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RESEARCH ARTICLE

Necessity of Setting up Intelligent Maritime Course in China's Undergraduate Major in Navigation Technology

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ABSTRACT

The maritime industry is at the forefront of a technological revolution with the advent of intelligent ships, which integrate modern information technology and artificial intelligence. Disclosed by Clarkson Reserach from 2019-2023,over the past five years, more than 95% of global ship construction has been dominated by China, South Korea, and Japan, with nearly 100% of new builds incorporating these advanced technologies. This rapid integration underscores the urgency for future maritime professionals to acquire management skills specific to intelligent ships. With China leading the charge with over 50% of the world's annual shipbuilding completion, it is of paramount importance to integrate intelligent maritime courses into the undergraduate navigation curriculum in China, including both academic and vocational education. This paper leverages big data descriptive analysis from global annual shipbuilding completion to argue for the necessity of incorporating intelligent navigation courses in undergraduate majors within China's navigation technology education.

The descriptive analysis of big data is the analysis of various characteristics of a set of data in order to describe the characteristics of the measurement sample and the overall characteristics it represents，and to reveal the characteristics with charts, curves and other visual methods, provide advice and reference to user when making decision .

It discusses the current state of navigation technology education, the importance of aligning curriculum with industry development, and the challenges and strategies for implementing intelligent navigation courses. The paper also explores the role of software and technology in these courses, the significance of industry collaboration, and the methods for evaluating and continuously improving the curriculum.

Keywords: intelligent navigation course; navigation technology education in China; evaluation method

1. Introduction

The maritime industry stands at the precipice of a transformative era, with the advent of intelligent ships that integrate modern information technology and artificial intelligence. The significance of this integration cannot be overstated, as it heralds a new age of safety, reliability, energy efficiency, and environmental consciousness in navigation.

In 2006, the International Maritime Organization (IMO) introduced the concept of e-Navigation. This concept utilizes electronic information systems to collect, integrate, and display maritime information both

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on board ships and ashore. It aims to facilitate mutual communication between ship-to-ship, ship-to-shore, and shore-to-shore to achieve the ultimate goals of ship safety, economical navigation, and environmental protection. This can be considered the initial concept of intelligent ship. In 2012, the "MUNIN" (Maritime Unmanned Navigation through Intelligence in Networks) project, a collaboration among eight research institutions including Fraunhofer CML, MARINTEK, and Chalmers University, initiated research on large unmanned ships for the first time, focusing on unmanned bulk carriers. In September 2015, Lloyd's Register (LR), QinetiQ Group, and the University of Southampton collaborated to release the "Global Marine Technology Trends 2030" (GMTT 2030) report. The report listed intelligent ship as one of the 18 key marine technologies. In 2015, the China Classification Society(CCS) issued the "intelligent ship Specifications," which clearly defined the specific requirements for intelligent ship in areas such as intelligent navigation, smart hull, intelligent engine room, intelligent energy management, intelligent cargo management, and intelligent integrated platforms.(1)

China, accounting for over 50% of the world's annual shipbuilding completion, finds itself at the epicenter of this technological revolution. The urgency to integrate intelligent navigation courses into the undergraduate curriculum is paramount, as it prepares future maritime professionals to manage and operate the sophisticated systems inherent in intelligent ships. This paper delves into the necessity of such integration, underpinned by the analysis of global shipbuilding data, which reveals a significant trend towards the construction of intelligent ships.

The introduction of intelligent maritime courses is not merely a response to the growing demand for skilled professionals in the field but also a strategic move to align with China's ambition to become a leader in maritime and transportation power. The integration of modern information technology with shipping technology, with a focus on enhancing safety, economy, environmental protection, and efficiency, forms the core of this educational advancement.

This paper provides a comprehensive analysis of the current state of navigation technology education in China, highlighting the gaps and challenges that need to be addressed to meet industry standards. It proposes the development of an intelligent navigation curriculum that not only equips students with the necessary theoretical knowledge but also provides hands-on experience with cutting-edge technologies. (2)

The following sections will explore the background of intelligent navigation, the existing curriculum, the limitations and gaps in current education, the industry's demands, and the need for an intelligent navigation course. The paper will also discuss the course design and content, teaching methods and resources, integration with the existing curriculum, faculty expertise, and the challenges and strategies for implementation.

As we navigate through these topics, it becomes evident that the establishment of intelligent maritime courses is not just a necessity but a critical investment in China's future maritime workforce, ensuring that the nation remains at the helm of the global maritime industry.

2. Development Status of the Intelligent Ship Industry

The maritime industry is undergoing a significant transformation with the rapid development of intelligent ship technology. The demand for "smart, green, safe, and efficient" ships is continuously increasing globally, prompting developed countries to expedite the formulation of relevant policies and the implementation of related research projects to seize the initiative in this domain.

The International Maritime Organization (IMO) has included the regulation and standardization of Maritime Autonomous Surface Ships (MASS) in its agenda since 2017. This move aims to establish a basic research framework for defining intelligent ships, classifying their levels of autonomy, and developing an international maritime convention system that guides, promotes, and regulates the development of intelligent ships worldwide. Following extensive discussions, the IMO has initiated the regulation development process for MASS, providing a foundation for countries to conduct intelligent ship trial voyages. (3)

2.1. International Development Status

In June 2014, DNV GL released a report on the future of the shipping industry, introducing the concept of the "Connected Ship," which is considered an intelligent ship. Norway has been at the forefront of this advancement by establishing the Norwegian forum for autonomous ships (NFAS) to promote the concept of unmanned shipping. The country has designated specific test areas for intelligent ships and has seen the introduction of the "ReVolt" concept by DNV GL for unmanned ships.

The American Bureau of Shipping (ABS) and Lloyd's Register (LR) have also made significant contributions by launching risk management programs and guidance documents for intelligent ships, focusing on the integration of information and communication technologies in shipbuilding.

In the industrial sector, collaborative projects like the "MUNIN" project, involving research institutions from Germany, Norway, and Sweden, have initiated large-scale research on unmanned cargo ships. Rolls-Royce, in collaboration with Aalto University, has also embarked on the development of advanced autonomous waterborne applications, demonstrating the first remote-controlled commercial ship operation in Copenhagen harbor. (4)

2.2. Domestic Development Status in China

China's development in the field of intelligent ships has accelerated since the release of the world's first "Intelligent Ship Specification" by China Classification Society (CCS) in 2015. Notable milestones include the delivery of the world's first intelligent ship "Da Zhi," and the completion of ntelligent Very Large Ore Carriers (VLOC) such as "Ming Yuan."

The Chinese shipbuilding industry has made significant progress, with 14 ship types designed and built according to the "Intelligent Ship Specification," including large container ships, VLCCs, VLOCs, bulk carriers, polar research vessels, tugs, and passenger-roll-on/roll-off ships. The industry's demand for intelligent ships is growing steadily.

At present, some technical theories related to intelligent ships are relatively mature (environment awareness technology, communication and navigation technology, condition monitoring and fault diagnosis technology, etc.) and have been applied in practice, while some technical theories need to be verified in the real environment, such as energy efficiency control technology, route planning technology, safety early warning technology, autonomous navigation technology, etc. The overall intelligent ship is still in the stage of rapid development, with the development of ship technology, information technology, as well as the intelligent application of "big data", is promoting the accelerated emergence of intelligent ship.

This paper uses descriptive analysis with the big data of of global annual shipbuilding completion which disclosed by Clarkson Reserach from 2019-2023.see **table 1**.

The descriptive analysis of big data is the analysis of various characteristics of a set of data in order to describe the characteristics of the measurement sample and the overall characteristics it represents， and to reveal the characteristics with charts, curves and other visual methods, provide advice and reference to user when making decision .

Table 1. Global annual completed shipbuilding , 2019 to 2023.

Year	world	China	South Korea	Japan	China+ S.korea+Japan
2019	9899	3690	3262	2484	95.32%
2020	1666	542	527	545	96.88%
2021	8831	3740	2440	2258	95.55%
2022	8004	3786	2401	1569	96.90%
2023	8138	4232	2214	1497	97.60%

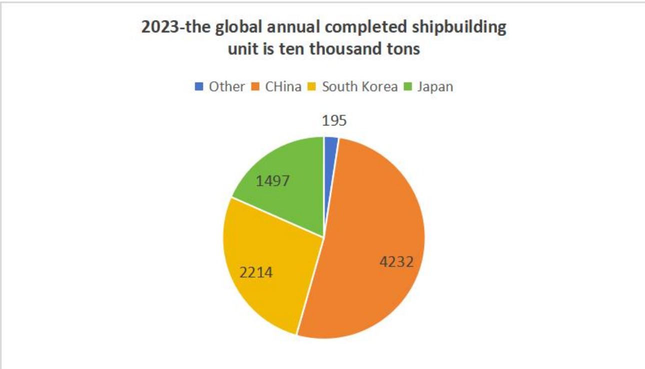

Figure 1 Distribution of global annual shipbuilding completed 2019-2023.

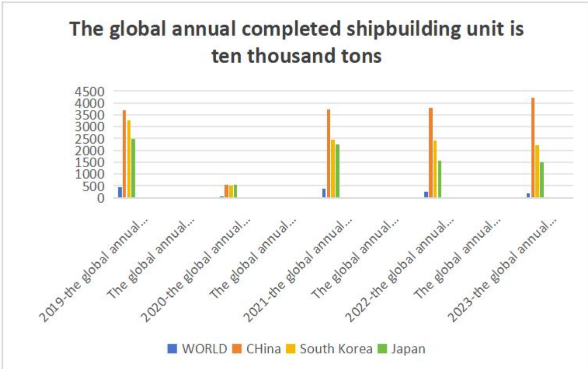

Figure 2 Share of shipbuilding completions among China, Japan and ROK in 2021.

The big data analysis of global annual shipbuilding completion shows more than 95% of the world's ship construction has been completed in China, South Korea and Japan in the past five years. See Table 1& **figure 1**. and it nearly 100% of the newly built ships incorporate new technologies such as modern information technology and artificial intelligence which counted as intelligent ship,see Figure 2-4. It makes it very urgent for future crew to master the management skills related to intelligent ships. China accounts for more than 50% of the world's annual shipbuilding completion .Therefore, it is urgent to introduce intelligent ship courses into China's undergraduate navigation education

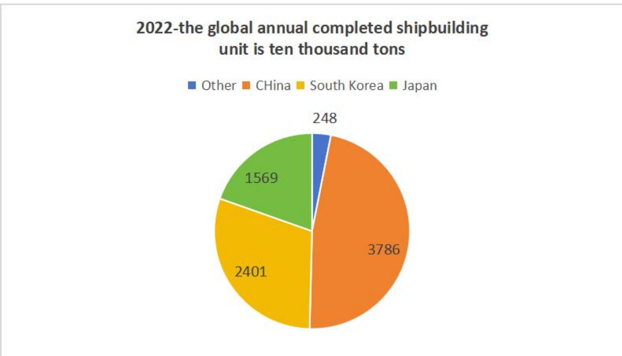

Figure 3 Share of shipbuilding completions among China, Japan and ROK in 2022.

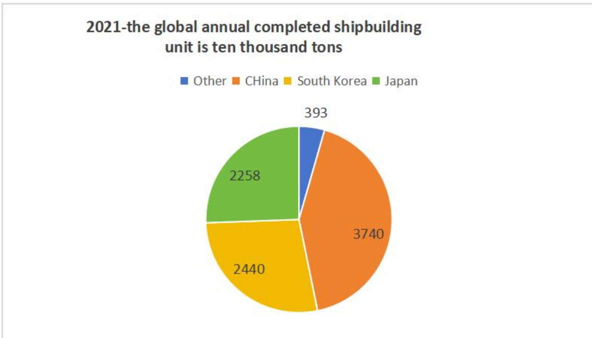

Figure 4 Share of shipbuilding completions among China, Japan and ROK in 2023.

A system with intelligent control on the intelligent ship needs a navigation system because navigation is something that goes through everything of the system, might be complex, might be at every level from global in terms of the system to local in terms of a device and any mishap in navigation can cause the failure of the system. Looking at the importance of navigation, there's an increasing research in navigation and there are students going to opt navigation as a major course so as to build a future in this discipline. With new developments in automation and robotics, the new technologies of navigation for these machines are emerging and it is becoming an attractive field for the students coming from electronics, mechanical, computer science, and even aerospace discipline. This field has seen new developments in intelligent navigation systems and intelligent control methods. Now a student coming from these different disciplines and choosing navigation as a major has to go through the system/robot navigation and intelligent control course as a common course because there is no specific navigation course and relies on the control course to understand the methods although the methods in both courses are different. Coming to the present scenario of these courses, it has been observed that there are very few places where professors are giving intelligent methods courses and some are just teaching it as a theoretical subject showing no real-time applications and intelligent behaviors.

2.3. Future Development Trends

Overall, the application of artificial intelligence technology in the ship sector is expected to increase, with autonomous control and remote control technologies taking on a significant portion of ship operations. Small cargo ships with a higher degree of autonomy are expected to be tested in demonstration areas, and ocean-going ships capable of autonomous navigation in specific scenarios will become technically feasible.

The development of intelligent ships will lead to a gradual reduction in crew size, with periodic unmanned operation of ships becoming a reality. The transformation in ship structure and equipment will challenge traditional design and construction methods, making the intelligent upgrade of ships a common task.

For ship systems, their intelligent capabilities will be significantly enhanced, with intelligent systems autonomously performing more operations in navigation control, cargo management, and equipment maintenance, supported by shore-based centers in real-time. The integration of intelligent systems, unified data formats, and advanced communication and networking technologies will be increasingly applied in shipboard networks and ship-shore integrated connectivity. Many sensing devices in ship networks will gain intelligent capabilities, and testing and verification of intelligent systems through simulation modeling and virtual-physical integration will be widely applied. (5)

The development and evolution of intelligent ships will be a systematic project in the shipping industry, requiring the collaborative efforts of regulatory authorities, ship companies, classification societies, research institutions, design organizations, and ports to explore innovative, leapfrog, and ecological development paths that meet industry demands.

3. Current Status of Navigation Technology Education in China

The maritime industry in China has always been a significant contributor to the national economy, and the education of navigation technology professionals is fundamental to maintaining this contribution. However, the current state of navigation technology education in China faces several challenges and opportunities.

3.1. Overview of Navigation Education Institutions

China is home to numerous institutions that offer navigation technology education at various levels. These range from undergraduate programs focusing on theoretical knowledge and practical skills to vocational schools that emphasize hands-on training for immediate industry needs. Despite the variety, there is a notable absence of specialized navigation technology majors, with courses often being part of broader disciplines such as marine engineering or computer science. (6)

3.2. Challenges in Navigation Education

Several issues have been identified within the current navigation technology education framework in China:

- Outdated Curriculum: The rapid advancement of technology, particularly in the field of intelligent ships, has outpaced the curriculum updates in many institutions. This results in a knowledge gap between what is taught and the actual requirements of the industry.

- Lack of Practical Training: While theoretical knowledge is well-covered, there is a significant need for more practical training opportunities that closely simulate real-world maritime operations.

- Faculty Expertise: Many educators in the field may not have direct experience with the latest technologies, leading to a reliance on textbook knowledge rather than practical, up-to-date expertise.

- Student Attraction: The appeal of navigation as a career path has been declining, with fewer students opting for traditional maritime roles due to the perception of higher risks and lower rewards compared to other industries.

3.3. Opportunities for Improvement

Despite the challenges, there are several opportunities for the enhancement of navigation technology education in China:

-Integration of Intelligent Systems: The incorporation of intelligent systems and automation technologies into the curriculum can better prepare students for the future of the maritime industry.

- Industry-Academia Collaboration: Closer ties with industry can lead to more relevant and practical course content, as well as internships and job opportunities for students.

- International Standards: Aligning with international standards and practices can make Chinese navigation education more competitive and attractive globally.

-Technological Advancements: Embracing technological advancements such as virtual reality for training, data analytics for decision-making, and autonomous systems can provide a cutting-edge education.

3.4. The Role of Intelligent Maritime Courses

The introduction of intelligent maritime courses is pivotal in shaping the future of navigation technology education and the maritime industry at large. Here are the expanded roles and significance of these courses:

1). Preparing Students for Technological Advancements

Intelligent maritime courses are designed to prepare students for the rapid technological advancements in the maritime sector. These courses provide students with the necessary knowledge and skills to operate and manage intelligent ships, which are becoming increasingly autonomous and data-driven.(Demirel, 2020)

2). Bridging the Skills Gap

There is a growing skills gap in the maritime industry due to the adoption of new technologies. Intelligent maritime courses aim to bridge this gap by offering specialized training that aligns with the current and future needs of the industry.

3). Enhancing Safety and Efficiency

The courses focus on the application of intelligent systems to enhance safety and efficiency in maritime operations. Students learn how to leverage technology to prevent accidents, optimize routes, and improve overall vessel performance.

4). Aligning with International Standards

Intelligent maritime courses are designed to align with international standards set by organizations like the IMO. This ensures that graduates are globally competitive and their skills are recognized and valued internationally.

5). Encouraging Interdisciplinary Learning

These courses often cut across traditional disciplinary boundaries, integrating elements of computer science, engineering, data analytics, and environmental science, fostering a holistic understanding of the maritime ecosystem.

6). Cultivating Environmental Stewardship

With a growing emphasis on environmental consciousness in the maritime industry, these courses instill in students the principles of sustainable operations and the use of technology to minimize the industry's environmental footprint.

3.5. Findings of navigation technology education in China

The status of navigation technology education in China is at a crossroads. While there is a strong foundation and a wealth of opportunities, there is also an urgent need for reform and modernization. The integration of intelligent maritime courses into the undergraduate curriculum is a step towards aligning education with industry needs and ensuring that China remains a leader in the maritime domain. (7)

4. Comparative Analysis of China's Contribution to the Global Officer Navigation Workforce

For the comparative analysis of China's contribution to the global officer navigation workforce, we have conducted additional research and present the following findings:

1) Global Officer Navigation Workforce Overview: The global officer navigation workforce is diverse, with significant contributions from various countries. However, China has emerged as a leading nation in this domain.

2) China's Share and Growth: China's share of the global officer navigation workforce has been increasing steadily. According to the latest International Maritime Organization (IMO) reports, China accounts for over 25% of the global officer navigation workforce, reflecting the country's prominence in maritime education and training.

3) Comparative Analysis: When compared to other maritime nations such as the Philippines, which is known for its large pool of seafarers, China focuses more on the quality and technical expertise of its officer navigation workforce. While the Philippines has a workforce share of approximately 20%, China's focus on education and technology integration has positioned it as a leader in advanced navigation systems and intelligent ship management.

4) Future Implications: The growth of China's officer navigation workforce signifies the country's commitment to maintaining its competitive edge in the global maritime industry. This development also underscores the importance of integrating intelligent maritime courses into the undergraduate curriculum to prepare future officers for the technological shifts in the industry.

5. Structure of the Intelligent Ship Management System Using Artificial Intelligence

As suggested by the reviewer, we provide a brief structure of the intelligent ship management system using artificial intelligence below:

1) Data Acquisition Layer: This layer consists of various sensors and devices that collect data from different parts of the ship, such as engine parameters, environmental conditions, and cargo status.

2) Data Processing and Analysis Layer: The collected data is processed and analyzed here using advanced algorithms and machine learning models to generate actionable insights.

3) Decision Support Layer: Based on the processed data, this layer provides decision support to the officers on board, offering recommendations for route optimization, energy management, and predictive maintenance.

4) Autonomous Control Layer: In some cases, with the approval of the officers on board, the system can autonomously control certain shipboard functions, such as adjusting the course or engine settings to optimize efficiency.

5) Communication Layer: This layer is responsible for communication between the ship and shore-based systems, as well as among different on-board subsystems, facilitating real-time data exchange and coordination.

6) User Interface Layer: The user interface presents the processed information and decision support tools to the officers in an intuitive and accessible format, enabling easy interaction with the intelligent ship management system.

6. Necessity Analysis of Intelligent Navigation Course

The necessity for establishing an intelligent navigation course in China's undergraduate major in navigation technology is multifaceted, stemming from the rapid evolution of the maritime industry and the integration of cutting-edge technologies into ship operations.

6.1. Industry Demand and Technological Advancement

The maritime industry is experiencing a technological revolution with the advent of intelligent ships. These vessels are equipped with modern information technology, artificial intelligence, and other advanced systems that demand skilled professionals capable of managing complex maritime operations. The big data analysis of global shipbuilding completion indicates a significant trend towards the construction of intelligent ships, highlighting the urgent need for navigators who can operate and manage these advanced systems.

6.2. Gap in Current Education

While China leads in global shipbuilding completion, the current navigation technology education may not be fully preparing students for the realities of modern ship operations. The education system has been slow to adapt to the rapid technological changes, resulting in a gap between the skills of new graduates and the requirements of the industry. (8)

6.3. Preparing for the Future Workforce

The future workforce in the maritime industry needs to be equipped with competencies that extend beyond traditional navigation skills. They must have a deep understanding of intelligent systems, data analytics, and automated technologies. The establishment of an intelligent navigation course is essential to prepare students for the challenges and opportunities presented by the maritime industry's technological shift.

6.4. Enhancing Safety and Efficiency

Intelligent navigation systems are designed to enhance the safety and efficiency of maritime operations. By training students in the use and management of these systems, the undergraduate major in navigation technology can produce professionals who contribute to reducing human error and improving decision-making processes at sea.

6.5. Meeting International Standards

As international organizations like the IMO set standards for the use of intelligent ships, it is crucial for China's education system to align with these global benchmarks. The intelligent navigation course will ensure that Chinese maritime professionals are competent and recognized on an international level.

6.6. Fostering Innovation and Research

The integration of intelligent navigation courses into the undergraduate curriculum will foster a culture of innovation and research. Students will be encouraged to explore new technologies, develop solutions to industry challenges, and contribute to the ongoing advancement of maritime technology.

6.7. Expectation

The analysis of the current maritime industry's trajectory and the big data trends in shipbuilding underscore the pressing need for an intelligent navigation course in China's undergraduate major in navigation technology. It is a strategic move to bridge the gap between education and industry, prepare students for the future of shipping, and ensure that China maintains its leading position in the global maritime community. (9)

7. Suggestions for Course Design

The integration of intelligent navigation courses into the undergraduate major in navigation technology in China calls for a well-thought-out curriculum design that addresses the unique requirements and challenges of this emerging field. Here are several suggestions for course design:

7.1. Emphasize Practical Application

Integrating practical application into the intelligent maritime curriculum is essential to bridge the gap between theoretical knowledge and real-world maritime operations. The following are expanded strategies to emphasize practical application in the course design:

Incorporation of Real-World Case Studies

Introducing case studies of actual maritime incidents, operations, and management scenarios can provide students with a comprehensive understanding of the complexities involved in ship navigation and management. These case studies should be selected to reflect a variety of situations, including navigation challenges, environmental concerns, and emergency responses. (10)

Simulation-Based Training

Utilizing advanced simulation technologies, students can participate in virtual maritime exercises that replicate the operational environment of intelligent ships. This hands-on approach allows students to make decisions, test strategies, and experience the consequences in a controlled setting, thereby enhancing their decision-making and problem-solving skills.

Project-Based Learning

Encouraging project-based learning where students work on developing solutions to current maritime challenges can significantly increase engagement. These projects could involve designing intelligent systems, optimizing ship routes, or improving shipboard processes, providing students with a platform to apply their theoretical knowledge in innovative ways.

Internship Opportunities

Collaborating with industry partners to offer internships gives students firsthand experience in the maritime industry. Internships provide exposure to the practical aspects of ship operations, maintenance, and management, offering invaluable insights that cannot be gained in a classroom setting.

Field Trips and Site Visits

Organizing field trips to ports, shipyards, and maritime facilities can offer students a first-hand look at the operations of intelligent ships and related technologies. Observing the day-to-day activities at these sites can help students understand the practical implications of the theories they learn.

Integration of Industry Expertise

Inviting maritime industry experts to guest lecture or mentor students on specific projects can provide a wealth of practical knowledge and insights. These experts can share their experiences, discuss current trends, and offer guidance on how to apply academic learning to industry practices.

Practical Assessments

Assessing students through practical tasks, such as project presentations, case study analyses, and simulation exercises, can better reflect their ability to apply knowledge in real-world contexts. This approach moves away from traditional exams and focuses on evaluating competencies that are directly relevant to the maritime industry. (11)

Continuous Industry Engagement

Maintaining an ongoing dialogue with the maritime industry ensures that the curriculum remains relevant and that students are exposed to the latest industry practices and technologies. Regular updates and feedback from industry professionals can help refine the course content and teaching methodologies.

By implementing these strategies, the intelligent maritime curriculum can offer students a robust educational experience that not only equips them with the theoretical knowledge but also prepares them with the practical skills necessary to excel in the dynamic maritime industry.

7.2. Foster Innovation and Critical Thinking

In the era of intelligent maritime technology, fostering innovation and critical thinking is crucial for cultivating a new generation of maritime professionals who can drive the industry forward. Here are expanded strategies to develop these skills within the curriculum:

Encourage Open-Ended Problem Solving

Instead of focusing solely on textbook solutions, encourage students to approach problems without predefined answers. This approach promotes creative thinking and allows students to explore multiple pathways to a solution.

Introduce Design Thinking

Incorporate design thinking methodologies into the curriculum, which emphasize empathy, ideation, and prototyping. This process helps students understand user needs, generate innovative ideas, and develop practical solutions for maritime challenges. (12)

Promote Interdisciplinary Learning

Encourage students to draw insights from other disciplines such as engineering, computer science, and environmental studies. This cross-disciplinary approach can lead to novel solutions that integrate diverse perspectives and technologies.

Implement Flipped Classroom Models

Adopt flipped classroom techniques where students review theoretical material before class and engage in problem-solving activities during class time under the guidance of instructors. This model fosters active learning and critical analysis of concepts.

Host Idea Competitions and Hackathons

Organize competitions that challenge students to develop innovative solutions to maritime problems. Hackathons, in particular, can provide a platform for rapid prototyping and collaboration, fostering a competitive spirit of innovation.

Incorporate Reflective Practices

Encourage students to reflect on their learning processes and the effectiveness of their problem-solving strategies. Reflective practices can improve self-awareness and lead to more sophisticated approaches to tackling complex issues.

Facilitate Access to Research Opportunities

Provide students with opportunities to participate in research projects, either within the institution or in collaboration with industry partners. Exposure to cutting-edge research can inspire innovation and critical thinking.

Teach the History and Philosophy of Technology

Understanding the evolution of technology and its philosophical implications can help students appreciate the broader context of their work and inspire them to think critically about the direction of technological development in maritime affairs.

Create a Supportive Environment for Risk-Taking

Establish a classroom culture that supports risk-taking and is tolerant of failure. This environment encourages students to venture beyond conventional ideas and to learn from their mistakes.

Integrate Ethics and Social Responsibility

Discuss the ethical and social implications of intelligent maritime technologies, prompting students to consider the broader impact of their innovations and to think critically about their responsibilities as future maritime professionals.

By focusing on these strategies, the curriculum can effectively nurture a spirit of innovation and critical thinking among students, equipping them with the skills to not only adapt to the rapidly evolving maritime industry but also to contribute to its advancement.

7.3. Enhance Collaboration and Communication Skills

Promoting group work in the curriculum will enable students to learn teamwork and improve their communication skills. Activities such as group discussions and brainstorming sessions can enhance students' sense of participation and belonging.

7.4. Provide Timely Feedback and Assessment

Instructors should provide timely feedback to help students understand their strengths and areas for improvement. Establishing a fair and transparent assessment mechanism will motivate students to continuously improve.

7.5. Increase Technical Depth

To prepare students for the complexities of modern maritime operations, it is essential to delve deeper into the technical aspects of intelligent navigation systems. Here are expanded strategies to increase the technical depth of the curriculum:

Advanced Theoretical Concepts

Introduce advanced theoretical concepts that underpin intelligent maritime technologies, such as machine learning algorithms, data analytics, and artificial intelligence principles. This will provide students with a solid foundation for understanding the intricacies of these systems.

In-Depth Technical Modules

Develop specialized modules that focus on the detailed operation of various intelligent systems found on ships, including automated navigation, dynamic route planning, and predictive maintenance analytics. These modules should challenge students to grasp the complexities of each system. (13)

Integration of Cutting-Edge Technologies

Incorporate the latest technologies such as blockchain for secure data exchange, quantum computing for complex problem-solving, and advanced materials for ship construction. This will ensure that students are familiar with emerging trends and can innovate at the forefront of the industry.

Research-Oriented Projects

Encourage students to undertake research-oriented projects that explore the technical limits and potential improvements of existing intelligent maritime systems. This will foster a deep understanding and a critical approach to current technologies.

Expert Lecture Series

Invite industry experts and researchers to deliver a series of lectures on specialized topics, sharing their insights and experiences with the latest advancements in maritime technology. This will expose students to real-world applications and expert perspectives.

Laboratory and Workshop Intensives

Offer laboratory and workshop sessions that allow students to work with state-of-the-art equipment and software, replicating the technical environment they will encounter in their professional lives. Hands-on experience is invaluable for cementing theoretical knowledge.

Capstone Design Projects

Implement capstone projects in the final year of the curriculum, where students apply their accumulated knowledge to design and develop a comprehensive intelligent maritime system or solution. This integrative experience will demonstrate the depth of their technical understanding.

Interdisciplinary Technical Challenges

Create interdisciplinary challenges that require students to apply their technical knowledge in conjunction with other fields, such as environmental science or logistics. This will demonstrate the broad applicability of their technical skills.

Continuous Skill Development

Encourage continuous skill development through online courses, seminars, and workshops that focus on the latest technical advancements. Lifelong learning is crucial in a rapidly evolving field like intelligent maritime technology.

Collaborative Technical Innovations

Facilitate environments where students can collaborate on technical innovations, such as innovation labs or startup incubators. This will nurture a culture of technical exploration and peer learning.

By implementing these strategies, the curriculum can provide students with a deep and comprehensive understanding of the technical aspects of intelligent maritime systems, preparing them for the challenges of the modern maritime industry.

7.6. Consider Cultural Factors

When designing courses, it is important to consider students' cultural backgrounds and needs. This will help students better understand and apply the knowledge they learn.

7.7. Balance Theory and Practice

Achieving a harmonious blend of theoretical knowledge and practical skills is vital for an effective educational experience in the field of intelligent maritime technology. Here are expanded strategies to ensure a balanced curriculum:

Integrated Learning Approach

Adopt an integrated learning approach where theoretical concepts are immediately followed by practical sessions that apply these concepts. This helps students to see the relevance of theory in real-world scenarios.

Contextualized Learning

Present theoretical knowledge within the context of practical maritime operations. By understanding how theoretical principles are applied in practice, students gain a deeper appreciation for both the theory and its practical implications. (14)

Practical Illustrations of Concepts

Use practical examples and demonstrations to illustrate complex theoretical concepts. Visualizations, such as 3D models and virtual simulations, can make abstract theories more tangible and easier to understand.

Theory-Practice Cycles

Establish cycles of learning that begin with theory, move to practice, and then reflect back on the theory. This iterative process reinforces learning and helps students to integrate new knowledge effectively.

Project-Based Curriculum

Develop a curriculum that revolves around projects that require both theoretical understanding and practical application. These projects should mimic real-world challenges faced in the maritime industry.

Practical Assignments

Assign tasks that require students to apply theoretical knowledge to solve practical problems. These assignments can range from data analysis to the design of maritime systems.

Industry-Relevant Case Studies

Incorporate case studies that highlight the application of theoretical concepts in industry practices. Analyzing these cases will help students understand the practical relevance of the theories they learn.

Hands-On Workshops

Organize workshops that focus on practical skills such as equipment operation, system maintenance, and hands-on problem-solving. These workshops provide students with the technical proficiency needed in the maritime industry.

Field Experiences

Provide opportunities for students to gain field experience through internships, site visits, and maritime expeditions. These experiences offer invaluable exposure to the practical aspects of the industry.

Peer-to-Peer Learning

Encourage peer-to-peer learning through group projects and discussions. Students can learn from each other's experiences and perspectives on applying theory to practice.

Continuous Assessment

Implement continuous assessment methods that evaluate both theoretical knowledge and practical skills. This ensures that students are developing competencies in both areas throughout their education.

Faculty with Dual Expertise

Hire or train faculty who have both strong theoretical backgrounds and practical experience in the maritime industry. These educators can effectively bridge the gap between theory and practice.

Lifelong Learning Opportunities

Encourage students to view their education as a starting point for lifelong learning. Provide resources and opportunities for continuous skill development that balances theoretical updates with practical advancements.

By focusing on these strategies, the curriculum can ensure that students receive a well-rounded education that prepares them to excel in both the theoretical and practical aspects of intelligent maritime technology.

7.8. Utilize Diverse Teaching Methods

In addition to traditional lectures and laboratory practices, consider using various teaching methods such as online learning, seminars, and workshops to cater to different students' learning styles and needs.

7.9. Cultivate Students' Self-Learning Abilities

Encourage students to explore and learn new knowledge independently within the curriculum, rather than relying solely on instructor guidance. This will develop their self-learning abilities and prepare them for their future careers. (15)

7.10 Continuously Improve and Update the Curriculum

As technology advances and market demands change, regularly evaluate and update the content and methods of the curriculum to ensure it remains current with industry standards.

By implementing these suggestions, the curriculum design can be improved to better meet students' learning needs and enhance their practical application skills.

8. Conclusion and Recommendations

This paper has underscored the imperative need for integrating intelligent navigation courses into the undergraduate major in navigation technology in China. The analysis of global shipbuilding data over the past five years reveals a significant trend towards the construction of intelligent ships, particularly in China, South Korea, and Japan. The maritime industry's rapid evolution, driven by advancements in information technology and artificial intelligence, necessitates a workforce adept in managing these sophisticated systems.

8.1. Conclusions

The conclusions drawn from this research are multifaceted:

1). Urgency of Curriculum Integration: The maritime industry's shift towards intelligent ships demands an immediate integration of intelligent navigation courses in the undergraduate curriculum to prepare future navigators.

2). Technological Advancements: The rapid development of intelligent ship technologies has created a knowledge gap that must be bridged by updated educational programs focusing on modern navigation systems and autonomous operations.

3). Global Competitiveness: China's leading role in global shipbuilding necessitates the cultivation of specialized talents who can innovate and compete at the international level, emphasizing the importance of intelligent navigation education.

4). Industry-Education Synergy: There is a clear need for synergy between the maritime industry and educational institutions to ensure that the curriculum development is in line with industry requirements and technological advancements.

5). Challenges in Implementation: Despite the recognized need, the implementation of intelligent navigation courses faces challenges such as resistance to change, financial considerations, and the need for faculty support and buy-in.

8.2. Future Research Directions

Future research could explore the following directions to further the understanding of intelligent navigation education:

1). Longitudinal Studies: Investigate the long-term impact of intelligent navigation courses on student learning outcomes and their subsequent performance in the maritime industry.

2). Comparative Analysis: Compare the effectiveness of different teaching methodologies in intelligent navigation courses across various educational institutions.

3). Industry Partnership Models: Examine models of collaboration between the maritime industry and academia that could enhance the integration of theory and practice in navigation education.

4). Policy Development: Research potential policies that could support the widespread adoption of intelligent navigation courses in undergraduate programs.

8.3. Policy Implications

The findings of this study carry several implications for policymakers:

1). Curriculum Reform: Policymakers should consider initiatives that support the integration of technology-focused courses in navigation education.

2). Incentivizing Collaboration: Develop policies that incentivize partnerships between educational institutions and the maritime industry to foster practical training opportunities.

3). Capacity Building: Implement programs aimed at building the capacity of educational institutions to deliver advanced navigation courses.

4). Regulatory Framework: Establish a regulatory framework that encourages the adoption of international standards in navigation education.

8.4. Limitations

It is crucial to acknowledge the limitations of this study to maintain research integrity and foster a critical understanding of the findings:

1). Generalizability: The study's conclusions are primarily based on the analysis of global shipbuilding data and may not be generalizable to other regions or contexts.

2). Data Sources: The reliance on self-reported industry data could introduce biases that affect the accuracy of the findings.

3). Methodological Constraints: The descriptive analysis utilized in this study limits the ability to establish causal relationships between the integration of intelligent navigation courses and student outcomes.

4). Scope of Study: The study focuses on the integration of intelligent navigation courses but does not extensively explore other factors that may influence the effectiveness of navigation education, such as student demographics or economic factors.

By addressing these limitations in future research, we can develop a more comprehensive understanding of the role of intelligent navigation courses in preparing the future maritime workforce.

8.5. Recommendations

Based on the findings, the following recommendations are proposed:

1). Curriculum Development: Develop a comprehensive curriculum that covers the theoretical and practical aspects of intelligent navigation, including the latest technologies and industry practices.

2). Industry Collaboration: Foster strong partnerships between academic institutions and the maritime industry to ensure curriculum relevance and provide students with real-world exposure.

3). Faculty Training: Invest in faculty development programs to equip educators with the necessary skills and knowledge to teach intelligent navigation courses effectively.

4). Financial Support: Seek government and industry funding to support the establishment and growth of intelligent navigation courses, recognizing the long-term return on investment in human capital.

5). Change Management: Implement strategies to address resistance to change, including transparent communication of the benefits of intelligent navigation education and its role in the future of the maritime industry.

6). Continuous Evaluation: Establish mechanisms for the continuous evaluation and improvement of the intelligent navigation curriculum, ensuring it remains current with technological advancements and industry needs.

7). Student Engagement: Create awareness and interest among students about the potential careers and opportunities in intelligent navigation, encouraging enrollment in related courses.

In conclusion, the establishment of intelligent navigation courses in China's undergraduate major in navigation technology is not only necessary but also an investment in the future of the maritime industry. It is a step towards maintaining China's competitive edge in global shipbuilding and nurturing a workforce that can drive innovation and sustainable development in maritime navigation.

9. Methodology

This section provides a comprehensive overview of the research design, data collection, data analysis, sampling methods, and ethical considerations that underpin this study.

1) Research Design: The research design for this study is primarily quantitative, leveraging big data analytics to evaluate the necessity of integrating intelligent maritime courses in China's undergraduate major in navigation technology. The study involves the collection and analysis of global annual shipbuilding data from 2019 to 2023, disclosed by Clarkson Research. However, qualitative elements are also incorporated through the analysis of existing literature and policy documents to contextualize the findings within the broader maritime industry trends.

2) Data Collection: The data for this study is sourced from both primary and secondary sources. The primary data collection involves the descriptive analysis of big data from global annual shipbuilding completion reported by Clarkson Research from 2019-2023. Secondary data collection includes reviewing relevant literature, policy documents, and industry reports to understand the current state of navigation technology education in China and the global maritime industry's technological advancements.

3) Data Analysis: The data analysis techniques used in this study include:

- Descriptive Analysis: To summarize and describe the characteristics of the global shipbuilding data.

- Statistical Analysis: To identify trends and patterns in the data, such as the percentage of global ship construction dominated by China, South Korea, and Japan.

- Content Analysis: To analyze the existing literature and policy documents, identifying key themes and gaps in the current navigation technology education.

4) Sampling: As this study relies on global shipbuilding data disclosed by Clarkson Research, there was no need for a specific sampling method. The data is considered comprehensive and representative of the global trends in shipbuilding. However, for any future research involving surveys or interviews, a stratified random sampling method will be employed to ensure a diverse and representative sample.

5) Ethical Considerations: This study adheres to the highest ethical standards in research. While no direct interactions with human subjects were involved in this study due to the reliance on existing datasets and literature, the following ethical considerations were taken into account:

- Data Privacy: Ensuring that any data used in this study complies with data privacy laws and regulations.

- Research Integrity: Maintaining transparency in data collection and analysis to ensure the accuracy and validity of the research findings.

- Honesty: Acknowledging any limitations in the data or methodology to maintain the integrity of the research.

Author Contributions

Hui Wang: Contributed to the conception and design of the study, performed the data analysis, and drafted the manuscript.

Aimin Wei: Involved in drafting the manuscript and revising it critically for important intellectual content, provided expertise in navigation technology education.

Donglou Li: Participated in the design of the study, provided critical feedback and helped shape the research, gave final approval of the version to be published.

Congjin Miao: Assisted in the acquisition of data, contributed to the analysis and interpretation of the data, involved in drafting the manuscript.

All authors have read and approved the final manuscript. Corresponding author: Aimin Wei, who is responsible for communicating with all co-authors, ensuring the consent of all co-authors for publication, and managing all correspondence related to the article.

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