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Autonomous Ships in the Perspective of the Skills of Cadet Graduates at Maritime Institute in Indonesia

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***Abstract*—Autonomous ships or unmanned ships in the digital technology have become a reality, in various countries have started to build ships without crew, including Norway, Germany and Japan. Norway and Germany have published their ships that are controlled using remote control from land. This is a challenge for the world of education in responding to the need for expertise related to unmanned ship technology for graduates of maritime schools in Indonesia in the future who want to compete internationally. This research uses a quantitative method, where the instrument used is a questionnaire to collect data related to the needs of the abilities or expertise of maritime school graduates in order to support and prepare for future learning. Analysis data from the questionnaire given was obtained using the fuzzy delphi technique that experts accepted all expertise needs with a consensus value exceeding 75% and a d threshold value <0.2, with the first ranking of the questionnaire elements being the expertise in knowing computer programs or software development which is needed for graduates of cadets at maritime schools in Indonesia.**

Keywords— Autonomous ship, MASS, Artificial Intelligence, Fuzzy Delphi Method.

I. INTRODUCTION

Industrial technology in its development began with the industrial era 1.0, industrial era 2.0, industrial era 3.0, and industrial era 4.0, even the industrial era 5.0 has been discussed. Industry 4.0, or revolution 4.0, is a phenomenon in the advancement of information technology that includes big data, robotics, automation, cloud computing , Internet of Things (IoT), and Artificial Intelligence (AI) [1] . Starting to be known since 2011, the focus of revolution 4.0 is to automate the manufacturing process using machines and technology, as well as in the maritime industry both from the port and ship side, in the port that we know as smart port, all systems use technology automatically, as well as for ships that are unmanned.

Industry 4.0, which focuses on modernizing automation systems, inspires the shipping industry to design and build autonomous or unmanned ships to increase efficiency and safety, and with the background of the Allianz study which states that ship accidents occur due to human error ranging from 75% to 96% [2] [3] and UNCTAD said that eliminating the “human role” from shipping could significantly reduce the possibility of human error but IMO is concerned about how unmanned autonomous ships at sea will face legal responsibility in the event of an incident*. Technological innovation continues to experience rapid development regarding autonomous ships , whether controlled remotely or fully automated. With autonomous ships will reduce the role of humans in its operation compared to traditional systems, but the role of humans is still very much needed in its operation. In analyzing human error in the operation of autonomous ships is how humans interact with the system [4].

Autonomous cargo ships or known as autonomous container ships or Maritime Autonomous Surface Ships (MASS) are unmanned ships that are transportation of containers or bulk cargo through a navigation system with few or no humans. The ability of a ship to monitor itself and its surrounding area is built and communicates based on real-time information so that autonomous ships can operate. What is needed is to form an electronic system that will become electronic brain information so that the ship can navigate safely, such as sensor fusion, algorithm control and communication and connectivity.

Automatic navigation systems have now become a reality that has been developed using remote control using software based on artificial intelligence (AI). This concept is applied to inland waterway transport in Flanders, Belgium for barges, which can avoid accidents, communicate with other barges, identify environmental area risks, and guarantee safety [5] . Operation boat automation also requires safety and security as well as a regulations. IMO, IALA have been actively supporting the future of this automated ship both in terms of regulation and technology.

The Maritime Safety Committee of the International Maritime Organization (IMO) has introduced a definition of autonomous ships as Maritime Autonomous Surface Ships (MASS) which also includes the level of automation of ships

that operate independently through interaction with humans. First Level, the ship operates automatically and with a decision system. The captain and some crew are on board to operate and control the systems and functions. For certain operations may be done automatically and at certain times without supervision, but the sailors on board are ready to take over control. Second Level, the ship is controlled remotely with the captain and some crew on board. The ship is controlled and operated from another location. The captain and crew are on board to control and operate the ship's systems and functions. Third Level: a ship that is controlled remotely without a captain and crew. The ship is controlled and operated from another location. There are no sailors on board. Fourth Level: A truly autonomous ship: The ship's operating system is able to make decisions on its own and determine its actions [6].

In the context of automatic ships or autonomous ships as MASS, expertise is certainly required in terms of navigation, maintenance, operation and interaction between humans and the ship's systems [7] [8] . an expertise to be able to operate MASS requires a structure and framework that is well-organized so that it is not only knowing but also defining a process of how autonomous ships work and perform [9] . This study aims to determine the perspective of the needs of cadet/student expertise with the presence of autonomous ships, because with increasingly sophisticated technology, input is needed for the world of education for the expertise needed both in terms of technical and soft skills.

The many important areas of competence, such as IT proficiency, legal and ethical proficiency, marine and technical proficiency, and core competency, which encompasses communication, adaptability, and the capacity to work with people and technology. The experts also emphasized the significance of keeping a human-centered design philosophy for MASS, making sure that technology is created to enhance rather than replace human capacities. The specialists recommended that lifetime learning and ongoing training be necessary to support the development of new skills and competences. The creation of MASS was viewed as a chance to redesign marine instruction and training. Overall, the findings emphasize how crucial it is to allocate resources towards human capital in order to successfully implement maritime autonomous surface ships.

II. RESEARCH METHODS

A. Method

The method in this study uses quantitative methodology in the form of questionnaires, several interviews with sailors and using analysis techniques with the Fuzzy Delphi method. The Fuzzy Delphi method is useful for obtaining opinions from experts to reach consensus and make decisions based on comprehensive information, and the application of this method in education is useful for improving the quality of the curriculum by adding subjects that are relevant to current technology such as the presence of autonomous ships . The Fuzzy Delphi method is also used with fuzzy theory to measure and summarize the opinions of several experts [10] . The questionnaire was submitted to each expert using a ranking method based on a Likert scale where 1 is strongly disagree, 2 is disagree, 3 is undecided, 4 is agree and 5 is strongly agree. The next process is to convert the variable into a fuzzy value form, where there are three values given, namely the minimum value, the most reasonable value and the maximum value, or known as a triangular fuzzy number symbolized by the values m1, m2, and m3 [11].

The important concept of the Fuzzy Delphi Method is the Triangular Fuzzy Number (TFN) which considers the fuzziness or dissimilarity of an expert's opinion. The results of the expert opinion questionnaire are converted from Likert scale values to TFN, namely three fuzzy values: n1 (minimum), n2 (medium) and n3 (maximum) as in Table 1. The average of the TFN values (n1, n2, n3) of each item from each expert opinion is a value symbolized by m1. m2, and m3 [11].

Table 1. Conversion of Likert Scale to Fuzzy Values

Likert Scale	Scale	Fuzzy Score		
		n1	n1	n3
5	Strongly Agree	0.6	0.8	1
4	Agree	0.4	0.6	0.8
3	Moderatly Agree	0.2	0.4	0.6
2	Disagree	0	0.2	0.4
1	Strongly Disagree	0	0	0.2

B. Defuzzification

The fuzzy values m1, m2 and m3 which are the average of n1, n2 and n3 from expert opinions or questionnaires submitted are called the defuzzification process. The defuzzification process (Amax) is the ranking process of each question/questionnaire item to identify the level of importance of each item. This ranking process is very useful for determining whether each item is still used or discarded, with the formula:

$$Amax == 1/3\ (m_1+m_2+m_3)$$

Several conditions must be met to determine whether each item is accepted or not, the first condition is that the value of the d threshold construction is less than or equal to 0.2, the second is that the percentage of consensus evaluation of each item has a value of more than 75% and the average of the Fuzzy value or the value of Amax is greater than or equal to 0.5 [12] [10] . The threshold value d is an indicator or consensus level given by experts, with the formula for the value d being

$$d(m,n) = \sqrt{(1/3[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2])}.$$

III. RESULTS AND DISCUSSION

Questionnaire in google form submitted to sailor both those sailing domestically and abroad abroad, employees related government with transportation sea and parties private related with industry voyage , where questionnaire the has get agreement clearance ethics from the National Research and Innovation Agency (BRIN) of the Republic of Indonesia Indonesia . From the results recapitulation implementation research , obtained amount large population so done taking sample from all over population , with use Slovin's formula at the level trust by 5% (0.05). The total research population was

90 (ninety) so a sample of 73 (seventy three) data samples was obtained. The profile of the research data results can be seen in Table 2., based on gender and citizen, and in Table 3, age and education data, Tabel 4. grouped by type of work and for Table 5., based on grouping of working experience.

Table 2. Research data profile

Description	Gender		Citizen	
	Man	Woman	Indonesian citizen	Foreigners
Amount	68	5	72	1
Percentage	93%	7%	99%	1%

Tabel 3. Research data profile

Description	Age		Education			
	<35	>=35	Diploma	Bachelor degree	Strata 2	Strata 3
Amount	24	49	40	16	13	4
Percentage	33%	67%	55%	22%	18%	5%

Table 4. Data based on type of work

	Sailor	Government Officer	Private
Amount	49	21	3
Percentage	67%	29%	4%

Table 5. Data based on working experience

Experience	Amount	Percent
5 - 10 years	22	30%
10 - 15 years	15	21%
15 - 20 years	19	26%
More than 20 years	17	23%
Total	73	100%

Job experience data from respondents who have a lot of experience with a minimum work period of 5 (five) years, from the experience data, experience of more than 10 years reaches 70% of which all respondents are experts and experienced. Data analysis using the fuzzy Delphi method, that the questionnaire/item indicator skill/competence for the need for expertise for graduates of maritime schools as in Table 6., based on the latest technology needs to understand artificial intelligence, data analysis, soft skills and related to safety regulations. Starting with a better understanding of the human role in autonomous maritime operations, future competence can be achieved through the introduction of new technological solutions that can change the way people work in several ways, for example, by changing existing tasks, automating them, moving roles from ship to shore, decreasing the size of a crew, or introducing new roles [13].

Table 6. Consensus indicators

No	Dimension	Indicator	Literature
Item 1	Technical	Graduates of maritime schools need to understand traffic management skills and traffic information services	Margareta Lutzhoft, Jonatan Earthy, 2024
Item 2	Technical	Security with autonomous ships plays a crucial role, making the introduction of cybersecurity essential for maritime school graduates	Blagovest Belev, etc,all, 2021
Item 3	Rules	Safety with autonomous ships plays a crucial role, so the introduction of safety procedures is essential for graduates of maritime schools	Margareta Lutzhoft, Jonatan Earthy, 2024
Item 4	Technical	Computer programming or software development is essential to support the skills of cadets	Margareta Lutzhoft, Jonatan Earthy, 2024; Mehrangiz Shahbakhsh, 2021
Item 5	Technical	Reading data and analyzing data play a role in supporting the expertise of cadets	Mehrangiz Shahbakhsh, 2021
Item 6	Technical	Understanding artificial intelligence and its implementation is needed for Cadet's graduates	Margareta Lutzhoft, Jonatan Earthy, 2024
Item 7	Management	With autonomous ships, Cadets graduates need to learn risk assessment	Camila Domenighini, 2024
Item 8	Soft skill	Cadet's graduates must have decision-making, problem solving and situational awareness	Krzysztof Boguslawski Etc,all, 2022
Item 9	Technical	Every maritime college graduate must have good knowledge of nautics, engineering and shipping management	Processed by the author

The presence of autonomous ships or unmanned ships is an implication of the use of technology that reduces the role of humans, where the role of humans is still needed in the operation of the ship so that the world of education must be able to adapt to the development of autonomous ship technology. A certain set of skills will be required to ensure the system's safety and efficacy, including remote situation awareness, even though the technology discussed is still in its infancy [14], so it is necessary to prepare the expertise needs of maritime school graduates, based on the recapitulation of survey results and data analysis that the data provided on a Likert scale will be converted into fuzzy values or fuzzy scoring (n1, n2, n3). The results of the fuzzy value conversion calculation are obtained from the average of the fuzzy values of each description/indicator to obtain the values of m1, m2, and m3 and then the results of the d threshold value are obtained , as in Table 7.

Table 7. Results of fuzzy delphi method analysis

No	Description	Average Likert Scale	Rata-rata Nilai Fuzzy	Value of d Threshold (<0.2)
1	Item 1	4.3	0.674	0.17
2	Item 2	4.2	0.656	0.17
3	Item 3	4.4	0.679	0.16
4	Item 4	4.3	0.683	0.17
5	Item 5	4.3	0.657	0.16
6	Item 6	4.3	0.66	0.15
7	Item 7	4.2	0.655	0.16
8	Item 8	4.3	0.663	0.16
9	Item 9	4.3	0.672	0.16

Table 8. Results of fuzzy delphi method analysis

No	Description	Consensus evaluation percentage (>75%)	Ranking	Consensus of experts
1	Item 1	87.67	3	Accepted
2	Item 2	86.3	6	Accepted
3	Item 3	89.04	2	Accepted
4	Item 4	87.67	1	Accepted
5	Item 5	86.3	9	Accepted
6	Item 6	89.04	8	Accepted
7	Item 7	84.93	7	Accepted
8	Item 8	87.67	5	Accepted
9	Item 9	89.04	4	Accepted

From the data in Table 8, it can be seen that the threshold value of less than 0.2 is more than 75%, indicating that all descriptive items are accepted. The item ranked 1 is "Computer programs or software development are essential to support the skills of cadets," and ranked 2 is "Safety, with autonomous ships playing a crucial role, thus the introduction of safety procedures is necessary for graduates of maritime schools." Ranked 3 is "Graduates of maritime schools need to understand traffic management and traffic information services", as Table 8. Changes in maritime technology will have a significant impact on ship crews. In the short term, changes are expected in the requirements for the qualifications and skills needed to apply these technologies and to integrate them into the real world. New competencies will be created, and the need for mastering and applying new fields of application in science and practice, such as the Internet of Things, big data, simulation of environments and events, etc. [15]

A survey conducted with one of the captains at the Port of Batam revealed that their ship's journey from the port of origin, Tanjung Perak - Surabaya, faced no navigational issues during the trip to Batam. The captain's concern, however, is what would happen if the ship encountered problems. Therefore, geographically speaking, Indonesia has the potential to implement ships with the MASS concept in the future.

Table 9. Item position by ranking

sort by ranking	Item Number	Indicator
1	Item 4	Computer programs or software development are needed to support Cadet skills
2	Item 3	In autonomous ships safety has a very important role, so an introduction to safety procedures is necessary for maritime college
3	Item 1	As a graduate from maritime institute, need to understand traffic management and traffic information's services skills
4	Item 9	Every maritime college graduate must have good knowledge of nautics, engineering and shipping management
5	Item 8	Cadet's graduates must have decision-making, problem solving and situational awareness
6	Item 2	In autonomous ships security has a very important role, so an introduction to cybersecurity is necessary for maritime college
7	Item 7	With autonomous ships, Cadets graduates need to learn risk assessment
8	Item 5	Reading data and data analysis have a role to play in supporting Cadet's skills
9	Item 6	Understanding artificial intelligence and its implementation is needed for Cadet's graduates

Changes in maritime technology will have a significant impact on ship crews. In the short term, changes are expected in the requirements for the qualifications and skills needed to apply these technologies and to integrate them into the real world. New competencies will be created, and the need for mastering and applying new fields of application in science and practice, such as the Internet of Things, big data, simulation of environments and events, etc.

In addition to the questionnaire in the form of a Likert scale, the author also provided an input column with three statements. For three questions, the author conducted an analysis by summarizing the text presented using a word cloud generator application. The first statement is about what resources and facilities are available for training or education in facing the era of autonomous ships. The results, as shown in Fig.1, indicate that the most dominant input is related to the preparation of instructors for training and simulator facilities with technology related to autonomous ships.

Fig. 1. Word cloud Statement about resources

The second statement is about the skills and competencies that lecturers should possess regarding autonomous ships, in order to gather open feedback to enhance lecturers' competencies. The summary of the text, as shown in Figure 2, indicates that based on the feedback, the aspects that need to be prepared are skills, knowledge, understanding, and regulations related to autonomous ships.

Fig. 2. Word cloud Statement about lecturers

The third statement is Input and suggestions for the advancement of Maritime Education in Indonesia, which relates to the views from each questionnaire to improve the quality of maritime education in Indonesia, as summarized in the text shown in Figure 3

Fig. 3. Word cloud Statement about advancement education

With the readiness of the education sector regarding autonomous ships, this will certainly support the ports that must also be prepared for the presence of autonomous vessels, so that both port organizers and port operators can meet the required human resources. In order to guarantee the safe and dependable functioning of these boats, regulatory frameworks must be established. Cybersecurity controls must be put in place to shield autonomous systems from any hostile hacking action. To enable the successful integration of autonomous ships, standardization and cooperation amongst stakeholders—including port authorities, shipping corporations, and labor unions—must also be addressed. In conclusion, there is a great deal of potential for the shipping sector to change if autonomous ships are integrated into container terminals [17].

IV. CONCLUSION

The development of technology in the shipping sector, particularly regarding ships, has seen rapid advancements aimed at reducing emissions in ports and improving the efficiency and effectiveness of human roles on board. The education sector must also quickly adapt to these developments, especially in adjusting the skills of maritime graduates in Indonesia. From research on the perspective of the skill needs of cadets/students using the fuzzy Delphi method analysis, the consensus results have met the criteria with a threshold value below 0.2 and a consensus percentage of more than 75%. Learning related to technology about autonomous ships, such as software development, safety and security, traffic information services, and traffic management, is essential. Supporting aspects include artificial intelligence, data analysis, cybersecurity, and the application of soft skills. Additionally, feedback indicates that the education sector must stay updated regarding training using simulators.

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The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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