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# Study on Cultivation Mechanism for Intelligent Navigation Talents Based on "Discipline Crossing, Interdisciplinary Integration"

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> Abstract: The advancement of intelligent navigation will lead the shipping industry and a profound change in our country's navigation higher education. Based on the analysis of the current problems faced by China's navigation education and the demand for intelligent navigation, this paper puts forward the general ideas and strategies for the reform of the training mechanism of compound intelligent navigation talents based on the integration of navigation technology, Marine engineering and multi-disciplines, and explores the training path of compound intelligent navigation talents, which can be used for reference for the training of "Emerging Engineering Education" talents in navigation in China's higher education.

> Key words: discipline crossing, interdisciplinary integration, compound talents, intelligent navigation, Emerging Engineering Education

### 1. The Historical Background of Intelligent Sailing Talent Cultivation

Sea freight is national transportation. "An economic power must be a maritime power and a sea transportation power", and "to develop the economy and strengthen the country, transportation, especially shipping, must be stronger first," specified by General Secretary Xi Jinping has profoundly clarified the relationship between sea transportation and the <sup>1</sup>economy, as well as between sea transportation and national strategy, and clearly demonstrating the direction for the future development of China's sea transportation industry [1].

In recent years, the undergraduate nautical colleges taken as the main fronts for training nautical talents, have extended to the current 16 institutions from the traditional 4, namely, Dalian Maritime University, Wuhan University of Technology, Shanghai Maritime University, and Jimei University, reaching a total amount of nautical talent training which has already met the needs of traditional nautical talents in China. In the strategic context of a great transportation power and maritime power, waterway transportation is being profoundly integrated with new energy technology, modern information technology, and artificial intelligence technology while the shipping

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industry is presenting a green, intelligent, and flexible technological development trend as a whole with a new generation of shipping systems characterized by "shore-based remote driving control dominance, and few people on board terminal assistance" developing into a new direction for industry development. The American Society for Engineering Education (ASEE) believes that innovation in engineering education requires constant interaction between educational research and practice [2]. This critical period of restructuring the important waterway transportation technology system has made it extensively necessary and urgent to cultivate a high-quality and highly qualified crew that can adapt to the needs of future waterway transportation development, and to train complex intelligent nautical talents who can adapt and take the lead in developing the industry.

#### 2. Analysis of the Cultivation Needs of Complex Intelligent Nautical Talents

As a national control major, the nautical major will carry out performance competent education under the requirements of the STCW Convention, with generally the same curriculum systems for undergraduate and senior high school nautical colleges, consistent talent training positioning from an appropriate perspective, and a focus on competent education and sailing skills education. Its standard is mainly on training qualified seafarers, and the cultivation is directing at mastering the operation, maintenance and repair of ships, their equipment and systems, and ship operation management and personnel management. Relatively, the professional curriculum system is single, and the knowledge level is narrow. Meanwhile, the system knowledge reserves for related fields such as intelligent control, data science, and information technology are scarce while the problem of lacking capable persons to drive and manage new intelligent ships has shown up with the advent and promotion of intelligent ships [3].

Regarding the above issues, it is imperative to probe into the hierarchical and classified cultivation of nautical talents and develop new nautical engineering science. On the basis of policy literature analysis, relevant research on the issues such as the relations of higher engineering education: teaching, research and social services, professional education and humanity education, ability education and knowledge education, theoretical teaching and practical teaching, development of education and development of national and regional economy has been conducted in this study in which the research samples including academicians [4], experts from the State Maritime Administration's crew department, university professors, and business representatives are selected for semi-structured interviews (refer to Table 1 for sample distribution) according to the principles of representation, independence, and comprehensiveness of the research samples.

	University experts	Marine Bureau experts	Enterprise representatives	Alumni	Outstanding graduates
Interviewees	25	16	16	20	20
Interview period	3 hours	2.5 hours	2.5 hours	2.5 hours	2 hours

Table 1. Distribution of interview samples

After arranging the interviewed contents, the main indicators for cultivating complex intelligent nautical talents are summarized as follows:

1) Considering the academic positioning and cultivation models, it is a must for

higher nautical education to orient towards intelligent shipping, to clarify the cultivation goals of intelligent nautical talents, take serving the "transportation power", "maritime power" and "shipping power" strategies as the overall goal, center on intelligent shipping, rely on scientific and technological innovations such as 5G+, AI+, BDS+, and big data+ to drive industry development in intelligent ships, intelligent ports, intelligent shipping services, intelligent shipping services, intelligent shipping protection, intelligent shipping supervision, etc., and develop a talent training knowledge system to carry out key tasks such as scientific and technological theory innovation, bottleneck technology breakthroughs, and equipment application system promotion. It is also necessary to aim at the cutting edge of intelligent shipping development, regard industry demands as the guidance, deem balance between rivers and seas as the cultivation positioning, perform comprehensive system reform, and focus on breaking through the complex nautical talent training mechanism for intelligent shipping, following the development trend of intelligent shipping a model for cultivating complex intelligent sailing talents.

2) In allusion to the subject and professional structure, while meeting the appropriate requirements of modern ships, the complex intelligent navigation professional curriculum system should also pay attention to industry development, deeply integrate key disciplines such as transportation engineering, marine engineering, environmental science and engineering, emergency safety and engineering, and establish a curriculum system meeting the needs of the future development of the shipping industry. To establish the core professional curriculum, the IMO model curriculum system can be referred to with the emphasis laid on the consistency between the demonstration course and the STCW Convention. Besides, the general knowledge and elective curriculum should focus on intelligent ship technology, assisted driving technology, while strengthening the tracking of the development frontier of the discipline of great navigation, exploring and developing comprehensive courses, multi-perspective problem-solving courses, interdisciplinary discussion courses, etc. in addition to promoting the updating of teaching content with cutting-edge disciplines, industry and technology developments related to intelligent ships, unmanned ships, etc., and establishing a curriculum system that meets the needs of future shipping industry development [5].

3) Considering talent training and output, complex intelligent nautical talents should both meet the job suitability requirements of the current industry and be equipped with a deep mathematical and scientific foundation as well as backed by a strong interdisciplinary background. In terms of competency composition, in addition to strong practicality, more emphasis is placed on cultivating the ability to solve complex engineering problems, innovation and entrepreneurship, etc in order that a large number of high-quality reserve talents can be accumulated for the future development of the industry. The output of intelligent nautical talents can greatly ease the demand for new jobs. Shore-based support and assisted driving will make navigation a "more decent job". Meanwhile, it is also an important part of the cultivation of new maritime engineering talents to promote the cultivation of innovative spirit through technological change, to realize the inheritance of maritime culture through cultural confidence, and to carry out the ideological and political development of the course through the education of national conditions and values.

#### 3. Suggestions on the Cultivation Needs of Complex Intelligent Nautical Talents

In the context of the strategies for becoming a transportation and maritime powerhouse, there is a deep integration of waterway transportation with new energy technologies, modern information technology, and artificial intelligence. The shipping industry is generally showing a trend towards green, intelligent, and flexible technologies. A new generation of shipping systems characterized by "remote onshore control as the mainstay and minimal manning onboard as assistance" is emerging as the new direction for the industry's development. At this critical period of reconstructing the key waterway transportation technology system, it is necessary and urgent to cultivate a high-quality and high-caliber crew that can adapt to the future development needs of waterway transportation, as well as to foster compound intelligent navigation talents who can adapt to and lead the industry's development [6]. At the same time, the cultivation of maritime professionals is a systematic project that requires collaborative efforts from maritime authorities, institutions of higher education, industries, and society to jointly create an environment conducive to the cultivation of high-quality maritime professionals.

# 3.1. Scientific Positioning, Hierarchical Classification, and Achieving Differentiated Training of Higher Nautical Talents

Accurately identify changes, scientifically respond to changes, and proactively seek changes from the aspects of the expansion of the connotation, technical extension, and regional extension of nautical majors. Further clarify the orientation of talent training in higher nautical education and achieve differentiated nautical talent training for undergraduates, higher vocational education, and specialized secondary education. National first-class undergraduate majors should not only be positioned to meet the needs of large ships, special ships, new ships, intelligent ships, etc. For qualified personnel, but also be positioned to cultivate nautical system and engineering personnel under the background of intelligent navigation, focusing on cultivating high-end nautical technology personnel for intelligent shipping.

# 3.2. Serve the National Strategy, Lead Industry Development, and Focus on Cultivating Intelligent Nautical Talents

In terms of positioning the goal of intelligent nautical talent cultivation, we take serving the strategies of becoming a "powerful transportation country," a "powerful maritime country," and a "powerful shipping country" as the overall objective. We focus on intelligent shipping, relying on technological innovations such as 5G+, AI+, BDS+, big data+ to drive industry development. We construct a knowledge system for talent cultivation in the directions of intelligent ships, intelligent ports, intelligent shipping services, intelligent navigation protection, and intelligent shipping supervision. We carry out key tasks such as scientific and technological theoretical innovation, breakthroughs in bottleneck technologies, equipment system research and development, and technology application promotion. We aim at the forefront of intelligent shipping development, take industrial needs as the guidance, take river and sea integration as the training orientation, reform comprehensively and systematically, make key breakthroughs in facing intelligent shipping with a focus on cultivating compound-type nautical talents. We follow the development trend of intelligent shipping and explore ways to cultivate compound-type intelligent nautical talents.

## 3.3. Overall Planning of Resources, Perfection of Mechanisms, and Creation of a Coordinated Support System for the Cultivation of Intelligent Nautical Talents

The guarantee system for the cultivation of intelligent nautical talents requires internal and external coordination, improvement of institutional mechanisms, and linkage of resources from all parties. In terms of external guarantees, it is necessary for the state and industry to improve relevant systems and mechanisms, further enhance the social status, income, and occupational security of nautical personnel, thereby enhancing their professional attraction and sense of honor, improving the attractiveness of nautical majors, and laying a solid foundation for high-quality professional students in intelligent nautical fields. In terms of internal guarantees, universities need to accelerate the construction of an intelligent nautical talent training mechanism based on the traditional nautical talent training system, the "double-qualified" teacher team building mechanism, and the practical experimental condition guarantee mechanism [7]. They also need to accelerate the exploration of comprehensive collaborative training in intelligent navigation, adopt collaborative methods, achieve multi-level, multi-directional, and multi-channel collaborative education, build school-enterprise collaboration. interdisciplinary collaboration, industry-education collaboration, and international cooperation multi-collaborative training modes, and ensure the quality of intelligent nautical talent training.

### 4. Exploration of the Training Path for Compound Intelligent Navigation Talents

Under the guidance of "serving the national strategy and docking the needs of industry", WHUT has carried out profound exploration and practice in the fields of training positioning, training program, curriculum system, curriculum ideology & politics, condition construction, training mode and implement approach for intelligent navigation talents, accelerating transformation and upgrading of the "Emerging Engineering Education" majors. WHUT comprehensively promoted training reform for the compound intelligent navigation talents.

### 4.1. Intelligence-oriented and Interdisciplinary, Scientific Positioning of Compound Intelligent Navigation Talents

In order to comply with a future imperative field and meet the training needs of "Emerging Engineering" for intelligent navigation talents [8-10], relying on two of national first-class professional construction points, namely navigation technology and marine engineering, and on the basis of intelligence navigation class in the direction of ship navigation and control in 2017, WHUT has added a navigation technology & marine engineering integration class in 2021, massive effort has been conducted to cultivate high-end leading talents for intelligent navigation. The training objective of this class is to service national strategy: transportation power, maritime power, shipping power, to comprehensively master the professional theory and practical skills of two majors, to hold a multidisciplinary background of transportation engineering, navigation & information engineering, data science & engineering, safety & emergency engineering, to adapt the development of domestic and foreign shipping industry, to cultivate highly qualified and compound intelligence talents with comprehensive dynamic adaptability, innovation and entrepreneurship ability. Henceforth, the overall structure of three

classified training system for navigation talents has been basically completed: competent talents based on "Two orientations, three stages and school-enterprise cooperation", intelligence talents based on "Interdisciplinary and international collaboration", innovative and entrepreneurial talent based on "Two Collaborations". The homogenization of navigation education, and the structural imbalance between talent training and industry demand has been eased, value-added classified education has been promoted.

# 4.2. Goal-oriented and Student-centered, Constructing Cross-dimensional Curriculum Matrix

WHUT has comprehensive constructed interdisciplinary, integrated, multi-dimensional curriculum matrix system for intelligent navigation which support the requirements of talent training objectives. Curriculum system for both major courses and professional courses were centered on multi-disciplinary cross-training system which includes transportation engineering, navigation & information engineering, data science & Engineering, and safety & emergency engineering, etc. A further "Navigation + X" interdisciplinary and professional courses integrated system were proposed, WHUT has emphasized curriculum system of two directions (ship communication navigation and ship remote control) within three modules (competency, communication, control), and opened professional cutting-edge courses for smart ships and unmanned cargo ships. Intelligent navigation talents training curriculum system were formed and showed in Fig 1. In accordance with the construction standards of "advanced, innovative and challenging", and focusing on the core courses of intelligent navigation and marine engineering, the curriculum system and teaching content were designed from a holistic, systematic and cutting-edge perspective. On this basis, the curriculum standards for the training of new navigation engineering talents were formulated. In view of the new characteristics of students' learning in the information age, additional extracurricular content and credit hours were added, the depth, breadth and communication of specialized courses were reasonably expanded by blended teaching.



Fig 1. Interdisciplinary and dimensional curriculum system for intelligent navigation

# 4.3. Competency-priority and Innovation-highlighted, Establishing Practical Training Teaching System Based on Profession-innovation Integration

In 2017, MIT proposed the "New Engineering Education Transformation" (NEET) program. This program clearly states that "the center of engineering education should

emphasize the development of students' thinking [11]. "WHUT laid out and established a series of intelligent shipping practical innovation platforms, promoted interdisciplinary talent training, industry-university-research collaboration and guidance on innovation and entrepreneurship, put forward measures maritime competency training, and innovative & entrepreneurship training as important foothold for training of intelligent navigation talents. On the basis of competency experimental training platforms, such as two 45,000-ton training ships, six DOFs ship maneuvering simulation platform, Huangpi Water Training Base, WHUT highlighted training of innovative practical ability and teaching system, intensified "industry competency ", "intelligent technology", "innovation & entrepreneurship" three types of practical capabilities, created competency-oriented virtual simulation + "marine campus" internship ship platform, intelligent-oriented marine emerging engineering integrated practical platform, scientific innovation-oriented Smart Shipping Creator Zoom, and established comprehensive Intelligent Navigation Integrated Practical Platform. A six-grades platform "Experimental Platform - Practical Platform - Practical Base - Competition Platform -Research platform - Innovation platform" was built, a five-levels process "Cognitive Practice - Individual training - Confrontation Drill - Comprehensive Assessment -Innovation & entrepreneurship" was implemented. The arrangement for progressive and successional practical training system would last for full period of student's cultivation. Students' thinking habits and learning patterns were rebuilt and intelligent navigation education supply system were improved [12]. The graduates have acquired practical & innovative ability for further employment and development (refer to Table 2 for sample distribution).

# 4.4. Expanding Actively and Multi-party Cooperation, Constructing New Model of Collaborative Training of Intelligent Navigation Talents

WHUT has actively explored multivariate cooperation of training modes under the background of new era and emerging navigation, coordinated various resources such as enterprises, research bases, intramural practice platforms, international colleges and multinational shipowners, signed strategic cooperation agreement and practice teaching base agreement with 35 large enterprises and public institutions including China Merchants Group, Eastern Navigation Service Center, principally organized Collaborative Innovation Platform for Inland Waterway Intelligent Shipping Transportation Industry, Ministry of Transport, and "Science, education & production" Development cooperation body for "The Next Generation of Smart Shipping and Ports", Yangtze River Economic Belt, Ministry of Education. Remarkable education results were achieved, regarding the reform of training system for compound intelligent navigation talents. In 2021, the results of a third-party survey showed 99% satisfaction of employers with the quality of graduates. The proportion of graduates working in transportation industry increased by 11%, graduates in enterprise cooperative class found 100% job on board, 43% of students in intelligent navigation class were examined or through exam free recommendation for master degree in interdiscipline. The proportion of employment in the world's top 500 and strategic emerging industries were 52.2%, and the proportion of graduates with overseas exchange study experience increased by 10%. Students have achieved superb results in innovation fields, more than 80 achievements at or above the ministerial level have been obtained in the past three years, e.g "Internet Plus" college Student Innovation and Entrepreneurship Competition silver award, First prize of National Traffic Science and Technology Competition, national invention patent.

Time	Training Process		Organizational Forms	Supported Platform	
1st Year	Cognitive Practice Single Training	The courses focus on ship cognition experiment, physics experiment and computer basic software experiment to cultivate general knowledge foundation	General experiment Professional experiment	Experimental Platform	Ship Cognition Experiment Platform, Intelligent Navigation Experiment Teaching Platform
2nd Year	Competency Training Engineering Practice	The courses focus on basic skills training for	Independent experiment Individual practical training Innovation & entrepreneurship training	Practical Platform	Six DOFs Ship Maneuvering Simulation Platform
		seafarers., rely on the innovation and entrepreneurship training to carry out project research, cultivate professional ability and scientific research awareness		Practice Base	Huangpi Water Training Base
				<b>Research</b> Platform	Intelligent Navigation Integrated Practical Platform
3rd Year	Science & Technology Competition Innovation & Entrepreneurship	Carry out practical courses via virtual simulation and practice ship, set up interactive and cooperative navigation operation, confrontation exercises; Carry out the compartition practice On the bacin of the bacin of	Comprehensive ability training Cutting-edge practice of science and technology Innovation & entrepreneurship training	Practice Base	Changhang Training Ship, Ship Traffic Big Data Platform, Water Traffic Accident Inversion Platform
				Research Platform	National University Student Social Practice and Science Contest on Energy Saving and Emission Reduction, National Ocean Vehicle design and production competition, National Competition of Transportation Science and Technology for students
		innovation and entrepreneurship projects		<b>Research</b> Platform	Intelligent Navigation Integrated Practical Platform
				Innovative Platform	Smart Shipping Creator Zoom
4th Year	Comprehensive Evaluation Innovation & Entrepreneurship Guided	The courses focus on the training for second/third officer competency certificate; Carry out graduation practice on employmentative training ship and intelligent ship research base; Dissertation writing, focus on transformation and promotion of achievements, economic benefits and social value.	School-enterprise collaborative practice Dissertation (Design) Research popularization	Practice Base	Changhang Training Ship, Intelligent Ship Research Base
				Practical Platform	Intelligent Navigation Integrated Practical Platform
				Innovative Platform	Smart Shipping Creator Zoom

### Table 2. Progressive and successional practical training system for navigational experiments

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### 5. Conclusion

Starting for the strategy of serving the national "transportation power" and "maritime power", and keeping a close watch at the evolution of the content of nautical specialties, carrying out "driving integration" research and practice on training new engineering talents in navigation with the goal of meeting the needs of intelligent shipping talents is a new and far-reaching exploration after the adjustment of the "integrated driving communication" specialty. On the basis of "driving-machine integration", its deep integration with communication engineering, navigation and information engineering, data science engineering, safety emergency engineering and other disciplines to create a multi-disciplinary new maritime engineering talent training mode, and focus on the training of high-end maritime talents are conducive to achieving the transformation and upgrading of higher nautical education in China, leading domestic higher nautical education from competent education to strong foundation and wide-caliber talent training, accelerating the classification and classification of sailing education in China's nautical colleges and universities, and comprehensively enhancing the service competitiveness and service capabilities of the maritime industry.

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