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A COM-B Perspective on Integrating Sustainability into Maritime Education

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ABSTRACT

The maritime industry, responsible for over 80% of global transport and around 3% of global greenhouse gas emissions, faces mounting pressure to decarbonise, increasing the need for sustainability education in Maritime Education and Training. Maritime education is crucial for equipping future professionals with the knowledge and skills to address environmental and social challenges. This study examines maritime educators' commitment to sustainability principles, their awareness of sustainability issues in port services, and the integration of behavioural change approaches into teaching. A quantitative study, guided by the Capability, Opportunity, Motivation= Behaviour (COM-B) model, was conducted using an online survey completed by 86 maritime educators from various countries. The findings indicate that educators are motivated to integrate behavioural change approaches, but need to strengthen their capability through training and resources and have limited opportunities, such as real case studies and interactive learning methods. The study also explores differences across demographic characteristics and offers implications that underscore the role of educators in fostering awareness and adoption of sustainable behaviours among maritime professionals, contributing to environmental and economic sustainability.

1 Introduction

The global maritime industry is central to international trade, transporting more than 80% of the world's merchandise by volume and generating approximately 3% of global greenhouse gas (GHG) emissions [1,2]. As a result, the sector faces increasing pressure to decarbonise. In response, the International Maritime Organization (IMO) adopted an ambitious strategy to reduce total annual GHG emissions from international shipping by at least 20%, with a target of 30% by 2030, and further aiming to reduce emissions by at least 70%, striving for 80% by 2040, compared to 2008 levels. The long-term objective is to achieve net-zero GHG emissions by or around 2050 [3].

Maritime decarbonisation strategies are predominantly focused on technological innovation and regulatory compliance, and the targets set by the IMO present excellent opportunities for low-carbon fuels technological advancement. However, growing evidence suggests that operational performance also influences emissions, drawing attention to how human behaviour, decision-making practices, and organisational culture shape environmental outcomes [4,5,6].

Within this context, maritime educators bear a vital responsibility in fostering sustainability principles among students, shaping their ability to implement environmentally and socially responsible practices in the workplace. Moreover, the European Green Deal underscores the essential role of education in achieving Eu-

rope's ambition of becoming carbon-neutral by 2050, promoting the integration of environmental topics across all levels of education and emphasizing the development of key competencies such as critical and systems thinking [7]. Although there is broad consensus that incorporating sustainability topics into curricula enhances understanding of the interconnections between social, economic, and environmental systems [8], the integration of sustainability into higher education remains limited in scope and impact [9,10].

In particular, Maritime Education and Training (MET) systems are largely dominated by compliance-based frameworks and standards, such as IMO Model Courses and the STCW Convention. Within these structures, behavioural frameworks are only marginally addressed, and sustainability is often treated as a discrete topic rather than as a process of behavioural transformation embedded within professional practice. Although social and behavioural sciences offer robust theories and models of behaviour change [11], their application within the complex maritime domain remains limited.

Efforts to integrate sustainability into MET remain under-researched from an empirical and behavioural perspective. There is limited evidence that the mere inclusion of sustainability content in curricula translates into measurable behavioural change or improved operational performance. In particular, educators' behavioural readiness for shaping sustainability-oriented curriculum and pedagogical transformation has not been systematically examined.

To address this research gap, the present study adopts the COM-B (Capability, Opportunity, Motivation = Behaviour) behavioural change model as a conceptual foundation and analytical framework [11], which posits that a certain behaviour can only occur if three key prerequisites are met: capability, opportunity, and motivation. The COM-B model moves beyond knowledge-based explanations and enables the identification of structural, psychological, and contextual determinants influencing educational practice. The model was selected for its simplicity, versatility, and demonstrated effectiveness across diverse domains, including health, education, and organisational change.

Within the COM-B framework, capability refers to the individual's psychological and physical capacity to engage in a behaviour, including knowledge, skills, and access to appropriate training. Research on human factors in maritime studies reveals that simply transferring theoretical knowledge is not enough to develop effective professional competence. It has been found that classroom training increases students' declarative knowledge, but without application and contextual reinforcement, it is often difficult to use this knowledge in real-life situations [6]. On the other hand, many educators state that they are aware of the importance of sustainability; but at the same time, they acknowledge that they do not have all the necessary competencies to integrate sustainable practices into course content more effectively, or that their access to additional training and workshops is limited [12]. This situation clearly reveals the need for both continuous professional development and the development of practical application tools in order to implement sustainability in educational settings [13].

Opportunity encompasses external factors that enable or facilitate behaviour, such as institutional support, teaching materials, technological infrastructure, and collaboration with industry stakeholders. Even if educators have high motivation and sufficient capacity, it becomes quite difficult to achieve a lasting and sustainable transformation in their work when appropriate resources are not provided. Indeed, many educators face various obstacles ranging from the inadequacy of didactic materials and practical examples that can be used in the teaching process to weak institutional support and limited opportunities for collaboration with external stakeholders [14]. Therefore, developing systems that will enable educators to access resources more easily, encouraging the sharing of knowledge and experience among educators, and strengthening the ties between educational institutions and other relevant stakeholders, especially the industry, are of great importance [15].

Motivation includes the internal cognitive and emotional processes that energise and sustain behaviour, ranging from reflective evaluation to habitual responses. In maritime education, many educators demonstrate high motivation to integrate sustainability issues into their work. Educators acknowledge the importance of developing sustainable development awareness among students and aim to contribute to raising more responsible professional generations. However, motivation alone is not sufficient. From the student's perspective, it is seen that the perception of educational content as meaningful, relevant, and well-structured increases student participation and motivation [6]. This shows that motivation is largely influenced by the perception of the meaningfulness and applicability of the educational environment. Sustainable behavioural change occurs only when capability, opportunity, and motivation interact in a balanced and reinforcing manner [16].

Based on this theoretical foundation, the questionnaire was structured in alignment with the COM-B components, providing a behavioural lens through which to explore the enablers and barriers affecting the integration of sustainability principles into maritime education. Through this approach, the study contributes empirical insights into how maritime educators can be better supported in developing the behavioural competencies required for advancing sustainability in the maritime sector. Specifically, it examines educators' readiness for shaping sustainability-oriented curriculum and pedagogical transformation.

2 Methodology

This study adopts a quantitative research design grounded in the COM-B behavioural framework. The COM-B model was adapted to structure a survey instrument aimed at assessing maritime educators' capability, opportunity, and motivation to integrate sustainability-oriented behavioural change approaches into Maritime Education and Training (MET).

More specifically, the study employs a survey-based quantitative and descriptive research, to determine maritime educators' commitment and understanding towards sustainability principles, their awareness of port service sustainability, their capability to incorporate behavioural change approaches into their training methods and the challenges in motivating learners to adopt behavioural change. Within this context, the following research questions (RQ) were developed:

(1) How much do maritime educators care about sustainability principles and what is their level of knowledge about these principles?

(2) What is their level of awareness of sustainability issues in port services?

(3) How effectively can maritime educators implement behavioural change approaches in maritime education?

(4) What are the main challenges that educators face in promoting sustainable behavioural change in students?

(5) Which methods motivate learners to adopt sustainable practices into their behaviours are more effective?

(6) Do educators' opinions change according to above areas with respect to their demographic characteristics?

The COM-B-based questionnaire enables a structured examination of educators' behavioural readiness. Capability is assessed through items related to knowledge, confidence, and pedagogical competence (RQ1–RQ3). Opportunity is examined through institutional support, availability of resources, and structural conditions influencing sustainability integration (RQ4). Motivation is explored through educators' attitudes and willingness to adopt and promote sustainability-oriented behavioural change (RQ5). In addition, RQ6 investigates whether demographic variables influence the three COM-B components and overall engagement with sustainability in maritime education.

The data were collected through an online questionnaire, which was administered to conveniently selected 86 educators working in the field of maritime education and training. The questionnaire was designed to cover the components of the COM-B model. Apart from demographics, there are 44 questions in total, some of which were adapted from [17, 18], while the majority were developed by the authors of this research due to the specific nature of its focus on maritime educators and port services. Questions were displayed under four sections where they were measured with a 5-point Likert Scale (1= Strongly Disagree .... 5= Strongly Agree) and a last section containing demographic variables. Data analysis was carried out with descriptive statistics (e.g., mean, standard deviation), Independent Samples t-test and One Way ANOVA. Normality and equality of variances were assured before undertaking mean comparisons. Even though internal reliability (Cronbach's Alpha) of the items in each section were high enough to carry out analysis with aggregated sums, no statistical differences were achieved with any of the demographics. Therefore, analyses with respect to mean differences were undertaken on an item basis.

The demographic characteristics of the sample participating in the research are as follows: 73.3% of the participants are male and 26.7% are female. 29.8% are under the age of 40, 33.3% are between the ages of 40-50, and 36.9% are over the age of 50. In terms of education level, 5.8% have a bachelor's degree, 27.9% have a master's degree, and 66.3% have a PhD degree. According to academic titles, 30.2% are lecturers, 24.4% are assistant professors, 32.6% are associate professors, and 12.8% are professors. Finally in terms of experience, 32.9% have less than 10 years, 40% have between 10-20 years, and 27.1% have over 20 years of experience. While 10% of the educators teach in more than one country, majority of the sample teach in Türkiye (20,5%), Bulgaria (14%), Romania (13%) and Croatia (9,3%), Lithuania (7%), Italy (6,5%) and Belgium (6,5%). Remaining 23% teach in Ukraine, Portugal, UK, USA, Poland, Germany, Greece, Slovenia, Georgia, Kazakhstan, Nicaragua, Montenegro, Tunisia, Iran, Spain and Northern Cyprus.

3 Results

In the first part of the analysis to answer research questions from 1 to 4, preliminary results of descriptive statistics pertaining to each section of the questionnaire was achieved. Findings regarding the first section of the questionnaire related to maritime educators' commitment and understanding towards sustainability principles is displayed in Table 1.

The findings of the first section reveal that maritime educators generally consider sustainability principles important and necessary. However, they appear to rate themselves as more limited in terms of participation in sustainability training and workshops, and integration into the curriculum. This indicates that instructors have awareness and a positive attitude towards sustainability; however, they need improvement in the application aspect.

Table 1 Descriptive statistics

	Mean	Std. Dev.
Section 1: Maritime Educators' Commitment and Understanding towards Sustainability Principles (Cronbach's Alpha= 0,879)		
1a. Sustainability principles in maritime education are important.	4,62	,513
1b. I am knowledgeable about sustainable practices in maritime operations.	3,99	1,012
1c. I incorporate sustainability topics into my courses whenever possible.	4,07	,851
1d. I participated in training or workshops related to sustainability in the maritime sector.	3,13	1,282
1e. I think integrating sustainability principles into maritime education is crucial.	4,48	,698
1f. I actively seek opportunities to include guest speakers or industry experts with sustainability knowledge.	3,51	1,093
1g. I have a good understanding of the concept of sustainability.	4,02	,945
1h. My curriculum effectively covers current maritime sustainability challenges and solutions.	3,42	1,000
1i. I encourage students to critically evaluate the environmental impact of maritime operations.	4,24	,853
1j. I am confident in my ability to explain sustainability principles in relation to maritime education.	3,88	,987
Section 2: Maritime Educators' Awareness of Specific Issues in Port Service Sustainability (Cronbach's Alpha= 0,870)		
2a. I am aware of the environmental impacts of port operations (pilotage, tug services, mooring etc.).	4,14	,948
2b. Academia should play a role in addressing sustainability challenges in port services.	4,47	,715
2c. I am familiar with the key sustainability challenges faced by port operations.	3,69	1,066
2d. I discuss sustainability issues related to port services in my academic circles.	3,48	1,155
2e. My curriculum addresses the environmental impact of port activities (e.g., air emissions, waste management).	3,55	1,092
2f. I am aware of emerging technologies promoting sustainable practices in port services (e.g., shore power, clean fuels).	3,97	,963
2g. I am knowledgeable of the social dimensions of port sustainability.	3,76	1,028
2h. I believe collaboration between educational institutions and industry stakeholders can contribute to addressing port service sustainability issues.	4,49	,646
Section 3: Current Capacity to Integrate Behavioural Change Approaches into Educational Offerings (Cronbach's Alpha= 0,822)		
3a. I believe behavioural change approaches are effective in teaching sustainability concepts to young people.	4,34	,745
3b. My educational institution effectively integrates behavioural change approaches into curriculum.	3,53	,929
3c. I am open to integrating behavioural change approaches related to sustainability into my teaching methods.	4,24	,825
3d. My curriculum includes case studies or projects that highlight successful examples of behavioural change in maritime sustainability.	3,09	1,134
3e. I am comfortable using educational methods that encourage students to adopt sustainable behaviours within the maritime industry.	3,78	1,045
3f. I feel confident in facilitating discussions about the psychological barriers to adopting sustainable practices at sea.	3,66	,965
3g. I have access to resources or training programs on integrating behavioural change techniques into my teaching.	3,27	1,121
3h. I believe behavioural change approaches are effective in teaching sustainability concepts to professionals.	4,03	,818
Section 4: Challenges in Motivating Learners to Adopt Behavioural Change (Cronbach's Alpha= 0,801)		
4a. Lack of awareness or understanding of sustainable practices.	4,06	,938
4b. Perceived difficulty or impracticality of implementing sustainable practices.	3,83	,897
4c. Organizational culture that does not prioritize sustainability.	3,91	1,113
4d. Limited resources or infrastructure for sustainable practices on board.	3,86	,972

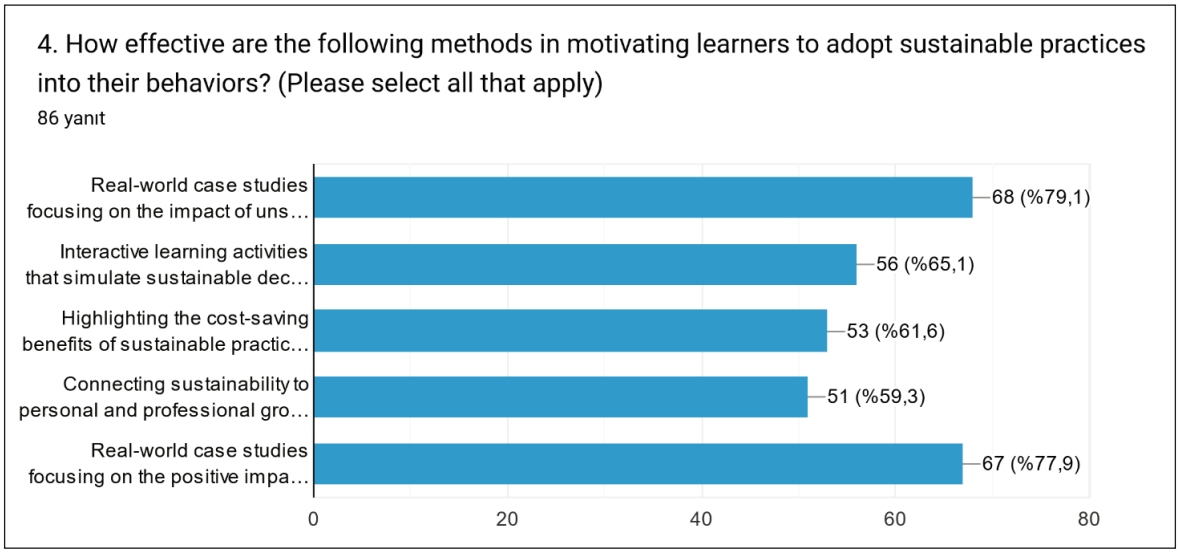

Figure 1 The effectiveness of learning methods

Second part of the questionnaire attempted to understand maritime educators' awareness of specific issues in port service sustainability. It is found out that instructors are aware of the environmental impacts of sustainability in port services and strongly emphasize the importance of academia-industry collaboration. However, educators perceive themselves as less proficient in discussing these issues in academic circles and incorporating environmental impacts into their curricula. These findings indicate that despite a high level of awareness, practical incorporation remains limited.

In the third part, educators' current capacity to integrate behavioural change approaches into educational offerings was measured. The results show that trainers believe behavioural change approaches are effective in sustainability education and are open to integrating these approaches into their courses. However, it was stated that these approaches are not sufficiently included in current curricula and that access to resources on this subject is limited. This suggests that motivation is high, but the opportunity and resource dimensions are relatively weak.

Finally, the fourth part of the questionnaire included questions regarding the challenges in motivating learners to adopt behavioural change. The lack of awareness among students regarding sustainable practices is seen as the most significant obstacle by educators. This is followed by an institutional culture that does not prioritize sustainability, limited resources or infrastructures for sustainable practices, and the perception that practices are difficult or impractical. A small number of instructors offered additional suggestions; which included AI-powered simulation training, e-learning platforms, awareness campaigns, community engagement projects, and role model and mentoring practices are among other important challenges.

To answer the fifth research question, the fourth section of the questionnaire also included binary questions where educators selected differing learning methods to be effective in motivating learners to adopt sustainable practices into their behaviours. As Figure 1 reveals, real-world case studies focusing on the impact of unsustainable practices and on the positive impact of sustainable practices appear to be the most effective learning methods, followed by interactive learning activities that simulate sustainable decision-making, highlighting the cost-saving benefits of sustainable practices and connecting sustainability to personal and professional growth. A small number of instructors offered additional suggestions; which included AI-powered simulation training, e-learning platforms, awareness campaigns, community engagement projects, and role model and mentoring practices.

Considering the final research question, mean differences pertaining to demographic characteristics were analysed and the results are displayed in Table 2. In terms of gender, female instructors emphasized the importance of sustainability and organizational barriers more strongly, while male instructors showed a higher awareness of the environmental and technological dimensions of port operations. It was noted that confidence in explaining sustainability principles and awareness of technological advancements were higher in educators over the age of 50. Another interesting finding here is that younger and older educators have higher mean levels than that of mid-aged educators. Similar findings have been observed concerning the year of experience. While the importance attributed to the integration of sustainability principles in maritime education and the understanding of the concept of sustainability are highest among educators with more than 20 years of experience, they are at the lowest level among educators with 10-20 years of experience.

Table 2 Mean differences with respect to demographic characteristics

Questions	Groups	Mean	t/F
Mean Differences with Respect to Gender			
1a. Sustainability principles in maritime education are important.	Males Females	4,57 4,74	-1,458*
2a. I am aware of the environmental impacts of port operations (pilotage, tug services, mooring etc.).	Males Females	4,22 3,91	1,346*
2c. I am familiar with the key sustainability challenges faced by port operations.	Males Females	3,84 3,26	2,291**
2d. I discuss sustainability issues related to port services in my academic circles.	Males Females	3,68 2,91	2,846**
2g. I am aware of emerging technologies promoting sustainable practices in port services (e.g., shore power, clean fuels).	Males Females	4,05 3,74	1,320*
2h. I am knowledgeable of the social dimensions of port sustainability.	Males Females	3,86 3,48	1,524*
4a. Lack of awareness or understanding of sustainable practices.	Males Females	3,94 4,39	-2,027**
4c. Organizational culture that does not prioritize sustainability.	Males Females	3,81 4,17	-1,351**
Mean Differences with Respect to Age			
1k. I am confident in my ability to explain sustainability principles in relation to maritime education.	<40 40-50 >50	3,96 3,57 4,16	3,113**
2a. I am aware of the environmental impacts of port operations (pilotage, tug services, mooring etc.).	<40 40-50 >50	4,08 3,89 4,42	2,439*
2g. I am aware of emerging technologies promoting sustainable practices in port services (e.g., shore power, clean fuels).	<40 40-50 >50	3,88 3,71 4,26	2,579*
Mean Differences with Respect to Education Level			
3c. I am open to integrating behavioural change approaches related to sustainability into my teaching methods.	Bachelor Master PhD	4,40 4,54 4,11	2,546*
Mean Differences with Respect to Academic Title			
1i. My curriculum effectively covers current maritime sustainability challenges and solutions.	Lecturer Asst. Assoc. Prof.	3,23 3,10 3,64 3,91	2,519*
2a. I am aware of the environmental impacts of port operations (pilotage, tug services, mooring etc.).	Lecturer Asst. Assoc. Prof.	4,31 3,86 4,00 4,64	2,194*
Mean Differences with Respect to Experience			
1e. I think integrating sustainability principles into maritime education is crucial.	<10 10-20 >20	4,50 4,29 4,74	2,908*
1h. I have a good understanding of the concept of sustainability.	<10 10-20 >20	3,93 3,82 4,43	3,202**

*Significant at p<0,1; **Significant at p<0,05

Differences in terms of education level emerged only in one area. Those with a bachelor's and master's degree were more likely to be open to integrating behavioural change approaches related to sustainability into their teaching methods than PhD graduates. Finally, mean differences with respect to academic title were observed in two areas. The level of coverage of sustainability challenges in the curriculum and awareness of the environmental impacts of port operations was highest among professors than among other academic titles.

4 Discussion

As the maritime industry faces increasing scrutiny over its environmental impact, the role of maritime educators is emerging as a pivotal element in fostering sustainability among future professionals. Integrating sustainable practices into maritime education is of vital importance, as it equips students with the necessary knowledge and skills to navigate their future careers. Maritime educators should develop and implement curricula that not only focus on technical competencies but also include sustainability principles, thereby encouraging future professionals who would be aware of the ecological consequences of their actions.

This study examined maritime educators' awareness of sustainability principles, especially in terms of port services sustainability, their capacity to incorporate behavioural change approaches into their courses, the challenges they face, and methods that would motivate learners to adopt sustainability into their behaviours. When evaluated within the framework of the COM-B model, the results provide inferences regarding the capability, opportunity and motivation levels of educators, offering important implications from both theoretical and practical perspectives.

The findings showed that maritime educators believe the integration of sustainability principles in maritime education has critical importance, although they consider themselves insufficient in the participation of sustainability-related training and workshops and the integration of sustainability into their courses. Educators' belief in the necessity of integrating sustainability principles into their courses, combined with their high awareness of the importance of these principles create a strong ground for the "motivation" aspect of the COM-B model. However, the aspect of "capability" requires development as the educators have inadequacy in the participation of sustainability trainings and incorporating these principles into their courses. Additionally, although awareness of port service sustainability is high among educators, they also feel inadequate in discussing sustainability issues related to port services and incorporating environmental impacts of port activities into their courses. This can be associated with both "capability" and "opportunity" aspects of the COM-B model. Finally, educators are open to incorporating behavioural change methods into their teaching materials, showing a positive indicator in terms of "motivation". However, the fact that they have limited resources in this regard pins that there is a lack of "opportunity". This finding supports the challenges acknowledged in maritime education research, where high awareness and motivation coexist with gaps in practical skills, institutional support and curriculum adaptation.

In that respect, these findings provide important clues for improving maritime education programs and increasing the competencies of instructors. However, the practical implications of this study are primarily regional, reflecting the characteristics of MET institutions in European and neighbouring countries represented in the sample, where similar regulatory and institutional contexts prevail. On the other hand, the use of the COM-B framework provides international insights for MET systems in other regions that seek to design interventions to strengthen educators' capability, opportunity and motivation to teach sustainability. Although educators have the motivation and are open to integrating behavioural change approaches into teaching methods, they need to improve their capability with more training and resources to more effectively incorporate sustainability principles into educational materials. On the other hand, they consider that there is a lack of necessary opportunities. Therefore, educational institutions can help educators by providing them with case studies, projects and educational materials where they can apply these approaches. Curricula should integrate practical and theoretical aspects, using a structured approach to develop participants' skills effectively.

The application of the COM-B framework suggests that sustainability-oriented curriculum and pedagogical transformation should be systematically structured. Learning activities and knowledge components must be sequenced in a coherent manner to progressively build educators' capability, supported by appropriate institutional conditions and reinforcement mechanisms.

The findings indicate that strengthening "Capability" requires curriculum design to move beyond conceptual discussions of sustainability and incorporate applied elements, including sustainability-oriented assessment methods, simulator-based operational decision-making scenarios, training in evaluating the environmental impact of maritime operations, and the development of practical mitigation and optimisation strategies. The identified "Opportunity" constraints also demonstrate that sustainability cannot be based solely on the individual motivation of educators. Therefore, institutions should redesign their curriculum. This process should involve establishing formal collaborations with port authorities, incorporating real-world case studies into lessons, and systematically integrating sustainability-focused simulation applications into MET programs. Although the level of "Motivation" appears relatively high, reinforcement mechanisms within the curriculum are necessary to sustain behavioural change. Sustainability practices should be linked to operational efficiency, cost reduction, regulatory compliance, and career development. This approach will strengthen both conscious and automatic motivation processes.

Additionally, significant differences are noted according to the demographic characteristics of instructors. However, when interpreting these differences, it should be considered that the statistical power is limited due to the sample size and the convenience sampling method. Considering gender, while female educators

show a higher awareness of the importance of sustainability principles and institutional barriers, male educators are more knowledgeable about the environmental impacts of port operations and new technologies. This result leads to a suggestion that the awareness of female educators should be increased, especially in terms of the sustainability-oriented outputs of port services.

It has been observed that educators are more confident in explaining sustainability principles, being aware of port service sustainability and integrating sustainability principles into training materials according to their age and experience. Considering the findings, the perspectives of educators between the ages of 40-50 and with 10-20 years of training experience on these issues can be increased with interactive training technologies and resources that will increase motivation. In addition, interactive platforms and mentor programs can be designed to convey the experiences of trainers over the age of 50.

When examined according to the level of education, educators with bachelor's and master's degrees are more open to incorporating behavioural change approaches into their training methods than PhD degrees. It should be ensured that up-to-date and effective teaching methods are also used by educators having high level of education. In this context, easily applicable modules that support behavioural change approaches can be developed.

Since it has been revealed that professors include more sustainability topics into their curricula and show higher awareness of environmental impacts, it is recommended that lower academic titles be supported in these areas. Advanced level working groups or forums can be created to deepen academic discussions.

This study has various limitations proposing opportunities for future research. Since the data was collected through an online survey, this may limit the possibility of obtaining in-depth information. In the future, mixed methods research designs can be used by integrating qualitative data collection techniques. In addition, although the findings highlight trends that require evaluation, they should be taken into account particularly in similar institutional and regional contexts. The adoption of convenience sampling method, the sample size and the fact that the sample primarily includes participants from Europe and neighbouring countries limit the generalization of the findings to the global context of maritime education. While these limitations do not preclude the validity of the findings, they necessitate careful formulation of broader policy and practical implications. Therefore, similar studies should be repeated with larger and more diverse samples. Furthermore, even though COM-B model has provided a compelling conceptual foundation, Theory of Planned Behaviour [19] or the Values-Beliefs-Norms Theory [20] can be suggested for future research to understand maritime educators' commitment to sustainability practices and intention to apply behavioural change approaches in their teaching practices.

Despite the increasing importance of sustainability in maritime education, behavioural change frameworks are not being utilized sufficiently. Yet, the maritime sector operates in areas directly related to behaviour, such as safety, security, environmental protection, operational efficiency, and human error. Today, stakeholders are moving beyond technical compliance to integrate the human factor into a safety and performance culture. In this context, a reassessment of behavioural and competency-based MET systems may be meaningful. Behavior-based safety practices and models like COM-B offer promise for targeted interventions. Furthermore, behavioural skills such as teamwork, leadership, and communication, included in STCW, demonstrate the importance of this approach. Therefore, future research focusing on behaviour-based frameworks not only in sustainability education but also in maritime safety, cybersecurity, emergency management, and risk mitigation processes would be valuable.

5 Conclusion

Sustainability is becoming increasingly central to the maritime sector, and education is a fundamental element of this transformation. The competence of seafarers is very important to ensure the safety of life and property at sea, environmental protection, and the efficient functioning of global trade. Therefore, the role of educators is critical in disseminating sustainable practices. This study examines the commitment of maritime educators to sustainability principles, their awareness of sustainability in port services, their capacity to integrate behavioural change approaches, and the challenges they face, within the framework of the COM-B model. The findings indicate a need for more training and resources to strengthen sustainability education.

Supporting educators in terms of capacity, opportunities, and motivation is crucial for both environmental and economic sustainability. Sustainability training plays a critical role, particularly in operational areas such as port services. It enables informed decisions regarding energy efficiency, fuel conservation, and resource use. This reduces operating costs and increases operational efficiency, ultimately contributing to economic sustainability. Furthermore, a qualified workforce trained through education is a fundamental element in gaining a competitive advantage in the sector. The sustainability awareness of the workforce would help port service providers adapt to international standards more quickly and achieve success in green port certification processes, allowing for not only short-term cost advantages but also long-term reputation and strategic gains. Thus, investing in sustainability education should be considered not only as part of

environmental responsibility but also as part of economic performance.

Last but not least, the maritime industry is directly dependent on human behaviour for issues such as security breaches, accidents due to human error, environmental risks, operational inefficiency, and regulatory compliance. Therefore, scientifically modelling behaviour is critical not only for sustainability, but also for maritime safety, security and operational excellence. Behavioural change models should be developed to achieve a strong foundation for industry professionals to acquire knowledge, as well as translating this knowledge into behaviour, maintain it, and disseminate it throughout the corporate culture.

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