energy+5G" projects, 80% of technical troubleshooting requires collaboration among cross-disciplinary teams, highlighting the shortage of interdisciplinary talents. International competencies are particularly weak: Shandong Port operates 24 overseas warehouses under the Belt and Road initiative, yet only 12% of its engineers hold international certification qualifications—a figure significantly lower than that of Singapore (45%) and Rotterdam Port (52%).

The Establishment of Academic Programs and Practical Training Facilities Lag Behind the Iterative Advancements in Industrial Technology

There are 8 vocational colleges specializing in the port and shipping sectors in Qingdao, offering 32 academic

programs; however, there exists a severe structural mismatch: 52% of these programs are concentrated on traditional port machinery operation, while only 18% involve intelligent shipping with insufficient depth; the alignment between these programs and the 8 categories of urgently needed positions within the port and shipping industry is merely 64%. Enrollment shows an oversupply of traditional programs, while training in emerging fields such as artificial intelligence and green energy remains severely inadequate. The updating of practical training equipment lags behind, with an average iteration cycle of 5.2 years—far exceeding the industry standard of 2.3 years—and the adoption rate of equipment for areas such as hydrogen-powered propulsion and digital twins remains low. Faculty resources are also weak, with the proportion of "dual-qualified" teachers falling below 30%, the number of senior dual-qualified teachers being less than 12%, and only 28% of faculty members able to transform enterprise projects into teaching cases. Overall, there is an urgent need for optimization and upgrading in terms of program establishment, student enrollment, practical training, and faculty development, which currently fails to adequately support the demands of Qingdao's port and shipping industry for its intelligent and green transformation^[8].

The Implementation of Industry-education Integration Projects Has Yielded Suboptimal Results, and the Cooperation Mechanism Remains Underdeveloped

Although school-enterprise cooperation is currently widely implemented, substantive integration remains insufficient. Issues such as the frequent establishment of joint practical training bases, low equipment utilization rates, restricted hands-on operational privileges for students (who often engage only in simulated operations), and a graduation rate of fewer than 30% among graduates capable of independently troubleshooting equipment have arisen. In the "Modern Apprenticeship Program" at Shandong Port, enterprise mentors typically exceed the reasonable mentorship load per person, and there is a lack of systematic training; furthermore, students' participation in real-world projects is significantly lower compared to the German "Dual System" program. The West Coast Smart Industrial Park involves substantial investment, yet its curriculum content remains disconnected from industry demands, resulting in an employment rate of only 38%. Project-based teaching has progressed slowly: less than 40% of teachers' practical achievements from their enterprise experience are converted into teaching cases, and there is a lack of standardized conversion tools; additionally, enterprise technological upgrade projects tend to be fragmented, making it difficult to develop systematic curriculum resources. These issues constrain the effectiveness of school-enterprise cooperation and require urgent resolution.

Significant institutional and systemic barriers exist, and there is insufficient policy synergy and collective action.

The deep-rooted contradictions in the integration of industry and education stem from a lack of institutional support. Enterprises lack sufficient motivation to participate, as tax and fee reductions are capped at a maximum of 30% of the payable tax amount, the declaration process is cumbersome, and the average annual implicit cost borne by receiving enterprises for interns reaches 23,000 RMB, resulting in an imbalance between input and output. Property rights are poorly defined; in mixed-ownership practical training bases, the ownership of enterprise equipment remains unclear, and the absence of a fault compensation mechanism deters long-term investment. Collaborative mechanisms are underdeveloped: no municipal-level specialized coordination body for industry-education integration has been established; departments such as education, transportation, and human resources remain compartmentalized, leading to disconnected planning and fragmented resource allocation. Funding comes from various projects—including "Improving the Quality and Excellence of Vocational Education," "Smart Port Development," and "Skills Qingdao"—making it difficult to coordinate these funds effectively. Evaluation criteria are misaligned: educational authorities prioritize "college admission rates" and "awards won in competitions," while enterprises focus on "employee retention rates" and "problem-solving capabilities"; this mismatch between supply and demand results in a graduate retention rate of only 41%, coupled with severe talent outflow, highlighting the urgent need for institutional restructuring.

STRATEGIES FOR BUILDING QINGDAO INTO A LEADING HUB FOR APPLIED EDUCATION IN MODERN PORT AND MARITIME TRANSPORTATION

Establishment of Shandong Maritime Engineering University to Integrate the Talent Cultivation System for Port and Shipping Sectors

It is recommended to focus on restructuring Qingdao's modern port and shipping education resources by leveraging the "Double High-Level" development foundation of Qingdao Port & Harbor Vocational and Technical College, integrating high-quality resources from institutions such as Shandong Maritime Vocational College and Qingdao Ocean Shipping Crew Vocational College, and establishing the Shandong Maritime Engineering University. This initiative aims to establish a comprehensive educational pipeline spanning secondary vocational education—higher vocational education—professional undergraduate programs—and professional master's degrees, thereby addressing the issue of "broken pathways" in vocational education. The new university

should concentrate on cutting-edge fields such as smart ports and shipping, green vessels, and international shipping management, with a particular emphasis on developing in-demand majors including automated terminal operation and maintenance, hydrogen-powered propulsion systems, and cross-border supply chain management, thereby creating the "Qingdao Model" for cultivating high-caliber technical and skilled professionals in the port and shipping sector. Through various approaches—such as the "linkage between secondary and higher vocational education and undergraduate programs," the "vocational education college entrance examination," and "enterprise-customized training classes"—the university will expand the supply of high-level technical and skilled talents, enhance the alignment between local talent cultivation and industrial demands, and strengthen Qingdao's attractiveness and retention capacity for port and shipping professionals.

Establishing a Three-pronged Development Pathway Comprising "Dynamic Adjustment of Professional Clusters + An Integrated Industry-Education Entity Platform + Export of International Standards"

First, establish a dynamic adjustment mechanism for academic programs to achieve precise supply of educational offerings. A coordinated mechanism comprising the "White Paper–Expert Committee–Evaluation System" will be established: in collaboration with the Municipal Transportation Bureau, the "White Paper on Key Industries in Qingdao Port and Shipping" will be compiled; annually, competency standards for 8 types of positions—including intelligent terminal operations and multimodal transport coordination—will be released; and an expert committee for program establishment, composed of corporate technical directors and leading academics from educational institutions, will be formed to implement a "annual evaluation – dynamic optimization" system. For programs where the employment rate has remained below 70% for two consecutive years (e.g., traditional port machinery), early warning or elimination measures will be implemented; for fields where job demand has increased by more than 20% (e.g., hydrogen energy applications), micro-degree programs or specialized tracks will be introduced. The curriculum system will be restructured to develop core "Intelligent + Green" courses such as "Port AGV Scheduling Algorithms" and "Fault Diagnosis of Hydrogen-powered Rail Hoists," while a virtual-physical integrated practical training center for "5G + Hydrogen Energy Ports" will be constructed, aiming to cultivate 5,000 interdisciplinary professionals within three years.

The second initiative is to promote the deep integration of industry and education by establishing a substantive innovation platform for industry-education collabora-

tion. Within the Qingdao Free Trade Zone, the "Qingdao Port & Shipping Industry-Education Integration Demonstration Park" (a mixed-ownership enterprise) will be established through a joint venture between the Municipal Education Bureau, Shandong Port Group, and Gangwan College under a shareholding ratio of 4:4:2. This initiative aims to explore an equipment depreciation compensation mechanism, whereby host enterprises will receive special compensation equivalent to 15% of their equipment investment amount. The park adopts a "One Core, Three Zones" layout, comprising the Smart Port Technology Core, Equipment Training Zone, Technology R&D Zone, and Enterprise Incubation Zone; it also facilitates the establishment of joint laboratories with participating enterprises to accelerate the commercialization of technological achievements. Additionally, the "Smart Port Technology Research Institute" will be founded, equipped with laboratories such as the Digital Twin Terminal Simulation Laboratory, to collaboratively address key technical challenges. Furthermore, a "R&D-Standards-Teaching" feedback mechanism will be established to transform technological achievements into industry standards and teaching cases, with over 20 such transformations implemented annually, thereby promoting patent applications and leveraging resulting revenues to support teaching activities.

The third initiative involves innovating the "Dual-Spiral" talent cultivation model to foster deep integration between the teaching chain and the industrial chain. This is achieved by implementing the "Enterprise Projects in the Classroom" initiative—using the Qingdao Port's "Hydrogen Energy + 5G" smart terminal project as a case study, breaking it down into real-world projects such as "AGV Path Optimization," and developing "Real-World Problems, Real-World Solutions" course packages that enable students to participate throughout the entire process of design and debugging. Simultaneously, the evaluation system is being reformed by introducing enterprise KPIs as assessment criteria and implementing a "Skills Passport" system, under which candidates who meet the requirements are given priority for employment. A "Dual-Station Integration" faculty mechanism is being established, including the creation of "Engineer On-site Workstations" where key enterprise personnel participate in the development of modular textbooks; furthermore, "Faculty-Enterprise Practice Mobility Stations" are being set up, implementing a system of "3-month on-the-job practice + technology transfer," with promotion to associate professor requiring both practical experience and successful translation of these practices into curricula. Additionally, mixed-structure teaching teams, such as those focused on "Port Intelligent Equipment," are being formed to collaboratively develop digital teaching materials, thereby comprehensively enhancing the effectiveness of talent cultivation.

The fourth measure is to establish an internationalized vocational education standards system to support the "Belt and Road" dual-node city strategy. In collaboration with the China Classification Society, Maersk Academy of Maritime Education, and other institutions, we will develop international job standards such as "Smart Equipment Operation and Maintenance" and "Green Port Management," align these standards with the STCW Convention, and promote recognition from leading international ports and mutual accreditation of qualifications. A "dynamic standard update mechanism" will be established, leveraging feedback from overseas projects at Shandong Port to optimize competency units every six months. At the SCO Demonstration Zone, we will set up a "Blue Craftsman Academy" and jointly build a "Belt and Road" port and maritime skills training base with COSCO Shipping University, offering training in five major categories—including AGV remote control and LNG vessel maintenance—and developing bilingual course packages combining "theoretical MOOCs" with "virtual simulation training." Over a three-year period, we aim to train 2,000 technical experts for countries along the route, establish a credit mutual recognition mechanism with Piraeus Port and Gwadar Port, and create a closed-loop system encompassing "international standardization, talent cultivation, and technology backflow."

Enhancing the Policy Support System to Foster a Favorable Development Ecosystem

First, improve the incentive mechanism for industry-education integration: raise the tax credit limit for enterprises' participation in vocational education to 50% and simplify the approval process; establish a "Industry-Education Integration Enterprise" certification system, providing support in areas such as land use and credit access; and set up a compensation mechanism for practical training bases, issuing financial subsidies based on the number of interns to cover the enterprises' costs.

Second, build a long-term cooperation mechanism: establish a municipal-level coordination office for industry-education integration in the port and shipping sector, coordinating efforts among departments including education, transportation, human resources, and social security, and finance; establish a warning system that links program offerings with industrial demands, enabling integrated planning, funding, and project implementation.

Third, deepen collaborative innovation in smart education: develop the "Qingdao Port and Shipping Smart Education Cloud Platform," which integrates university courses, corporate case studies, and practical training data to promote resource sharing, mutual course selection, and mutual credit recognition, thereby fostering co-

ordinated development of vocational education in the region.

Fourth, strengthen international exchanges: leveraging the China–Shanghai Cooperation Organization Local Economic and Trade Cooperation Demonstration Zone, organize the "International Port and Shipping Vocational Education Forum," release the "Qingdao Port and Shipping Vocational Education Development Report," and enhance Qingdao's influence in the global port and shipping education field. Fifth, establish a port and shipping industry press group: cultivate high-end academic resources by launching specialized journals such as the "Port and Shipping Forum," "Shandong Port," "Port Machinery Engineering," and "Smart Port," thereby strengthening academic discourse power.

CONCLUSION

Through systematic reform and innovation—by eliminating institutional and systemic barriers, optimizing resource allocation, and innovating talent cultivation models—Qingdao is well-positioned to become the first city in China to establish a leading, exemplary, and international modern port and maritime transportation applied education hub, thereby providing the "Qingdao Experience"—a replicable and scalable model—for the implementation of the national "Double High Strategy," and contributing to the high-quality development of vocational education and the building of China as a maritime power^[9].

DECLARATION

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Conflict of interests

The authors declare that they have no competing interests.

Data availability statement

No additional data.

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