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Research on the reform of marine education in the era of intelligent ship development

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Abstract: *Intelligent ships integrate new technologies such as information technology and artificial intelligence, and have significant characteristics such as safety and reliability, energy conservation and environmental protection, and economic efficiency. It is the key direction of the future development of commercial ships. Higher education in navigation under the background of ship intelligence should make full use of the advantages of traditional navigation majors, actively master the core technology of intelligent ship development, and actively carry out the cross-integration of computer science, control theory, communication science, artificial intelligent and other information sciences. High-quality compound "new engineering" navigation talents who master information technology and navigation science are cultivated under the background of intelligent ships. Under the background of intelligent ships, reconstructing the training of professional marine technology professionals in higher vocational colleges is conducive to the transformation and upgrading of traditional navigation majors in higher vocational colleges, and provides cutting-edge exploration for the development of high-quality compound "new engineering" navigation majors.*

Keywords: *Nautical education, education reform, intelligent ships, navigation technology*

1. Introduction

In recent years, the development of information, computer, communication, network, new energy, artificial intelligent and other technologies, as well as the application of the Internet of Things, big data, integrated bridge systems and cyber-physical systems, have made great progress and promoted the process of ship intelligence, and making it possible to become green, safe, and efficient unmanned smart ships [1]. Since the concept of smart ships was proposed, various countries have started research and exploration, and major research institutions have successively released “Road Map” for the development of smart ships [2]. Among them, the “Road Map” proposed by the International Maritime Organization (IMO) focuses on technology, the “Road Map” released by Lloyd's Register (LR) focuses on analyzing the relationship between people and ships, and the road-map presented by the China Classification Society (CCS) from the perspective of ship automation [3].

The “Road Map” is presented by Rolls-Royce describes four distinct phases [2]. The first stage requires remote control ships with a small crew, the second stage requires remote control of unmanned maritime vessels, and the third stage requires remote control. For unmanned ocean-going ships, the fourth stage requires autonomous navigation of unmanned ocean-going ships [4].

Intelligent ships have good application requirements and development prospects, it is the inevitable trend of future ship development. Seafarers trained in traditional sailing disciplines will not lose their jobs, but the nature of their work will change dramatically. Specifically, the command & control center of ocean-going ships will be transferred from the ship's bridge to a centralized command center onshore [5]. The crew of the future will be the same as onshore crews, remotely monitoring autonomous ships at sea from their own offices. Such remote-controlled ships will make sailing practitioners more popular and their image more noble. Smart ships are still in the stage of rapid development and have not yet fully matured [6]. The environmental perception technology, communication and navigation technology, condition monitoring and fault diagnosis technology of intelligent ships have been practically applied, but the safety early warning technology and autonomous navigation technology are still lack of

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verification in the real environment.

With the continuous breakthrough of science and technology such as integrated bridge system, cloud computing, artificial intelligence and "big data", as well as human's pursuit of safety, environmental protection and high quality of life, the cost of the shipping industry will continue to increase. It will be an inevitable trend for the development of the shipping industry to gradually reduce the manning of ships, improve the level of intelligence of ships and eventually realize unmanned ships [7]. 90% of world trade is transported by sea, which is an irreplaceable means of transportation. With the increasing number of ships and busy shipping routes, serious environmental pollution related to water transportation, high labor costs and insufficient safety have also received increasing attention.

In the smart ship project, artificial intelligence related knowledge series, such as Internet of Things, automatic control, information, big data, cloud computing, machine learning, ship motion control and risk management, are the supplement and extension of the traditional crew knowledge structure, which is very important for maritime talents [8]. The cultivation of new challenges and higher requirements is also worthy of attention. Through in-depth research on the concept of intelligent ships and sorting out key intelligent technologies, and a comparative analysis of the current shortage of professional personnel training in navigation technology, a new direction for the training of marine professionals based on intelligent ship technology is proposed via integrating a series of related technical projects and developing supporting projects.

2. New requirements for crew quality training in the development stage of intelligent ships

2.1. Crew quality structure required for ships integrated with automation and decision support functions

The current degree of ship automation is at this stage. Ocean-going ships are equipped with advanced navigation aids such as automatic identification systems, radars, electronic charts, speed logs, depth sounders, and fiber-optic gyro-compass in accordance with the requirements of international conventions, as well as integrated bridge systems supported by these instruments, Systems such as autopilot, smart stowage instrument and automated cabin [6]. The "crew" at this stage should not only have the vocational and technical qualities required by the relevant conventions according to the job classification, but also improve their ability to learn and apply computer software.

2.2. Crew quality structure required for ships with remote control function of the crew

Ships at this stage use technologies such as computers, the Internet of Things, and big data to achieve semi-autonomous navigation by connecting to shore-based centers, which provide ships with regular advice on safety, environmental protection, and energy efficiency optimization. The current progress of ship intelligence is in the transition period from the first stage to the second stage. Rolls-Royce and Switzer company conducted a remote operation test on commercial ships [3]. During the test, the tugboat was still equipped with the captain and crew to ensure the safety of the tugboat in the event of a system failure. The downsizing of the ship at this stage is obvious, and the crew positioning has two roles: onboard support personnel and onshore remote-control personnel.

On the basis of the crew qualities required in the first stage, the auxiliary personnel on board should master technologies such as the Internet of Things, artificial intelligence, sensors, control theory, and virtual reality, to ensure the safe operation of the manned ship through remote control and assist developers in promoting implementation of manned systems.

2.3. Crew quality structure required for ships without crew remote control function

At this stage, via ship data analysis, the port logistics information is added to the unmanned system to realize the seamless connection between the unmanned ship and the shore information, and achieve the optimization of navigation, ship scheduling and port operations in real time and dynamically. Ship intelligence has developed to this stage, and the technical difficulties that hinder the development of unmanned ships have been overcome [9].

To ensure the safety of the ship's navigation in the event of a sudden failure, the ship can be equipped with robots to perform auxiliary work, and all the “crew” will be transferred to the shore and become “land navigators”. The crew no longer needs to master basic skills such as the maintenance of the hull,

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the operation of equipment and the use of mechanical equipment, and only need to focus on the manipulation, scheduling and remote control of the safe operation of the ship, and master the Internet of Things, virtual reality, artificial intelligence and knowledge of control theory and other aspects to correctly identify abnormal phenomena during system operation and deal with faults in time.

2.4. Crew quality structure required for ships with fully unmanned autonomous function

The ships will be achieved fully autonomous unmanned driving and port handling and logistics automation, it is the goal of the development of unmanned ships at this stage. A series of technical difficulties represented by information transmission security, power plant stability and remote-control reliability have been overcome, and artificial intelligence has developed to a level of "strong intelligence" comparable to the human brain [10]. Although human hand over the transportation process to the intelligent ship system, the actual operation is still controlled by humans. For example, the instructions of the destination still require human input, and the unmanned automated container terminal also requires workers to operate in the centralized control room. At the same time, the name "crew" will be withdrawn from the historical stage except for the very few original crew members who continue to work in shore-based monitoring centers, the profession of "crew" will be dissolved in the emerging industries derived [11].

3. The reform of crew education in the new era of intelligent ship development

Smart ships will bring large-scale changes to the shipping industry and bring a new definition to the future crew industry. The era of intelligent ships will not cause the unemployment of traditional crew members, but only realize the transformation of the crew's working location from ship to shore; It is no longer necessary for the crew to directly contact and control the ship, but remote control by the crew on the shore. In the future, marine employment opportunities will be transferred to jobs related to the design, production, manufacturing, maintenance, operation, and operation of intelligent navigation systems and products. The job position of the crew may change from "pilot" and "engineer" to "ship status monitor", "ship remote operator" and so on. Meanwhile, it should be emphasized that the change of job location and work content will put forward higher requirements on the knowledge structure and skills of the crew [7].

Ship intelligence is a high degree of integration of multi-skills and data science, including external environment data perception, data cognition and other processes. The crew required by intelligent ships in future will be faced with the use of multi-disciplinary knowledge and skills to solve complex problems related with ship intelligence. The required knowledge and skills show a trend of multi-post skills and multi-professional knowledge, which is bound to have a profound impact on the reform of crew education in the new era [11].

3.1. Deep integration of multi-post, multi skills and multi-professional for intelligent ships

The pilot position of the traditional ship only needs to master the navigation and maneuvering skills to ensure the safe operation of the ship. The engineer position masters the operation and maintenance skills of the ship's main engine and auxiliary engines to ensure the smooth operation of the main engine, etc. The ship's electronic electrician position needs to complete the ship automation equipment. For maintenance and repair work, the personnel in each post have a clear division of labor and cooperate with each other to ensure the normal operation of the ship. Since the new intelligent technology has replaced the traditional ship operation skills, a crew member in the ship control center on the shore can control the traditional multi-position work such as ship driving and engine management, the scope of work is expanded, and the multi-positions are integrated into one position, which is called "one specialization with many abilities".

ISSN 2522-6398 Vol. 6, Issue 4: 48-55, DOI: 10.25236/FER.2023.060409

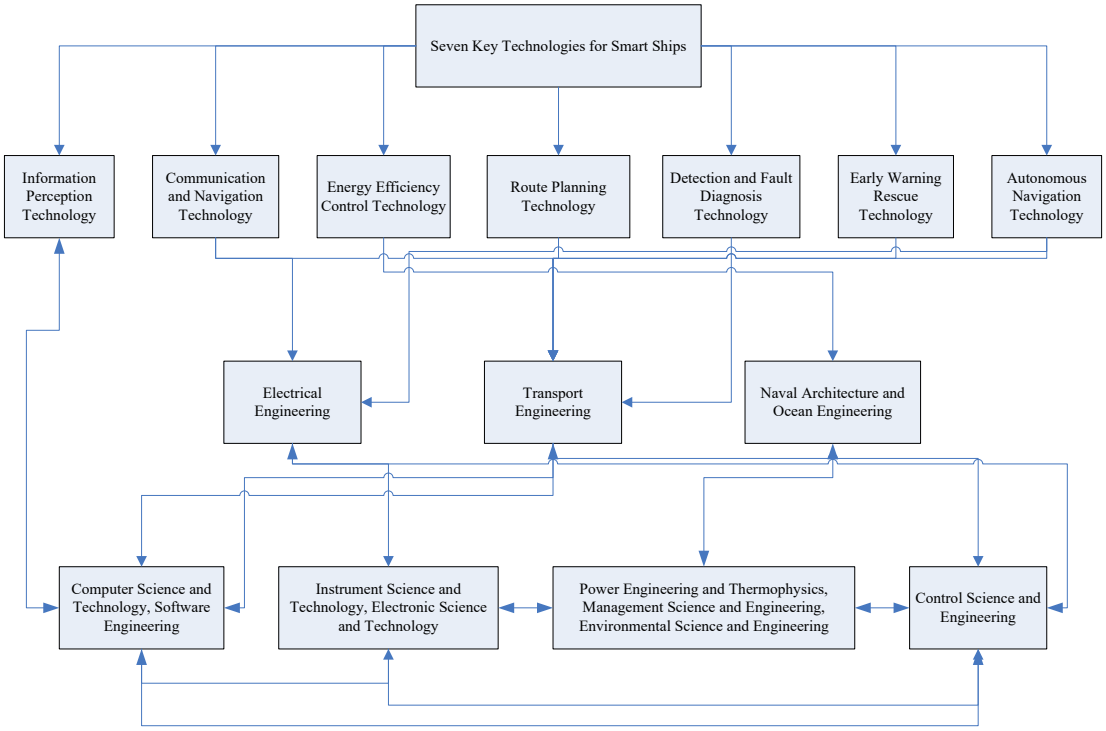

Figure 1: Core majors integrated into the seven technologies of smart

An intelligent ship crew member will be competent for the work completed by conventional multi-post and multi-person collaboration, and the knowledge structure of the crew member will be the cross-integration of multiple professions [3]. Crew members must also master relevant nautical professional knowledge, such as navigation technology, marine engineering technology, ship electronics and electrical technology, etc., as well as new knowledge of intelligent ship principles, remote control system operation, Internet of Things, artificial intelligent and other professional knowledge, to complete tasks such as remote monitoring of ships, operation status and adjustment of ship navigation. Figure 1 shows the core majors integrated into the seven technologies of smart ships. The trend of high cross-integration of multi-post skills and multi-professional knowledge shows that traditional navigation education can no longer meet the needs of crew training in the age of intelligent ships. The future crew education will undergo profound changes in terms of educational concepts, teaching modes, and training paths.

3.2. Professional adjustment and connotation construction for compound high-quality crew education

We can learn from the exploration of the Institute of Robotics of Zhejiang University and establish an intelligent ship research institute in the comprehensive navigation college to break through the barriers of disciplines and professions and train senior navigation personnel of intelligent ships. Under the background of the new era, the education of the crew runs through the whole life cycle of the concept, designing and operation of intelligent ships. Therefore, we should pay attention to the educational concept of "big caliber, thick foundation", abandon the overly detailed division of disciplines and majors, and adopt the mode of recruiting large categories and interdisciplinary integration for talent training. For crew education in the ship's operation phase, classification and training based on the seven functions defined in the STCW Convention's Manila Amendment is expected to replace the traditional classification and training model according to the ship's workplace and business sector [5]. Navigation engineers, marine engineers, electrical and electronic engineers, data network engineers, remote monitoring and operation personnel, route planners, meteorological and sea state forecast and analysis personnel, emergency decision-makers will gradually replace traditional ship pilots and electrical and electronic personnel.

In the past, the crew of one ship required a variety of skills, and now they will develop into a multi-functional high-quality crew who can manage and serve multiple ships. Therefore, the three traditional maritime professions must develop new professional connotations to satisfy the needs of the development of intelligent ships. It is not only necessary to establish a new education and training carrier, but also to integrate new courses and teaching links to complete the connotation construction. At present, the course

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system for seafarers in sailing colleges still refers to the capability requirements of the operation-level seafarers based on the Manila Amendment of the STCW Convention, while the training goal of seafaring talents based on the Manila Amendment of the STCW Convention is only to train qualified seafarers. Therefore, this training mode is far from the quality and ability of intelligent ship crew. Although the training objectives of the undergraduate navigation major are relatively broad and the course content is richer, it is still difficult to get rid of the shackles of international conventions, and it is far from meeting the training requirements of "broad caliber". Therefore, the establishment of seafarer education and training standards is very important for seafarers in the new era, and the ability to "solve complex ship problems" should be the core of seafarer training standards. It is necessary to integrate the curriculum, break the boundaries of disciplines, systematically reorganize the knowledge of related disciplines, and develop a multidisciplinary cross-integrated curriculum system to support the realization of the training goal of high-quality crew [2]. Focusing on the education and training goals, the core courses are determined according to the principle of "big caliber, thick foundation", so that students not only have the basic knowledge and skills of this major, but also learn and expand independently.

3.3. Crew education reform measures under the background of intelligent ships

At present, the training of seafarers mainly relies on the three majors of navigation, marine technology and ship electrical and electronic engineering. Disciplines supporting professional construction and personnel training mainly include traffic information engineering and control, navigation science and technology, marine transportation, ship engineering, power system and its automation, power electronics and power transmission, etc. Under the background of the new era, there are obvious limitations in the support of talents in existing disciplines [6]. To meet new educational requirements, it is necessary to transform or upgrade traditional or existing disciplines. The method to achieve this goal is the informatization, digitization and intelligent development of original disciplines on the one hand, and the penetration and intervention of other disciplines on traditional majors on the other hand.

With the application of new technologies such as big data, cloud computing, Internet of Things and artificial intelligence, crew education and professional construction need effective support from backbone disciplines including Control Science and Engineering, Computer Science and Technology, Software Engineering, Management Science and Engineering.

3.4. Reconstructing a complex high-quality seafarer training system

In viewing of the job content and job competency standards of future smart ship crew members, navigation colleges and universities need to conduct in-depth research on the future development direction and timetable of smart ships. And with the "Smart Ship Development Action Plan" and "Smart Ship Code", the "AI + Navigation" intelligent navigation professional group curriculum system is reconstructed by using the four parts of "AI General Education", "Professional Group General Education", "Professional Core Courses" and "Intelligent Crew Quality Development Course" [8]. Navigational colleges and universities should combine navigation majors and artificial intelligence majors in a timely manner to develop "ship intelligent control", "ship networking" and other related intelligent ship courses across industries. The latest achievements of ship intelligence and other related teaching content are simultaneously integrated into the professional core courses.

At the same time, the course explores a modular teaching model, infiltrates artificial intelligent, Internet of Things and big data into maritime applications, stimulates students' interest in learning, enhances the effect of intelligent ship knowledge learning and skill training. And technical training courses, such as ship shore-based monitoring technology, intelligent ship remote control technology, etc., should set up early and forward-looking to cultivate students' skills in operating intelligent ships.

3.5. The crew education and training model built for “smart shipping”

3.5.1. Reform of Crew Education Mode for Intelligent Ships

The "three-in-one" development system is established based on the government, enterprises and schools, and the government's overall planning is also strengthened. Continuous innovation has been made in terms of school-running concept, cooperation mechanism, organization and implementation methods, and a new ecology of "integration of production and education, school-enterprise cooperation, and cooperative school-running" has been built. The school has set up an academic committee, a teaching committee, a professional construction steering committee, and an employment and entrepreneurship

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steering committee, and has established an intelligent shipping college by adopting a public-private-partnership model with local governments, shipyards and shipping companies; The company has fully participated in the discussion of major issues such as professional construction, curriculum and textbook development, and teacher training; it focuses on deepening the construction of professional clusters that closely link intelligent shipping and the intelligent shipping industry chain, and strives to achieve mutual penetration and cross-integration of traditional majors such as marine engineering, navigation technology, and ship electronics and electrical, artificial intelligence, and big data, and build new engineering disciplines, which is actively responded to the "Belt and Road" initiative and provided services for the construction of a maritime power.

3.5.2. Curriculum system design for intelligent ships

With the development of major strategies such as the construction of maritime power and the transformation of new and old kinetic energy and the development of intelligent ship technology, traditional maritime education institutions urgently need to update the existing talent training system and adjust training plans. To meet the development needs of high-end equipment manufacturing and modern marine industry, explore the path of high-quality crew training.

First, according to the needs of the crew at different stages of development of smart ships, professional courses related to artificial intelligence such as the Internet of Things, automatic control, information perception, big data, cloud computing, machine learning, and ship motion control are set up, and interdisciplinary and professional courses are reconstructed.

Secondly, the information platform should be fully utilized in the teaching process. By deepening information technology to promote education and teaching reform and promoting new teaching models such as flipped classroom and blended teaching, a teaching model that combines online and offline teaching is constructed. In the whole teaching process, the main body status of students is constantly strengthened. At the same time, according to the characteristics of majors, the existing examination methods have been reformed, and the proportion of average course grades has been raised. And, Public examinations, thesis designs, research reports, physical/software works, and other forms of assessment should be encouraged, and the relevance and scientific nature of course assessment should be also enhanced.

3.6. Establishing a composite professional teacher innovation team

A faculty team that integrates teaching, science, and research has been built, and the teaching ability training of part-time faculty has been promoted. Maritime experts from government departments are regularly invited to give special lectures online and participate in the evaluation of the effect of practical training and select front-line personnel of enterprises to carry out extensive teacher training and participate in professional teaching. The offline training is promoted by the full-time teachers in the school and the part-time teachers in the company.

Professional skills development of the teaching team is promoted. Relying on the school's "Double Hundred Plan" to serve teachers' growth, after clarifying the training goals of high-level talents in the virtual simulation center, he or she will be implemented with key training. With the help of the resources of the National Maritime Survey Laboratory and cooperative units, according to the project development plan of the virtual simulation center, teachers are arranged to go to Norway, the United Kingdom, Germany and the United States to conduct relevant navigational driving simulator business training and promote the precise training of the professional skills of the teacher team. In addition, the mechanism of scientific research feeding back teaching is adopted, and the teacher team conducts secondary research and development on specific sea areas, ship models, etc. on the Kongsberg navigation simulator platform, which provide indispensable basic teaching materials for school teaching and promote the reform of teaching mode.

3.7. Deepening the cooperative education of production, learning and research

The government takes the lead and cooperates with top shipping companies, artificial intelligence companies and smart ship R&D institutions to build a collaborative innovation service and exchange center for smart navigation [11]. A community of shared destiny of "government, school, research and enterprise" with multiple inputs, technology integration and mutual benefit has been established. The functions of the intelligent navigation collaborative innovation service and communication center focus on the research and development of intelligent ship technology and carry out technology application

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research in the field of ship networking and intelligent perception of ship operating environment.

Today, with the rapid development of smart ships and unmanned ship technologies in related companies, industry-academia-research cooperation is more important and critical than ever. Partners must be relevant and progressive. The partners must be related to the vocational education of seafarers, be representative of the industry and occupy a leading position, and at the same time have certain advantages and rich technical accumulation in their leading industries. Guided by market demand, an effective cooperation platform has been built as soon as possible with schools and enterprises as the main body, focusing on the innovative adaptability of students applying for high school, collecting industry resources, and realizing a shared education system integrating education, practice and research.

3.8. Optimizing and improving the quality assurance system for crew education and training

3.8.1. Construction of quality standard system for crew education

The construction of the crew education quality standard system includes three parts: the construction and evaluation of the quality standard system. A talent training quality system that is similar the "Excellent Crew Education and Training Program" has been established, including national standards (mainly based on the STCW Convention), industry standards and school standards. The national standard is the general minimum standard, the industry standard is the professional standard specially used for navigating the subject, and the school standard is a higher standard established based on the above two standards, which is consistent with the actual situation of the school and has the characteristics of the school.

3.8.2. Building a dynamic adjustment mechanism for crew education

With the rapid development of new technologies in the maritime field, the establishment of a dynamic professional adjustment mechanism is important and critical to the sustainable development of the crew. So, it is suggested that according to the results of the quality evaluation of seafarer education and the new situation, the teaching objectives, standards, plans, modes, contents, etc. should be adjusted in time to ensure that the composite high-quality seafarers can meet the requirements of the industry and enterprises.

In addition, the requirements of the STCW convention system should be tracked in real time, and the education and training system should be dynamically updated to obtain the quality system certification of the State Maritime Safety Administration. The social evaluation of personnel training in colleges and universities, including third-party organizations such as classification societies, industry associations, and social employers, has been actively accepted and followed up. According to the evaluation results, timely adjust the talent training plan of the new marine engineering department.

4. Conclusion

Under the background of intelligent ships, higher navigation colleges should recognize the situation, grasp the development opportunities, and focus on the education development for compound high-quality seafarers. The paper briefly expounds the status quo of the development of intelligent ship technology, and systematically analyzes the changes brought by the intelligent ship era to the education of seafarers. A high-quality crew team with patriotism, innovative spirit, multi-professional knowledge and skills, and strong practical ability has been created to meet the higher needs of intelligent ships.

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