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Maritime Stakeholders' Insights on Maritime Education and Training in the Autonomous Shipping Era. A Small-Scale Study in Spain

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ABSTRACT

Recent advancements in telecommunications, computing and sensors are driving ships to become increasingly more autonomous. Despite concerns about the decline in the number of seafarers and maritime jobs, this new trend is expected to be an opportunity for the creation of new businesses and roles requiring highly skilled crews and operators. Maritime Education and Training (MET) must evolve by updating curricula, incorporating new topics and upgrading teaching methodologies while maintaining compliance with the STCW (Standards of Training, Certification and Watchkeeping) Convention. This article aims to analyse maritime stakeholders' perceptions of this emerging topic, contributing to the conceptualisation of the new MET framework in Spain through a small-scale study. Questionnaires were run to gather opinions about the new topics, skills and competences that future seafarers should acquire in their education. The results reveal an ongoing and open debate regarding the preparation of future maritime professionals and the recognition that changes are necessary in the framework to integrate Maritime Autonomous Surface Ships (MASS) into maritime curricula. This need for adaptation is further emphasised by the development of new courses by the European Maritime Safety Agency (EMSA) and the International Maritime Organization (IMO).

1 Introduction

Recent advancements in maritime technology and Artificial Intelligence (AI) are paving the way for the next-generation fleet of partially and fully autonomous ships. The increasing interest in autonomous ships is bringing changes to the industry and transportation infrastructure, influencing all maritime sectors, including shipbuilding and port operations. The main objective of most companies and shareholders involved is to achieve high levels of safety and efficiency in order to provide solutions to human-related issues in the maritime industry, such as the prevention of marine accidents and the improvement of the work environment. Other crucial objectives include reducing operational costs by eliminating crew accommodations and minimising crew-related systems and energy consumption. Additionally, the use of fully-electric autonomous ships as new transport systems, based on smaller ships as an alternative to road transport, could significantly contribute to reducing environmental impact [1].

A significant number of projects are currently in the design phase and extensive research on the operation and construction of autonomous ships has been ongoing over the past few years [2]. Examples of these projects include the vessel Yara Birkeland, a Zero Emission Autonomous Container Feeder developed by the Konsberg group, which is already undergoing gradual

implementation and testing of all its autonomous functional capabilities [3]; a fully-electric ferry concept (PILOT-E) [4], developed by the same group; the ReVolt project by DNV GL (currently known as DNV after a rebranding in 2021), a battery-powered autonomous ship [5]; and an Intelligent Navigation Assistant System (HiNAS 2.0) that collects data through sensors attached to the vessel and its equipment, and integrates it using AI, developed by Hyundai [6]. Notable research programmes ongoing worldwide include EU projects such as the Autonomous Shipping Initiative for European Waters [7] and Advanced, Efficient and Green Intermodal Systems [8], as well as the Korean Autonomous Surface Ship project [9] and the Norwegian SFI AutoShip [10]. All technological innovations require updated higher education and training to meet the demands of new job creation [11]. Nevertheless, the existing International Convention on Standards of Training, Certification and Watchkeeping (STCW) [12] does not encompass regulations for autonomous ships. Maritime Education and Training (MET) programmes must adhere to the minimum requirements set by the STCW. However, the emergence of MASS has led to new scenarios that require education and training to evolve in order to prepare specialised, qualified staff capable of handling the latest technologies and developments, both on board and ashore [13, 14, 15]. In this context, the direct application of AI [16], the development of new communication and data transmission systems, sensor optimisation, and control of ship routing are resulting in the design of the Remote-Control Centres (RCC). As systems progress towards higher autonomy and new job opportunities for seafarers emerge, these workers will need to adapt and acquire knowledge in areas such as AI, remote operations, data transmission and cybersecurity, among others. All maritime professions, from port operators to ship crews and from shipyard workers to surveyors, are expected to undergo significant changes. While some of the main positions on board will remain, they will require additional skills and competences. As pointed out in the literature review [17], much work remains to be done regarding Maritime Education and Training in the context of unmanned ships. Nasur & Bogusławski [18] identified the autonomous merchant ships as a topic rarely addressed in maritime curricula and emphasised the importance of including comprehensive coverage of MASS in MET Institutions (METIs).

The levels of autonomy are classified by the International Maritime Organization (IMO) as follows [19]:

(1) Ship with automated processes and decision support: seafarers are on board to operate and control shipboard systems and functions; some operations may be automated.

(2) Remotely controlled ship with seafarers on board: the ship is controlled and operated from another location, but seafarers are on board.

(3) Remotely controlled ship without seafarers on board: the ship is controlled and operated from another location; there are no seafarers on board.

(4) Fully autonomous ship: the operating system of the ship is able to make decisions and determine actions by itself.

Considering the various levels of autonomy (LOA), eliminating existing STCW competences or topics will clearly not be possible in the initial stages. However, at the level of fully autonomous ships, certain competences may become obsolete as crew interaction will not exist.

Therefore, the primary focus is to identify the skills and competences that future crews will need to acquire, considering legislation barriers. The STCW code has not yet been updated. However, several researchers agree that this is the fundamental gap, highlighting the need for further development in training programmes for future bachelor's and master's degrees [18, 20, 21, 22, 23]. Based on this idea, some European maritime educational institutions have already incorporated autonomous shipping concepts in their curricula. For example, Novia University of Applied Sciences in Finland and Nikola Vaptsarov Naval Academy in Varna have taken steps in this direction. Others are research partners in European projects such as Aalborg University (AAU) on AEGIS, and Glasgow's University of Strathclyde on AUTOSHIP [7].

We must move forward and focus our efforts on all maritime institutions. In order to initiate the transition from conventional maritime education to future-oriented education, it is essential to gather insights from a wide range of stakeholders. These include not only seafarers on board ships but also agents in various roles across the maritime industry, such as port staff, ship operators and surveyors, as well as maritime teachers and trainers.

The main objective of this paper is to analyse perceptions of various stakeholder groups regarding the contents, skills and competences related to unmanned ships that future seafarers will need to acquire. Additionally, it presents the findings of a small-scale study conducted in Spain that explores the perspectives of different stakeholders on new skills and topics relevant to seafarers in the context of MASS. The groups include maritime students, lecturers, seafarers, port and shipping industry operators, maritime authorities, shipyard operators, Vessel Traffic Services (VTS) operators, and maritime inspectors. Additionally, the study examines the current integration of MASS-related content into the curricula of Spanish METIs.

The paper is organised as follows. Section 2 describes the methodology used to conduct the above study as a case study. Section 3 classifies and analyses the results of the most significant questions. In Section 4, the findings are compared with recent research and developments in MET. Finally, the conclusions and a synthesis of the findings are presented in the last sec-

tion, highlighting future directions for research and development in the field of MET and MASS.

2 Materials and Methods

The research method used in the study is detailed in Figure 1 and can be summarised as follows:

- **Identification of the aim of the research.** The aim of this research is to explore potential new topics and skills related to autonomous vessels that future seafarers will need to acquire.
- **Research design**. As this research is in its early stages, the descriptive method was used to ensure consistency in the results and identify potential topics or discussion points for consideration in further projects [24, 25]. Like for previous studies undertaken in various fields, a questionnaire was run as the central instrument of this research. The development of the different steps is outlined in the following points.
- **Variable definition**. To elaborate the questionnaire, key areas of focus, such as simulator knowledge, potential new topics and STCW competences, were identified.
- **Sample selection**. A cluster sampling was established due to the large number of potential participants. The focus groups were subdivided and a more detailed questionnaire was developed for each group. This way of proceeding enabled us to gather results without knowing the actual number of participants and work with a broader range of outcomes [26]. The sample was selected from various stakeholder groups related to the maritime sector, such as seafarers, maritime authorities, port and VTS operators, inspectors, lawyers, teachers and trainers, among other parties, comprising 70 individual informants. Although the number of respondents is relatively small, it provides valuable insights into the perspectives of key stakeholders. Additionally, the seven Spanish METIs were included and treated as collective entities for comparison purposes.
- **Questionnaire design**. To gather detailed and focused information, the questions were divided into three blocks: the first collected participant profiles; the second focused on educational background, training and professional experience; and the third addressed the aim of this study and gathered opinions about skills and competences related to unmanned ships that future seafarers need to acquire. Open-ended, multiple-choice and closed-ended questions were used across the three blocks, with a total of 18 questions. The key terms and relevant questions of this questionnaire are summarised in Table 1. Although the inquiry was slightly modified for different groups, the results yielded similar responses, allowing a unified analysis.

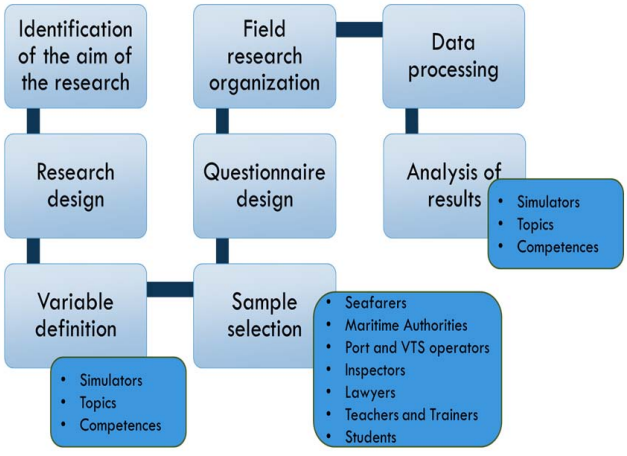

Figure 1 Research methodology flowchart

Table 1 Questionnaire design: key terms and relevant questions

Key Term	Relevant questions about MASS
Simulators/practices	– Are they important for maritime education? – Are more training simulators necessary? Which one/s?
Topics	– Any of the current topics will not be applicable/drop out or should be changed/adjusted? which one/s? – Any new topics should be added?
STCW competences	– Any of the current competences will not be applicable/drop out or should be changed/adjusted? which one/s? – Any new competence should be added?

- **Field research organisation**. The questionnaire was conducted from January to June 2023 through both electronic submission and manual completion. It was forwarded from various departments and the secretary's office at Barcelona School of Nautical Studies. The anonymity of all participants was guaranteed.
- **Data processing**. After the questionnaire was closed, a preliminary data review was conducted to ensure that all key questions had been answered by all participants. This also helped to identify the relevant questions, based on key terms, to be analysed in greater detail.
- **Result analysis**. The relevant questions were identified as outlined in point 2. Graphical and chart-based results, as well as any open comments from participants, helped to analyse the results.

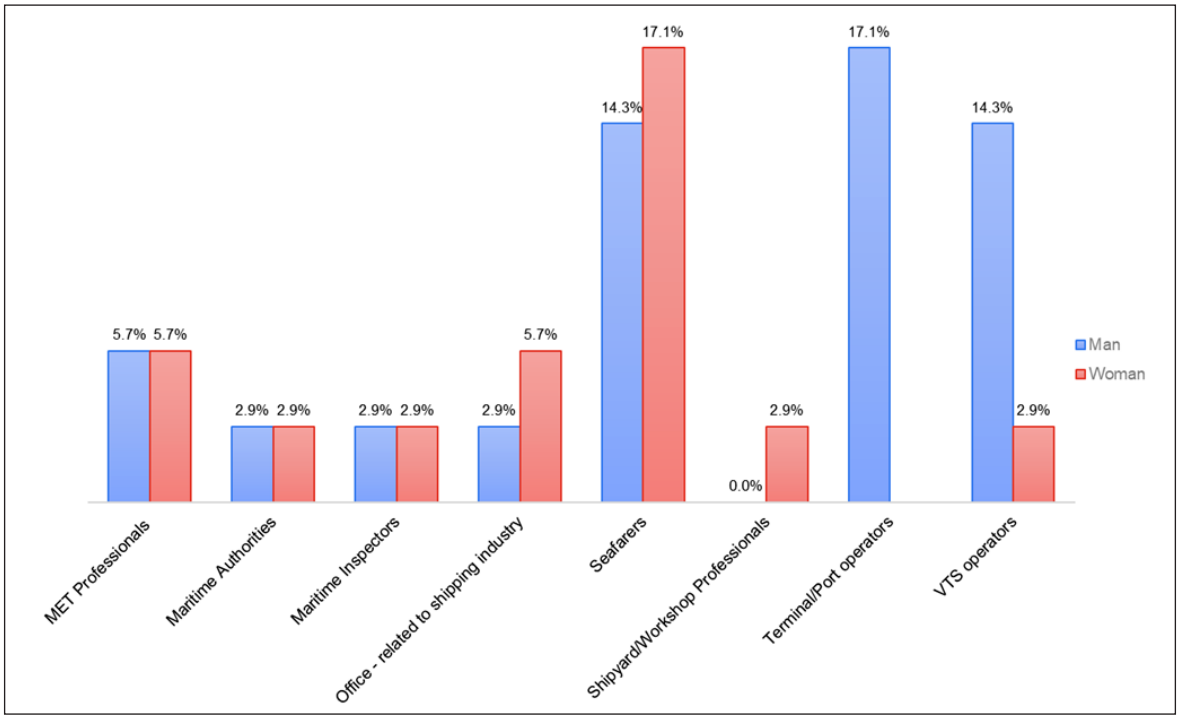

Figure 2 Participant professional experience

3 Results

The results of the survey are being analysed on the following points.

3.1 Participant profiles and educational background, training and professional experience

As previously mentioned, a small-scale study was conducted among a wide range of professionals from the Spanish maritime sector. Figure 2 shows participant work position within the maritime context: about 43% are seafarers while the remaining 57% work on shore.

Additionally, efforts were made to include a wide range of age groups in the study, with nearly 40% of participants aged under 30 and an equivalent percentage falling within the 30 to 50-year age range (Figure 3). This suggests that a portion of the surveyed participants have already used simulators in their maritime education. It must be highlighted that 40% of participants are women.

Regarding their professional experience with various degrees of vessel automation, 40% of participants are familiarised with Integrated Bridges (IB) and 51% with Unattended Engines (UE). This means that almost all participants are experienced in some level of technological autonomy, mainly in partially autonomous bridges or engines and/or fully unattended engines (Figure 3).

As a second key point, the results indicate that over 30% of young professionals have not yet gained any experience in any form of autonomy, despite having spent the most hours on simulators during their education and training. This suggests that their limited experience may have been restricted to on-board training or very old vessels, being another important point to take into account for the future analysis.

3.2 Stakeholder perceptions

For a better analysis, the results of this section are grouped into the above three key terms, namely Simulators/practices, Topics and STCW competences.

3.2.1 Simulators/practices

The first set of questions explores various aspects related to simulators, including their importance, the level of knowledge required by participants to use them, and their current and potential future use in training.

When asked, “Do you think simulators are important in maritime education?”, almost all participants confirmed that simulators are crucial for MET. One hundred percent of professional agreed on this. However, among the students, only one response indicated that simulators were not used in their training, which is probably an isolated case. It is worth noting that all Spanish METIs have been employing some kind of simulators for their main practical courses for a long time, see Section 3.3.

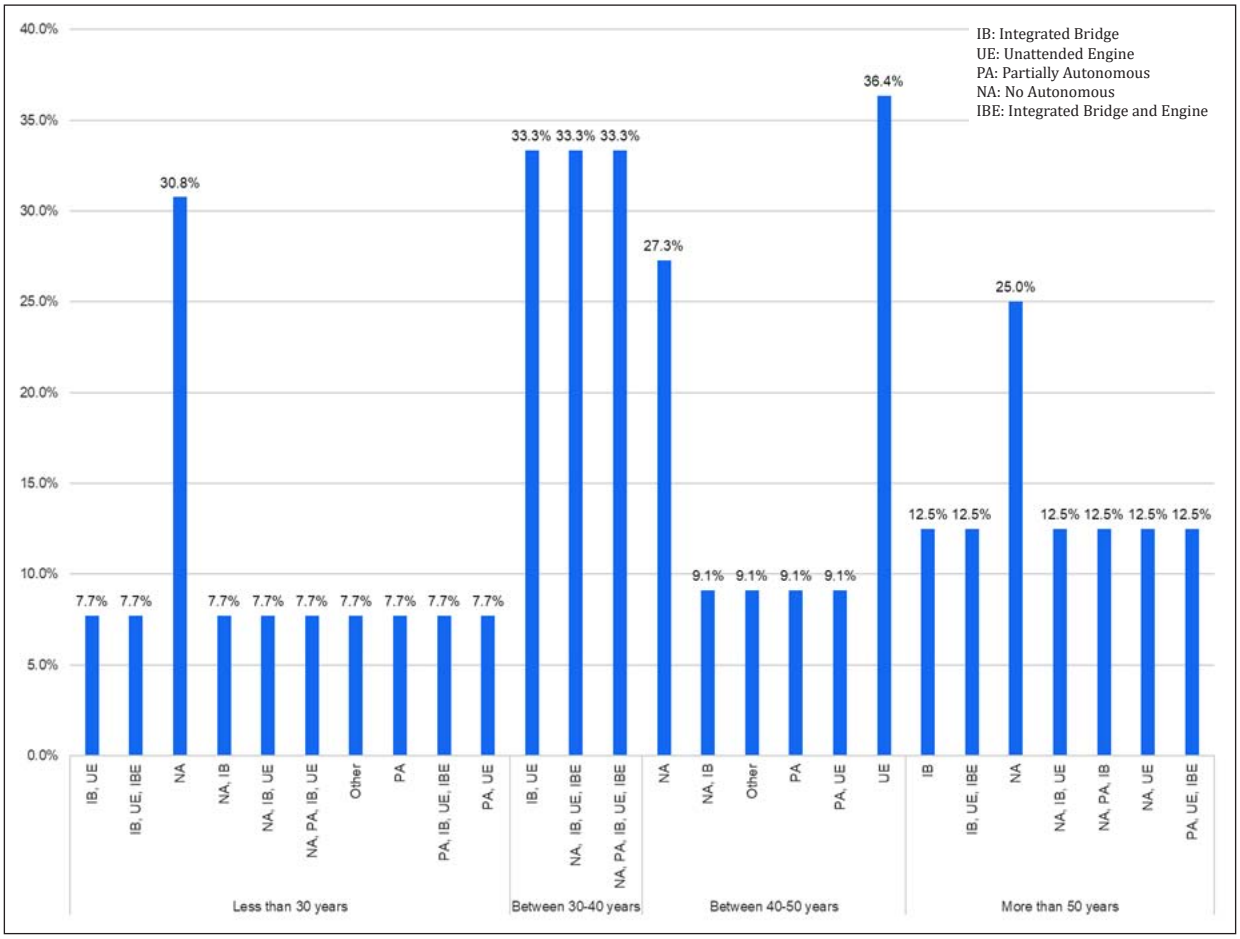

Figure 3 Participant age in relation to the degree of vessel automation in their professional experience.

A list of the main simulators currently used by METIs was shown to participants to determine the actual use of these simulators and their importance in training, see Figure 4.

In response to the question, "Which of the following simulators do you believe is it important to be experienced in?", 82% of participants answered that Conventional Simulator Training (such as ARPA/Radar, ECDIS and AIS) is the most relevant, followed by the Radio Communications simulator and the Manoeuvring simulator.

The reason for this high percentage lies in the fact that these types of simulators are used when teaching some of the main subjects, such as positioning, communication and manoeuvring, which are essential for accurate navigation on all vessel types. It is worth mentioning that the simulators with the highest results, i.e. manoeuvring, radio communications and conventional simulators, are mandatory for gaining STCW competences.

In response to the question, "Do you think that more training simulators will be needed?", 74% of participants answered affirmatively. They provided examples in their open-ended responses, such as simulators for remote control, manoeuvring in virtual reality environments and those specifically designed for MASS.

Regarding this last question about simulators, 100% of METIs agreed that more simulator hours will be needed to prepare future crews, not only in the simulators currently in use but also in future ones.

Since simulators enable students to explore situations and scenarios without having to experiment on actual vessels, all Spanish METIs are trying to offer the maximum possible practice hours on the available equipment. However, considering that future crews will control vessels remotely, it is clear that current simulators will have to be upgraded, changed and enhanced. These changes will facilitate not only the teaching of new training areas and topics but also the analysis and evaluation of the new competences and skills that future students will need to master. Therefore, all METIs strongly agreed on the need to increase simulator hours as one of the changes to the future STCW.

3.2.2 STCW Competences

The second set of questions looks into STCW competences to identify those that may become obsolete or no

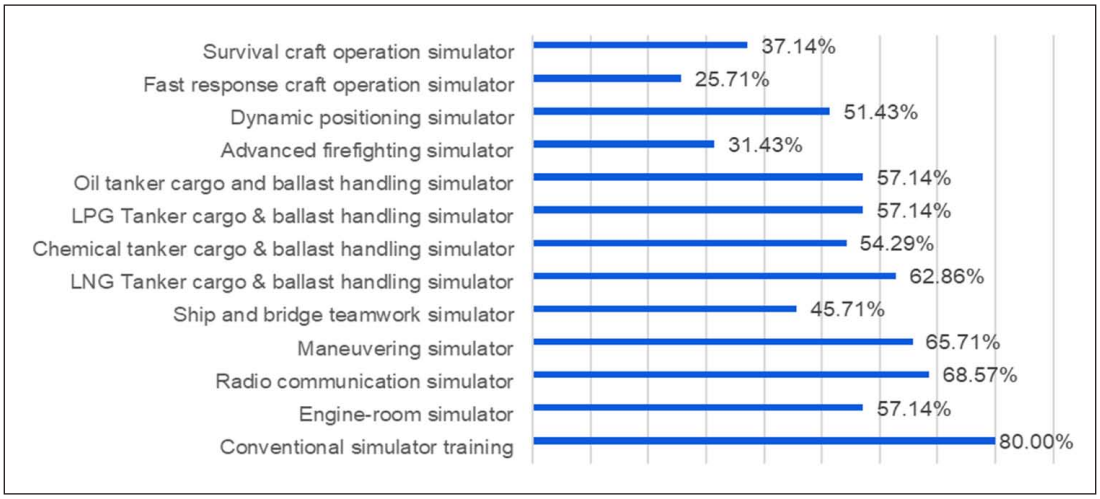

Figure 4 Distribution of the most well-known and relevant simulators currently in use at Spanish METIs (based on participants' responses)

longer relevant, as well as new competences that could emerge to address the challenges of autonomous vessel technologies. A significant difference was observed between students' and professionals' responses to the question "Do you think any of the competences will no longer be applicable or should be changed/adjusted in autonomous vessel operation?". While 81% of students answered affirmatively, only 46% of professionals shared this opinion.

The combination of both results gives an almost halved value. This underscores the concern that eliminating existing competences may lead to inadequately prepared crews and might not be the best solution for a forward-looking approach. A similar response was obtained from METIs, emphasising that removing knowledge to advance towards a new generation of crews for autonomous vessels might not be the solution or, at least, remains unclear or uncertain.

Despite the previous responses about the elimination of current competences, when asked, "What competences should be eliminated?", almost 45% of participants agreed on the need to remove "Apply medical first aid on board". This was followed by "Navigation, plan and conduct passage and determine position", "Maintenance and repair at the operational level" and "Manoeuvre the ship" (Figure 5). Age-based analysis re-

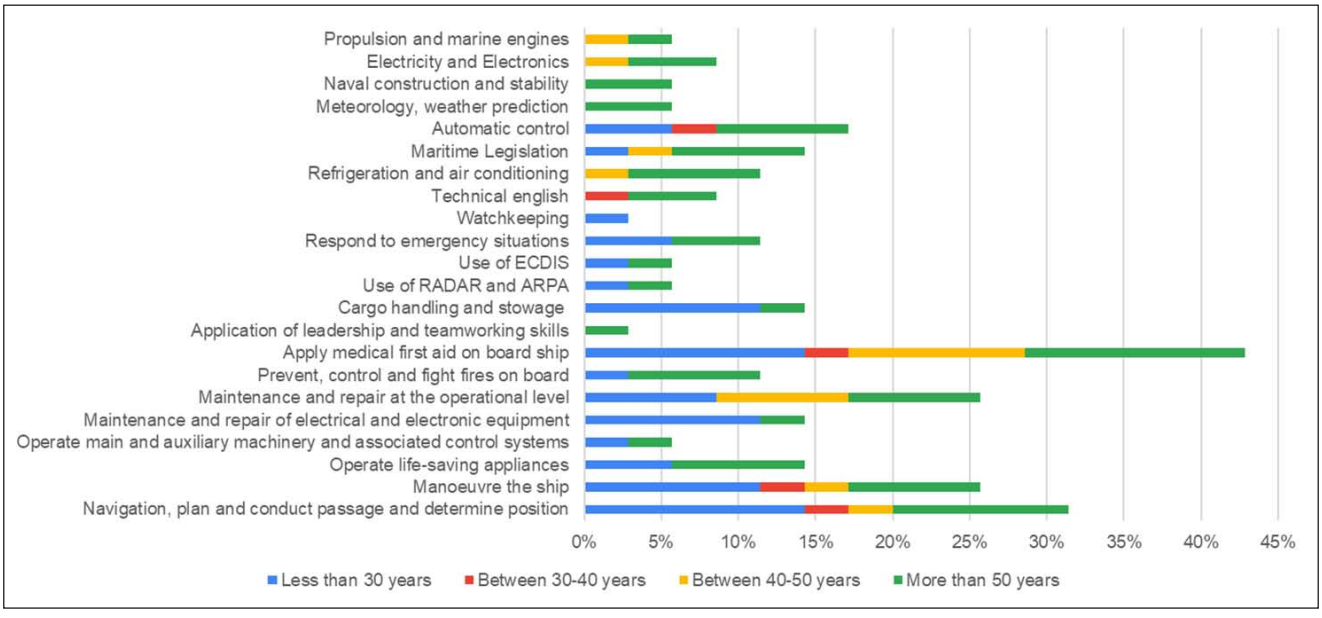

Figure 5 Distribution of current competences that should drop out or are no longer applicable regarding autonomous vessels depending on the age range (based on participants' responses).

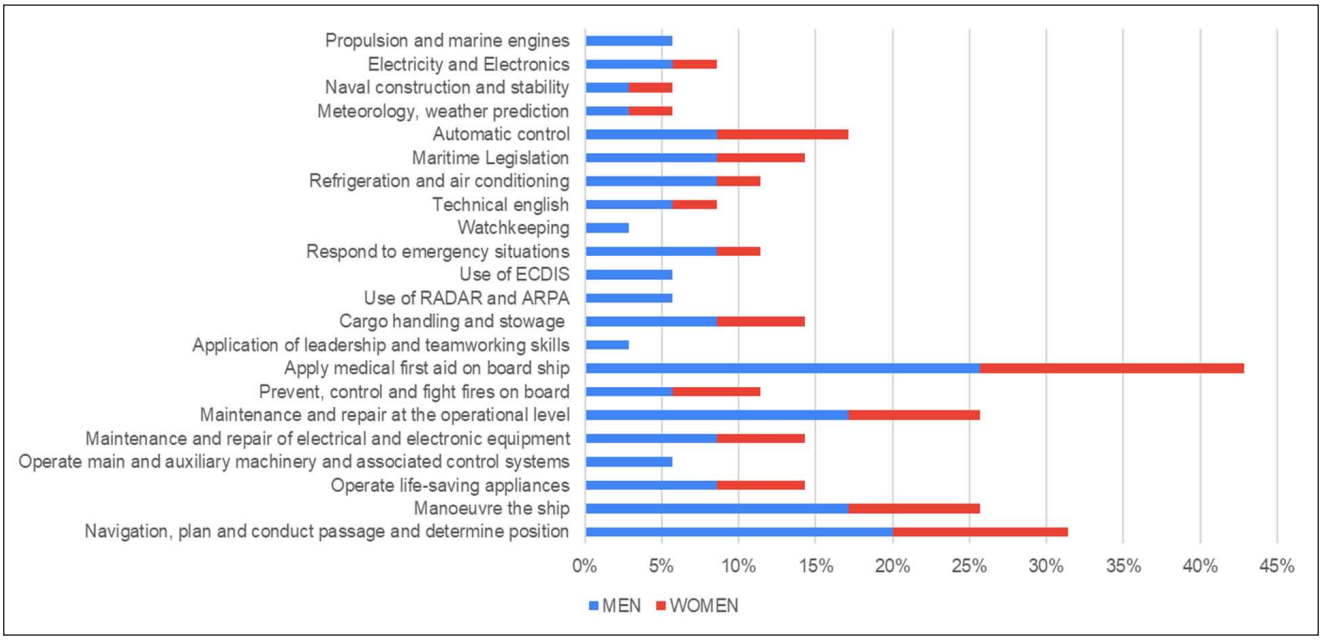

Figure 6 Gender-based distribution of competences most likely to drop out or be inapplicable in autonomous vessels (based on participants' responses).

veals that respondents under 30 and over 50 gave more feedback on this question, while those aged between 30 and 40 contributed less.

Specific results showed that participants over 50 provided a broader range of responses, probably on account of their vast experience. This wide range of opinion gives a result that all the competences have been considered as inessential by at least one respondent.

The analysis of these responses in relation to participant gender (Figure 6) shows that women provided significantly fewer answers than men, aligning with the response patterns of the younger age group. This outcome is likely influenced by the relatively recent entry of women into the maritime industry, meaning that their age range is generally younger [27]. Again, the competence with the highest result, "Apply medical first aid on board", is considered as non-essential according to both points of view.

When asked, "Do you think any new competences should be added to the STCW?", a consensus was reached, with 100% of affirmative responses.

Therefore, responses suggest that changes in the STCW should include the integration of new competences related to autonomous ships in the upcoming years. Apparently, this is the starting point for shaping the future direction of MET.

When asked, "Which one(s) should be added in relation to the previous question?", the number of responses was evenly distributed among the four proposed competences, which might suggest that they are all regarded as relevant for the future of maritime education (Figure 7). Similar responses were obtained when work position was considered. Only those involved in education and training seem to have more doubts about the incorporation of new competences, likely due to their awareness of limitations.

Participants who responded "Other" suggested further possible competences such as leadership, programming skills and virtual reality management.

Similar outcomes were obtained from Spanish METIs. Therefore, it can be concluded that the above four competences may be the starting point for future updates of the STCW code, not forgetting other previously mentioned competences.

3.2.3 Topics

The last set of questions focuses on topics. In this line, Chirea-Ungureanu [28] explores the relevance of Maritime English /IMO SMCPs (Standard Marine Communication Phrases) in the context of autonomous ships, as no personnel will be on board to use the standardised safety language for clear intercommunications. Topics should be related to competences, so very similar responses were expected. When asked, "Regarding topics that must currently be acquired in education in relation with autonomous vessels, do you think that any will no longer be applicable or should be changed/adjusted?" Again, discrepancies were observed between students and professionals. However, in this case, only 45% of students believed that none of the current topics should be eliminated, compared to 75% of other respondents, who supported the removal of some topics. A similar trend was

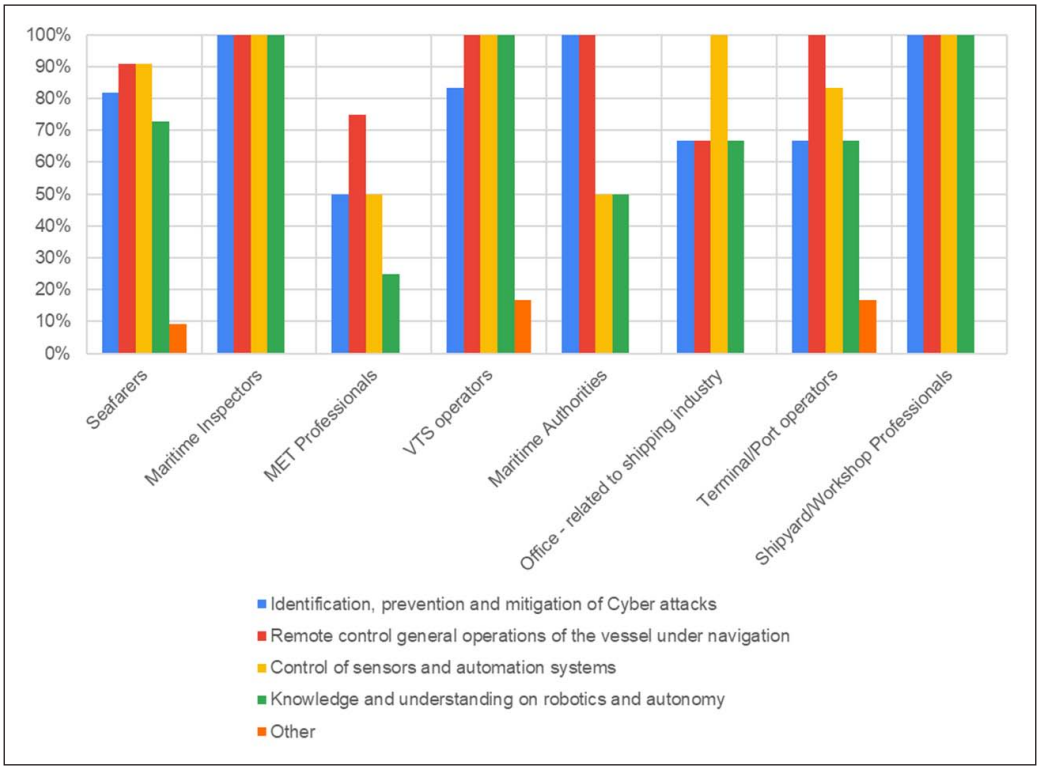

Figure 7 Potential new competences to be incorporated (based on participants' responses).

observed in responses to competence-related questions. Nevertheless, the sector was again divided almost in half, suggesting that eliminating topics might not be the solution. A similar outcome was obtained from METIs, with only 57% of participants believing that certain topics should be eliminated. It can therefore be concluded that incorporation of new topics or modification of existing ones is preferred over their elimination.

When participants who believed that certain topics should be removed were asked which one(s), nearly 43% singled out "Medicine" (Figure 8), in accordance with the results from the questions on the previous

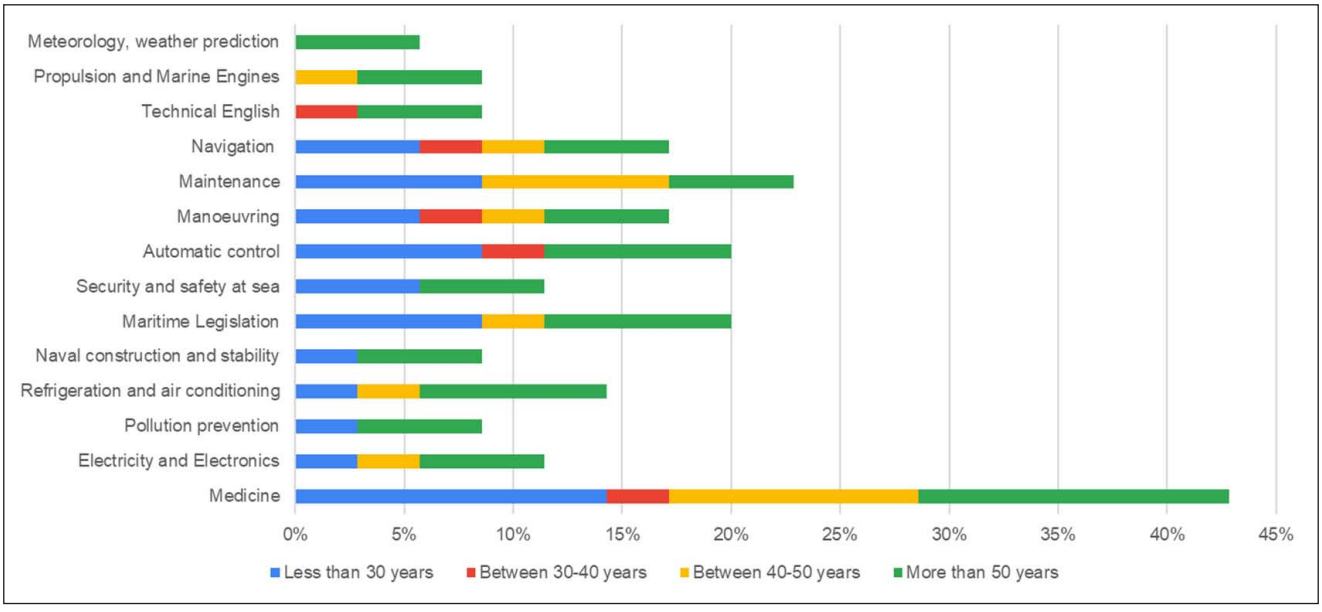

Figure 8 Distribution of current topics that should be eliminated or are no longer applicable to autonomous vessels in relation to participant age (based on participants' responses).

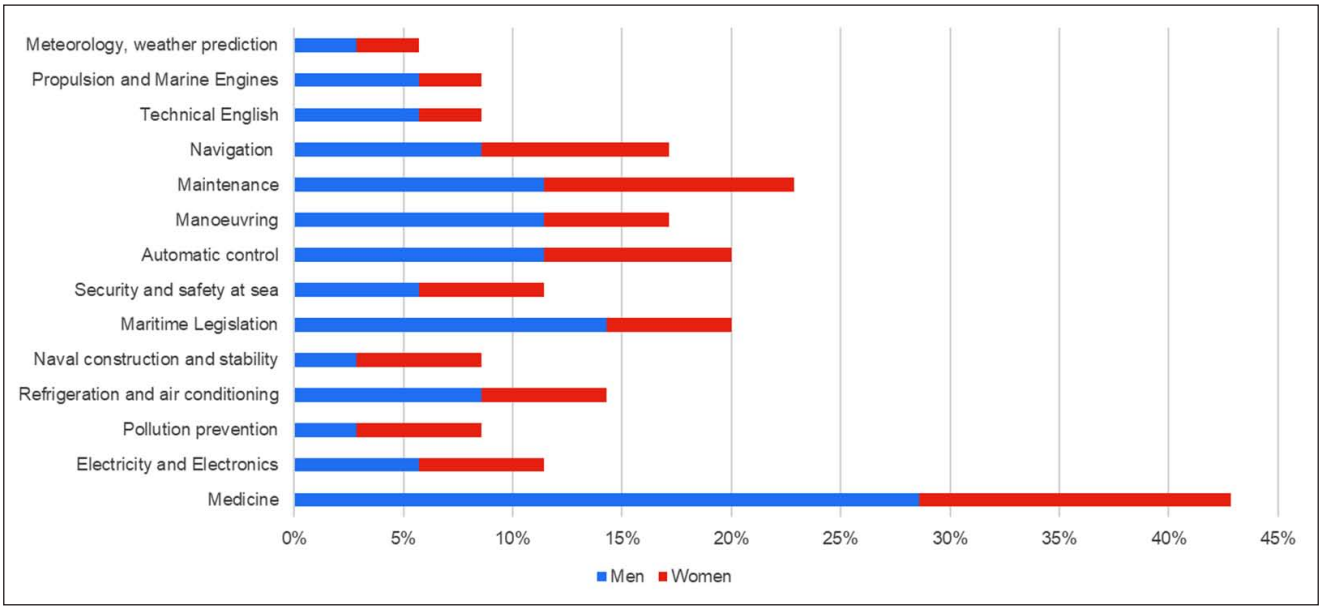

Figure 9 Gender-based distribution of the actual subjects that might drop out or are inapplicable in autonomous vessels (based on participants' responses).

point. Correlating this response with participant age reveals that, again, the groups under 30 and over 50 show higher response rates.

Again, the results reveal that respondents over 50 years gave a more diverse range of responses. According to them, all topics should be partially or totally eliminated. Participants in the 30 to 40 year age group provided limited feedback. The group over 50 as shown in Figure 3, has more experience with some form of autonomy. Therefore, their criteria for evaluating and identifying potential topics to eliminate should be given greater consideration in future analyses.

When relating this response to a gender perspective (Figure 9), the results appear to be quite similar from both points of view.

To the final question, "Which of the following new topics is necessary and should be incorporated into the new MET programme?", participants selected E-navigation (15.7%) followed by Cyber-security (13.6%), Remote control operation (13.6%) and Autonomous ship docking and harbour manoeuvring (13.1%).

Table 2 illustrates the correlation between emerging topics and novel competences, as perceived by respondents. The data indicates that E-navigation exhibits a

Table 2 List of potential new topics to be incorporated in relation to the new competences (based on participants' responses).

	COMPETENCES			
TOPICS	**Identification and prevention of cyber-attacks**	**Remote control operations**	**Control of sensors and automation systems**	**Knowledge and understanding of robotics and autonomy**
E-navigation	68.57%	77.14%	77.14%	68.57%
Augmented reality	25.71%	31.43%	31.43%	25.71%
Maritime cyber-attacks and security issues training	60.00%	71.43%	62.86%	57.14%
Data transfer communication	37.14%	34.29%	37.14%	31.43%
Internet of things	22.86%	25.71%	25.71%	22.86%
Big Data/AI	31.43%	34.29%	34.29%	28.57%
Remote control operation training	65.71%	71.43%	62.86%	62.86%
Abilities in any remote critical situation	54.29%	62.86%	57.14%	48.57%
Engineering background for deck officers	34.29%	37.14%	37.14%	31.43%
Autonomous ship docking and harbour manoeuvring	57.14%	62.86%	62.86%	57.14%

significant correlation with all the proposed new competences. It is closely followed by Maritime cyber-attacks and security issues training, Remote-control operation training, Abilities in any remote critical situation and Autonomous ship docking and harbour manoeuvring. Thus, the integration of these topics could facilitate the acquisition of knowledge and comprehension of the above competences. In contrast, Internet of things and Augmented reality emerge as topics that respondents consider insignificant for inclusion in maritime curricula and acquisition of new MASS competences.

4 Comparative research

A comparative overview of some key competences and future requirements will indicate how 'close to' or 'far from' this study Spanish METIs are.

4.1 Competence requirements gathered by other researchers

The qualification requirements for future seafarers, both on board and on shore as part of the crew in any Remote Operator Centre (ROC), have been explored in previous scientific studies. Various competences have been found to be less crucial when some functions are taken over by automation technologies. For example, Sharma and Kim evaluated the significance of the existing 66 Knowledge, Understanding and Proficiency (KUP) requirements in STCW table A-II/1. After three years of research, they laid down 26 as less relevant in remotely controlled MASS operations and 11 new competence themes and cognitive skills [29, 30]. This position seems to be in accordance with the results from our study, where some participants suggested removing some competences from the future MET programme while including new ones or improving existing ones. In their study, Kim and Mallam revealed that the main determinants for reliable MASS operations are the ability to apply decision-making techniques, handle large amounts of data, and maintain situational awareness [31]. Very similar findings emerged from Saha's research, which proposed some key competences for future shore control centre operators, with the three main ones being system understanding, communication and technical knowledge, and maritime skills [32]. Certain similar concepts were featured in the questionnaire as part of the new competences and topics to be added to the future MET programme.

4.2 Programme developed by the Autonomy Research Group at the University of South-Eastern Norway (USN) under the AUTOSHIP project

Since the AUTOSHIP project started in 2019 [7], many discussions and reports have been published. Within the group's training framework for crew, operators and designers, the following general competences and characteristics are recommended for remote operators, apart from the conventional ones: good sense of situational awareness with digitised information, quick-thinking response, self-discipline, mental confidence and attitude, leadership, critical thinking, and ability to remain calm and balanced [33].

In addition to the above competences, remote operators can significantly benefit from acquiring conventional navigational and technical competences. It is interesting to note that the initial training course under development by the University of South-Eastern Norway includes all technical insights for training of remote-control operators, along with human elements and management skills to operate in the most reliable way.

The Massterly ROC, still in the testing phase, is worth mentioning. It is a pivotal remote-control centre for autonomous vessels which is responsible for overseeing the management of two ships: the Yara Birkeland and the Asko. Daily analyses are conducted to gain insights into the new competences and skills that well-trained and experienced operators should acquire.

While none of these new competences and skills were mentioned in the responses, some answers under the "other" category hinted at them.

4.3 Competences for MASS Operators in Remote Operation Centres as per EMSA last report

Based on the future tasks of MASS operators, the latest report commissioned by EMSA [34] concluded that future crews and operators will need to acquire new competences and be trained in line with these tasks. The skills, knowledge and abilities that professionals must possess to effectively execute their roles in the ROC have been compiled into a competence catalogue used by EMSA as groundwork to develop future training programmes.

After defining the structure of the ROC and the roles of each position and rank, the report outlines a group of five qualification fields, some at operational levels and other at management levels. It also sets up the development of the new competences, along with personal and social abilities, by analysing the various processes that arise during a ship's voyage from berth to berth.

Based on the EMSA report, it is justified that MASS operators need the competences provided by STCW training as a baseline. Firstly, holding certificates in accordance with the STCW is a prerequisite to qualify as a MASS operator. Secondly, a competence-based curriculum for MASS ROC operators, organised in several modules, should be completed. Still under development, these modules will focus on navigation and monitoring of a MASS fleet, operating technology and automation, and required computer systems [35].

5 Discussion and conclusions

The analysis of the results shows that the study's objective was achieved, i.e. successfully collecting perceptions from different groups regarding potential new skills that seafarers may require in the context of unmanned ships. The findings and observations of this study illustrate how advancements in autonomous vessels are creating an open debate about the future of maritime professionals' training.

Not all responses from the groups yielded the same results. In fact, certain questions even led to contradictory outcomes, which have been discussed and analysed. However, a common conclusion from all groups is that changes are necessary. These changes include the use of more and new advanced simulators, the development of new STCW competences, and the incorporation of new topics into the existing Maritime Education and Training (MET) curriculum.

No consensus was found about the optimal approach to preparing future crews in regards the elimination of certain competences and/or topics outlined in the current STCW curriculum. However, all groups agreed on the need to incorporate new topics and knowledge of autonomy, robotics and cybersecurity into maritime curricula.

A specific survey was conducted among all Spanish METIs to determine the degree of MASS implementation in their curricula and gather perceptions on this matter.

All surveyed Spanish METIs use simulators as part of their training. However, they all confirmed that more simulator hours will be needed to train future crews, employing both existing simulators and future ones to be developed.

Currently, these METIs do not provide any specific knowledge or content on autonomous vessels. The survey conducted across the aforementioned maritime asked whether the centre offers training or tuition on topics related to autonomous vessels and 100% of respondents answered negatively. The next step should therefore involve the development of new competences and topics, or even the adaptation of existing ones to incorporate skills related to autonomous vessels.

In order to help develop new skills, almost all participants agreed that simulators will be important, even essential, equipment to prepare the next generation of maritime professionals. Additional training hours on current simulators will be required and new simulators related to autonomous vessels are sure to appear. Consequently, the next step should be to maximise simulator hours for all students and cover most topics related to manoeuvres and navigation, among others, to pave the way from autonomous vessel control to remote control centres.

While this survey was being conducted, the IMO's Marine Safety Committee moved ahead with a new code for the operation of Autonomous ships [19]. Regulations such as SOLAS will have undergone changes by 2025. It will be mandatory to designate a "master" for each MASS responsible for operations from a remote centre. The most important part regarding this study is that the master will be subject to new STCW training requirements.

As concluded in a previous work [17], anticipating changes necessary to accommodate emerging technologies and innovation in maritime curricula means that efforts can be focused on preparing potential legislation changes and ensuring that future crews acquire the required capabilities. Although the new STCW requirements have not yet come through, this survey and other research works indicate that using new technologies and more advanced simulation in current programmes, and including new topics addressing cyber-attacks and data transfer analysis, among others, will help all stakeholders to prepare for future developments.

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