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Preparing the Maritime Workforce for the Twin Transition: Skill Priorities and Educational Needs

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Abstract

The maritime sector is confronted with substantial obstacles in its efforts to adjust to the changing requirements for digital and green skills, which are essential for the advancement of technological innovation and sustainability. In order to remain competitive and adhere to rigorous environmental regulations and technological advancements, it is imperative to address these skill disparities. The objective of this study is to assess the responses to three primary enquiries: Which maritime occupations are in the highest demand, which are the most prominent in terms of digital and green skills, and what is the minimum educational requirement for the most sought-after professions in the maritime industry. This research is based on two components: desk research and field research. The maritime-related sectors that have been investigated in this study are: (a) Shipping, (b) Ports and terminals, (c) Shipbuilding and ship repair, (d) Supply chain management and maritime logistics, and (e) Marine technology and equipment. The objective of this approach is to identify current job market deficiencies and prioritise essential green and digital skills for future educational and training programmes in the maritime sectors.

Keywords: blue skills, green skills, digital skills, maritime sector

1. Introduction

The Twin Transition, which incorporates both ecological and digital transformations, is presently the most pressing issue on the EU's agenda, and it is expected to have a substantial impact on various aspects of life in the short, medium, and long term. Although a green transition and a digital transition are distinct in that they are each subject to unique dynamics, their twinning, or their ability to reinforce one another, warrants further investigation. The global community acknowledges digital technologies as a critical enabler in the pursuit of biodiversity restoration, pollution reduction, and climate neutrality. This is achieved by monitoring pollution exposure and obtaining access to environmental data. In addition, Ramesohl et al. (2021, 2022) underscore the importance of digital solutions in the transformation of stakeholders' incentive systems, market structures, business models, and behavioural patterns as prerequisites for transformative changes towards sustainability and climate protection. Furthermore, this facilitating role is further enhanced by the necessity of multiple economic operators to achieve climate neutrality and energy efficiency by 2030, such as in data centres and cloud infrastructures. The greening of other technologies, such as the internet of things, blockchain, and big data analytics, will be enabled by this.

The maritime sector, in particular, is currently at a critical juncture, and the concurrent transition is not only advantageous but also essential. As a significant contributor to global greenhouse gas emissions, the maritime industry must implement both green and digital transformations in order to achieve sustainability objectives. The sector's environmental footprint can be substantially diminished through the implementation of digital technologies, including automated and data-driven systems for emissions monitoring and route optimisation. Furthermore, in order to achieve climate neutrality, the maritime sector must incorporate renewable energy sources and develop innovative port infrastructures. The combined efforts of environmental sustainability and digital innovation will bolster the broader objective of a sustainable blue economy, which will also lead to increased operational efficiencies and reduced pollution.

The Twin Transition is the primary focus of current maritime policies, which are becoming more closely aligned. The European Union has implemented numerous comprehensive strategies, including the European Green Deal and the Fit for 55 program, with the objective of reducing greenhouse gas emissions from maritime transport and promoting sustainability and carbon neutrality by 2050 (European Commission, 2019; European Council, 2022). The EU Emissions Trading System (ETS) for maritime transport is a specific initiative within these frameworks that mandates emissions reductions and encourages the adoption of greener technologies (European Commission, 2024b). Furthermore, the Renewable Energy Directive (RED II) promotes the utilisation of alternative fuels, including hydrogen and biofuels, in maritime operations (European Commission, 2023). Digital solutions that enhance operational efficiency and transparency are promoted by expert groups such as the Digital Transport and Logistics Forum (DTLF) in order to accelerate the digitalisation of the maritime sector. Additionally, the EU's Action Plan on the European Maritime Space promotes the development of innovative technologies, including advanced port logistics systems and autonomous vessels. As the maritime industry navigates these policies, there is an increasing recognition of the necessity for a qualified workforce that possesses both green and digital competencies. This workforce is essential for driving the industry's transition towards sustainable practices while leveraging technological advancements. This alignment not only enables compliance with

regulatory frameworks but also promotes resilience and competitiveness in a global market that is swiftly evolving.

One of the critical elements of this transition is the function of skills, as well as the upskilling and reskilling requirements of the workforce. Personal and professional success necessitates the acquisition of skills. They facilitate the efficient and effective completion of tasks, resulting in superior outcomes in both professional and personal life. Career advancement is also significantly influenced by skills, as employers frequently evaluate candidates for both technical and interpersonal abilities when employing or promoting them. In the ever-evolving world, particularly in the realms of technology and the workplace, adaptability is indispensable. Individuals are capable of adapting to new challenges and opportunities by possessing a diverse array of skills and the capacity to acquire new ones.

Whether it is technical expertise or critical reasoning, problem-solving abilities are indispensable for surmounting challenges. Skilled individuals can increase their confidence and independence, thereby decreasing their dependence on others. Soft skills, such as empathy and communication, are essential for the establishment and preservation of relationships in both personal and professional contexts. The acquisition of new skills cultivates a lifelong learning perspective, which in turn keeps individuals prepared for the future, curious, and open-minded. In essence, skills are the fundamental components that empower individuals to accomplish their objectives, flourish in their professions, and navigate the intricacies of life with assurance and proficiency. The European Skills Index (ESI) is a composite indicator developed by Cedefop (2024) that assesses the performance of skills systems throughout the European Union. ESI comprises three fundamental components, namely skills development, activation, and matching. Each component assesses a distinct facet of a skills system. The foundation of the ESI consists of 15 distinct indicators derived from several worldwide sources (see Figure 1).

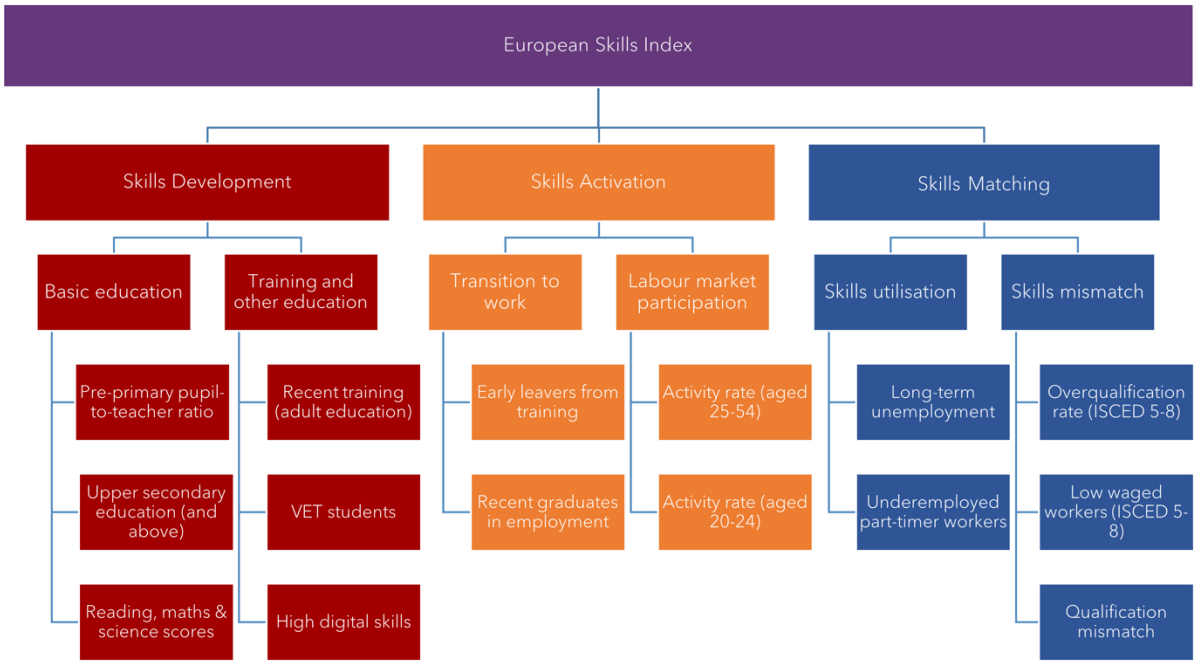

Figure 1 - European Skills Index (ESI)

2. Methodology

The purpose of this study is to evaluate the responses to three primary enquiries: Which maritime occupations are in the highest demand, which are the most prominent in terms of digital and green skills and what is the minimum education required for the most demanded professions in the maritime industry. This research is based on two components: computer research and field research. The initial phase involved the concentration of the maritime value chain's primary sectors. We conducted a comprehensive analysis of the marine industry, attempting to classify it into specific sectors by utilising a variety of authoritative sources in the field of maritime studies and industry reports. including the (IMO, 2024; Stopford, 2009; UNCTAD, 2023). We identified 10 sectors as presented in Table 1. However, Maritech Talent expert group decided to focus on 5 out of these 10 sectors for this study, namely, (a) Shipping, (b) Ports and terminals, (c) Shipbuilding and ship repair, (d) Maritime logistics and supply chain management, and (e) Marine technology and equipment.

Table 1 - Sectors within the Maritime Industry

SECTOR	*DESCRIPTION*
Shipping	Including container shipping, bulk shipping (such as oil tankers and dry bulk carriers), and passenger cruise lines, this encompasses the transportation of products and passengers via ships.
Ports and terminals	The port is a critical centre for maritime activities, which include the loading and unloading of cargo, as well as the provision of a variety of services, including warehousing, storage, and logistics.
Shipbuilding and ship repair	Shipyards, naval architects, marine engineers, and associated manufacturing and service providers are all involved in the construction, repair, and maintenance of ships, which are substantial sectors of the maritime industry.
Maritime logistics and supply chain management	This entails the coordination of a variety of activities that are associated with the movement of products via sea routes, such as cargo handling, warehousing, transportation, and distribution.
Marine technology and equipment	The development, manufacturing, and sale of marine apparatus and technology, including navigation systems, communication equipment, propulsion systems, and safety devices, are all included in this sector.
Offshore oil and gas industry	Maritime infrastructure, vessels, and services are essential for offshore exploration, drilling, and production operations in offshore locations.
Fisheries and aquaculture	The maritime sector also includes activities related to fishing, fish farming, and aquaculture, which contribute to the production and distribution of seafood products.
Marine tourism and recreation	This sector encompasses activities such as recreational boating, yachting, sailing, and cruise tourism, which rely on maritime infrastructure and services for leisure and travel purposes.
Maritime law and insurance	Legal and insurance services specific to maritime activities play a crucial role in ensuring compliance, risk management, and financial protection for stakeholders involved in the maritime sector.
Maritime education and training	Institutions and organizations offering education, training, and research related to maritime studies, including maritime law, maritime engineering, naval architecture, and maritime management.

To ascertain the occupations and skills associated with these five sectors, we utilised the ESCO Classification, which is a multilingual classification system that categorises European Skills, Competences, and Occupations (European Commission, 2024a). ESCO is a component of the Europe 2020 strategy, which is the European plan for intelligent, sustainable, and inclusive economic expansion. The ESCO categorization system defines and categorises skills, competences, and jobs that are relevant for the labour market and education and training in the European Union. ESCO encompasses a total of 3008 professions at Level 0. It is based on the International Standard Classification of professions (ISCO-08), which provides the hierarchical framework for ESCO's occupations pillar. Occupations are categorised into four levels: Level 1, Level 2, Level 3, and Level 4. Each level corresponds to a different number of occupation groups: 10 groups for Level 1, 42 groups for Level 2, 126 groups for Level 3, and 426 groups for Level 4. ESCO's skills pillar offers an extensive inventory of knowledge, skills, and competences that are pertinent to the European labour market. The dataset consists of 13,896 concepts, including 10,831 skills/competences and 3,059 knowledge concepts, organised in a hierarchical framework with four sub-classifications.

A systematic review was conducted to transfer the ESCO Occupations (level 3) onto the five maritime sectors, which are as follows: (a) Shipping, (b) Ports and terminals, (c) Shipbuilding and ship repair, (d) Supply chain management and maritime logistics, and (e) Marine technology and equipment. The evaluation resulted in the identification of 33 occupations. These occupations were subsequently divided into two categories: "blue-collar" and "white-collar" jobs. "Blue-collar" workers are responsible for physically demanding manual tasks in manufacturing, construction, mining, and maintenance, and they may work outdoors or operate heavy equipment. "White-collar" professionals may work at desks in clerical, administrative, management, or executive roles. White-collar workers seldom engage in physical labour, in contrast to blue-collar workers. (Investopedia, 2024).

In ESCO v1.1.2, the skills pillar is organized in a hierarchical structure that consists of four sub-classifications:

- Knowledge
- Language skills and knowledge
- Skills
- Transversal skills

The skills pillar in the ESCO database differentiates between skill/competence concepts and knowledge concepts by specifying the skill type. There is no differentiation between skills and competences. The Skills and Knowledge concepts are categorized into three levels: Level 1, Level 2, and Level 3. Level 1 corresponds to 8 groups of skills and 11 groups of Knowledge Concepts. Level 2 corresponds to 74 groups of skills and 29 groups of Knowledge Concepts. Level 3 corresponds to 296 groups of skills and 86 groups of Knowledge Concepts.

The ESCO system also identifies talents categorised as green to facilitate the transformation of the EU labour market towards a more environmentally sustainable model. In order to address the requirement of decreasing emissions in working practices, it has become necessary for workers to possess a skill set that can effectively respond to this demand. As a result, the Skills/Competences pillar has been enhanced by incorporating new information at the skill level, which allows for the differentiation of green skills and knowledge ideas (European Commission, 2022). In order to develop and deploy the net-zero technologies necessary to achieve climate neutrality by 2050, Koundouri et al. (2023)

sought to identify the new set of Green Digital Skills that will define the present and future course of action required to skill and upskill individuals within the EU and beyond.

- **Green skills** are defined by the European Centre for the Development of Vocational Training (Cedefop) as "the knowledge, abilities, values, and attitudes required to reside in, foster, and develop a resource-efficient and sustainable society" (Cedefop, 2012). Green skills are the skills required to mitigate environmental impacts and facilitate economic restructuring in order to achieve cleaner, more climate-resilient, and efficient economies that maintain environmental sustainability and offer acceptable work conditions.
- **Digital skills** are a collection of skills that enable individuals to access and manage information through the use of digital devices, communication applications, and networks. They allow individuals to generate and distribute digital content, communicate, collaborate, and resolve issues in order to facilitate effective and innovative learning, work, and social activities (UNESCO, 2018). Entry-level digital skills, which are fundamental functional skills necessary for the basic operation of digital devices and online applications, are widely regarded as a critical element of a new set of literacy skills in the digital era, in addition to traditional reading, writing, and numeracy skills. Higher-level abilities that enable users to leverage digital technologies in transformative and empowering ways, such as the utilisation of artificial intelligence (AI), machine learning, and big data analytics, are located at the advanced spectrum of digital skills (Koundouri et al., 2023).

The maritime sector's green and digital skills-gap was identified through the development of an online survey. The survey is divided into four sections. The survey collects data on personal and organizational characteristics, as well as occupations and skills need. It evaluates the presence of these 33 occupations on the payroll, the challenges associated with recruiting employees within these groups, and the level of interest in full-time employment within these groups. The top green and digital skills (level 3) identified by Koundouri et al. (2023) were employed to evaluate the most critical Green & Digital skills gaps that should be addressed by educational/training programs in the context of the skills-gap review. In addition, other questions address the frequency with which the skills and training requirements of their employees are reviewed, the vacancies that are currently available, the challenges in replacing vacant positions and the minimum education and training requirements for each occupational group for the above-mentioned occupations. The survey was distributed to 150 stakeholders in Bulgaria, Cyprus and Greece via Survey Hero[1] and it was available between April and June 2024.

3. Results

3.1. Descriptive statistics

The results were analysed using the same methodology derived from Koundouri et al. (2023), who created a framework to categorise occupations and skills according to their degree of "Greenness," "Digitalisation," and "Greenness and Digitalisation" by utilising the aforementioned setup and the classifications and hierarchies provided by the ESCO API. The calculation of a score, which is defined as the proportion of green, digital, and jointly green

[1] https://www.surveyhero.com/c/7pyp3zqf

and digital skills and knowledge concepts in each occupation or occupation group, is a component of their data-driven methodology. The score spans from 0 to 100.

A total of 33 responses were utilised for the analysis after a data cleansing process in which we eliminated respondents with a very low response time, response inconsistencies, and very low variance across the various questions. Table 2 displays the frequency distribution of socio-demographic characteristics of the sample. The frequency distribution of the socio-demographic characteristics of the sample shows that it is sufficiently heterogeneous. The study sample comprised more females (60%), and consequently fewer males (40%). In terms of age, the frequency distribution across the five categories is quite balanced. However, people aged less than 25 were underrepresented (4%). Furthermore, the majority of the respondents hold a master's degree or an MBA (60%), while 32% has a PhD, thus implying an underrepresentation of the lower educated people. Lastly, the majority of respondents are employed in a freelance status or in a position of top or intermediate management.

Table 2 - Frequency distribution of socio-demographic characteristics of the sample.

Highest degree of education	
BSc	8%
MSc/MBA	60%
PhD	32%
Position in the company	
Top Management	28%
Middle Management	36%
Professional	28%
Administrative Staff	8%
Age	
Above 55	16%
Between 46 and 55	28%
Between 36 and 45	36%
Between 26 and 35	16%
Up to 25	4%
Gender	
Male	40%
Female	60%

Table 2 illustrates the organisation information statistics of the survey sample. The heterogeneity of the organisations' profiles is evident in their frequency distribution. The sample of the survey consisted of a greater number of responses from Bulgaria (50%), compared to 25% and 25% from Greece and Cyprus, respectively. The frequency distribution across the five categories is quite balanced in terms of the number of personnel within the organisation, as defined by OECD (2020). Nevertheless, the majority seems to be small and medium-sized enterprises (SMEs) that employ fewer than 250 people (60%), while giant enterprises are well represented (28%). There are 16,5% (weighted average) of employees who are under the age of 30. Additionally, the ports and terminals sector is over-represented, while the shipbuilding and ship repair sector is under-represented. This is due to the fact that ports and terminals appear to be more cognisant of the EU legislation regarding green and digital challenges, which has piqued their interest in participating in comparable studies and initiatives. In addition, 40%, 23,3%, and 33.3% of the organisations involved in this study are open to national, European, and global markets, respectively. Finally, the majority of respondents (62.5%) are unaware of the existence of an ESG report within their organisation.

Table 3 - Organisation information statistics, survey results

Country	
Bulgaria	50%
Cyprus	25%
Greece	25%
Number of employees within the organisation	
1-9 persons employed	12%
10-19 persons employed	16%
20-49 persons employed	12%
50-249 persons employed	32%
250 or more persons employed	28%
Sector	
Shipping	27,3%
Ports and Terminals	51,5%
Shipbuilding and ship repair	0,0%
Maritime logistics and supply chain	15,2%
Marine technology and equipment	6,1%
Geographic Market	
National	40,0%
Regional	3,3%
European	23,3%
Global	33,3%
Share of <30 year-old employees	
Less than 10%	52%
10-25%	28%
25-50%	16%
Over 50%	4%
Existance of ESG report	
Yes	12,5%
No	25,0%
I don't know	62,5%

3.2. Demand for White- and Blue-collar Jobs in the maritime industry

Figure 2 and Figure 3 present the demand for white- and blue-collar jobs respectively. The respondents were requested to indicate whether they concurred with the following statements for each occupational group: A) This occupational group is represented among the employees of my organisation; B) My organisation is experiencing difficulty in locating employees within this occupational group; and C) My organisation is actively seeking full-time employment within these groups. The color-coding is organized as follows. The boxes marked in red indicate that no one selected this option, while the boxes marked in orange indicate that less than 40% of the respondents selected it. The boxes marked in green indicate that more than 40% of the respondents selected this answer. Almost all white- and blue-collar occupations are represented within the respondents' organisations, with the exception of Business Services Managers, which validates the initial desk work mapping of “blue” occupations for the five selected sectors. The open-ended question regarding the presence of any additional occupational groups among employees of their organization did not indicate any new occupational group of Level 3.

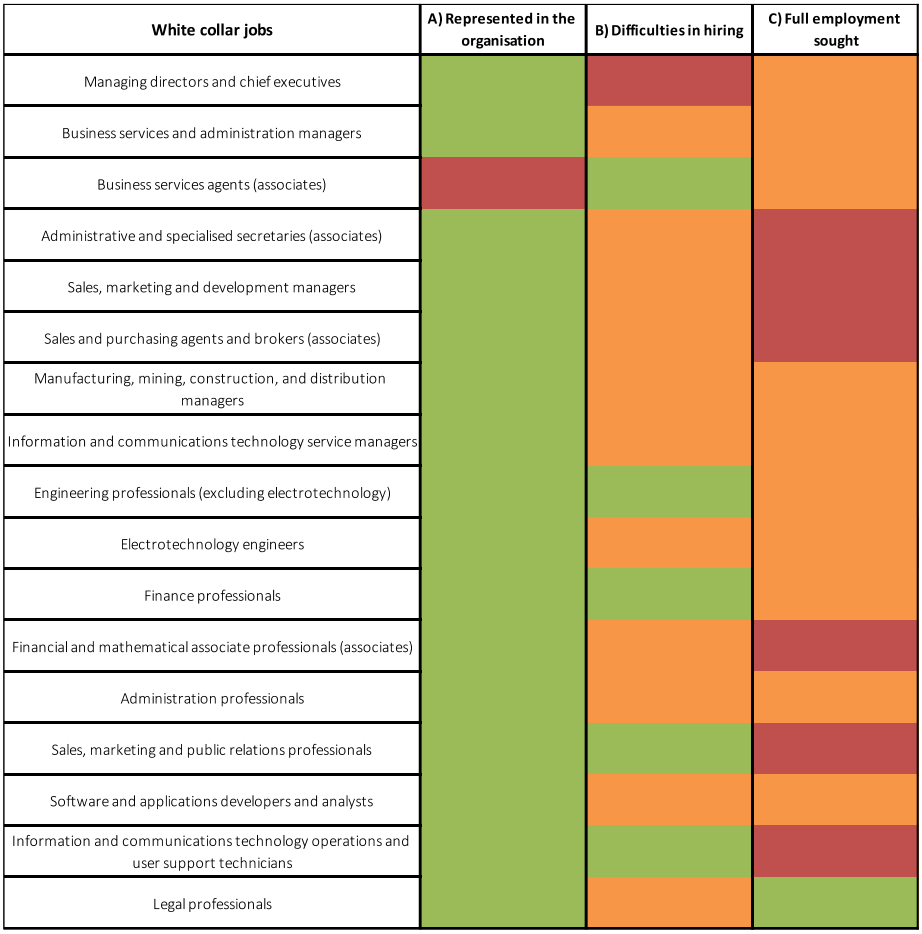

Figure 2 – White-collar jobs demand mapping in the maritime industry (Level 3)

As we can see, in Figure 2, the majority of respondents agree that almost all indicated occupations can be found within their organisations, which shows that the organization employs individuals from these occupational groups. This may indicate that the organisations possess the requisite knowledge and skills within the team, which could potentially enhance operational efficiency and expertise. In regard to the question B), a prospective skills shortage in the labour market for this specific occupational category is indicated by the high levels of agreement with this statement. This could demonstrate that the demand for these positions exceeds the supply of qualified candidates. The organisations who seek these professionals, such as business service agents, engineering, finance, IT or PR professionals, may be prompted to consider strategies for talent acquisition, such as investing in training programs for prospective employees, offering competitive compensation, or enhancing recruitment efforts, in light of these findings.

Finally, the last column shows if the organisations are seeking full-time employment within these categories. Here, we see a low level of agreement that may indicate a lack of available positions or a transition in organisational focus to a more flexible workforce (part-time or freelancing) away from this occupational group. However, for legal professionals, we observe an active recruitment strategy, which signifies that the organisations acknowledge the significance of these roles in its operations.

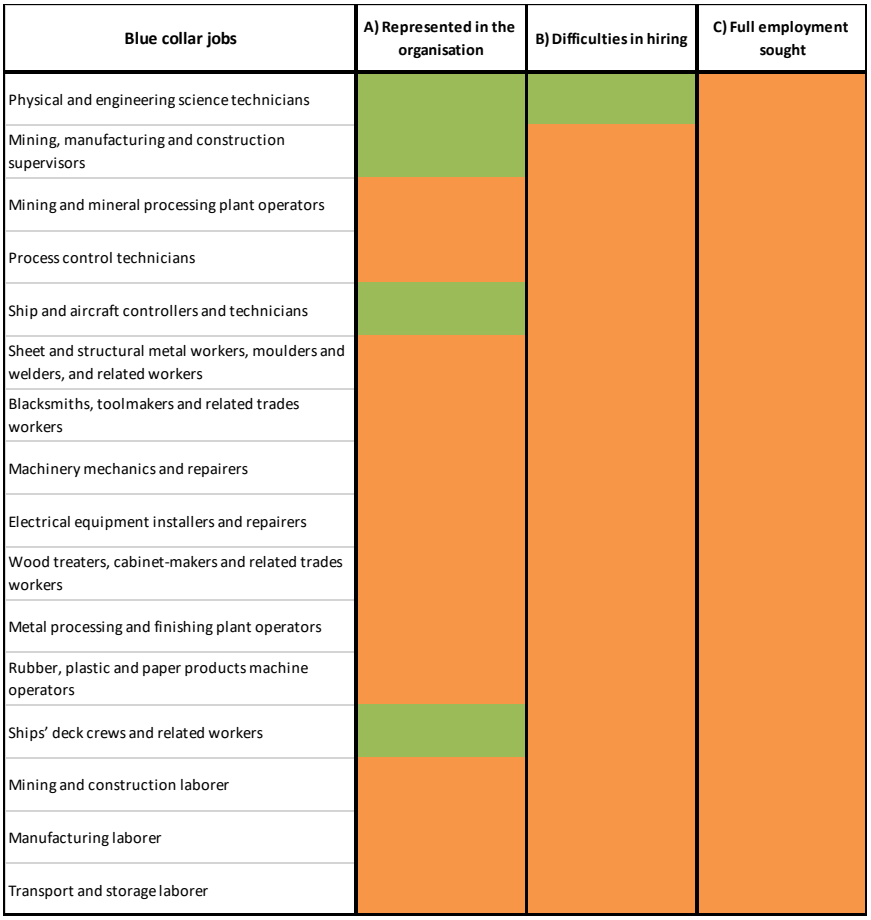

Figure 3 – Blue-collar jobs demand mapping in the maritime industry (Level 3)

Responses in Figure 3, on the other side, exhibit a substantial degree of variation (with some individuals disagreeing), which may indicate a lack of diversity in skills or a requirement for training and development in these specific occupations. Here, we observe that fewer than 40% of respondents confirm statements A and B, which suggests potential trends and challenges within the responding organizations regarding these occupational groups. These could include underrepresentation in the workforce, hiring challenges, low demand for full-time roles, and a shift towards part-time, freelance, or temporary contracts. Low agreement on statement A) suggests that these professions are either underrepresented or not a strategic focus, potentially impacting the organization's ability to innovate or meet operational needs.

Hiring challenges (statement B) may be due to inadequate recruitment strategies, uncompetitive salaries, or a limited labor market for this role (insufficient candidates who are suitable for these positions). Low confirmation of statement C) suggests a transition to a more flexible workforce model or a lack of perceived value in expanding this role full-time, possibly due to changing organizational needs or budgetary constraints. Overall, these findings highlight the need for organizations to address these challenges and ensure a diverse workforce for innovation and operational success.

3.3. Classification of Green and Digital Occupations in the maritime industry

By utilising the setup presented above and the classifications and hierarchies provided by the ESCO API, we have created a framework that categorises occupations according to their level

of "Greenness", "Digitalisation", and "Greenness and Digitalisation". We applied the data-driven methodology used in (Koundouri et al., 2023), which is available in Appendix – Technical and involves the calculation of a score that ranges from 0 to 100. This score is defined as the proportion of green, digital, and jointly green and digital skills and knowledge concepts in each occupation or occupation group. Table 4, which adheres to our methodology, displays the classification of the top 15 occupations at Level 3 in accordance with their scores on "Greenness", "Digitalisation", and "Greenness and Digitalisation", individually. The vast majority of the top green and digital occupations are white-collar and correspond to the ESCO groups 1, 2 and 3.

Table 4 - Top 15 Green, Digital and Green and Digital Occupations in the maritime industry

Green Occupations	**Blue-/White-Collar Job**	**Score**
Business services and administration managers	White	8,743812
Managing directors and chief executives	White	8,124147
Engineering professionals (excluding electrotechnology)	White	7,335767
Financial and mathematical associate professionals	White	6,91959
Business services agents	White	6,355862
Electrical equipment installers and repairers	Blue	5,040044
Electrotechnology engineers	White	4,972895
Finance professionals	White	4,972895
Machinery mechanics and repairers	Blue	3,766835
Sheet and structural metal workers, moulders and welders, and related workers	Blue	3,545557
Information and communications technology operations and user support technicians	White	3,249207
Metal processing and finishing plant operators	Blue	3,249207
Blacksmiths, toolmakers and related trades workers	Blue	3,018712
Sales, marketing and development managers	White	2,521322
Legal professionals	White	1,234145
Digital Occupations		
Electrotechnology engineers	White	28,1393
Engineering professionals (excluding electrotechnology)	White	12,30742
Blacksmiths, toolmakers and related trades workers	Blue	8,068908
Electrical equipment installers and repairers	Blue	8,068908
Managing directors and chief executives	White	7,102754
Information and communications technology service managers	White	7,102754
Legal professionals	White	7,102754
Manufacturing, mining, construction, and distribution managers	White	7,102754
Financial and mathematical associate professionals	White	7,102754
Machinery mechanics and repairers	Blue	7,102754
Sales, marketing and public relations professionals	White	6,54191
Electrical equipment installers and repairers	Blue	5,786213
Mining, manufacturing and construction supervisors	Blue	3,891142
Metal processing and finishing plant operators	Blue	3,891142
Process control technicians	Blue	3,679313

Green & Digital Occupations		
Electrotechnology engineers	White	0,252881
Engineering professionals (excluding electrotechnology)	White	0,231481
Information and communications technology service managers	White	0,173913
Business services agents	White	0,059102
Finance professionals	White	0,046083
Financial and mathematical associate professionals	White	0,046082
Managing directors and chief executives	White	0,046081
Sales, marketing and development managers	White	0,04608
Sales, marketing and public relations professionals	White	0,046079
Software and applications developers and analysts	White	0,046078
Physical and engineering science technicians	Blue	0,046077
Mining, manufacturing and construction supervisors	Blue	0,046076
Manufacturing, mining, construction, and distribution managers	White	0,046075
Process control technicians	Blue	0,046074
Ship and aircraft controllers and technicians	Blue	0,046073

3.4. Highest-demand occupations and their corresponding twin skills

The findings of sections 3.2. and 3.3. suggest a statistically significant and unambiguous positive correlation between the demand of occupations and their degree of digitalisation and greenness. Additionally, the demand for digital and green capabilities has increased significantly from 2016 to 2022 (CEDEFOP, 2024). Based on the survey results regarding the maritime industry's requirements, Table 5 displays the top five of the most sought-after maritime occupations and their most critical complementary skills.

Table 5 - Top 5 demanded occupations in the maritime industry and their corresponding top skills

Engineering professionals (excluding electrotechnology)	conducting academic or market research	0,044407895
	using computer aided design and drawing tools	0,039802632
	designing industrial materials, systems or products	0,038980263
	analysing business operations	0,037993421
	designing systems and products	0,035032895
Finance professionals	analysing financial and economic data	0,11829653
	providing financial advice	0,087539432
	managing budgets or finances	0,074921136
	monitoring financial and economic resources and activity	0,071766562
	performing risk analysis and management	0,065457413

Sales, marketing and public relations professionals	developing professional relationships or networks	0,067875648
	developing financial, business or marketing plans	0,05492228
	conducting academic or market research	0,039378238
	planning events and programmes	0,034196891
	analysing business operations	0,033678756
Legal professionals	advising on legal, regulatory or procedural matters	0,135842881
	mediating and resolving disputes	0,085106383
	advocating for individual or community needs	0,06710311
	presenting information in legal proceedings	0,052373159
	protecting privacy and personal data	0,049099836
Physical and engineering science technicians	creating artistic designs or performances	0,098579041
	installing wooden and metal components	0,0477842
	complying with health and safety procedures	0,047591522
	interpreting technical documentation and diagrams	0,041811175
	monitoring quality of products	0,036223507
Information and communications technology operations and user support technicians	protecting ict devices	0,164794007
	managing, gathering and storing digital data	0,112359551
	creating artistic designs or performances	0,08254717
	setting up computer systems	0,059925094
	working with computers	0,056179775
Business services agents	preparing documentation for contracts, applications, or permits	0,042335116
	technical or academic writing	0,04144385
	ensuring compliance with legislation	0,040998217
	communicating with colleagues and clients	0,040552585
	managing budgets or finances	0,038770053
	installing wooden and metal components	0,081980519

Machinery mechanics and repairers	interpreting technical documentation and diagrams	0,068181818
	repairing and installing mechanical equipment	0,0625
	complying with health and safety procedures	0,047077922
	maintaining operational records	0,040584416
Mining and mineral processing plant operators	complying with health and safety procedures	0,078636959
	installing wooden and metal components	0,070773263
	operating mining, drilling and mineral processing machinery	0,070773263
	operating lifting or moving equipment	0,03931848
	maintaining operational records	0,038007864
Transport and storage labourers	loading and unloading goods and, materials	0,075848303
	operating lifting or moving equipment	0,055888224
	moving or lifting materials, equipment, or supplies	0,045908184
	marking materials or objects for identification	0,03992016
	storing goods and materials	0,03992016

3.5. Twin Skills-gap

In the final segment of the survey, participants were asked to identify the isolated green and digital skills that they believe that are lacking within their organisation and should be the focus of educational/training programs, as identified in (Koundouri et al., 2023). Table 6 displays the order based on which isolated twin skills are demanded by the industry. As we can see "complying with environmental protection laws and standards", "environmental protection technology" and "monitoring environmental conditions" are the dominant green and digital skills in the maritime industry as a whole. The shipping industry is a significant contributor to environmental pollution, which includes the discharge of hazardous substances into oceans, oil spills, and carbon emissions. It also poses a threat to marine life by causing disturbances to marine habitats, noise pollution, and the discharge of ballast water. Specialised expertise in environmental protection measures is necessary to adhere to more stringent environmental regulations, including the International Maritime Organization's MARPOL Convention and emission control areas. In order to mitigate environmental impact, the maritime sector is implementing new technologies, including energy-efficient ship designs, alternative fuels, and emission-reducing systems. Additionally, ship operations are being optimised through the implementation of digitalisation and monitoring, necessitating that employees possess both digital and green competencies. The demand for green and digital skills in the shipping sector is being driven by sustainability demands and alignment with global sustainability objectives.

Table 6 – Top 10 Green and Digital Skills for the maritime industry, as revealed by sector experts

1. complying with environmental protection laws and standards
2. environmental protection technology
3. monitoring environmental conditions
4. electronics and automation
5. database and network design and administration
6. designing electrical or electronic systems or equipment
7. computer use
8. analysing and evaluating information and data
9. electricity and energy
10. maintaining electrical, electronic and precision equipment

3.6. Bridging the gap between skills and demand for education

Figure 4 indicates the minimum education required for the 10 most demanded (both white- and blue-collar) jobs. The red boxes denote that no one selected this option, while the orange boxes denote that less than 40% of the respondents selected it. The green boxes denote that this response was selected by more than 40% of the respondents. Advanced degrees are often required for certain professional roles due to their complexity, specialized knowledge, and critical thinking skills. Engineering professionals, such as civil, chemical, and mechanical engineering, require a Master's degree for specialized study in complex areas like systems design, materials science, and project management. Finance professionals, particularly in investment banking, risk management, and economic analysis, often require an MBA or Master's degree in finance, economics, or accounting. Sales, Marketing, and Public Relations professionals often require MBAs or other advanced business degrees for higher-level roles, covering strategic skills like market analysis, consumer behavior, and data-driven decision-making. ICT Operations and User Support Technicians, particularly those involving system design, network security, or data management, increasingly demand specialized MSc degrees in information technology or cybersecurity. Legal professionals, like JDs, LLMs, require advanced degrees for a sophisticated understanding of the law, legal precedents, and courtroom procedures.

However, a bachelor's degree or vocational education and training (VET) degree is typically required for roles such as Physical and Engineering Science Technicians, Mining and Mineral Processing Plant Operators, Machinery Mechanics and Repairers, and Transport and Storage Laborers. These positions require technical skills and specialized knowledge to perform safely and effectively. Physical and Engineering Science Technicians assist engineers and scientists in conducting tests, collecting data, and analyzing results. Mining and Mineral Processing Plant Operators handle heavy machinery, complex equipment, and hazardous materials, requiring training in mining technology, environmental safety, and machinery operations. Machinery Mechanics and Repairers have a detailed understanding of mechanical systems, hydraulics, and electronics, requiring hands-on training and theoretical knowledge for troubleshooting and maintenance. Transport and Storage Laborers manage logistics, organize inventory, and handle

materials, often requiring training in forklift operation, warehousing technology, and inventory software.

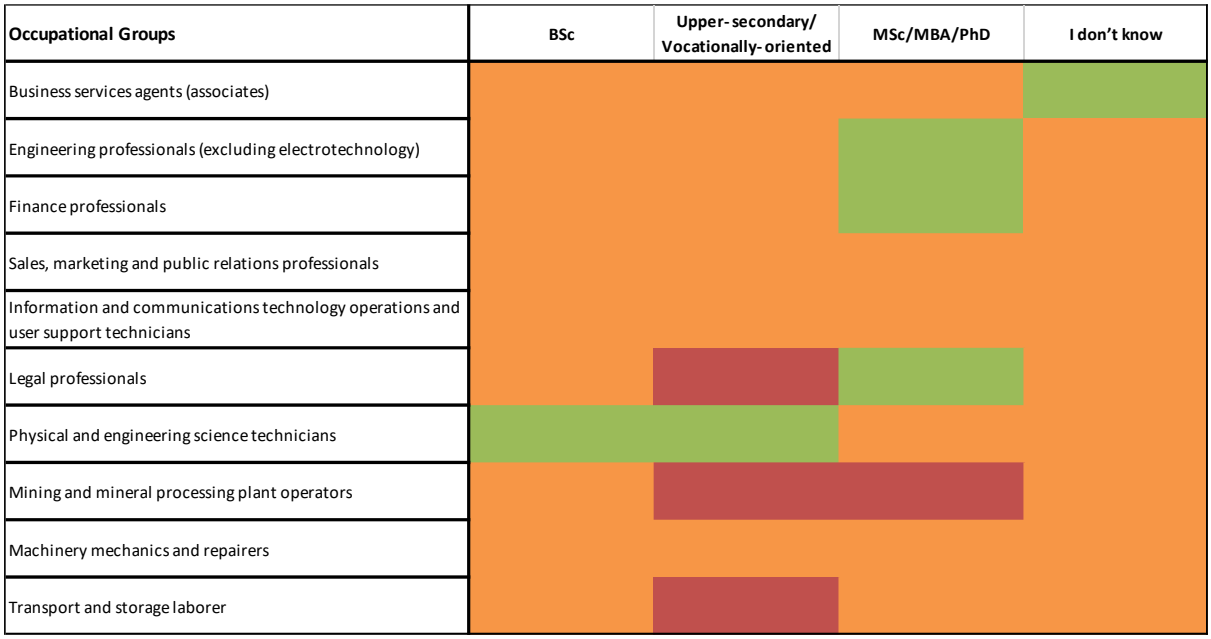

Figure 4 – Minimum education required for the 10 most demanded jobs (Level 3)

The MariTech Talent program is intended to provide a standardised service for green and digital skilling and upskilling that is tailored to the industry's distinctive needs. It also endeavours to make a substantial contribution to the "human-centered and ethical development of digital and industrial technologies" destination. It focusses on the implementation of a systemic approach to the utilisation of technologies in industry and society, with a particular emphasis on the needs of maritime companies and their personnel. This training approach is innovative in that it standardises the development of tandem skills and competencies through technological adoption, thereby promoting the modernisation of the maritime industry.

Conclusions

The twin transition is a comprehensive strategy for addressing the multifaceted challenges of sustainability, as it seamlessly incorporates digital and ecological initiatives. In addition to the cultivation of a sustainable, resilient future in a variety of sectors, including the critical maritime industry, it is essential for the advancement of the European Union's ambitious climate and energy objectives. The maritime sector is significantly impacted by the Twin Transition, which integrates digital and ecological transformations, as the analysis emphasises.

This is essential for the realisation of more comprehensive sustainability objectives. The sector is a significant contributor to global greenhouse gas emissions, and the adoption of digital technologies and green initiatives is not only beneficial but also indispensable. It is expected that these transformations will lead to substantial changes in the industry's operational landscape, including the integration of renewable energy sources, the development of smart port infrastructures, and the implementation of automated systems for emissions monitoring and route optimisation. The reduction of the environmental impact of maritime activities and the advancement towards the EU's ambitious climate and energy objectives will be contingent upon these modifications.

The objective of this study is to assess the responses to three research questions: Which maritime occupations are in the highest demand, which are the most prominent in terms of digital and green skills, and what is the minimum educational requirement for the most sought-after professions in the maritime industry. The survey revealed that the most in-demand occupations today are Business services agents, Engineering professionals, Finance professionals, Sales, marketing, and public relations professionals, Information and communications technology operations and user support technicians, Legal professionals, Physical and engineering science technicians, Mining and mineral processing plant operators, Machinery mechanics and repairers, and Transport and storage labourers.

Furthermore, this study underscores the importance of confronting the skills deficit in the maritime industry, with a particular focus on digital and green competencies. A personnel that is adequately prepared to navigate the industry's changing requirements is necessary for the integration of these twin transitions into maritime operations. By identifying specific occupations and skill sets that are essential for the sector's adaptation to these changes, the analysis emphasises the necessity of targeted educational and training programs. The top five green and digital skills for each of the most demanded occupations presented above are displayed in Table 5.

The maritime industry is facing the complexities of the Twin Transition. This shift is aiming to overhaul traditional operations, promoting advanced, sustainable practices while integrating digital innovation. Equipping the workforce with the necessary competencies is crucial for addressing these demands. A minimum education standard, such as a bachelor's degree for technical roles and advanced degrees for professionals in engineering and finance, ensures employees can understand and adopt these innovations. This aligns with the maritime sector's goal of a sustainable blue economy, prioritizing economic growth, ocean health, and sustainable resource use. Higher education levels prepare the workforce to innovate and lead responsible maritime practices.

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Appendix – Technical

This Technical Appendix provides a more comprehensive outline of our methodology for evaluating individual occupations (Level 0), groups of occupations (Levels 1, 2, and 3), and groups of skills and knowledge concepts (Levels 1, 2, and 3) as Green, Digital, and jointly Green and Digital.

We define the following green dummy variables at the granular (Level 0) level of skills and knowledge concepts:

$$green\_skill_i = 1\ if\ i^{th}\ Skill\ is\ classified\ by\ ESCO\ as\ green\ and\ 0\ otherwise, i = 1, \dots, 10831.$$

$$green\_knowledge_j = 1\ if\ j^{th}\ Knowledge\ is\ classified\ by\ ESCO\ as\ green\ and\ 0\ otherwise, j = 1, \dots, 3059.$$

The green skills and green knowledge indices for the underlying group are calculated by dividing the total number of Skills/Knowledge Concepts in the group by the number of Skills/Knowledge Concepts classified as Green. This is applicable to all skill or knowledge groups (Levels 1, 2, and 3).

In the same vein, we establish the subsequent Digital Dummy variables:

$$digital\_skill_i = 1\ if\ i^{th}\ Skill\ is\ classified\ by\ ESCO\ as\ Digital\ and\ 0\ otherwise, i = 1, \dots, 10831.$$

$$digital\_knowledge_j = 1\ if\ j^{th}\ Knowledge\ is\ classified\ by\ ESCO\ as\ Digital\ and\ 0\ otherwise, j = 1, \dots, 3059.$$

Also, the digital skills and digital knowledge indices for the underlying group are calculated by dividing the total number of Skills/Knowledge Concepts in the group by the number of Skills/Knowledge Concepts classified as Digital. This is applicable to all skill or knowledge groups (Levels 1, 2, and 3).

Finally, we define the following Green and Digital dummy variables:

$$green\&digital\_skill_i = 1\ if\ i^{th}\ Skill\ is\ classified\ by\ ESCO\ as\ green\ and\ digital\ and\ 0\ otherwise, i = 1, \dots, 10831.$$

$$green\&digital\_knowledge_j = 1\ if\ j^{th}\ Knowledge\ is\ classified\ by\ ESCO\ as\ green\ and\ digital\ and\ 0\ otherwise, j = 1, \dots, 3059.$$

The green & digital skills and green & digital knowledge indices for the underlying group are equivalent for all skill or knowledge groups (Levels 1, 2, and 3). They are calculated by dividing the total number of skills/knowledge concepts in the group by the number of skills/knowledge concepts classified as green and digital.

The Dummy variables can be employed to determine the levels of Greenness, Digitalisation, and Greenness and Digitalisation for all occupations or groups of occupations.

The Green, Digital, and Green & Digital Scores for Occupations (Level 0), Groups of Occupations (Levels 1, 2, 3 and 4), and Groups of Skills (Level 1, 2 and 3) are defined as:

$$GreenScore_i = \frac{\sum_{j=1}^{S} green_{skill_j} + \sum_{j=1}^{k} green_{knowledge_j}}{S+k} x100 \ \ (eq1),$$

$$DigitalScore_i = \frac{\sum_{j=1}^{S} digital_j + \sum_{j=1}^{k} digital_{knowledge_j}}{S+k} x100 \ \ (eq\ 2),$$

$$Green\&DigitalScore_i = \frac{\sum_{j=1}^{S} green\&digital_j + \sum_{j=1}^{k} green\&digital_{knowledge_j}}{S+k} x100 \ (eq\ 3),$$

Where:

$S = number\ of\ Skills\ related\ to\ the\ ith\ Occupations\ or\ Skills\ group.$

and

$k =$
$number\ of\ Knowledge\ Concepts\ related\ to\ the\ ith\ Occupations\ \ or\ Skills\ Group\ .$