Interdisciplinary Development of Maritime Education and Training Orienting to Career Planning in the era of Artificial Intelligence

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Abstract

Artificial intelligence (AI) potential impact on the future of maritime transportation has been extensively discussed in recent years, increased autonomy of the shipping industry is inevitable. This study investigated maritime students' and educators' perception of the impact of AI influence, and explore how to optimize the maritime education and training (MET) curriculum to increase their lifelong career ability. Traditional MET focuses on the specific equipment operation and convention-required certificate examination, the result of market demand-oriented is the training institutions only pay attention to the seafarer's ship operating ability and seamanship experience, which brings challenges to the seafarer's lifelong career planning. The investigation results show that the AI-influenced MET curriculum requires multi-disciplinary integration, keeping the overall difficulty and curriculum intension significant to keep student study willing. The training schools, academic institutions, policy-making institutions, and international regulations-making institutions need to achieve unified coordination to deal with these challenges.

Keywords

Maritime education and training (MET); Interdisciplinary collaboration; Seafarers career; Intelligent ship navigation; Demand-oriented.

1. Introduction

The information technology and intelligent development have changed the operation mode and direction of many industries. Traditional maritime shipping industry also has gradually been advanced from digitization and informatization to intelligence [1]. E-navigation has been advancing for ten years, for safe ship navigation, a number of sensors have been deployed, a large of digital data can be storing and mining. Data is the energy source for the advancement of AI. With the accumulation of database scale, the enhancement of computing power, and the improvement of machine learning algorithms, shore-based long-distance monitoring and unmanned control will become possible, related service training and professional skill seafarer education will become a new trend. In the era of AI, the interaction mode of traditional shipping elements will be subverted. Market demand-oriented MET will also face new challenges [2]. The comprehensive talent of the seafarers will be required. In particular, the number of shore-based seafarer with professional skills which has maritime background will be significantly increased [3]. With the automation level of Maritime Autonomous Surface Ships (MASS) continuously being improved over the next two decades, the current MET curriculum cannot equip marine engineers and seafarers with adequate skills and knowledge to meet the needs for future intelligent shipping. Therefore, the maritime education system and training model need to be systematically reformed [4].

In 1967, the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) issued Circular No. 37 entitled "Ship Automation"; in 2018, the MSC provided some achievements on the regulatory scoping work for MASS. Indeed, intelligent ship navigation can reduce the number of maritime accidents caused by human error, reduce the number of casualties, carbon emissions; saving seafarers space, energy, and some other operating costs [5]. The goal of the International Association of Maritime Universities (IAMU) is to make tangible contributions to the international maritime community through the education and training of top-notch maritime personnel and by conducting academic research activities in maritime safety [6]. In the era of AI, IAMU and the members of maritime universities should drive and guide this reform and innovation through interdisciplinary collaboration and education institution differentiation. At present, providing the maritime certificates of competency is the main purpose of MET [7]. The curriculum has been developed focusing on ship manipulation, navigation aid devices operation, and the relevant international conventions [8]. Uniformed evaluation standards and training systems have led to a narrow career development path for seafarers, and increased homogeneity competition. Hence, maritime universities should take the development of smart ships and intelligent shipping as the main line, promote the deep integration between maritime education, cutting-edge technology and industry development, redesign the MET framework [9]. A multi-level maritime training model, from junior college, undergraduate, master to doctor degree, would be preferred to meet the future needs.

From the view of educator, interdisciplinary collaboration is required for maritime education and seafarer’s career planning in the era of artificial intelligence. The new format of intelligent shipping means that MET teachers need to integrate multiple disciplines, especially the in-depth integration of information technology, artificial intelligence and traditional maritime transportation engineering. Smart ship and intelligent shipping demand more sophisticated requirements and skills of ship manipulation, management, operation and maintenance. The teacher with other different professional backgrounds will play crucial roles in the MET.

From the view of seafarer, institutional differentiation is a useful way to realize the differentiation of seafarer’s career planning. The traditional competency of the seafarer will be transformed into a new professional model of shore-based monitoring and ship-shore interaction. The traditional training and certification standards for maritime talents divided by the attributes of the deck department and the engineering department will be changed. The intelligent transformation of the shipping industry will be able to place high-quality maritime talents in more wider fields, such as maritime finance, insurance, law, ship management, and maritime administration. For intelligent shipping, the functional settings included: intelligent navigation, intelligent ship architecture, intelligent engine room, intelligent energy efficiency management, intelligent cargo management, intelligent ship control, and intelligent integration platform, closely focus on the maritime industry chain, implement the training and differentiate development of navigation and shipping talents, make sure varied career directions of seafarer have good development prospects [10].

2. Materials and methods

2.1 related work

We demonstrate the detail of research progress and development direction of the shipping industry in the era of AI, including review the latest developments of computer vision, human-computer interaction, path planning, autonomous decision-making, and control. Identify the gap between the current developing situation and the possible development direction in the near future. How to step by step approach to achieve the goals from the technical perspective. As shown in figure 1, the whole survey map can be separated into three different modules. User interaction module including shore-based surveillance (shipping company, whole related administrations) and all possible communication (satellite, shore to ship, and ship to ship). Ship navigation module including ship bridge navigation, engine room support, and cargo & ship hull maintenance. Environmental sensing module including data platform construction and sensors data fusion. The top priority of

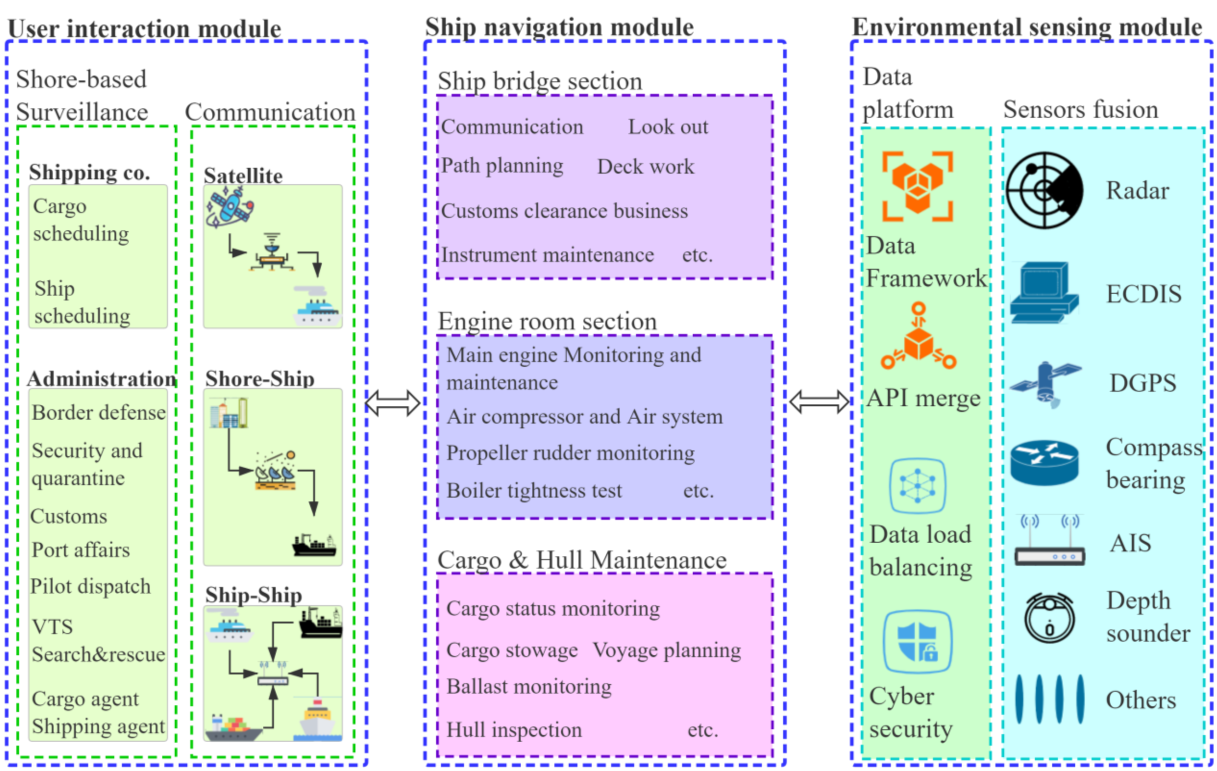

Figure 1. The elements of ship navigation and shipping business.

the project is to figure out the relationship between different modules and their involved disciplines, illustrate every potential new technology into different specific sections, evaluate its automation level, and find out the approach of complete autonomous operation without human involvement. For example, for path planning of the ship bridge section, in the past, we had to manually set a waypoint on the chart. For the unmanned ship bridge, we have to consider the way to achieve all possible waypoints based on the user interaction module and environmental sensing module information. The task will define the interdisciplinary relationship and its direction of automation.

At present, these three modules all can't be fully unmanned, and they involve different subject knowledge. If ships are truly unmanned, the maritime talents to be cultivated will need to have a good knowledge base. This means students will face more difficult and stressful courses in the future. In the next, we will conduct a survey on students to understand their thinking. Then in the context of smart ships, exploring to design curriculums that can enhance the student's lifelong professional abilities and student can accept.

2.2 Survey design

The aim of this study is to investigate the current MET curriculum, navigation knowledge and skill gaps for manipulating different level intelligent ships. Three key stakeholders: maritime education institution, educator, and seafarer should be considered in the survey questionnaire design. We explore and identify a series of new elective courses which highlight the interdisciplinary collaboration and institutional differentiation for seafarer lifelong career development in the era of AI. Before design our survey, we provided four questions for clarify our objective:

(1) Does the current curriculum of MET provide seafarer's knowledge and skills for careers planning in the future?

(2) With the increase of automation level, how to enhance the seafarer's ability to adjust lifelong careers planning?

(3) According to different levels of intelligence ships, what kind of navigation competency skills need to be acquired?

(4) To adapt to this upcoming change, how to re-design the MET curriculum to achieve the best interdisciplinary integration?

At present, we designed two questionnaires for maritime students and maritime educators, in March 2021, an anonymous online survey was distributed to students at Dalian Maritime University. We divided the students into three categories according to the type of work: on-board majors (navigation technology, engine technology, etc.), maritime-related majors and others. As shown in figure 2, we use a fishbone diagram to sort out the influence factors of the work onboard willingness, according to the five elements of "people, event, time, place, and things", find out all possible elements. Based on the survey design, we summarized the influence factors of the seafarers' career planning fishbone diagram as follows.

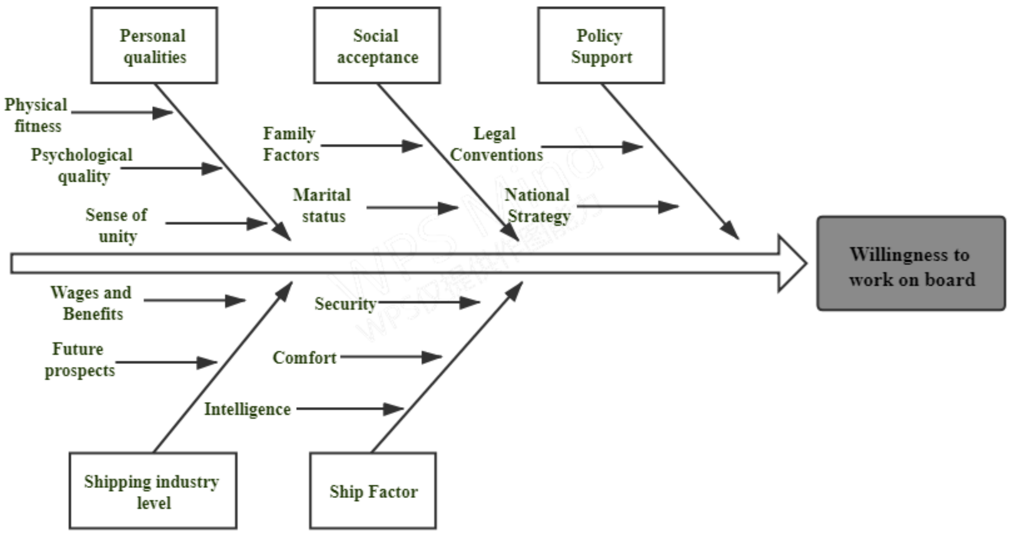

Figure 2. Analysis chart of willingness to work on board

3. Data analysis

3.1 Students state analysis

Among 266 student respondents and 43 educator respondents, we use a fishbone diagram to analyze three factors that might influence maritime students to work onboard: social recognition; salary and company brand. Chi-square test have been used to analyze the differences between these three factors. For the statistical inference of large categorical data, the chi-square test has the advantage of convenient and simple than the T-test. The analysis results shown as table 1.

Table 1: The distribution of seafarers' salary satisfaction among different majors.

Title	Options	Professional category			Proportion	χ^2	p
		on-board majors	maritime-related majors	others			
Salary	Very satisfied	10.64%	9.09%	21.82%	15.93%	9.376	0.154
	Fairly satisfied	51.06%	36.36%	60.00%	53.98%		
	Less satisfied	23.40%	36.36%	10.91%	18.58%		
	Dissatisfied	14.89%	18.18%	7.27%	11.50%		

As shown in table 1, maritime-related major students have less rate of salary satisfaction. Other major students have higher satisfaction level than on-board major students and maritime-related major students. However, the satisfaction of the seafarers' salary does not show significant difference for the three categories (if the probability p>0.05, it means no significant difference).

Table 2: The distribution of seafarers' social recognition among different majors.

Title	Options	Professional category			Proportion	χ^2	*p*
		on-board majors	maritime-related majors	others			
Social Recognition	Very Recognized	14.89%	0.00%	30.91%	21.24%	26.294	0.000**
	Basically recognized	31.91%	72.73%	54.55%	46.90%		
	Not very much	51.06%	18.18%	14.55%	30.09%		
	Not Recognized	2.13%	9.09%	0.00%	1.77%		

Table 3: The distribution of seafarers' company brand among different majors.

Title	Options	Professional category			Proportion	χ^2	*p*
		on-board majors	maritime-related majors	others			
company brand	Salary	65.96%	54.55%	47.27%	55.75%	24.051	0.007**
	Business Scope	6.38%	0.00%	18.18%	11.50%		
	Promotion Speed	10.64%	18.18%	1.82%	7.08%		
	Promotion Space	12.77%	27.27%	7.27%	11.50%		
	Ship condition	2.13%	0.00%	14.55%	7.96%		
	Other	2.13%	0.00%	10.91%	6.19%		

As shown in table 2 and 3, both the probabilities less than 0.05, it means the social recognition and company brand self-identity of seafarers showed a significant difference (chi=26.294, p=0.000<0.01). A significant difference analysis shows that seafarer’s social recognition is less than other careers.

Table 4: Different majors' views on unmanned ships.

Title	Options	Proportion	χ^2	*p*
The realization of ocean-going unmanned ships navigation	Must	29.20%	2.631	0.854
	Possible	58.41%		
	Impossible	4.42%		
	Uncertain	7.96%		
Development directions	Human involvement	50.44%	9.084	0.059
	Remote control	37.17%		
	Autonomous driving	12.39%		
Current difficulties	Unfilled and other	12.38%	15.365	0.222
	International rules	19.47%		
	Autonomous decision making	19.47%		
	Port construction	5.31%		
	Cabin Watch	17.70%		
	Information Perception	25.66%		

Table 4 shows that on-board majors, maritime-related majors and other major students have different views on the factors that affect the willingness of marine students to work on board. We use the chi-square test (cross analysis) to analyze the major categories for unmanned ships navigation. The intelligent shipping realization, development directions and current difficulties are the three significant differences.

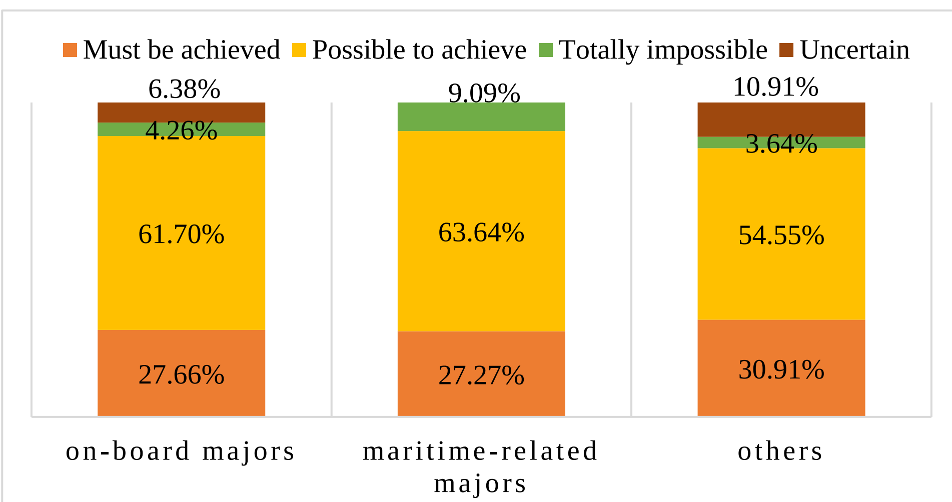

Figure 3. Unmanned ships implementation attitudes from the different majors' students

As shown in Figure 3, it is not difficult to find that the three different major categories hold a cautious attitude towards unmanned ships navigation. There are 61.7% (on-board majors), 63.64% (maritime-related majors), and 54.55% (other majors). It is believed that full unmanned ships navigation may be realized in the future. As shown in figure 4, there are also different opinions on the unmanned level can be approach: It is generally believed that ocean-going ships require human participation or remote-control. 87.23% from on-board major students, 100% from maritime-related major students, 85.25% from other major students.

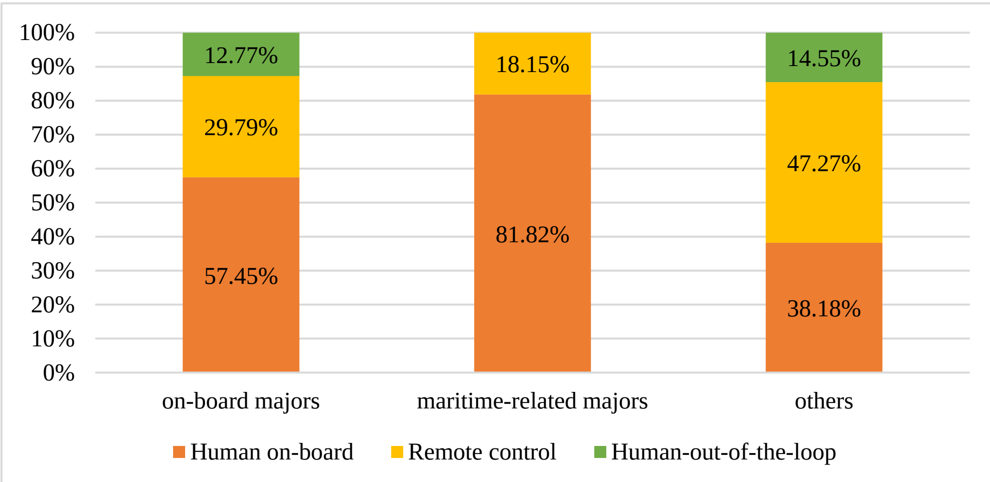

Figure 4. Intelligent shipping industry attitudes from the different majors' students

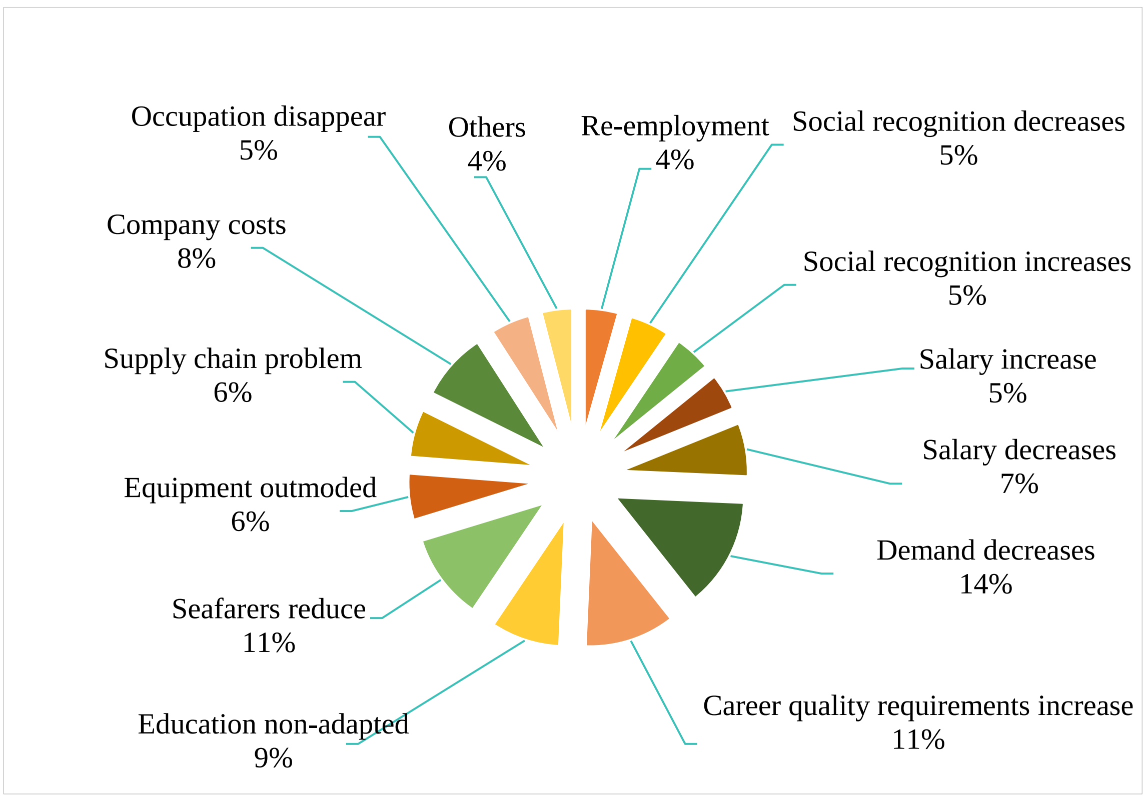

Figure 5. Response rate of the current problems and intelligent shipping

As shown in Figure 5, for the distribution of multiple-choice questions, the chi-square goodness-of-fit test was used for analysis, and response rate can be calculated by this element. The goodness-of-fit test showed significant difference (chi=94.958, p=0.000<0.05), it means that the selection ratio of each item is obviously different.

3.2 Educators state analysis

First, we validated the effectiveness of the research data. Ignore the correspondence between the dimensions and the analyzed items, the variance interpretation rate and other factors, Kaiser-Meyer-Olkin (KMO) test used to analyze the reasonable and meaningful of the collected data. The KMO value is 0.773, which is between 0.7 ~ 0.8, and the validity of the research data is Acceptable.

Table 5: Kaiser-Meyer-Olkin (KMO) test, effectiveness analysis

KMO & Bartlett test		
KMO value		0.773
Bartlett sphericity check	Approximate cardinality	67.024
	df	10
	p value	0

As shown in table 6, multi-categorical logit regression used to analyze the effect of X on Y. The Y value is the student's willingness to learn, and the X value is the relevance of course category, course difficulty, and future development. Take the very high willingness to learn near 1.0 as a reference, X has a total of 3 items and 1.0 as the reference comparison item, the final model formula as follows:

ln(2.0/1.0) = -1.437 + 0.672*course category - 0.302*3 course difficulty + 1.080*6 future development correlation.

ln(3.0/1.0) = -7.751 + 0.455*course category + 2.175*3course difficulty + 0.974*6 future development correlation.

The regression coefficient value for course difficulty is 2.175 and shows a significance at the 0.05 level (z=1.971, p=0.049<0.05), implying that high course difficulty has a significant positive effect relationship on high willingness to learn. The difficulty of intelligent ships knowledge such as artificial intelligence is higher than current MET curriculum. It should be considered how to integrate existing MET courses without increasing either the academic burden or the difficulty of the course for students is a big challenge.

Table 6. Results of multi-categorical logistic regression analysis.

	independent variables	Non-independent variables
X1: Course category	0.672	0.455
	-0.79	-0.405
X2: Course difficulty	-0.302	2.175*
	(-0.481)	-1.971
X3: Future development correlation	1.08	0.974
	-1.554	-1.064
Intercept	-1.437	-7.751**
	(-0.976)	(-2.837)
Likelihood ratio test	$\chi^2(6)=16.942, p=0.009$	

Y: Dependent variable: willingness to learn

McFadden R-squared: 0.211

Cox & Snell R-squared：0.332

Nagelkerke R-squared：0.390

* p<0.05 ** p<0.01 z-values in parentheses

4. Results

To discuss how AI could potentially affect future shipping industry, interdisciplinary collaboration as the core must be discussed. In the era of AI, the education of maritime students will not just be limited on ship bridge and engine operation, meanwhile, new disciplines will be added, unnecessary courses will be reduced. Through analyzing the interviews and questionnaires, we obtained the following consequences.

1) Consensus: the shipping industry will undergo a great change under the influence of AI.

2) Interview & investigation: the development of intelligent ships will affect the seafarer occupation, which may decrease in quantity and will increase in required quality. Most of the seafarers trained by current MET institutions have specialized technical skills, but lack many intelligent-related abilities. For example, the deck department has limited understanding of the engine department, while the engine department is not familiar with the bridge operation. Furthermore, seafarers will not be limited to the current division in the era of AI.

3) MET curriculum: MET courses outdated. Under the current MET system, related institutions have many resistances to make changes, the current MET curriculum has not been adapted to the development of intelligent shipping. Artificial intelligence courses are difficult to integrate into existing MET courses without increasing the amount of learning.

5. Discussion

The influence of AI requires two aspects to improve the current MET system: curriculum design and career orientation.

5.1 Curriculum design

The curriculum setting should correspond with the status quo of smart shipping, equip the educated seafarers with sufficient adaptability to the new shipping technology, and enable them to have the ability to engage in industries other than the shipping industry only. Currently, numbers of maritime education institutions still apply textbooks in the old version and curriculum syllabuses fail to keep pace with shipping industry trends, making it the trained seafarers hard to apply their expertise into use in many aspects. Meanwhile, we obtained that the difficulty of courses is an important influencing factor in learning willingness. Therefore, the curriculum setting should expurgate the superfluous courses, set up compulsory courses, to avoid pushing too hard on students. The specific measures are summarized as follows:

1) Heightening the frequency for textbook updating to reduce problems caused by textbook lag among the educated.

2) Increasing curriculum diversity, adding diversified compulsory and optional courses, such as AI-related and Electronic Information Basic Courses, for the potential technology updating and the competitiveness for seafarer’s reemployment.

3) Sifting out and expurgating courses which are unfit for seafarer training and lagging in smart shipping development to reduce seafarers’ pressure.

4) Offering more AI-related lectures, popularizing artificial intelligence knowledge, and uploading intelligent transportation public courses.

5.2 Career orientation

The current MET training program was formed under a long historical experience, although there is a certain lag, its professionalism and importance are still unquestionable. However, increased autonomy of the shipping industry is inevitable, our work should consider beyond the current MET system, not just focus on the certificate, but also the seafarers' career development.

1) Gradually blur the boundaries of disciplines and cultivate integrated talents. Comprehensive talents will better adapt to the ever-changing shipping industry, be more capable of more shipping jobs, and have higher competitiveness in the industry.

2) Update current discipline and incorporate new disciplines, cultivate new types of technical personnel. As intelligent shipping develops rapidly, the demand for technical talents in the

shipping industry is certain to increase. Cultivating talents with mastery in new tech will fill the talent gap and instill momentum for shipping-tech development.

3) Encourage learning outside of training and cultivate adaptable talents. Laying too much emphasis on specialized instruction may lessen seafarers' vocational adaptability. Therefore, cultivating seafarers with multiple skills and capabilities is necessary. Adaptive personnel also possess better re-employability.

6. Conclusion

AI will large-scale change the current shipping model. The career planning of seafarers needs to consider the impact of AI technology, and the development of intelligent ships will affect the seafarer occupation, which may decrease in quantity and increase the quality of the marine-related seafarer. This study investigates the maritime students and educators, the results of the investigation and SPSS analysis show that the AI-influenced MET curriculum must be updated, keep the overall difficulty and curriculum intension is a big challenge for students absorbing the newest AI-related MET courses.

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