INVESTIGATION OF STUDENT PERSPECTIVES ON CURRICULUM NEEDS FOR AUTONOMOUS SHIPPING

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ABSTRACT

Digitalization and automation are reshaping the maritime industry, particularly through advancements in designing Maritime Autonomous Surface Ships (MASS) and the expected proliferation of autonomous shipping. These innovations are altering traditional roles in ship design, operations, and the maritime sector in general. The influx of cybersecurity, automation, and IT experts into the maritime sphere is necessary for MASS integration in logistic chains. This paper examines students' perspectives on autonomous shipping, future job markets, and educational needs related to MASS. A survey of 159 students from Finnish universities studying in the fields of IT, maritime studies, engineering, naval architecture and business and law revealed significant interest in MASS-related education, driven by its anticipated impact on their careers. The study areas of interest include automation, computer engineering, general IT knowledge, Artificial Intelligence, and cybersecurity. The findings highlight the need for interdisciplinary curricula in MASS-related education, integrating technology, safety, legal, and business aspects of MASS.

KEYWORDS

Autonomous shipping, MASS, job market, profession.
CDIO Standards: 2, 3.

INTRODUCTION

Digitalization and automation are reshaping the maritime industry (Tsvetkova, Gustafsson, and Wikström, 2021). Particularly, the wide adoption of Maritime Autonomous Surface Ships (MASS) in the maritime sector is expected to affect several sectors such as logistics and shipbuilding, creating opportunities for new technological and business model innovations (Munim, 2019), while also changing the labour market. The role of the crew will, if not completely re- moved, see drastic changes in terms of tasks, responsibilities, and necessary skills (Tsvetkova, Hellström, and Ringbom, 2021). Remote operations of MASS, which are considered more likely than full autonomy at least in the near future, would require the understanding of the technology behind autonomous operations to ensure safe and secure operations, thus highlighting the importance of the knowledge of cybersecurity, Artificial Intelligence (AI) and automation. Ship- building and ship equipment manufacturing will see opportunities for further innovation, which will require professionals skilled in IT, automation, and cybersecurity, on the one hand, and in naval architecture and maritime engineering, on the other hand (Bolbot et al., 2022). Simultaneously, autonomous shipping will serve as a practical setting where IT engineers can apply their skills.

Engineering education needs to reflect these changes and prepare specialists who have sufficient knowledge and skills to design, build and operate MASS. Besides the cross-disciplinary engineering knowledge, the understanding of technical, legal and business aspects of au- tonomous shipping as a whole is relevant for these professionals. While several studies made comprehensive overviews of future skills necessary in seafarers' jobs, professionals involved in shipbuilding and maritime logistics (Bolbot et al., 2022), it is necessary to acknowledge that the labour market will evolve under many influencing factors, including the attitudes towards MASS and the perceived attractiveness of the jobs related to it. To address this research gap, this study aims to uncover the interest of current students in MASS-related education, as well as their perceptions of how the future labour markets will change due to the adoption of MASS and how this affects their professions. The study is based on a survey of students in seven higher educational institutions in Finland which provide MASS-related education. By explicating the changes students expect in their future jobs and corresponding them to the most interesting aspects of MASS-related education, we identify the commonalities and differences in the expectations towards such education among students in several relevant fields, such as maritime operations, maritime engineering and naval architecture, IT, and other engineering students.

LITERATURE OVERVIEW

The analysis of MASS's impact on the general maritime industry has attracted interest from multiple researchers. Examples constitute the identification of skills that will be required in the general maritime industry (Bolbot et al., 2022; Cicek et al., 2019). Other researchers have undertaken the tedious exercise of determining the new skills for navigators and remote control operators (Bachari-Lafteh and Harati-Mokhtari, 2021; Baum-Talmor and Kitada, 2022; Emad and Ghosh, 2023; Saha, 2023; Shahbakhsh et al., 2022; Sharma and Kim, 2022). The impact of MASS on gender equality was investigated by Kim et al. (2019). Several studies (Akbar et al., 2021; Kooij and Hekkenberg, 2021; Ziajka-Poznańska and Montewka, 2021) conducted the techno-economical analysis of MASS operations. The impact of MASS on safety has been

investigated, too (Bačkalov et al., 2023; de Vos et al., 2021; Wróbel et al., 2017). The general impact of MASS on logistics has been considered in studies by Tsvetkova and Hellström (2021) and Tsvetkova et al. (2022), whilst the general influence of MASS on the economy has been analysed by Bolbot et al. (2020), and Jo and D'agostini (2020).

However, understanding the perspectives of the general public is also important for drawing prudent public policies in connection to MASS (Goerlandt, 2020; Van Hooydonk, 2014). Several studies have investigated the public attitude towards MASS. One of the first stakeholder perspective analyses on MASS was conducted in the Munin project (Munin, 2023), where the flag states and external stakeholders, generally endorsed MASS adoption. The investigation of general public perception towards MASS in Halifax, Nova Scotia, Canada by Goerlandt and Pulsifer (2022) demonstrated that the general public might have safety concerns in connection to remotely controlled MASS and that men generally see MASS more favourably than women. Multiple stakeholders' perspectives towards MASS were investigated in a study (Theotokatos et al., 2023), where a generally positive attitude towards MASS was confirmed, but a seeming resistance from seafarers towards MASS was also identified. This finding was partially con- firmed in Chan et al. (2023), where the seafarers expressed their concerns in connection to jobs security.

Yet, the students' perspectives towards MASS were largely omitted in this and other studies. This constitutes an important research gap. Furthermore, the perspectives of students in connection to MASS-related courses have not been reported in previous literature to the best of the authors' knowledge. This gap is addressed in this study.

METHODOLOGY

In this study, we conducted research on student interest in MASS-related education to understand how this group perceives the impact of MASS and affects their interest in particular topics. We were driven by the question of whether students within and beyond traditional maritime-related education find MASS-related education relevant, and how the study interests differ across students with different educational backgrounds. The study began by aggregating contact information from teachers who teach MASS-related courses at the partner institutions of the Finnish autonomous maritime university network AutoMare (Bolbot et al., 2022) and asking them to distribute the questionnaire to their students. To ensure the validity of the questionnaire, it was designed in collaboration with teachers from partner institutions, including a broad range of disciplines within MASS-related education. Thus, the list of options for which aspects of MASS-related education was built based both on reviewed literature and the experience of these teachers. The options to provide own open answers were added so that respondents would have the possibility to add new items and would not be constrained by the proposed categories.

The survey was conducted in April 2023 and was filled by 159 students from several Finnish higher education institutions. The survey response rate was not calculated given that it was an open invitation to multiple email lists to voluntarily respond. Students from Novia University of Applied Sciences, South-Eastern University of Applied Sciences, Satakunta University of Applied Sciences, Turku University of Applied Sciences, University of Turku, Aalto University, and Åbo Akademi University were among the respondents.

The survey included questions on students' demographics, education, and interest in studying in courses related to autonomous shipping. Initial inquiries covered age, university, degree, and field of study. Following this, participants were asked about their motivations for studying autonomous shipping and the specific aspects they find of interest to study (based on Bolbot et al., 2022). The survey also explores potential barriers to related course participation and identifies preferences for elective courses and study methods. These questions, however, are not included in the scope of this study. The final questions were open-ended and touched on opinions on the impact of MASS on job markets and the students' views on the role of the person who should be in charge of an unmanned ship. The questions used in the survey are listed in the Appendix. The answers to the questions marked with (*) have been used in the analysis presented in this paper. The answers to open-ended questions were analyzed using content analysis and the discussed topics were thematically grouped into several key topics to understand students' perspective on the job market changes and the descriptions of their future jobs. This served as a context for analyzing quantitatively their answers related to the aspects, they are interested in studying and their general interest in MASS-related education.

RESULTS

Sample characteristics

A total of 159 responses were collected during the survey. The respondents' educational degrees are distributed as follows. A prominent respondent segment is studying for bachelor's degrees, constituting a majority share of 60.4%. Individuals studying for master's degrees from universities stand at 30.8%. The share of respondents aiming for vocational degrees or secondary school qualifications is at 6.3%. The remaining percentages are allocated to a category encompassing other degrees, including doctoral degrees, licentiate degrees, master's degrees from universities of applied sciences, as well as qualifications equivalent to comprehensive school education (see Figure 1).

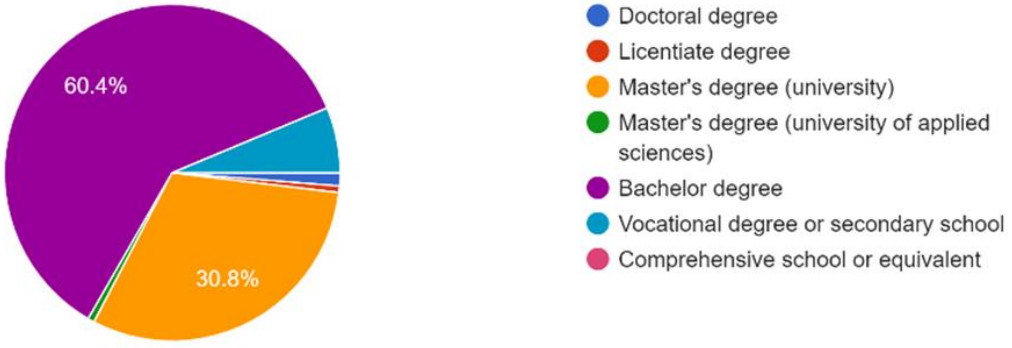

Figure 1. Respondents' degrees

The respondents represented a diverse array of study fields, which was beneficial for understanding the cross-disciplinary aspects of MASS-related education. Information Technology (IT) represented 34% of the survey respondents. Students in maritime engineering and naval architecture, as well as students in other engineering (such as e.g. process and chemical engineering) constituted 18% of respondents each. 15% of students

were studying for a degree in maritime operations and navigation. Finally, 12% of students were in natural sciences (such as marine biology), and 3% were studying in the fields of business, law, social and other sciences (see Figure 2).

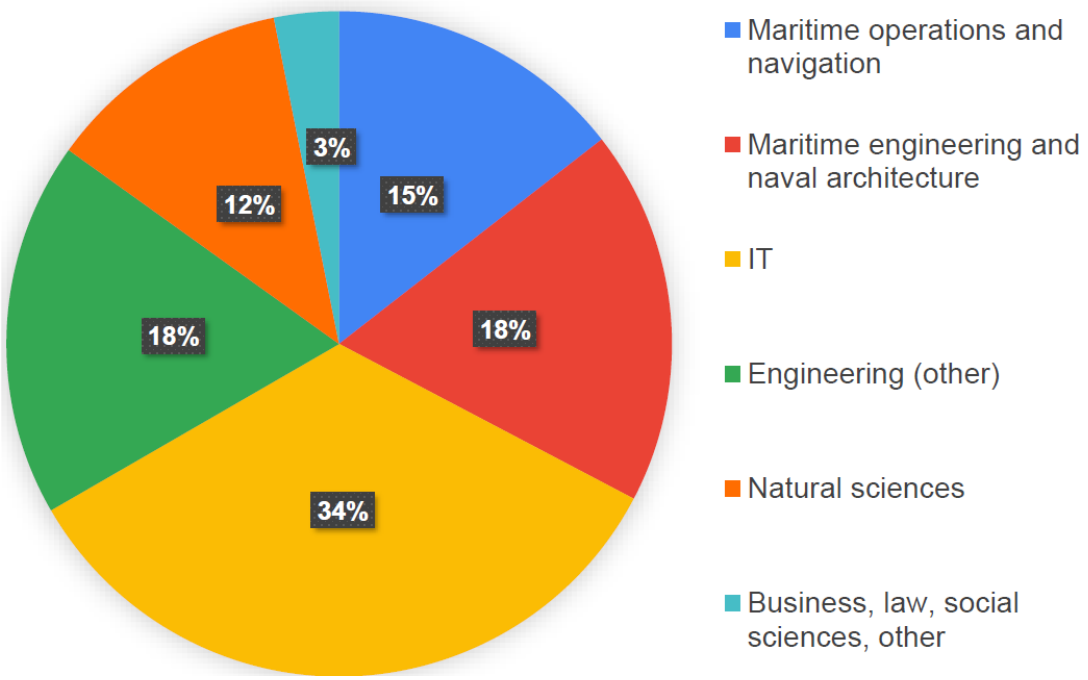

Figure 2. Main fields of study of the respondents (N = 159)

Students' perspective on the changes in the job market in response to autonomous shipping

During this study, respondents were asked to share their visions and opinions regarding the future of autonomous shipping and its impact on existing and future jobs. A recurring topic in terms of new job possibilities that may emerge as a result of the broad deployment of autonomous shipping is the significant need for IT specialists and automation engineers. The development of MASS systems, requiring expertise in software development, AI, machine learning, and autonomous system design, stands out as a necessary condition for successful autonomous shipping.

Beyond technology, the importance of cybersecurity in safeguarding these advanced vessels was emphasized. Legal and regulatory compliance is another area that was often mentioned. Professionals experienced in maritime regulations will be crucial to ensuring adherence to international and national laws and navigating the particulars of the changing regulatory landscape. The management and oversight aspect of autonomous shipping is anticipated to create new jobs as well. Supervising transactions, shipping processes, and managing autonomous ship operations will necessitate professionals to ensure efficient functioning. Furthermore, the environmental impact and sustainability of autonomous shipping were highlighted by several respondents. As the industry shifts, professionals with the expertise to evaluate the environmental footprint of these vessels and ensure sustainable practices are expected to become increasingly valuable. Finally, it was mentioned that rather than creating new jobs, the wider diffusion of autonomous shipping would change the job descriptions of seafarers

and that the crew size would gradually reduce.

According to students, concerning the jobs that will cease to exist, the advent of autonomous shipping is expected to lead to higher automation or reduction of several traditional job roles within the maritime industry. Based on the respondents' comments (78 responses), crew members, such as deckhands, engineers, and navigators, may face diminished roles or potential elimination due to the autonomous operation of ships. Pilots[1] and harbour masters[2] might see reduced demand as autonomous vessels navigate ports independently. Additionally, stevedores involved in loading and unloading cargo could experience a decrease in employment opportunities, as automated cranes take over these tasks. Furthermore, students anticipate that marine surveyors may encounter a change in their roles as advanced sensors and monitoring systems reduce the need for extensive manual inspections. The occupation of captains and deck crew members could witness shifts in responsibilities or reduced demand as autonomous ships take over navigation tasks.

As can be observed from the opinions regarding the jobs that will change or become obsolete, the roles of the crew members are expected to be affected the most. The changes to the role of the Master of a ship [3] are especially challenging to foresee, given the unclear responsibility if accidents happen involving a MASS. Thus, the respondents were asked who the Master (or captain) of an unmanned ship should be, i.e. someone who holds the highest authority and responsibility for the safe and efficient operation of the ship. The most common opinion (around 51% of the respondents) is that a person responsible for the remote operation of the ship (e.g. a shipping company executive) should bear this responsibility. Almost as many respondents considered the remote operator to be a suitable person who can be considered the Master of a MASS. Around 21% of respondents suggested that any qualified person appointed by the shipowner can serve this function, while 7,5% of respondents believed that no Master is required for an unmanned ship onboard.

The question of who should hold the position of master on an unmanned ship has generated diverse viewpoints. While some respondents foresee a gradual shift towards increased autonomy in maritime operations, particularly for short-voyage cargo vessels, others stress the importance of maintaining a human presence in critical roles. It is suggested that this person should possess both expertise in manual ship navigation and training in remote control technology, ensuring their ability to intervene in unforeseen circumstances. This approach is seen as a balance between technology-driven automation and the need for human intervention. A perspective is also offered that unmanned ships may not become a reality within the respondents' lifetimes. Instead, they express interest in systems that enhance autonomy while still involving human oversight. Some respondents believe that the shipping company should assume ulti mate responsibility, with remote operators functioning as pilots or Vessel Traffic Services (VTS). They argue against attributing sole responsibility to an individual who lacks full control over the ship's systems.

[1]A pilot is a local advisor to the ship master who provides navigational assistance to vessels sailing along the fairways and increasingly ensures the safe manoeuvring of ships to quays in destination ports.
[2]A harbour master is the official in charge of a harbour
[3]Master of a ship is the term that is given to the captain of a ship or the chief commanding officer of a ship.

As discussed in the following section, the changing roles of technology and crew influence the perceived educational needs of the students, especially those within the maritime domain.

Interest in MASS-related education

To understand the interest in MASS-related education among students, they were asked whether they were interested in studying courses in autonomous shipping. The term 'autonomous ship- ping' was used in the survey to ensure that students who are not familiar with a rather specific term MASS can understand the question, and that subjects beyond MASS design, construction and operation can also be included. The majority of all respondents (62,3%) claim they are in- terested in the subject, while around a quarter of students neither agree nor disagree with the statement that they are interested. Only around 11% of students say they are not interested in studying courses related to autonomous shipping. Therefore, strong interest in MASS-related topics from students was concluded.

To better understand the students' interest in MASS-related education, we analysed how the responses differed based on the student's background. As can be seen from Figure 3, there is a pronounced interest in MASS-related education among students in the maritime professions, including those related to shipbuilding and ship operations. IT students and students in engineering (other than those directly connected to maritime engineering) also appear to be interested in such education, while students in natural sciences appear to have a lower interest in the subject. The interest in MASS-related education is not very pronounced among students in business, law, and social sciences, too.

Further, students explained the reason for their interest in MASS-related education, if present, citing most commonly the general interest in new technologies and ship designs and the belief that there will be more MASS operating in the future. Around a third of the respondents believe that knowledge of autonomous shipping will be needed in their future work. Only around 20% of students believe that autonomous shipping will radically change the field they are studying or working within.

Students mentioned other reasons for their interest in addition to those listed above. Some students are intrigued by the practical applications and technical aspects of autonomous systems, seeing the potential for cross-field utilization and the widening of their knowledge. Others express interest in specific areas, such as robotics, AI, and information security, with a de- sire to explore autonomous systems, including ships, as part of their educational curriculum. There is also a distinct interest in understanding the environmental impact and the potential to develop environmentally friendly autonomous vessels. Additionally, some students share a broader interest in AI and automation, often without a clear connection to shipping. A few students mentioned that they are already engaged in the autonomous vessel industry through their current work or thesis focus. Several students have reservations about the practicality and speed of widespread autonomous shipping adoption, emphasizing the continued need for human involvement and careful consideration of the risks involved. As one respondent com- mented, "There are huge information security concerns in this type of ship".

Different aspects of the subject raise the interest among the respondents. Automation, com- puter engineering and basic knowledge of IT and operational technology are the most com-

monly mentioned topics that students would like to study in regards to autonomous shipping (see Figure 4).

Other commonly mentioned topics include those related to IT, such as artificial intelligence and data analytics, and safety and security aspects of MASS. Although topics related to ship design and ship systems automation are mentioned less, this can be explained by the fact that these are the subjects relevant mostly to professionals in the shipbuilding sector. Additionally to the aspects listed in Figure 4, topics like the impact of MASS on wildlife and marine environments, legal considerations tied to personal freedom, and electricity-related aspects were mentioned as areas of interest.

We further analyzed the most commonly mentioned aspects of autonomous shipping that different student groups are interested in studying. As can be seen from Figure 5, the interests differ depending on the current field of study, although some aspects appear to be universally important for students. This includes automation and basic knowledge of IT and operational technology. Safety aspects related to autonomous shipping and cybersecurity are highly prioritized by students from different fields. It can be noted that students within maritime domain, both in ship design and engineering and maritime operations, are highly interested in under- standing human-machine interaction. IT students maintain the focus on their current domain; however, their interest indicates which knowledge in the IT field is seen as most relevant for their future jobs and in relation to MASS. These areas include cybersecurity, artificial intelligence, and computer engineering.

DISCUSSION AND CONCLUSIONS

The study on students' interest in and requirements for MASS-related education presented in this paper provides insights into the expectations for how students' future professions might change and the corresponding needs for such education. First, it is evident that there exists an interest among students engaged in a variety of subjects in pursuing education related to MASS. This interest stems from various factors, including the promising career prospects in this evolving field, an awareness of the potential technological advancements, and an acknowledgement of the growing significance of autonomous shipping in the maritime industry.

Students have indicated a range of motivations for enrolling in MASS-related courses, from career advancement to personal interest in technology. Certain differences in such motivations and the interest in studying particular aspects can be observed among the different student groups depending on their main subject. In particular, future maritime professionals understand the need for basic IT knowledge and are interested in understanding safety and cybersecurity in relation to MASS. Human-machine interaction is yet another pronounced topic of interest. This can be explained by the understanding that the role of seafarers and shipping operators will change together with responsibility, and a certain fear for job security as highlighted in earlier studies (Chan et al., 2023; Theotokatos et al., 2023). Maritime engineering and naval architecture students, in turn, are especially interested in safety, human-machine interaction, but also automation (also in terms of propulsion), which indicates which are the main changes in naval architecture and engineering expected with the advent of autonomous ships. IT students' interests reflect the understanding of which

particular subjects may be applicable in the maritime domain and include cybersecurity, artificial intelligence and automation. The interest of students across subjects to study cybersecurity echoes the expected new safety challenges in the advent of MASS (Bačkalov et al., 2023; Wróbel et al., 2017).

This study emphasizes the importance of curriculum development that aligns with industry trends. Moreover, the study underscores the need for educational institutions to adapt and evolve to meet the changing demands of the maritime industry in the era of autonomous shipping. As MASS is increasingly introduced in shipping, educational programs and institutions must remain responsive to the evolving needs and expectations of the students. This will require more interdisciplinary education and possibly the development of new programs and modules that better reflect new jobs in the maritime industry.

Generally, a good alignment between the student's responses and the findings concerning educational needs for wider MASS implementation derived using expert feedback (see e.g. an extensive study by Bolbot et al., 2022) can be observed based on the research findings. Only a few of the proposed skills in earlier studies were not considered relevant by the students. This can be attributed to the personal interests of the students as well, but overall, it can be concluded that the students demonstrated a good awareness of the required skills in the future. The main contribution of this study is, however, in eliciting the differences in the interests of different student groups based on their main study subject, and a more nuanced analysis of the required interdisciplinary in the education for autonomous shipping from the students' perspective.

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BIOGRAPHICAL INFORMATION

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APPENDIX

Survey questions (the answers to questions marked with * were used in this study)

1. Age
2. University
   - If other, which educational organisation?
3. Current degree (*)
4. Field of study (*)
   - If other, please indicate field of study
5. I am interested in studying courses on Autonomous Shipping (*)
6. Why are you interested in Autonomous Shipping (choose up to three most important alternatives)? (*)
   - If other reason, please clarify
7. What aspects of Autonomous Shipping would you like to study? (choose up to four most important alternatives) (*)
   - If other, please indicate what
8. What is currently restricting you from taking (more) Autonomous Shipping related courses (choose the two most important alternatives)?
   - If other reason, please indicate what
9. Would you like to have more freedom when choosing elective courses?
10. What course(s) would you like to study in addition to your curriculum?
    - I prefer the following way of studying when it comes to Autonomous Shipping related topics (1= theory only; 2= more theory; 3= both; 4= more practice; 5= practice only)
    - I prefer the following way of studying when it comes to Autonomous Shipping related topics (1= lectures only; 2= more lectures; 3= both; 4= more self-study; 5= self-study only)
    - I prefer the following way of studying when it comes to Autonomous Shipping related topics (1= Individual work only; 2= more individual work; 3= both; 4= more teamwork; 5= team work only)
    - I prefer the following way of studying when it comes to Autonomous Shipping related topics (1= online only; 2= more online presence; 3= both; 4= more in-class presence; 5 = in-class presence only)
11. In your opinion, what new jobs would Autonomous Shipping create? (*)
12. In your opinion, which jobs will cease (stop existing) once autonomous ships become more common? (*)
13. In your opinion, what could be the benefits of Autonomous Ships?”
14. Who should be the Master (captain) of an unmanned ship? (*)
    - If other, please explain.

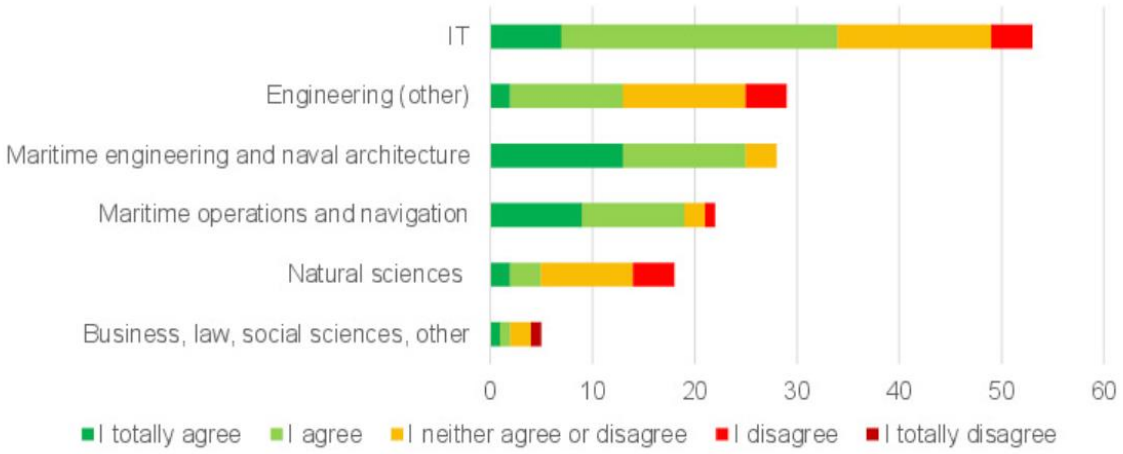

Figure 3. Students' interest in MASS-related education by the current field of study. Responses to the statement: "I am interested in studying courses in Autonomous Shipping" (N = 159)

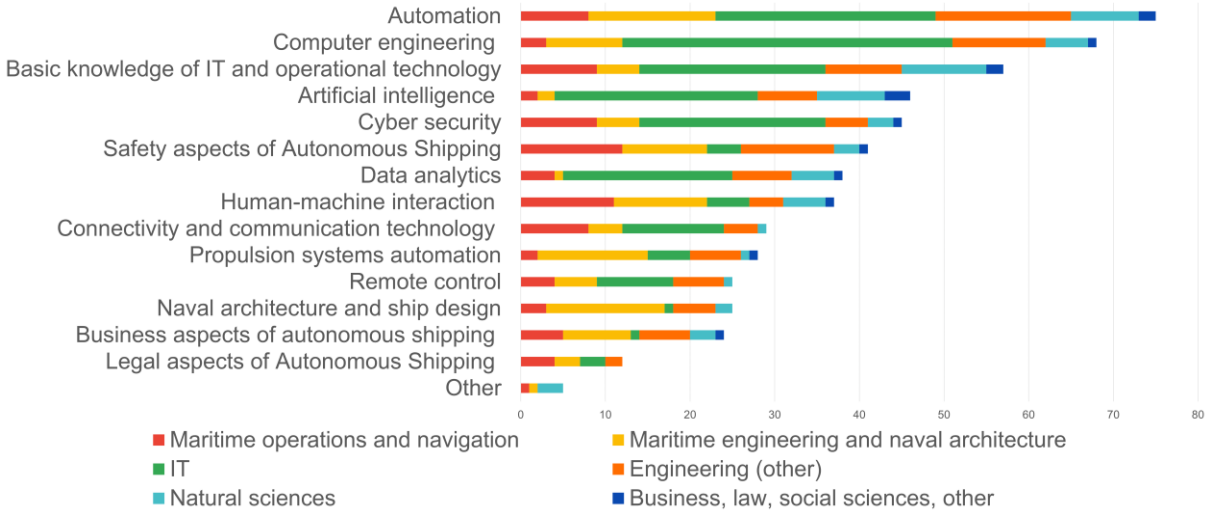

Figure 4. Aspects of MASS-related education that students are interested in studying (N = 159)

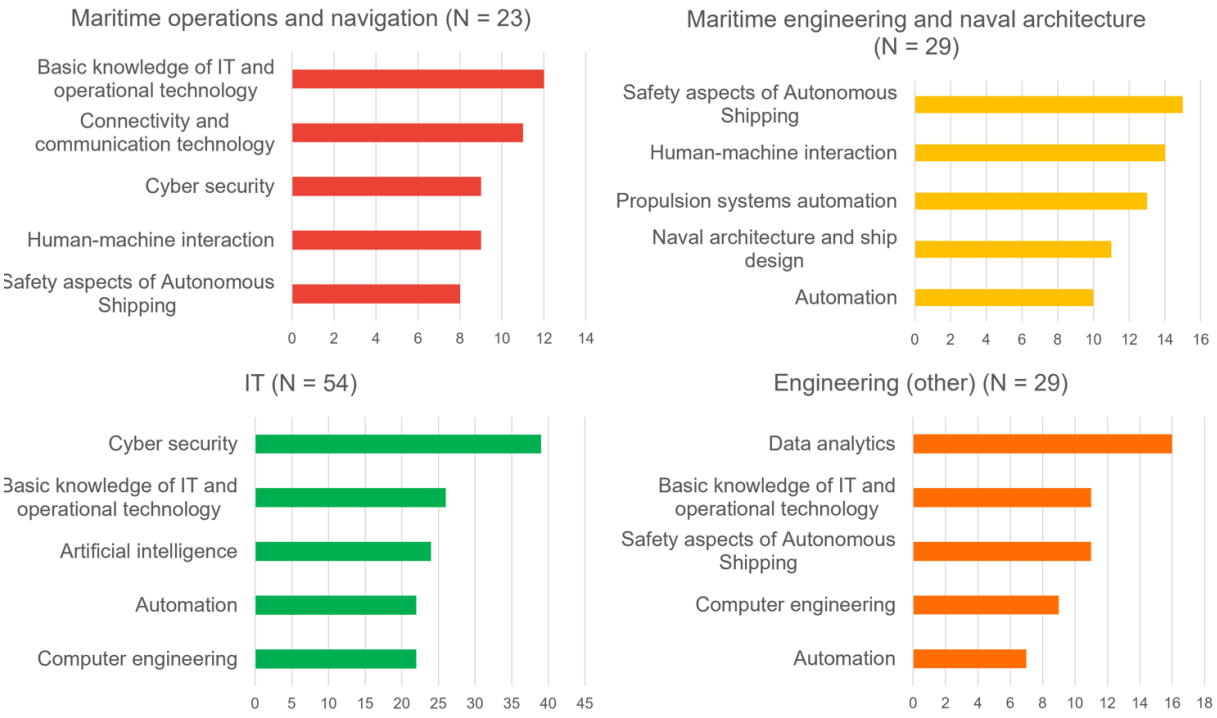

Figure 5. Most relevant aspects of MASS-related education that students are interested in studying separated by four key student groups.