
# Proceedings of the International Association of Maritime Universities (IAMU) Conference

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International Association of Maritime Universities

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GENERAL ASSEMBLY
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# Proceedings of

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# Table of Contents

# Preface

As a part of the Annual General Assembly (AGA), the International Association of Maritime Universities Conference (IAMUC) brings together academicians and researchers of each member university from all over the world to discuss recent progress and future trends in maritime education, training, research, and other matters within the scope of the IAMU.

IAMUC 2024 is the 24th conference as a sequence of events that started in Istanbul in 2000 and were held more recently in Alexandria (2021), Batumi (2022) and Helsinki (2023). This year, the IAMUC will be held at Massachusetts Maritime Academy on Cape Cod in Massachusetts, USA. This year's theme, "Protecting Our Mariners – Promoting Our Industry – Providing for the Future," reflects the dynamic and interconnected challenges facing the global maritime sector as we chart the course toward sustainable growth into the future.

The Proceedings of the 24th IAMU Conference contains papers presented at the technical sessions of the IAMUC held on 10-11 October 2024. This year's IAMUC has received 159 abstract submissions from 26 different countries and 45 different IAMU member universities. Based on the following full paper submissions and the double peer-review process, 49 papers were accepted for inclusion in the Proceedings.

On behalf of the International Program Committee (IPC), we extend our deepest thanks to authors, reviewers, presenters, and participants for commitment to advancing maritime knowledge and practice. We also deeply indebted to our colleagues on the IPC, the staff at the Massachusetts Maritime Academy, and the IAMU Secretariat for their support, direction, and contributions to making this conference as successful as it can be.

Paul S. Szwed, IAMUC 2024 Program Editor
Boris Svilicic, IAMUC Chief Program Editor

# Theme

## Protecting Our Mariners

Our mariners are the lifeblood of global trade, and ensuring their safety, well-being, and professional development is paramount. From enhancing training and education programs to integrating advanced technologies, the maritime community must continue to innovate in creating safer and more secure working environments. This conference brings together experts who will explore new approaches to health, safety, and skills development, while addressing the evolving risks that our seafarers face in an increasingly complex world.

## Promoting Our Industry

The maritime industry is at the heart of global commerce, responsible for the transportation of over 80% of the world's goods. To remain competitive and relevant, we must embrace innovation, foster collaboration, and advocate for the critical role the industry plays in the global economy. This conference provides a unique platform to highlight cutting-edge research, exchange best practices, and shape policies that will drive the maritime industry forward. By fostering partnerships and innovation, we can ensure the continued success and global leadership of the maritime sector.

## Providing for the Future

Our future hinges on how well we prepare the next generation of maritime professionals. With the rise of digitalization, decarbonization, and diversity, the demands on our workforce are changing rapidly. This conference will explore strategies to enhance maritime education and training, equipping our students and professionals with the skills they need to thrive in the maritime careers of tomorrow. We will also examine the environmental, economic, social, and policy challenges that lie ahead, ensuring that our industry remains both resilient and responsible.

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# Contents

# Economic / Trade Aspect

The 24th IAMUC
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# Comparative Analysis of Arctic and International Shipping Routes – A Comprehensive Update

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**Abstract:** Some Arctic routes may allow container shipping between Asia and Europe in the future as a result of the global warming of Arctic ice. A study continues on the cost-effectiveness of transportation via four Arctic routes at six alternative passages, compared to two current international shipping routes since 2020. This study references voyage distances and durations based on ice thicknesses and weather conditions for 11 different-sized container ships. Considerations encompass capital, operational, and voyage costs, fuel consumptions, and freight rates in empirical calculations. Cost-effectiveness analyses are based on the Fuzzy Analytic Hierarchy Analysis (FAHP) method. The 2020 study posited the prospective feasibility of the Central Arctic Ocean (CAO) and Northwest Passage (NWP) routes around the year 2050. A long- time frame is evident until some frequent shipping routes are established, but updates in the studies provide some guidelines. In this paper, updated results due to the deviations in prices and rates are investigated. Current results, compared to the 2020 study show an increase in the feasibility of CAO and NWP routes in the year 2050 for all sizes of container ships. This study continues to bring implications for future investment decisions along with strategic and environmental awareness.

*Keywords*: Arctic Shipping, International Shipping, Global Warming, Fuzzy Analytic Hierarchy Process

## 1. Introduction

The decline in the Arctic ice extent as shown in Figure 1 and the thicknesses of the ice due to adverse effects of global warming have led researchers to study on different aspects of possible future shipping operations between Europe and Asia via Arctic routes and passages. Cost-effectiveness and profitability of container shipping via

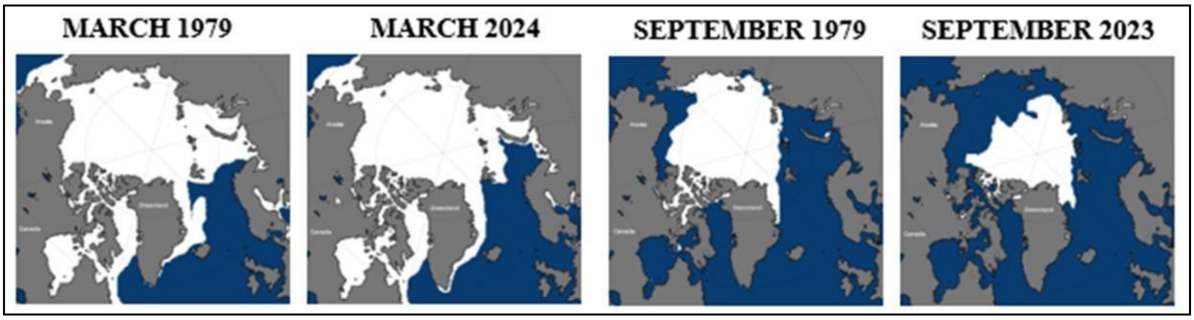


Figure 1. Arctic sea ice extent for the Winter period (left two figures) and Summer-Autumn period. (Image: Courtesy of the National Snow and Ice Data Center, University of Colorado, Boulder, 2024.)

four Arctic routes at six alternative passages and two current shipping routes between Asia and Europe were started to be studied by the Authors (Kocak and Yercan, 2021). Subsequently, a comprehensive examination of entropy and environmental impact was undertaken with the same dataset by Yercan and Sogut (2023). Those studies referenced 11 different size container ship voyages between Shanghai-China and Rotterdam-

Netherlands via the Suez and Panama Canal routes; Russia's Arctic Northern Sea Route (NSR) through Northeast Passage (NEP), Central Arctic Ocean (CAO) and also Northwest Passage (NWP) through

South of Greenland. Ship dimensions, speeds, sea depths, ice thicknesses, and weather conditions helped to define voyage distances and durations. Considerations encompassed capital, operational and voyage costs, fuel consumption, fuel prices, and freight rates.

A large number of academic and research studies have been published in the last 60 years examining maritime transportation in the Arctic zones and routes for various purposes, types of vessels, and analysis models. Researchers around the world have continued to study different aspects of possible future shipping operations between Europe and Asia via Arctic routes and passages between 2020 and 2024. Operational and commercial perspectives, comparative studies between traditional and Arctic routes were studied recently by Bayirhan and Gazioglu (2021), Benz et al. (2021), Dai et al. (2021), Theocharis et al. (2021), Karamperidis and Valantisas-Kanellos (2022), Chen and Liu (2022), Zhou et al. (2023) and Zhang et al. (2024) Twenty-six more publications were seen on the navigability in Arctic seas, status and political aspects of the Arctic region, sea ice and navigational issues, port-related issues, risk-based analyses and environmental concerns for the potential of commercial shipping in the Arctic, technical aspects and quantitative research methods.

For container shipping between Asian and European ports, the Suez Canal route is a costly and highly fuel-consuming choice for the transit voyage of all containership sizes, along with some maritime security issues in this period, but it is still the most cost-effective route today. However, CAO and then NWP routes around the year 2050 may become more cost-effective if Ice Class construction will not be needed, no ice exists on the routes, harsh climatic conditions lessen, specially trained crew for Arctic navigation becomes unnecessary, and Search & Rescue (SAR) means are improved.

In this ongoing study, an update was deemed necessary as of early 2024 due to the deviations in fuel prices, freight rates, capital and operational costs, and canal tolls.

## 2. Conceptual Framework

The four Arctic routes with six alternatives from Shanghai to Rotterdam studied in this research are shown in Figure 2.

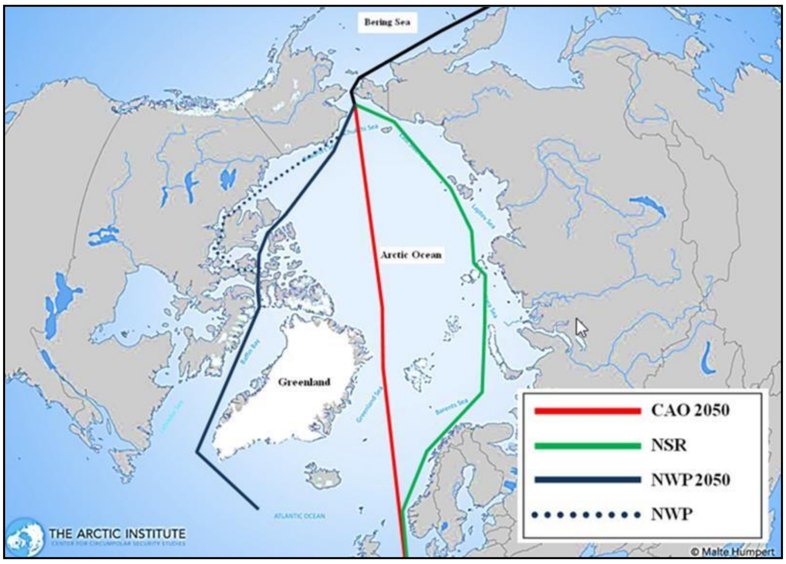


Figure 2**.** Arctic routes in this study.

(Image: Courtesy of https://www.thearcticinstitute.org/arctic-maps/ The Arctic Institute and Malte Humpert as copyright-holders, with own route lines.)

The route decisions depend on sea depths compatible with ship dimensions, ice thicknesses, voyage periods (years and seasons), the necessity of ice breaker escort and Ice pilot services. Seasonally some deep routes and coastal routes in NSR and NWP are kept cleared by icebreakers. The studied Arctic routes and alternative scenarios are (Kocak and Yercan, 2021);

1) **NSR** and NEP, deeper than 10 m. and least icy routes from Shanghai, via Bering Strait (Cape Dezhnev), Cape Zhelaniya (NSR), off Lofoten (NEP), and the North Sea to Rotterdam.

- Alternative 1: now i.e., current status until the year 2030, during the Summer-Autumn periods and All-Year-Around in the year 2050, with no icebreaker escort but Ice Pilot service. The ships are assumed to have a PC7/FS1A/Arc4 level (minimum) Ice Class, therefore an icebreaker escort is not obligatory during Summer-Autumn periods, but Ice Pilot service is obligatory in Russian waters,
- Alternative 2: now i.e., current status until the year 2030, in the Winter period, sailing via NSR's six zones out of seven behind an icebreaker including Ice Pilot services.

2) **CAO2050**, assumed in the year 2050, All-Year-Around; from Shanghai via Bering Strait (Cape Dezhnev), East to West at 80°N Latitude, off Lofoten, and the North Sea to Rotterdam.

- Alternative 1: some ice floes, may be regionally thicker than 80 cm., an icebreaker escort will be needed at Summer tariff. Since navigating at International waters, no Ice Pilot service will be needed.
- Alternative 2: some first-year ice thinner than 80 cm.; since ships are PC7/FS1A/Arc4 level (minimum) Ice Class, no icebreaker and Ice Pilot service will be needed.

3) **NWP**, All-Year-Around now, from Shanghai via Bering Strait, Baffin Bay (NWP), Labrador Sea, and North Atlantic to Rotterdam; sailing at current NWP coastal route via cleaned channels by coastal countries' icebreakers at no cost; no Ice Pilot service and no icebreaker escort are needed since ships are PC7/FS1A/Arc4 level (minimum) Ice Class.

4) **NWP2050**, assumed in the year 2050, sailing at a more direct and shorter northern route than the current NWP coastal route, via cleaned channels by coastal countries' icebreakers at no-cost; no Ice Pilot service and no icebreaker escort are needed since ships are PC7/FS1A/Arc4 level (minimum) Ice Class.

The main characteristics of the referenced real 11 container ships are given in Table 1. The ships' maximum container carrying capacities are at close intervals. Ship numbers in Table 1 identify each ship's nominal Twenty-Foot Equivalent Unit (TEU) container carrying capacity after the abbreviation "CS (Container ship)".

Table 1. List and main characteristics of the 11 container ships. (Kocak and Yercan, 2021)

| SHIP | DWT | GT | TEUS14T[a] | Loa; B; d (m.) | Max. Speed (kts.) | Engine power (kW) | Ice Class | Panama Canal |
|---|---|---|---|---|---|---|---|---|
| CS 23756 | 228,149 | 232,618 | 13,500 | 400; 61.5; 16.5 | 25.1 | 75,570 | - | Post |
| CS 20170 | 196,878 | 210,678 | 12,350 | 400; 58.8; 16 | 24 | 82,440 | - | Post |
| CS 17722 | 186,745 | 175,688 | 11,980 | 370; 54; 16 | 23 | 63,910 | - | Post |
| CS 13892 | 150,936 | 151,963 | 11,260 | 398; 51; 15.5 | 24 | 62,030 | - | Post |
| CS 9953 | 120,541 | 111,200 | 7,198 | 350; 42.8; 15 | 25 | 68,640 | - | Neo |
| CS 7846 | 93,570 | 82,794 | 6,072 | 300; 42.8; 14.5 | 25 | 68,520 | - | Neo |
| CS 5782 | 73,234 | 65,247 | 4,390 | 277; 40; 14.5 | 25 | 57,100 | - | Neo |
| CS 5108 | 66,502 | 64,502 | 3,927 | 276; 40; 12.4 | 24.6 | 49,500 | Arc 4 [b] | Neo |
| CS 4253 | 50,790 | 39,941 | 3,050 | 260; 32; 12.6 | 25 | 36,515 | - | Super |
| CS 2200 | 24,765 | 21,611 | 1,430 | 182; 30.2; 10.5 | 21 | 22,890 | - | Super |
| CS 1195 | 18,583 | 15,095 | 1,120 | 169; 27.2; 8.4 | 17.5 | 10,100 | - | Regular |

DWT=Dead weight ton, GT=Gross ton, Loa = Length overall, B = Beam, d = Draft, m =meters, kts=knots, kW=kilowatt [a] TEUS14T = 14-ton 20-foot standard containers; [b] Originally built as.

However, the nominal TEU capacity is rather a volumetric measure, and those containers may not be fully loaded depending on other weights onboard, such as fuel, etc. In the calculations, the ships carry 14-ton containers, named TEUS14T, as fully loaded with. The voyages are single transit, without interim port calls.

## 3. Methodology

This ongoing study aims to evaluate the cost-effectiveness of the alternative routes per ship size by a multi-criteria decision-making (MCDM) method and also to observe voyage profitability rates empirically. The Fuzzy

Analytic Hierarchy Process (FAHP) is used as the MCDM method, a more reliable method than the common empirical calculations. The raw data for calculations were gathered from the literature and the Internet.

Before FAHP analyses, voyage durations are empirically calculated from voyage distances and ship speeds. Ship speeds, which change at calm and heavy seas, and thin and thick ice conditions per route also provide fuel consumption information. Voyage distances referenced in the calculations are given in Table 2.

Table 2. Voyage distances in nautical miles (nm.) of Arctic routes and legs used in calculations. (Kocak and Yercan, 2021)

| Voyage Routes | Total | Calm open waters | Heavy seas | Thin ice | Thick ice |
|---|---|---|---|---|---|
| NSR route | 7,735 | 1,570 | 4,055 | 965 | 1,145 |
| CAO2050 route | 7,190 | 1,525 | 4,465 | 1,200 | - |
| NWP route | 8,738 | 2,870 | 3,473 | 1,565 | 830 |
| NWP2050 route | 8,228 | 2,420 | 3,858 | 1,180 | 770 |

Capital, operational, and voyage costs of each ship, including additional premiums for Arctic voyages, that are needed for FAHP analyses were calculated as detailed in Kocak and Yercan (2021). Profitability is evaluated by net profit margin ratio. Revenue of the voyages is based on the container freight rate and the number of fully loaded 14-ton 20-foot containers (TEUS 14T) on the ships.

Voyage distance via the Suez Canal route is taken as 10,750 nautical miles (for non-Malacca capable ship CS 23756 as 11,200 nautical miles), and via Panama Canal is taken as 13,611 nautical miles excluding Post-Panamax ships. Due to current maritime security problems in the Suez Canal route, some ships prefer the Cape of Good Hope route nowadays, which is about 200 nm. shorter than the Panama Canal route and without a canal toll. (The current security problems for NSR, and preference to the Cape of Good Hope route rather than the Suez Canal route are deemed as temporary in the long-time frame and not taken into consideration at this phase.)

In Table 3, the factors affecting the cost-effectiveness of the routes and alternative passages investigated are classified under the main criteria and subcriteria structure for FAHP analyses, along with their Fuzzy normalized weights (NWi), and cost items.

Table 3. Main criteria and subcriteria structure for FAHP analyses with Fuzzy normalized weights (NWi). (Kocak and Yercan, 2021)

| **GOAL:** Cost-Efficient route for the voyage | | | |
|---|---|---|---|
| **MAIN CRITERIA** | | | |
| Ship Characteristics (NWi : 0.491) | Operational Factors (NWi : 0.217) | Route &Transit Factors (NWi : 0.164) | Risks (NWi : 0.128) |
| **SUBCRITERIA** | | | |
| TEUS 14 T Capacity (NWi : 0.522) | Avg. Ship Speed (NWi : 0.405) | Voyage Distance, Thick Ice (NWi : 0.584) | Crew Health & Safety Risks (NWi : 0.656) |
| Engine Power (NWi : 0.137) | Ice Crew (NWi : 0.272) | Voyage Distance, Thin Ice (NWi : 0.261) | Search and Rescue Means (NWi : 0.188) |
| Fuel Type LNG (NWi : 0.118) | Harsh Operating Conditions (NWi : 0.323) | Voyage Distance, Heavy Weather (NWi : 0.098) | Environmental Concerns (NWi : 0.156) |
| Ice Class Upgrade (NWi : 0.223) | | Clear Visibility (Daylight) (NWi : 0.057) | |
| **COST ITEMS** | | | |
| Capital Cost, Operational Cost, Fuel Cost, Canal Toll, Port Call Cost | | | |

**4. Analyses and Results**

Current analyses cover updates in fuel prices, Shanghai Containerized Freight Index (SCFI), capital, operational, and voyage costs, and Canal tolls in the first quarter of 2024, as given in Table 4. Their comparison to previous values in the 2020 study (Kocak and Yercan, 2021) is mentioned in Table 4 and a summary of the results of the current analyses is given in Table 5.

In the 2020 study, the Suez Canal was found as the most effective route, 68% on average, with ca. 30% more effectiveness compared to CAO and NWP routes since Ice Class construction is still necessary, navigation conditions are harsh, Ice crew is necessary, Search and Rescue (SAR) means are limited in Arctic waters. The same is valid as of 2024 which results in no changes in route effectiveness values. The Panama Canal route is the longest and costliest route while the Suez Canal route is shorter and more effective, but also the second costliest route. CAO and then NWP routes have lower costs due to shorter voyage distances and also about ten-to-five-day shorter durations than the Suez Canal route respectively. Excluding the current political situation, the NSR+NEP route during the Summer-Autumn period without icebreaker service (NSR Alternative 1) is the second cost-effective passage as shown in Table 5. Based on the current calculations, effectiveness values and net profit margin ratios of the current most cost-effective two routes, Suez and NSR Alternative 1 are given in Table 5.

Table 4. Comparison of prices between the 2020 study (Kocak and Yercan, 2021) and this 2024 study.

| | 2020 study | 2024 study | Remarks |
|---|---|---|---|
| Fuel (VLSFO)[a] prices | 500 USD/ton | 655 USD/ton | A 31% increase from the 2020 study; in the first half of April 2024 at Shanghai. (https://sin.clarksons.net) |
| LNG[b] to VLSFO rate | + 10% | - 5% | LNG (marine use) price in the second half of 2023. (https://www.maritimegateway.com) |
| SCFI | 1,000 USD/TEU | 1,770 USD/TEU | An average 77% increase from the 2020 study; in the first half of April 2024. (The extreme increases in 2021 (6120 USD/TEU) and 2022 (4850 USD/TEU) are excluded during the evaluations, which were local abnormalities due to COVID-19.) (https://sin.clarksons.net; https//en.sse.net.cn) |
| Capital costs | | | New shipbuilding prices for container ships increased between 48% (ships less than 10,000 TEU) and 62% (ships bigger than 22,000 TEU). (https://sin.clarksons.net) |
| (Scrap rate) | 295 USD/ton | 445 USD/ton | World average (https://www.go-shipping.net) |
| Operational costs | A 14% increase from the 2020 study; in the first half of April 2024. for all container ship sizes. (https://sin.clarksons.net) | | |
| NSR tolls | Reduced 21% in USD in 2024 compared to 2020 tariffs due to the devaluation of the Russian Ruble against USD in the same period. (http://www.nsra.ru/en/) | | |
| Suez Canal tolls | Increased 32% on average (between 5% and 46%) in 2024 compared to 2020 tariff. (https://lethagencies.co m/suez-calculator) | | |
| Panama Canal tolls | Increased 26% on average (between 9% and 53%) in 2024 compared to 2020 tariff. (https://www.wilhelmsen.com/tollcalculators/panama-toll- calculator/) | | |
| Port call costs | An average 9% increase from 2020 study (Port of Rotterdam, General Terms and Conditions, 2024) | | |

[a] very low sulphur fuel oil; [b] liquid natural gas

Table 5. Most Cost-Effective Routes.

| | Now | | | | In 2050 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Suez Route | | NSR Alt.1 Summer-Autumn w/o icebreaker | | CAO2050 Alt.2 | | CAO2050 Improved | | NWP2050 Improved | |
| Ship | Eff. | NPRM | Eff. | NPRM | Eff. | NPRM | Eff. | NPRM | Eff. | NPRM |
| CS23756 | 0.63 | 0.80 | 0.30 | 0.87 | 0.32 | 0.89 | 0.69 | 0.91 | 0.91 | 0.89 |
| CS20170 | 0.65 | 0.79 | 0.31 | 0.86 | 0.33 | 0.87 | | | | |
| CS17722 | 0.67 | 0.80 | 0.33 | 0.86 | 0.35 | 0.88 | | | | |
| CS13892 | 0.70 | 0.81 | 0.36 | 0.88 | 0.38 | 0.89 | | | | |
| CS9953 | 0.68 | 0.81 | 0.34 | 0.88 | 0.37 | 0.89 | 0.73 | 0.90 | 0.74 | 0.89 |
| CS7846 | 0.70 | 0.78 | 0.36 | 0.86 | 0.38 | 0.87 | | | | |
| CS5782 | 0.69 | 0.74 | 0.35 | 0.83 | 0.38 | 0.84 | | | | |
| CS5108 | 0.69 | 0.69 | 0.36 | 0.80 | 0.38 | 0.82 | | | | |
| CS4253 | 0.68 | 0.71 | 0.34 | 0.79 | 0.37 | 0.83 | | | | |
| CS2200 | 0.66 | 0.47 | 0.33 | 0.62 | 0.35 | 0.66 | | | | |
| CS1195 | 0.80 | 0.42 | 0.52 | 0.59 | 0.53 | 0.63 | 0.87 | 0.69 | 0.87 | 0.63 |

Alt. = Alternative; Eff. = Effectiveness; NPRM = net profit margin ratio.

For the year 2050, CAO2050 Alternative 2 (some first-year ice thinner than 80 cm.; ships are PC7/FS1A/Arc4 level (minimum) Ice Class, no icebreaker and Ice Pilot service) is calculated as the most cost-effective route under today's navigational conditions, i.e., harsh climatic conditions, Ice crew necessity and limited SAR means. Considering future possibilities, additional FAHP analyses were made in 2020 and updated now, for three ship sizes, the smallest (CS1195), a medium (CS9953), and the largest (CS23756) of this study. The assumptions for the year 2050 period, named "Improved" conditions, are no requisite for Ice Class construction, nonexistence of ice except some floating ice on CAO2050 and NWP2050 routes; use of LNG instead of VLSFO; 50% better operating conditions due to warmer climate; ample SAR means and regular crew without any special training need. Compared to the Suez Canal route the Improved CAO2050 Alternative 2 and NWP2050 routes become the first two most cost-effective routes as shown in Table 5. The two Arctic routes under improved navigational conditions become very feasible around the year 2050 if the decrease in ice extent and thickness continues due to global warming.

During this study, an increase in profitability is seen compared to the 2020 study, due to a high increase in freight rate and rather a low increase in fuel prices as given in Table 4. The effect of economies of scale especially for big-size container ships was noticed. Also, compared to the 2020 study, the smaller size container ships now benefited from the increase in the freight rate.

The achieved FAHP results are still clear, with the distinct separation of alternatives at the end of the evaluation, and the planned route optimization by the Multi-Objective Optimization method is on hold for the time being.

## 5. Conclusions

For container shipping between Asian and European ports, the Suez Canal route is a costly and highly fuel-consuming choice for the transit voyage of all containership sizes, along with the maritime security issues in this period, but it is still the most cost-effective route today. However, CAO and then NWP routes around the year 2050 may become more cost-effective and profitable if Ice Class construction will not be needed, no ice exists on the routes, harsh climatic conditions lessen, specially trained crew for Arctic navigation becomes unnecessary, and Search & Rescue (SAR) means are improved.

Further increases in freight rates, and possibly lower fuel cost of LNG compared to VLSFO will increase profitability for all container ship sizes.

This study will continue to forecast future trends in container ship construction and preparations for a global level change in maritime shipping routes.

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# Unveiling the Potential of AI-Enhanced Resource Management for Sustainable Fisheries and Aquaculture in the Indian Ocean

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**Abstract:** Fisheries serve as a primary source of food and protein in specific global regions and the rapidly expanding aquaculture sector is anticipated to surpass traditional fishery production within the next decade. By 2030 global fish production will reach 200 million tons with half of this output originating from aquaculture. Despite the dominance of freshwater in aquaculture, oceans are expected to play a significant role in meeting the world's food needs. This shift towards aquaculture not only addresses nutritional requirements but also generates employment and prosperity. The Indian Ocean acts as a vital lifeline for numerous coastal communities and stands as a central hub for global fishing by contributing 14% to the global captures harvest. Recognizing the influential role of the resource environment and advancements in scientific and technological management, this research explores the transformative potential of the Blue Economy in marine fisheries and aquaculture in the region of Indian Ocean. This research delves into the integration of Artificial Intelligence (AI) for species identification which aims to enhance precision and efficiency in ecosystem monitoring. This proposed AI driven species identification plays a crucial role in unravelling the intricacies of marine biodiversity by enabling the researchers and resource managers to swiftly and comprehensively assess the abundance, distribution and health of various marine species. The timely acquisition of this information will be utilized for informed decision-making in resource management. By facilitating the identification of endangered or overexploited species, AI contributes to the prevention of overfishing and also fostering the conservation of marine ecosystems. This approach provides an intricate balance among resource management, economic enhancement and sustainability by underlining the pivotal role of AI-driven methodologies in comprehending and overseeing marine biodiversity for effective resource management practices.

*Keywords*: Marine Resources, Resource Management, Artificial Intelligence, Sustainability

## 1. Introduction

The underwater environment, particularly coral reefs, is home to a varied range of ecosystems with high biodiversity. These reefs are made up of various corals, algae, and sponges. This complicated structure provides a great habitat for many animals, particularly those that require protection and eating. Pollution, overfishing, and climate change all pose threats to the underwater environment, which is vital both environmentally and commercially. These elements are degrading the ecosystem and hasten the extinction of coral and fish species that live there. It is therefore vital to track the evolution of these ecosystems in order to detect and even anticipate any potential damage. This monitoring is accomplished by watching and estimating the diversity and abundance of fish species in order to better understand the structure and dynamics of the coral reef community. Traditional strategies for observing ecosystems and monitoring biodiversity, such as fishing, anaesthesia, and underwater visual census (UVC), are damaging and/or fail to assure continual monitoring of underwater biodiversity. It is critical to use more advanced approaches that are non-destructive and enable continuity in ecosystem monitoring.

Underwater object detection is now used to research climatic aspects, port safety, resource exploration, and other topics. Manual analysis methods are labor-intensive and time-consuming, therefore automatic ROVs can eliminate the need for human intervention. ROVs can automatically process enormous volumes of video data, eliminating the need for tedious manual processing. These vehicles aim to automatically identify manmade and offshore structures, recognise objects, and avoid obstacles, among other tasks.

## 2. Literature survey

This assessment provides an overview of existing relatively mature and representative underwater image processing models, which are divided into seven categories: enhancement, fog removal, noise reduction, segmentation, salient object recognition, colour constancy, and restoration. The author (Jian,et al.,2021) objectively assess the existing state and anticipated development trends in underwater image processing, as well as provide some insights into potential research directions to assist the development of underwater vision and beyond.

In this study, (Marini et.al. 2018) created a novel genetic programming-based methodology for contentbased image analysis. The photos were taken every 30 minutes for two years, day and night. The very varied environmental conditions allowed us to test our approach's performance in the presence of fluctuating light radiation, water turbidity, backdrop confusion, and bio-fouling growth on the camera housing. The automated recognition results were closely connected with manual counts and were extremely dependable when used to track fish fluctuations on hourly, daily, and monthly time intervals. Furthermore, this approach might be simply applied to additional cabled video observatories.

This study (Shortis et al., 2016) discusses the methods for detecting, identifying, measuring, counting, and tracking fish in underwater video sequences. The research examines the most often used procedures, resulting in an assessment of the strategies that are most likely to provide a comprehensive answer to the entire process of candidate discovery, species identification, length measurement, and population counts for biomass calculation.

To generate a depth map from damaged underwater photos, author have developed a new method known as maximum attenuation identification. At the same time, regional background estimation is used to assure the best performance. Experiments are carried out with three types of images: natural underwater scene, calibration board, and colormap board. The study (Wang et al.,2017, Padate 2020) quantitative and qualitative comparisons of our approach to current state-of-the-art approaches. The performance evaluation of contrast enhancement and colour restoration confirms that our methodology beats current state-of-the-art methods.

The CNN was also able to identify fish individuals partially covered under corals or other fish, and it was more effective than humans in identifying fish in small or fuzzy images, although people were better at identifying fish individuals in odd situations The author (Villon et al.,2018) Proposed CNN took an average of 0.06 seconds to identify each image using typical hardware. Deep Learning algorithms can thus perform efficient fish identification on underwater photos, promising the development of novel video-based protocols for monitoring fish biodiversity at a low cost and effectiveness.This article is a survey (Raveendran et al.,2021) of underwater picture enhancing methods. This article provides an overview of several underwater picture enhancing techniques and their broad classifications. The methods for each classification are briefly reviewed. Underwater datasets essential for experiments are compiled from existing literature.

The (Li, Yujie et al., 2016 Rajeeshkumar 2021) used a variety of machine learning algorithms for classification, including support vector machines and convolutional neural networks. Experimental results reveal that the suggested approach outperforms current general-purpose underwater picture contrast enhancement algorithms (Ramesh et al 2013). The experiment also proved that the proposed strategy is effective for image categorization.

The suggested model (Ge, H., Dai et al.2022), can learn to improve underwater image quality through paired and unpaired training. Most crucially, the augmented photos improve the performance of standard models for underwater item detection, human position estimation, and saliency prediction. These findings demonstrate that it is appropriate for real-time pre-processing in the autonomy pipeline of visually guided underwater robots (Sathianarayanan et al 2013).

Because of the increased volume of picture data, automatic detection and classification currently necessitates the use of deep neural network-based classification. The goal of this research (Kalaiarasi et al.,2023, Vedachalam, 2022, Narayanaswamy,2013)) is to propose a systematic approach to analysing recent underwater pipeline pictures using deep learning. The analytical approaches are organised logically based on the recognised items, and the deep learning architectures used are described in detail. Deep neural network processing of digital photographs of the seafloor offers enormous promise for automation, notably in the finding and monitoring of underwater pipeline imagery.

**3. Proposed Methodology**

The proposed method is designed to detect marine animals using image analysis and pattern recognition algorithms. The system use a dataset of marine species image to train and evaluate the model. Figure 1 shows the sample marine species. The dataset can be obtained using a variety of ways, including Kaggle and marine database. The marine species image in the dataset are preprocessed and trained with the suggested model. The framework developed in this study is divided into four main modules: Dataset collection and preprocessing, Model Architecture, Transfer learning and fine-tuning and Training and Evaluation.

Figure 1: Sample Marine Species

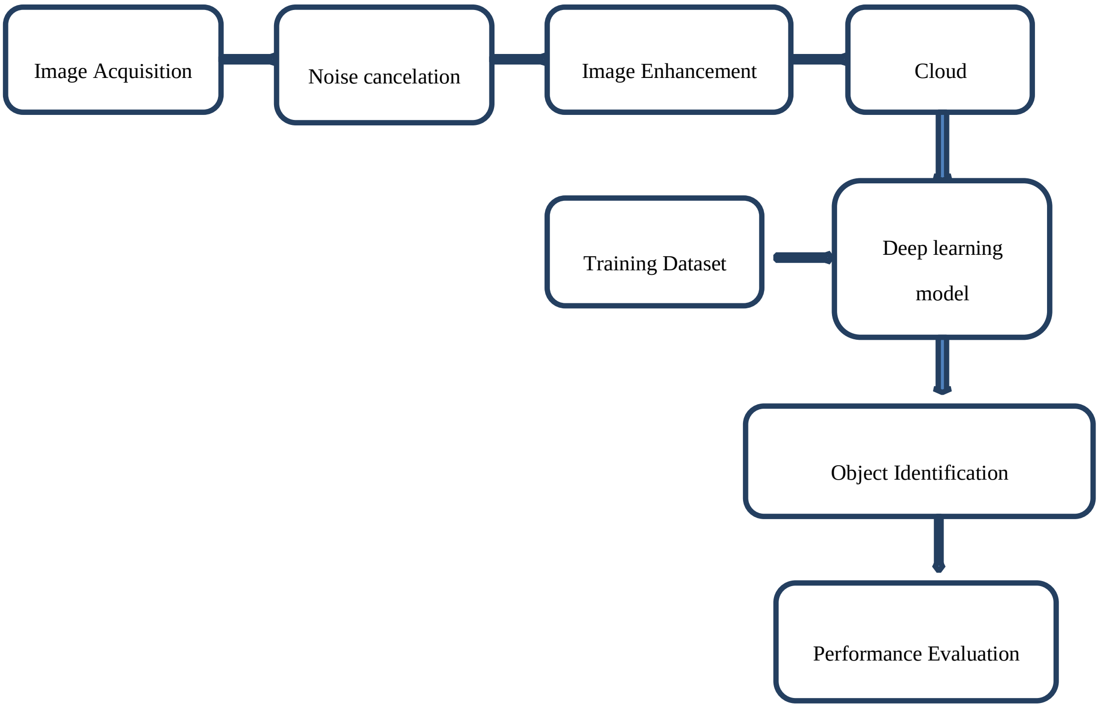

Figure 2: Block Diagram of automated deep sea exploration system

After enhancement the images are given as input to the deep learning model to identify the species. The developed deep learning model will be trained using the custom dataset. The accuracy of the system can be evaluated using cross validation techniques and metrics such as precision, recall, F-score. As the underwater images are affected with noise, the images undergo noise cancellation and enhancement technique.

After enhancement the images are given as input to the deep learning model to identify the species. Collected data will be processed through different preprocessing techniques such as noise cancellation, image enhancement, outliers removal, etc., The preprocessed images are used for data augmentation to increase the dataset making it suitable for deep learning. Data augmentation is carried out using rotation, flip and contrast. Stratifying the preprocessed data into training, testing and validation as 80%, 10% and 10% respectively. Deep neural network modelling using Artificial Intelligence will classify the different types of species will be carried out to predict the possibility of medicinal usages. The data would be the combination of Time Series (Sequential data), Images; the model building utilizes Deep Learning Algorithms such as ResNet, Mobile Net, Inception Net, t for Image data. The suitable deep learning model will be trained using the custom dataset generated. The deep learning models to predict the performance of models effectively; since to utilize the significance of algorithms as per the data. The accuracy of the system can be evaluated using cross validation techniques and metrics such as precision, recall, F-score. Species identification and characterization through the process staining procedure is followed for the identification of species.

## 4. Result and Discussion

The overall framework of the proposed work is shown in figure 2. In the DL approaches, the images are pre-processed and reduced to 256 × 256 pixels to fit in the model. The dataset is randomly split into 80% training, 10% validation and 10% testing ratios. The suggested models are fed with the training and testing images, and the features are retrieved. Finally, the DL algorithms will recognize the marine species. The performance of the deep learning model are done using metrics such as detection accuracy and classification accuracy. Loss and accuracy were also evaluated for various trials of epochs for three different DL models initially. For data augmentation, the standard open-access dataset of marine species are used. The results of cross-validation and testing of the updated and improved EDL findings are recorded. Some of the fine-tuned EDL model settings included the ADAM optimizer's learning rate of 0.0001, batch size of 32, and epochs of 20. The Keras Tuner technique library was used to select the optimal values for the EDL model parameters for each dataset. Precision was used once more to evaluate the performance of the updated and fine-tuned EDL model. Table 1 displays the values of the hyper parameters used in the proposed work.

Table 1 Hyperparmeter Specification

| S.No | Parameter Specification | Parameter Values |
|---|---|---|
| 1 | No of labeled Classes | 12 |
| 2 | Learning Rate | 0.0001 |
| 3 | Batch Size | 32 |
| 4 | No of Epochs | 10 |
| 5 | Activation Function | ReLu |
| 6 | Optimization Method | ADAM |

**Experimental setup**

The Jupyter notebook environment and Python 3.6 were used for all pre- processinging, deep ning-based feature extraction, and classification in this study. The OpenCV-python3 package and the Keras library are used to create the model. The suggested work is completed using a 3.40 GHz Intel(R) Core (TM) i5-6700 Central Processing Unit (CPU) and 16 GB of Random Access Memory (RAM).

**Experimental Validation**

The experimental assessment for this research was carried out on a Google Colab using Python. To build DL models, the Scikit-learn and Keras packages were used, accordingly. Grid-search with stratified cross-validation, as well as the Keras Tuner utility, were used to optimize DL models. The suggested model was built using the Scikit-learn and Keras packages. The dataset were used for 80% training, 10% validation, and 10% testing of DL models. For training the model, the batch size was set at 32, and 20 epochs were considered for validation. Ten epochs and 1000 images for each ailment were utilized to test the model. Finally, the loss and accuracy of the ResNet 152, MobileNet, and Inception Net models were calculated, as shown in table 2.

**Table 2 presents performance evaluations of several DL models.**

| Metrics | MobileNet (%) | InceptionNet (%) | ResNet152 (%) |
|---|---|---|---|
| Accuracy | 87.99 | 89.32 | 91.45 |
| Precision | 85.48 | 90.61 | 90.85 |
| Recall | 86.45 | 89.75 | 91.95 |
| F1 Score | 88.85 | 90.65 | 92.45 |
| **Overall Detection (%)** | **87.1925** | **90.0825** | **91.675** |

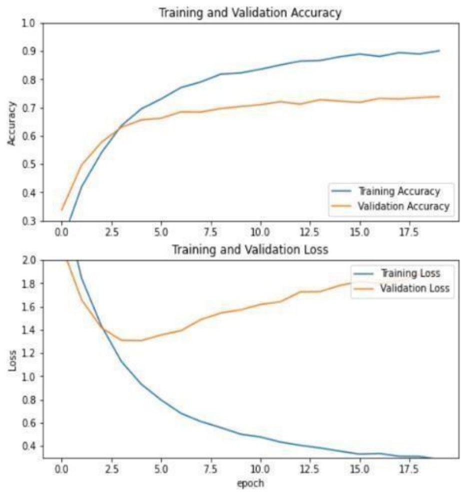


Figure 3 Accuracy and loss vs epochs for Mobile Net

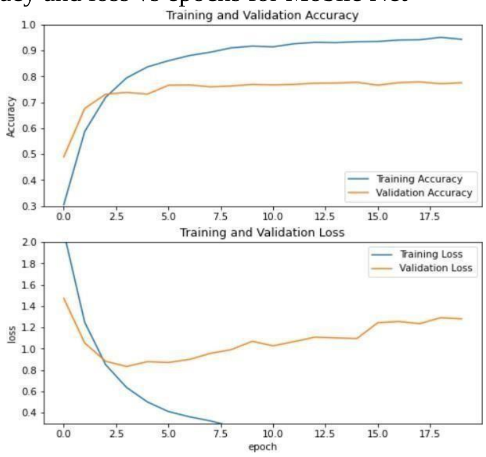


Figure 4 Accuracy and loss vs epochs for Inception Net

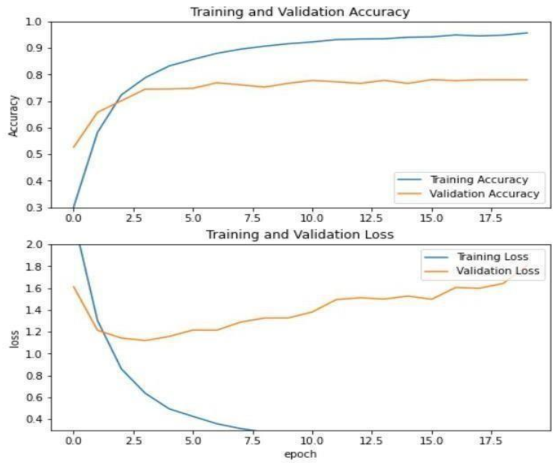


Figure 5 Accuracy and loss vs epochs for ResNet152 model

Based on the performance analysis, the best performing model is chosen. Based on performance, an efficient DL model is chosen, and hyper parameters are fine-tuned to improve accuracy. According to table 2, ResNet 152 outperforms InceptionNet and MobileNet with an accuracy of around 91.6%. Figure 4 clearly shows that the ResNet 152 model outperforms the other models in terms of accuracy.

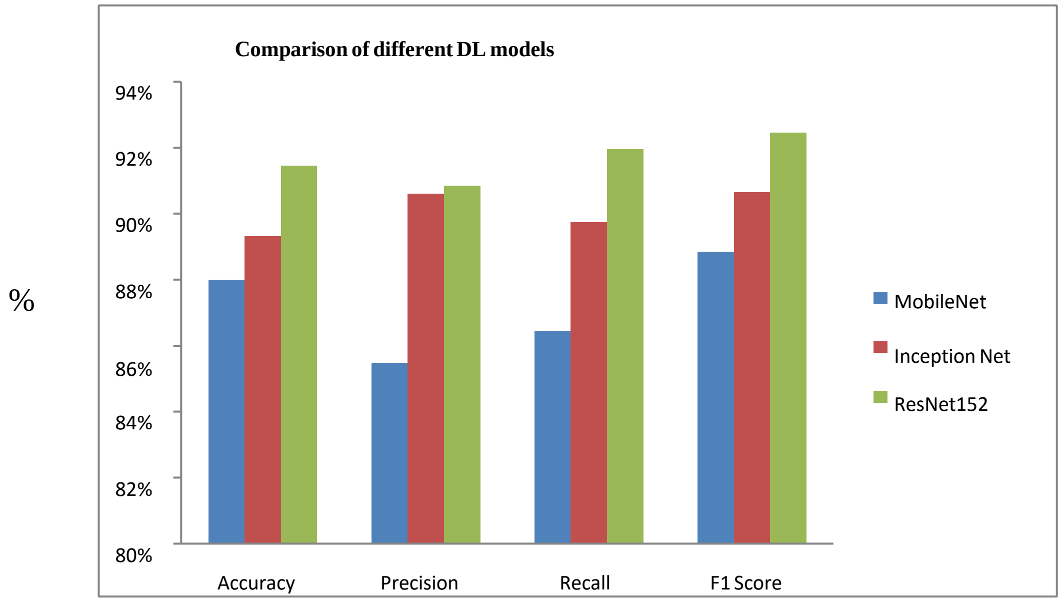


Figure 6 Comparison of different DL Model

The training & validation loss, and training accuracy & validation accuracy for the MobileNet, InceptionNet, and ResNet 152 models are depicted in Figures 3, , and 5, respectively. Furthermore, training and validation accuracy for various epochs, as well as loss for various epochs, are investigated. There were twenty epochs in the implementation. Based on the data in figure 6 and when compared to ResNet 152 clearly outperforms the other models

## 4. Conclusion

An automatic fish detection and their species classification technique, which utilises an advanced Deep learning approach. DL models were investigated in order to improve the system's accuracy for identifying crop diseases.

Three deep learning models— MobileNet, InceptionNet, and ResNet 152—were selected for implementation. Data augmentation techniques were used in this paper to enlarge the dataset and make it suitable for DL models. The performance analysis was repeated using training and validation loss, and accuracy. According to the results, the ResNet 152 model is the most EDL model, with an accuracy of around 92% when compared to MobileNet and InceptionNet.

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# Environmental Aspect

# Alternative Energy Sources for Cargo Ships: Turkish Shipping Sector

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**Abstract:** Several alternative marine fuels are an important strategy for maritime decarbonization. These alternative marine fuels include liquefied natural gas (LNG), liquefied biogas (LBG), hydrogen, ammonia, methanol, ethanol, hydrotreated vegetable oil (HVO), nuclear power and electricity. Wind and solar power are other energy sources for ships, but these are not alternative fuels; they are supporting energy sources, such as hybrid ships. In the maritime sector, wind and solar power are currently in the research phase. There are fewer wind or solar hybrid ships at sea. Shipping companies are focusing more on alternative fuels such as LNG, methanol, and ethanol. The Turkish merchant fleet consists of 475 vessels, of which 250 (4.5 million DWT) were imported and 225 (1.3 million DWT) were built in Türkiye. The 475 ships are broken down by type: 23.8% dry cargo ships, 12.2% chemical tankers, 10.3% service ships, 9.9% container ships, 7.0% bulk carriers and 36.8% other types. The number of alternative fuel ships in the Turkish fleet is very small.

*Keywords*: Alternative energy; cargo ship; biofuel; alternative fuel.

## 1. Introduction

Several alternative marine fuels are considered to be an important strategy for maritime decarbonization. These alternative marine fuels include liquefied natural gas (LNG), liquefied biogas (LBG), hydrogen, ammonia, methanol, ethanol, hydrotreated vegetable oil (HVO), nuclear power and electricity. Wind and solar power are other energy sources for ships, but these are not alternative fuels; they are supporting energy sources, such as hybrid ships. In the maritime sector, wind and solar power are currently in the research phase. There are fewer wind or solar hybrid ships at sea. Shipping companies are focusing more on alternative fuels such as LNG, methanol and ethanol. Opportunities for decarbonizing the shipping industry include: the development and use of new technologies, such as electric and hybrid engines using biofuels; the use of gas technologies, etc. will reduce pollutant emissions; the increased use of renewable energy sources on board ships, such as solar and wind power, will also help reduce pollutant emissions; the introduction of new materials and technologies will help improve the efficiency and productivity of maritime transport; and the development of the disposal and recycling of plastic waste on ships will help reduce the amount of plastic waste entering the marine environment.

Most of the international trade is conducted by sea, involving more than 85,000 registered vessels (Hsieh and Claus, 2017). Waterborne transport (including inland waterways) is generally considered to be energy efficient when compared to road transport and aviation, and when greenhouse gas (GHG) emissions (per tonne/km) are used as a metric. Despite the relatively good efficiency of the propulsion systems, the use of heavy fuel oil (HFO), which is considered a low-quality fuel, results in high pollutant emissions (e.g. $CO_2$, $SO_x$ and $NO_x$) and consequently high environmental and mental impacts (Toscano and Murena, 2019). $CO_2$ emissions from shipping are projected to increase in the range of 1.1e3.7 Gt of $CO_2$ per year in 2050 under a business-as-usual scenario, an increase of 270% compared to 2007 (Rehmatulla and Smith, 2015).

The shipping industry is responsible for a wide range of negative impacts on the marine environment, some of which include the release of toxins from untreated sewage, bilge and scrubber water, effluent and antifouling paint. Scrubber wash water and $SO_x$ deposits contribute to acidification, hull fouling, and ballast water can spread invasive species, and noise pollution and bilge water can disrupt marine ecosystems. In addition, shipping affects natural systems through the processes of eutrophication and acidification (Islam Rony et al., 2023).

The revised IMO GHG Strategy, adopted at the Marine Environment Protection Committee (MEPC 80), includes an increased shared ambition to achieve net zero GHG emissions from international shipping by or around 2050, i.e. close to 2050, and a commitment to ensure the introduction of alternative zero and near-zero GHG fuels by 2030.

With the IMO committing to a 50% reduction in the industry's GHG emissions by 2050 compared to 2008 levels, and a cross-industry coalition seeking to have net-zero emission ships in service by 2030, the race is on to find alternative fuel sources for the 50,000 ships plying the world's oceans.

## 2. Alternative Energy Sources for Cargo Ships

Alternative marine fuels include LNG, LBG, hydrogen, ammonia, methanol, ethanol, HVO, nuclear power and electricity. HFO (72%), marine diesel oil (MDO) (26%) and LNG (2%) are the petroleum-derived fuels consumed by ships (Gray et al., 2021). According to the European Environment Agency (EEA), ships emit 0.61% of global CO emissions, 9.84% of $SO_x$ emissions, 14.74% of $NO_x$ emissions and 6.75% and 3.56% of PM2.5 and PM10 emissions, respectively (2021). In addition, the IMO, in its fourth GHG study, found that shipping accounts for 2.89% of global $CO_2$ emissions (IMO 2020).

The most commonly used marine fuels today are HFO and MDO. After HFO and MDO, LNG is the third fuel of choice for shipping. In addition, methanol is the fourth most commonly used alternative fuel in ships (Deniz and Zincir 2016).

### *2.1 Liquefied natural gas (LNG)*

Emissions reduction targets are forcing the maritime sector to adopt greener and more energy-efficient technologies. One proposed solution is to use cleaner fuels instead of traditional marine fuels. LNG is the most widely used alternative fuel in the shipping industry (Deniz and Zincir 2016). Its use reduces emissions and operating costs, but its wider use as a marine fuel is severely limited by safety concerns, infrastructure requirements and investment costs. Natural gas is cheap, non-toxic, non-corrosive and has a lower carbon content than diesel, making it a viable alternative fuel for shipping. Initially, natural gas existed only as a gas.

Natural gas is cooled to -163 ◦C to liquefy it and make it easier to handle. LNG is 600 times smaller in volume than in gaseous form (Percic et al., 2021).

Although the fleet of LNG-fuelled ships is growing rapidly, LNG is not a carbon-zero fuel and has a carbon footprint depending on how it is produced, transported, consumed, its well-to-pump and pump-to-wake emissions. While there are many benefits to using LNG, there are also challenges and drawbacks. Figure 1 shows the world's first LNG*-powered bulk carrier name M/V HL Green (Marine Insight, 2021).

**Figure 1.** The world's first LNG-powered bulk carrier HL Green (Marine Insight, 2021)

Benefits:

- LNG could be considered a transition fuel for global zero carbon targets.
- Reduces carbon intensity.
- Significantly reduces NOx, SOx and PM emissions.
- Developed engine and storage technology enables infrastructure for future zero carbon fuel.
- Globally available supply options. Compatibility benefits in emission control areas.

Challenges:

- Large and expensive fuel tanks required (membrane, moss and TGZ Mark III).
- Not a zero-carbon fuel, requires a pilot fuel such as MDO. Eventually needs to be replaced.
- Methane slip must be mitigated as it's the main contributor to higher $CO_2$ equivalent emissions.

*2.2 Methanol*

Methanol as an alternative green fuel has been tested in the maritime industry for more than 10 years. Thanks to these studies, the IMO has developed rules for the safe use and transport of methanol (Zincir and Deniz 2021). Due to the obvious emission advantages of methanol, there are already many ships in the order/production phase using methanol as their main fuel. According to (Clarksons 2023), the orderbook of methanol capable ships will account for 36% of the alternative fuel tonnage contracted in 2023, making it the second most popular choice for owners after LNG-fuelled ships.

The use of methanol also demonstrates lower nitrogen oxide emissions and, when produced from renewable sources, lower CO2 emissions over the fuel's life cycle. Methanol blends significantly reduce SOX and particulate emissions. (T. Paulauskiene, et al. 2019) also concluded that a blend of 10% bio methanol and

20% biodiesel showed the best results for the use of alternative fuels in marine applications according to the ISO 8217:2012 standard and environmental requirements.

Renewable resources such as wood and agricultural products can be used to produce methanol, but it should be noted that methanol is toxic, corrosive and requires more storage space compared to conventional fuels (Deniz and Zincir 2015). The Safety of Life at Sea Convention (SOLAS) is not met by methanol due to its low flashpoint of 11°C, but this is being addressed by the use of double-walled methanol compartments (N.R. Ammar 2019).

Benefits:

- Sulphur-free and biodegradable
- Significant reduction in NOx, SOx, CO, CO2 and PM emissions (N.R. Ammar 2019)
- Minor modifications required for use in dual-fuel engines.
- Regulations and guidelines established.

Challenges:

- Toxic and corrosive, requiring strict safety standards for handling and storage.
- Requires much more storage space than conventional marine fuels.
- Requires double-walled storage and piping systems.
- Expensive fuel source
- Difficult to meet shipping industry demand at short notice.

*2.3 Ammonia*

Another promising alternative fuel for the future is ammonia. With appropriate modifications to LNGLPG-fuelled ships, ammonia can be used as the main fuel. The shipping industry is aware of the handling and storage characteristics of ammonia, as it is one of the top three chemicals transported by ships worldwide (Ampah et al., 2021). However, ammonia is highly toxic to human health and must be handled very carefully.

Although the potential of ammonia varies depending on how environmentally friendly it is produced, green ammonia is characterised as zero carbon as it is produced entirely from renewable resources. Depending on how it is produced, ammonia can be divided into three types: brown ammonia, blue ammonia and green ammonia. While brown ammonia could lead to worse emission results compared to MDO, green ammonia could offer promising emission results and comply with the IMO 2050 targets (Zincir, 2022).

Despite the carbon and sulphur free nature of green ammonia, which meets the IMO's CO2 emission targets, disadvantages such as the production of green ammonia, the global availability of reserves, the high price and the need for a selective catalytic reduction system to prevent the resulting increased N2O emissions make ammonia unsuitable as an alternative fuel in the short term (Zincir, 2022).

Benefits:

- Green ammonia is carbon free.
- There are no tailpipe emissions during ship operation.
- Engine technology developed.
- Class regulations and guidelines have been developed.
- Easier to contain than hydrogen (-33 C vs. -253 C)

Challenges:

- High toxicity
- Can result in high NOx emissions, which need to be mitigated by exhaust gas cleaning systems, i.e. SCR.
- Supply is a significant issue; in 2018, 80% of ammonia produced was used as fertiliser (AlEnazi. Okonkwo, Bicer et al., 2021).

- Unlike diesel, ammonia burns more slowly and has a much higher auto-ignition temperature than diesel (630 °C vs. 210 °C).
- Initially requires a pilot fuel such as MGO.
- Requires double piping and ventilation environments for safe operation, increasing capital cost.

## 3. Current Alternative Energy Status on Turkish-Owned & Controlled Merchant Fleet

Table 1 shows the list of Turkish owned alternative fuel ships and Table 2 shows the list of Turkish owned ships under construction or contracted to shipyards. Such data has been obtained through exclusive interviews with a company which has a reputable position in terms of data, information and analyses on the maritime industry worldwide. These data are needed in order to monitor the Turkish maritime industry's approach to alternative fuels in a concrete way.

As shown in Table 1, Turkish shipowners have not yet been proactive in the field of alternative energy. Investments in alternative fuels have been made for a very small number of vessels, but given the size of the remaining fleet, the number of vessels capable of burning alternative fuels or under construction is limited (Clarksons 2024). It should also be noted that some of the alternative fuel tugs built in Türkiye are export products.

Table 1: Turkish-owned fleet in service (Clarksons 2024)

| # | Name | Type | GT | DWT | Built | Main Engine Fuel Type | Alter. Fuel Type |
|---|---|---|---|---|---|---|---|
| 1 | Ertugrul Gazi | LNG/Regas. | 108.919 | 93.550 | 2021 | LNG, VLSFO | LNG |
| 2 | KARMOL LNGT Powership Asia | LNG/Regas. | 106.792 | 66.802 | 1991 | LNG, VLSFO | LNG |
| 3 | Karadeniz LNGT Powership Anatolia | LNG Carrier | 97.742 | 86.385 | 2006 | LNG, VLSMDO | LNG |
| 4 | Karadeniz LNGT Powership Black Sea | LNG Carrier | 46.555 | 35.760 | 1997 | LNG, VLSFO | LNG |
| 5 | Pasco Marsel | LPG Carrier | 26.541 | 29.175 | 2023 | LPG, VLSFO | LPG |
| 6 | Pasco Roni | LPG Carrier | 26.541 | 29.991 | 2023 | LPG, VLSFO | LPG |
| 7 | Pasco Berke | LPG Carrier | 23.697 | 30.000 | 2024 | LPG, VLSFO | LPG |
| 8 | Advantage Vital | VLCC | 156.186 | 299.590 | 2023 | LNG, VLSFO | LNG |
| 9 | Advantage Vision | VLCC | 156.186 | 299.454 | 2023 | LNG, VLSFO | LNG |
| 10 | Advantage Victory | VLCC | 156.186 | 299.467 | 2022 | LNG, VLSFO | LNG |
| 11 | Advantage Verdict | VLCC | 156.186 | 299.450 | 2022 | LNG, VLSFO | LNG |
| 12 | Chief Dan George | Tug | 292 | 100 | 2023 | Electric | Electric |
| 13 | Gisas Power IV | Tug | 282 | 31 | 2023 | Electric | Electric |
| 14 | BB Electra | Tug | 277 | 100 | 2024 | Electric | Electric |
| 15 | Gisas Power 2 | Tug | 107 | 8 | 2023 | Electric | Electric |
| 16 | Gisas Power 3 | Tug | 107 | 31 | 2023 | Electric | Electric |
| 17 | Gisas Power | Tug | 104 | 31 | 2020 | Electric | Electric |

By the end of 2023, the Turkish-owned fleet will consist of 2028 vessels of various types and sizes (Turkish Republic Ministry of Transport and Infrastructure, 2024). However, the number of existing alternative-fueled vessels is only 17, or 0.84 per cent of the fleet.

Table 2: Turkish-owned fleet being constructed (Clarksons 2024)

| # | Name | Type | GT | DWT | Due | Main Engine Fuel Type | Alter. Fuel Type |
|---|---|---|---|---|---|---|---|
| 1 | N/B Hyundai Ulsan 3505 | Ammonia/LPG | 48.627 | 56.000 | 2027 | LPG, VLSFO | LPG |
| 2 | N/B Hyundai Ulsan 3506 | Ammonia/LPG | 48.627 | 56.000 | 2027 | LPG, VLSFO | LPG |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | N/B Hyundai Ulsan | LPG Carrier | 47.759 | 55.000 | 2027 | LPG, VLSFO | LPG |
| 4 | N/B Hyundai Ulsan | LPG Carrier | 47.759 | 55.000 | 2027 | LPG, VLSFO | LPG |
| 5 | Pasco Bercim | LPG Carrier | 27.647 | 35.000 | 2025 | LPG, VLSFO | LPG |
| 6 | Pasco Berfin | LPG Carrier | 27.647 | 35.000 | 2026 | LPG, VLSFO | LPG |
| 7 | Advantage Sierra | Suezmax tanker | | 157.100 | 2025 | LNG, VLSFO | LNG |
| 8 | Advantage Smooth | Suezmax tanker | | 157.000 | 2025 | LNG, VLSFO | LNG |
| 9 | Advantage Solo | Suezmax tanker | | 157.000 | 2025 | LNG, VLSFO | LNG |
| 10 | N/B Uzmar 158 | Tug | 850 | | 2024 | LNG, VLSMDO | LNG |
| 11 | N/B Uzmar 159 | Tug | 850 | | 2024 | LNG, VLSMDO | LNG |
| 12 | Electra 2501 SX | Tug | 472 | | 2024 | Electric | Electric |
| 13 | Electra 2502 SX | Tug | 472 | | 2025 | Electric | Electric |
| 14 | Electra 2302 | Tug | 292 | | 2024 | Electric | Electric |

It can be concluded that the Turkish merchant fleet is taking steps in the process of transition to alternative fuels but believing that IMO's tightening of the rules will be effective and a motivator to accelerate this process.

## 4. Result and Discussion

In terms of number of vessels, the number of Turkish owned vessels will increase from 1,574 in 2021 to 2028 by the end of 2023. The Turkish flag fleet will reach a capacity of 6.9 million DWT by the end of 2023, an increase of 7.2 per cent compared to the previous year. However, only 17 vessels have alternative propulsion, and another 14 will be added this year and next (Turkish Republic Ministry of Transport and Infrastructure, 2024). We are just at the beginning of the journey, but I believe the Turkish fleets will reach the International Maritime Organization (IMO)'s net-zero framework by 2050.

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# MET / Social Aspect

# An Ingenious Method to Reveal Seafarers' Situational Awareness: A Bio-signal and Video Analysis

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**Abstract:** The ability to acquire and maintain situational awareness is regarded as one of the crucial nontechnical skills for seafarers. Moreover, the importance of situational awareness has been frequently cited in a growing body of literature discussing the necessary skills of autonomous ship operators. Realizing this importance, several studies have been conducted to examine seafarers' situational awareness. However, these studies typically relied on ships or ship simulators to fulfill their research objectives. This study proposes a simpler and cost-effective approach for evaluating seafarers' situational awareness, based on their bio-signal responses when viewing relevant ship operational videos. This study finds notable differences between student and experienced harbor pilots, indicating that the latter have better situational awareness due to a more developed mental model acquired through training and experience. These findings align with prior studies, reinforcing the usability of the proposed evaluation method. In the future, additional respondents are needed to further validate the findings of this study. Moreover, the applications of image processing and machine learning may be necessary for a thorough analysis of respondents' situational awareness when analyzing the relevant bio-signals.

*Keywords*: maritime education and training; MASS; *kansei*; heart rate monitor; eye-tracking technology

## 1. Introduction

Endsley (1995) defines situational awareness (SA) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of the status in the near future". Endsley also comes up with a model of SA in dynamic decision-making highlighting the importance of SA to decision-making and performance of action. According to the model, a lack of SA will lead to faulty decision-making resulting in poor performance. Consequently, within the maritime domain, where split-second decisions can mean the difference between safety and disaster, the absence of SA can have catastrophic consequences, posing significant threats to human lives and the environment.

While extensive literature exists on the implications of human errors on maritime safety, research on the role of SA in this specific domain remains limited in comparison. Nevertheless, a handful of research articles have investigated the role of SA in maritime safety. Sandhåland et al. (2015) analyzed 23 accident reports involving collisions between attendant vessels and offshore facilities on the Norwegian continental shelf from 2001 to 2011, finding that 18 of the accidents were attributed to the loss of SA. Similarly, Sætrevik and Hystad (2017) found that SA affects crewmembers' unsafe actions and subjective risk assessments and concluded that SA plays a crucial role in maritime safety. As important, Cordon et al. (2017) provided psychometric evidence indicating SA is crucial to the safety of shipping operations.

According to Sharma (2023), SA will be particularly crucial in the future with the rise of autonomous ships, given the risks associated with automation bias and complacency. Most studies assessing the necessary skills required by autonomous ship operators consistently highlight the importance of SA. For instance, BachariLafteh and Harati-Mokhtari (2021) surveyed 96 university researchers, Kennard et al. (2022) surveyed 108 deck officers, and Kim and Mallam (2020) consulted 36 subject matter experts, all of whom emphasized the critical role of SA in this domain. These findings collectively demonstrate the widespread acknowledgment of the significance of SA across various stakeholders in the maritime industry.

Recognizing the increasing importance of SA in the maritime domain, researchers have dedicated substantial efforts to studying SA among seafarers. However, many existing studies rely on ships or ship simulators, posing challenges in terms of expenses, time consumption, and specialized personnel requirements. These limitations underscore the need for simpler and more cost-effective approaches to studying seafarers' SA. In response, this study explores the potential of leveraging bio-signals, such as heart rate variability (HRV) and ocular behavior (OB), in conjunction with ship operational videos, to measure seafarers' SA. By utilizing HRV and OB as proxies for cognitive and physiological responses associated with SA, and employing videos of entering and leaving port operations to provide visual and audio contexts, this study aims to answer the following research question:

"Can bio-signals and ship operational videos effectively measure seafarers' situational awareness?"

Drawing on Endsley's SA model, which emphasizes the role of well-developed mental models generated from training and experience in influencing SA, this study seeks to validate the proposed method by investigating differences in HRV and OB responses among novice, intermediate, and expert seafarers while viewing videos of entering and leaving port operations.

## 2. Methodology

### *2.1 Respondent*

In this study, three respondents were recruited and categorized according to their seafaring experience into three groups: Novice, Intermediate, and Expert. The novice seafarer (NS) is a final year undergraduate student at the Tokyo University of Marine Science and Technology (TUMSAT), majoring in marine systems engineering. The NS has two months of onboard experience as a deck cadet and aspires to be a deck officer in the future. The intermediate seafarer (IS) is currently working as a third-class pilot in the Tokyo Bay area, holding third-class deck officer and pilot licenses. The IS possesses four and a half years of experience as a seafarer, including one year as a deck cadet, one year as a deck officer, and two and a half years as a pilot. Lastly, the expert seafarer (ES) is presently employed as a first-class pilot in the Tokyo Bay area, holding a first-class pilot license and possessing 10 years of experience as a pilot.

### *2.2 Ship Operational Video*

As previously discussed, respondents were shown videos of entering and leaving port operations. The videos show the scenery of ships' bridges during the entering and leaving port operations captured from a camera mounted on the head of the pilot maneuvering the ship (see Figure 1 and Figure 2). As shown in the figures, the videos were divided into two segments: 1) Actual View, and 2) Portable Pilot Unit (PPU) Display. Moreover, the entering and leaving port operations used as the evaluation videos were segmented into three stages (see Table 1). The respondents were given the following instructions before viewing the evaluation videos.

"When you watch the video, try your best to imagine yourself as the person in charge responsible for safely maneuvering the ship."

Figure 1. Entering Port Operation

Figure 2. Leaving Port Operation

Table 1. Stages of Entering and Leaving Port Operations

| *Entering Port Operation* | *Leaving Port Operation* |
|---|---|
| Stage 1: Approaching Port Entrance | Stage 1: De-berthing |
| Stage 2: Approaching Berth | Stage 2: 180-degree turn |
| Stage 3: Berthing | Stage 3: Leaving Port |

*2.3 Bio-signal①：HRV*

This study utilized the VitalgramCT2 heart sensor, developed by AffordSENS Corporation (2014), for measuring respondents' HRV. The VitalgramCT2 is a belt-type sensor equipped with a corresponding mobile app that facilitates real-time monitoring of respondents' biological information, body movement, posture, and environmental factors. Among the various data points available for HRV measurement, including RR interval and heart rate, this study focused specifically on the LF/HF value. The LF/HF value was chosen based on its established efficacy in quantifying cognitive workload. Notably, a review paper by Lean and Shan (2011) demonstrated the utility of the LF/HF value across diverse fields, indicating its widespread usage. Most importantly, within the maritime settings, Murai et al. (2004) and Wu et al. (2017) demonstrated the efficacy of the LF/HF value in measuring the cognitive workload of deck officers and engineers, respectively.

*2.4 Bio-signal②：OB*

This study utilized the EMR-ACTUS eye tracking device, developed by nac Image Technology Inc. (2018), to measure respondents' OB. The device is accompanied by the EMR-dStream2 analysis software, enabling quantitative analysis of gaze durations, fixations, and other relevant metrics. Additionally, it facilitates data visualization options such as gaze plots, beeswarm plots, heatmaps, and focus maps, allowing for comprehensive analysis. While various metrics can be employed for OB measurement, this study specifically focuses on fixation due to its effectiveness in revealing respondents' perceptions, which is one of the main foundations of SA. Holmqvist and Andersson (2017) define fixation as an OB occurring when the eye remains still, and the pupil is stationary for approximately 0.2 to 0.4 seconds.

## 3. Result

*3.1 HRV*

Figure 3 shows the change in the LF/HF value of the respondents.

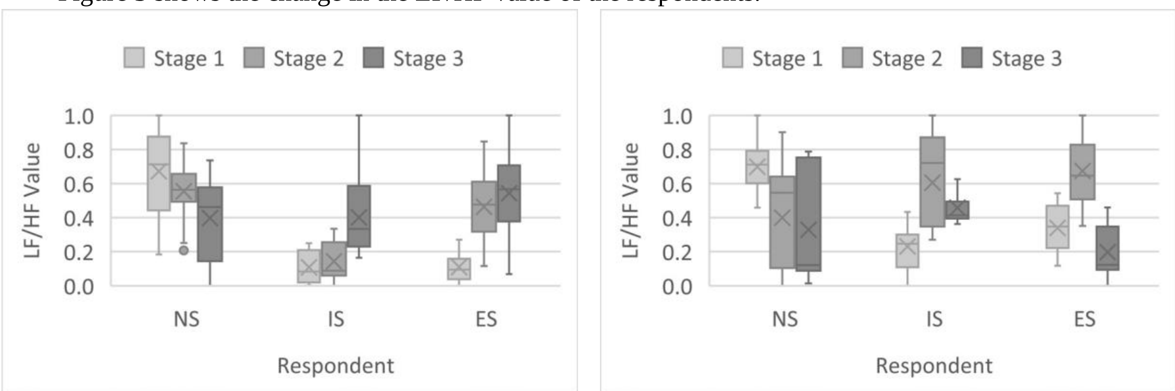


Figure 3. Change in LF/HF Value (Left: Entering Port Operation, Right: Leaving Port Operation)

*3.1.1 Entering Port Operation*

As shown in Figure 3, it is evident that the last stage represents the least mentally taxing phase for the NS. Interestingly, while no significant difference exists between the first and second stages ($p$ > .05), the LF/HF value during the last stage is significantly lower than during the other stages ($p$ < .01). Conversely, for IS and ES, the last stage emerges as the most mentally taxing phase of the operation. It is noteworthy that the ES exhibits no significant differences between the second and third stages ($p$ > .05), whereas the IS shows no significant differences between the first and second stages ($p$ > .05).

### *3.1.2 Leaving Port Operation*

As exhibited in Figure 3, it is apparent that the first stage represents the most mentally taxing phase for the NS. Notably, while no significant difference exists between the second and third stages ($p > .05$), the LF/HF value during the first stage is significantly higher than during the other stages ($p < .01$). Conversely, the second stage emerges as the most mentally taxing phase for IS and ES. It is important to note that ES exhibits significant differences across all stages of the operation ($p < .01$), whereas IS shows no significant difference between the second and third stages ($p > .05$).

## *3.2 OB*

### *3.2.1 Entering Port Operation*

As shown in Figure 4, NS fixates more on the PPU Display at all stages compared to IS and ES during the entering port operation. Note that despite the notable differences, there are no significant differences across all respondents ($p > .05$). Figure 5 shows the heat maps of the respondents during the third stage of the operation. From the heat maps, IS and ES fixate more on the areas between the berth and the port side of the ship, while the NS fixates more on the berth areas and the PPU display.

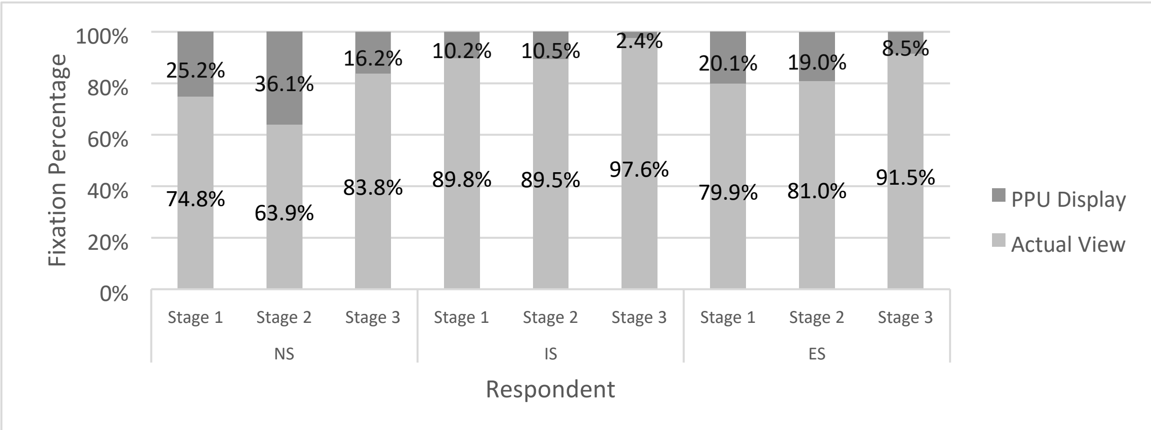


Figure 4. Change in Fixation Percentage (Entering Port Operation)

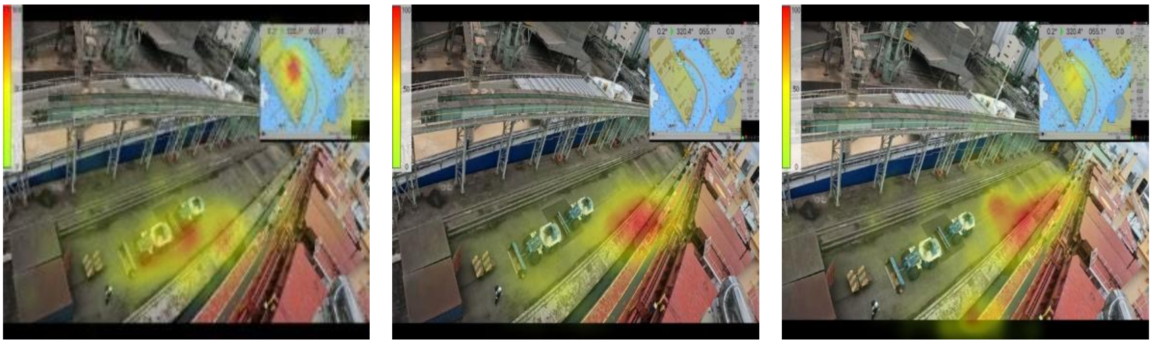

Figure 5. Heat Maps of Entering Port Operation, Stage 3 (Left: NS, Middle: IS, Right: ES)

### *3.2.2. Leaving Port Operation*

As shown in Figure 6, similar to the entering port operation, NS fixates more on the PPU display compared to IS and ES. There are significant differences between NS and the remaining respondents ($p < .01$). No significant differences between IS and ES. Next, Figure 7 shows the heat maps of the respondents during the second stage of the operation. From the heat maps, it is evident that NS fixates mainly on the PPU display, while IS and ES mainly focus on the starboard side of the ship and a little on the PPU display.

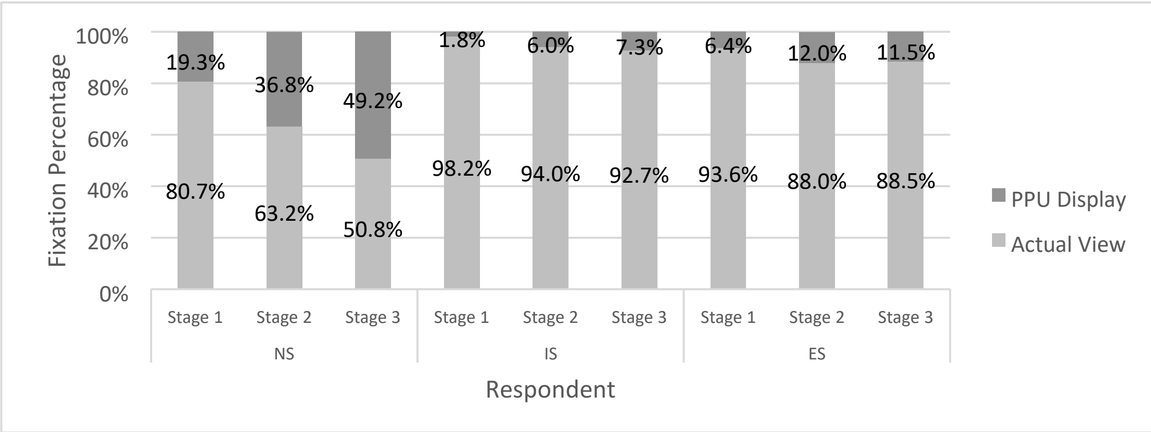


Figure 6. Change in Fixation Percentage (Leaving Port Operation)

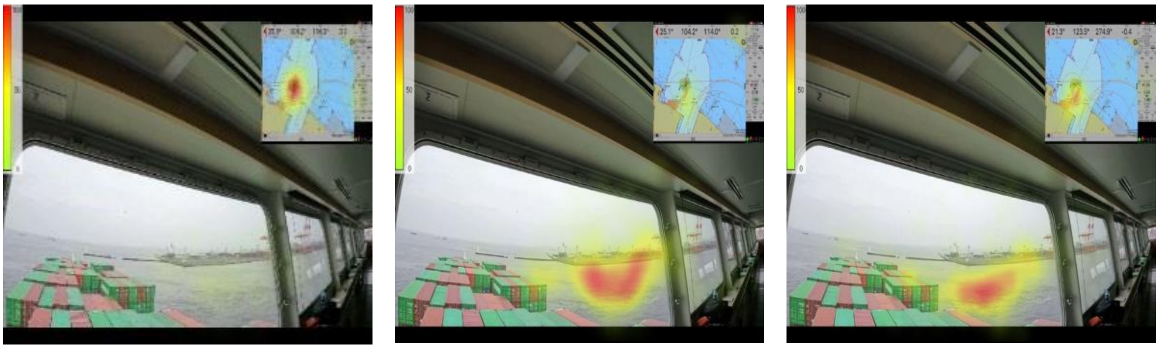

Figure 7. Heat Maps of Leaving Port Operation, Stage 2 (Left: NS, Middle: IS, Right: ES)

## 4. Discussion

### *4.1 Entering Port Operation*

The last stage of the entering port operation (i.e., berthing) is the least cognitively challenging part for the NS, whereas the opposite holds true for IS and ES. This difference can be attributed to the significant involvement of tugboats during this stage, with 48 out of 58 orders issued during this stage being tugboat-related orders. Due to the lack of experience and training in handling tugboats, the NS may not have a well-developed mental model to fully comprehend the meaning of the orders administered during this stage. This finding is consistent with the study conducted by Sugimoto et al. (2019), which demonstrated that professional seafarers exhibit a higher increase in LF/HF value when performing intricate navigational tasks. As shown in Figures 5 and 6, the NS shows a partially similar OB to IS and ES, indicating the NS has some awareness of what elements to be mindful of during the stage, but may lack understanding of their significance or intricacies.

### *4.2 Leaving Port Operation*

While the first stage of the leaving port operation (i.e., de-berthing) poses the greatest cognitive challenge for the NS, the second stage (i.e., 180-degree turn) is the most demanding for the IS and ES. This outcome likely stems from the complex nature of the stage, which involves turning the ship more than 150 degrees while carefully considering factors such as speed, rate of turn, and heading. Due to their limited training and experience, the NS may struggle to efficiently process the information perceived during this stage. This can lead to information overload, causing the NS to focus primarily on the PPU display while overlooking other crucial elements of the stage (see Figure 7). Consequently, the NS's perception and understanding of the stage are compromised. This finding is consistent with those of Atik (2020) and Forsman et al. (2012), which indicate that experienced seafarers tend to spend more time fixating on the outside scenery than on navigational equipment.

## 5. Conclusion and Future Research

In conclusion, the findings of this study suggest that seafarers' SA can be effectively measured using a combination of bio-signals and ship operational videos. OB serves to assess seafarers' perception, while HRV provides insight into their comprehension, two of the three building blocks of SA. The alignment of these findings with previous research lends further support to this assertion. As a future endeavor, the application of image processing may be necessary to thoroughly analyze seafarers' perceptions when viewing ship operational videos. Additionally, the application of machine learning may be required to measure seafarers' ability to project future states of relevant elements, representing the third building block of SA. Furthermore, it is essential to expand the participant pool by recruiting more respondents, which would enhance the robustness of the study's findings and provide broader insights into seafarers' SA.

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# Technology-Assisted Instruction: Its Impacts on the Academic Performance and Satisfaction of Maritime Students

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**Abstract:** This inquiry aimed to determine the impacts of technology-assisted instruction on the academic performance and satisfaction among selected first-year BSMT (Bachelor of Science in Marine Transportation) students during the first semester of the Academic Year (AY) 2018-2019. Pretest results were as follows: Group A (Control Group) *M=23.75 SD=3.92*, Group B (Experimental Group) *M=22.28 SD=4.08*. Further, post-tests results were: Group A (control group) *M=34.60 SD=2.97*, Group B (Experimental Group) *M=40.45 SD=2.70*. Moreover, there is no significant difference (*p=0.103)* in the pretest results of Group A and Group B. However, post-test result showed significant difference (*p=0.000)* between Group A and Group B. According to Gulek and Demirtas (2005), substantial evidence showed that incorporating technology, in the classroom as an instructional tool enhances student learning and educational outcomes. The key determinants affecting students' satisfaction with the use of technology are as follows: accessibility, facilitating integration of learning, eco-friendly learning style, time saver, and easy compilation of documents. Caruso and Kvavik (2005) determined the convenient usage of technology in academic and social activities among students.

*Keywords*: technology-assisted instruction, impacts, academic performance, satisfaction, maritime students

## 1. Introduction

Technology-assisted instruction includes the use of digital tools such as computers, digital cameras, iPads, tablets, and smartphones which can be used at any time and is mostly best combined with other teaching techniques (Gilbert, Sawyer, and MacNeil (2015). Some studies have found that technology integration in the classroom generates a rich, effective, and efficient learning environment that enhances student performance and learning (Cronin, Meadows, and Sinatra, 1990). According to Bagui (1998), the introduction of multimedia in the classroom or via independent study has been indicated as having a positive effect on learning and retention. Several studies have also suggested that students' satisfaction and motivation are higher when multimedia tools are used (Astleitner and Wiesner, 2004). The new technologies, knowledge about these new technologies, and approaches to education are already having a clear and positive impact on education provision (Fletcher, 2003). However, research investigating the effectiveness of technology-assisted instruction has resulted in mixed findings. According to Garrett (1995), some studies have not presented a benefit in student performance and learning as a result of technology integration. In addition, a systematic review compared the learning of clinical skills in undergraduate nursing education which showed no significant difference between the online and traditional delivery of instruction ((McCutcheon, Lohan, Traynor, & Martin, 2015). In the light of this mixed data, it is clearly evident that more research should be conducted to determine appropriate and effective uses of technology in education.The integration of technology has become integral in education. More so, according to Pittman and Gaine (2015), integrating technology in a meaningful and state-of-the-art instruction remains a great challenge.

JBLFMU-Arevalo, Inc. aimed to integrate technology towards producing globally competitive seafarers. Making technology an integral part of maritime education, thus, this present study was done to identify the effectiveness of technology integration in the academic performance and satisfaction of Maritime students. This present study used online platforms such as Google Classroom, Weebly, wixsite and multimedia such as PowerPoint presentations, videos, and eportfolio in the delivery of instruction in Understanding the Self-classes

Generally, this study aimed to determine the impacts of technology-assisted instruction on the academic performance and satisfaction of selected first-year BSMT students during the first semester of the academic year (AY) 2018-2019.

Specifically, it sought answers to the following questions:

1. What is the average pretest score in Understanding the Self subject among BSMT (Bachelor of Science in Marine Transportation) students when taken according to control and experimental group?
2. What is the average post-test score in Understanding the Self subject among BSMT (Bachelor of Science in Marine Transportation) students when taken according to control and experimental group?
3. Is there a significant difference in the pretest and post-test results in Understanding the Self subject among selected BSMT (Bachelor of Science in Marine Transportation) students when taken according to control and experimental group?
4. What determinants affect the satisfaction of students in the use of technology in the subject Understanding the Self?

## 2. Methods

*Research Design*

This pretest-post-test control group design study aimed to determine the impacts of technology-assisted instruction on academic performance (pretest and post-test) and satisfaction among the two sections of BSMT students.

To determine the impact on the academic performance, the average results of the pretest and post-test in Understanding the Self subject of the students were used. Further, to determine the significant difference in the pretest and post-test results, the t-test for independent samples was used. In addition, an interview through an essay was done to determine students' satisfaction with the impact of the use of technology in the delivery of instruction.

*Respondents*

This study utilized the participation of the selected 80 first-year BSMT students taking the subject Understanding the Self during the first semester of AY: 2018-2019. Specifically, sections Polaris 1B and Blackwall were purposively selected. The sampling technique used was purposive sampling as this takes samples from the two sections where one of the researchers is their teacher. Further, these sections were grouped homogeneously based on their Senior High School General Weighted Average. Randomization through toss coin was done determine the control and experimental group.

*Instruments*

A teacher-made pretest and post-test on Understanding the Self duly validated by experts was used to assess academic performance. A teacher-made lesson guide was used in the conduct of the instruction. One lesson guide utilized technology in the delivery of instruction, while the other lesson guide maintained the traditional delivery of instruction. For the group utilizing technology, use of the google classrooms was introduced to students. The group was tasked to have their e-portfolios using Weebly site, wixsite, or Google site.

A set of questions was used to identify common themes to measure the satisfaction of students in the use of technology in the delivery of the lesson.

*Data Collection*

The teacher prepared the pretest and post-test as well as the lesson guides. This was then utilized in the delivery of instruction. The lesson guide incorporated the use of Google Classroom, PowerPoint presentations, videos, Weebly site, or wixsite for the experimental group, while no technology was introduced or used for the control group. The results of the pretest and post-test was used to determine the impact of technology on the academic performance of the students.

A question interview was given to let them reflect and write their thoughts about their satisfaction with the learning process aided by technology.

*Data Analysis*

Mean. This was used to identify the pretest and post-test results to determine the impact of technology on the academic performance of the students.

Standard Deviation. This was used to determine the homogeneity and heterogeneity of the pretest and post-test results.

T-test for independent samples. This was used to compare the difference of the pretest and post-test results.

Coding. This was used to identify common themes recurring in the interview.

**3. Results and Discussions**

The pretest results were: Group A (Control Group) (*M=23.75, SD=3.92)*, Group B (Experimental Group) (*M=22.28, SD=4.08)*. The pretest was given before the intervention. Results showed that based on the average of scores, the control group obtained higher average compared to the experimental group. More so, the posttest results were: Group A (*M=34.60, SD=2.97)*, Group B (*M=40.45, SD=2.70)*. Results showed that the experimental group had the higher average over the control group. It must be noted that the experimental group was exposed to the use of technology in the teaching and learning process. They utilized the Google Classroom as a platform in the delivery of the lessons. Further, PowerPoint presentations and videos also aided instruction. Weebly site or wixsite were utilized as ePortfolios for the experimental group. The control group, however, was not given the opportunity to use technology throughout the completion of the course. The control group were required to submit requirements in hard copy and handouts were distributed to them. Further, the chalk and blackboard were used in discussing the lesson. More so, it was compulsory for the control group to submit a portfolio for the course.

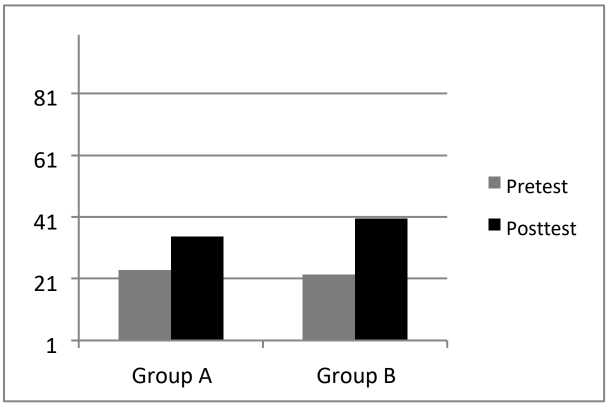


Figure 1. Pretest and Post-test Results in the subject Understanding the Self of Selected BSMT Students

The t-test for independent samples was used to compare the difference of the pretest and post-test of the control and experimental group in the study. Results showed that there is no significant difference in the pretest result (*p=0.103*) of the control and experimental group. It showed that the control and experimental group were on the same level as there was significant difference in their pretest result. However, the post-test result (*p=.000*) showed a significant difference. This shows that utilization of technology impacts academic performance. According to the study of Baytak, Tarman, & Ayas (2011), most students believed that their learning is enhanced and improved through the integration of technology in the classroom.

| Test | t | df | Sig. (2-tailed) |
|---|---|---|---|
| Pretest | 1.648 | 78 | .103 |
| Post-test | -9.224 | 78 | .000 |

Table 1. t-test for Independent Samples Results for the Pretest and Post-test in the Subject Understanding the Self among Selected BSMT Students

Furthermore, the key determinants affecting the satisfaction of the students in the use of technology are as follows: accessibility, facilitating integration of learning, eco-friendly learning style, time saver, and easy compilation of documents. According to the National Educational Technology Standards for Students, International Society for Technology in Education (2002), technology should become as accessible as all other classroom tools. Since introducing Google for Education tools, schools have reduced their paper use by a third, saving them thousands of dollars (Horwitz, 2016). Learning using technology has become paperless.

## 4. Conclusion

Based on the pretest results Group A (Control Group) (*M=23.75, SD=3.92)*, Group B (Experimental Group) (*M=22.28, SD=4.08)*, the mean showed that the control group had higher average of scores than the experimental group. Further, the post-test results Group A (*M=34.60, SD=2.97)*, Group B (*M=40.45, SD=2.70)* showed that the experimental group achieved a higher average of score compared to the control group. It must be noted that the experimental group was subjected to the use of technology in the teaching and learning activities throughout the Understanding the Self subject. The experimental group were tasked to submit activities using an online platform, and were allowed to utilize technology in meeting the objectives of the course. However, the control group was restrained from using any form of technology.

The t-test for independent samples results showed that there is no significant difference in the pretest result (*p=0.103*) of the control and experimental group. Both groups started on the same level as there was significant difference in their pretest result. However, the post-test result (*p=.000*) showed a significant difference. The use of technology in the experimental group created an impact in their academic performance. This shows that the effective use of technology can improve students' performance.

According to Heid and Blume (2008), technology has been found to positively impact mathematics instruction in documented ways. Technology provided enriched visual representations, flexibility to adapt and differentiate instruction, and ease of movement between concrete and abstract ideas. Similarly, the finding agrees with the studies of Llach and Gallego (2012), whose study confirmed that computer-aided instruction (CAI) has been more effective in enhancing students' performance in other subjects than conventional classroom instruction.

The key themes that arose from students' responses are determinants that affect the satisfaction of students in the use of technology accessibility, facilitate the integration of learning, eco-friendly learning style, time saver, and easy compilation of documents. Students find the use of technology very accessible. The use of technology allows students to explore and discover about concepts using the wide range of information available. Learning using technology has become paperless. No more hurry in printing the output. Students just have to click submit to pass their work. Students can access their work even after the semester is over. Students don't have to worry about compiling the bulk of papers because documents are saved in the drive.

## 5. Recommendation

Based on the aforementioned findings, the following recommendations are directed to:

1. Students. They must be given more opportunities to explore the learning process. They should not only be limited to learning within the four walls of the classroom. They should also keep pace with their learning through the use of technology. Other platforms should be introduced to them to develop their skills in manipulating technology which is one of the key skills required in the industry.

2. Instructors. They must be given training opportunities in the use of the different technology platforms used in teaching and learning activities. They must be made aware of the different uses of technology in facilitating learning. They must be adept in using technology to advance quality education.

3. Administration. Top management should provide a budget for purchasing technology facilities and equipment as well as training opportunities, especially for teachers who will serve as facilitators in the learning process.

4. Future Researchers. This study is limited to selected BSMT students. They may examine a larger population in different maritime universities in the integration of technology in the curriculum. Further, they may explore hyflex learning in relation to maximizing the use of technology in education.

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# Incorporating the Human Capability Standards (HCS) Framework into the STCW Code for future seafarers

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**Abstract:** Current and past research has focused on identifying soft skills future seafarers are expected to possess or acquire for operating 'smart' ships influenced by fast-changing technologies and increasing levels of automations (also known as Maritime Autonomous Surface Ships or MASS). In the absence of an existing framework, the authors of this paper propose drawing insights from an award winning, globally recognized, and validated Human Capability Standards (HCS) Reference Framework to identify the required, transferable soft skills and associated abilities. The HCS Framework is based on more than 30 years of research and dedicated to identifying the human capabilities that are most predictive in creating a future- ready workforce, career, profession or graduate. However, since the standards of competence for a traditional seafaring licence are dictated by the Standards of Training, Certification, and Watchkeeping (STCW) Code, it was imperative to investigate if the Code, in its current form, already incorporates the soft skills from the HCS Framework or focuses on perishable technical skills that do not enhance non-technical, durable skills. This paper highlights the advantages and challenges of assimilating the Framework into the STCW Code, but further research work is required to shed light on a coherent structure of education and training which may guide the instilling of the required soft skills in seafarers allowing them to be future-ready for employment.

*Keywords*: STCW Code; seafarer education and training; Maritime Autonomous Surface Ships (MASS); future-ready; Human Capability Standards (HCS)

## 1. Introduction

Technological advancements (such as automation and information technology) and innovation (such as blockchain) within the shipping industry is resulting in the rapid development and commercial use of Maritime Autonomous Surface Ships (MASS) with differing levels of autonomy in ship operations (International Maritime Organization or IMO 2019). For example, at Level 1 of autonomy, there will be seafarers on board to operate and control shipboard systems, but at Levels 2 and 3, ships will be controlled remotely with minimum seafarers and no seafarers onboard respectively until at Level 4, fully autonomous ships which are able to make decisions by itself are launched (Sharma et al. 2019). Hence, it is evident that as autonomy increases and ships are controlled from shore-based stations, the role of the seafarers will evolve, requiring them to acquire new skills and competencies (for example, to identify automation failures and rectify them as required) to operate and manage ships. Current and past research (Bachari-Lafteh & Harati-Mokhtari 2021; Sharma & Kim 2021; Emad, Enshaei, & Ghosh 2021; Hogg & Ghosh 2016) has focused on identifying the technical or job-specific (information and communication technology, electronic and computer engineering, artificial intelligence, etc.) and non-technical, transferable, durable, or more colloquially titled soft skills (communication, leadership, and problem-solving) which allow workers, such as seafarers, to transition smoothly into future roles and careers being reshaped by technology and changing way of working. The current standards of global competence (and the associated knowledge, understanding, and proficiency) required by seafarers to find employment on ships are dictated by the Standards of Training, Certification, and Watchkeeping (STCW) Code which came into force in 1978 (subsequently revised in 1995 and 2010 and the latest edition being from 2017) by the International Maritime Organization (IMO).

However, there is a dearth of studies which have defined the technical and non-technical skills, especially through a structured framework which lists and defines the skills at differing levels of expertise required (Emad & Ghosh 2023a; 2023b) for seafarers intended to be employed for different aspects of MASS operations. This is predominantly because the roles and design of work in the future have not been clearly predicted nor described. The research presented in this paper argues that although it may be challenging to define the technical skills in future roles, the non-technical skills (which may be transferable to different roles and occupations) may be highlighted by drawing lessons from validated skills and capability frameworks which have been previously implemented successfully for workforces across the globe.

In the absence of an existing skills and competency framework which may be used to upskill future seafarers involved in MASS operations, the authors of this paper suggest extracting the non-technical skills from the Human Capability Standards (HCS) Framework which has been successfully deployed by over 200 companies listed in the Australian Stock Exchange and global Forbes 500 companies across multiple industries and companies within commercial, government, and not-for-profit sectors (Working Future 2020). For example, using a sample of 71 employees, a research study by Reynolds, Bowles, & Ghosh (2023) identified and correlated selected non-technical skills from the HCS Framework to high performance in an Australian telecommunication company.

The non-technical skills drawn from the HCS Framework may be added to the STCW Code (Part A which outlines the mandatory standards of competence) allowing the Code to evolve to the changing requirements of skills and competencies ensuring pertinency and adaptability. However, before the assimilation of the new skills to the STCW Code, it is imperative to draw comparisons between the Code and the HCS Framework to assess the suitability of the Code in its current form (or identifying the revisions required) to successfully incorporate the suggested changes. This paper presents the findings of a theoretical and analytical research conducted on the STCW Code to highlight its strengths and limitations in outlining and describing non-technical skills which may be described as standards of achievement expected of future seafarers to adjust to new roles, education and training institutes to design curriculum, regulators to set benchmarks, and employers to assess the suitability of employees towards awarding employment.

## 2. Background

### *2.1. The HCS Framework*

The HCS Framework is based on more than 30 years of research and dedicated to identifying the human capabilities that are most predictive in creating a future ready workforce, career, profession or graduate. The HCS Framework derives from applied research and comparative analysis undertaken across the globe on future skills or capabilities, for example, Deakin University's capability standards that underpin their Professional Practice Credential, Queensland Tertiary Admissions Centre, and international research into the future of work and development of core skill and employability frameworks (The Institute of Working Future or IWF 2020). The research is well grounded, rigorous, and starting to concentrate on a consistent set of descriptors, both for work and to navigate disrupted labour markets. For instance, the ground-breaking Deakin University work from 2014 resulted in Deakin Digital joining with IBM Watson to analyse 60,000 current and future global jobs before they framed their Professional Capability Standards.

At this stage of the paper, it is essential to distinguish between the terms 'capability' and 'soft skills'. Soft skills are non-technical skills which may be implicit, hard to draw up a curriculum for teaching purposes, and observed in workplace contexts or social settings through interpersonal interaction only (Bowles 2023). However, soft skills underline performance of technical skills, long-lasting once acquired (durable skills) and fundamental towards success at the workplace. In comparison, capabilities may be defined as an innate quality of an individual to integrate, build, and reconfigure their technical and non-technical skills when performing workplace tasks (Bowles 2023). Examples of capabilities, as drawn from the HCS Framework, are communication, collaboration, critical thinking, etc. While one may argue that capabilities (like communication or critical thinking) may also be classified as soft skills, the similarity in their nomenclature is not the only reason this research study drew the skills from the HCS Framework for the use in seafaring industry.

Capabilities were introduced in the mid to late 1990s for organisations to respond to rapidly changing environments and focused on individual employees to come together as a workforce to adapt and deliver to the future needs of an organisation (Bowles 2023). The development and deployment of capabilities reflects an enduring desire to assure viable futures for organisations, regions, industries, and individuals (IWF 2020). With the advent of MASS in the near future, the seafaring industry is facing similar, rapid changes in which ships will be operated and it is crucial for the employees (i.e., seafarers) to recognize their innate capabilities to find a place in the industry. Due to this reason, the authors of this paper decided that the capabilities recognized by the HCS Framework (and accepted by reputed organizations) may provide the required soft skills which if integrated into the STCW Code, will provide indications towards their recognition in seafarers or identify training and upskilling requirements which promotes their instilling in individuals. For example, including the capability of Agile and Innovative (from the HCS Framework) as a soft skill in the STCW Code may develop a seafarer's competence to devise innovative strategies in digitizing paperwork (thus reducing the maritime industry's reliance on paper-based systems) and reducing the environmental footprint of ship operations.

The HCS Framework is reviewed and updated every four years through a rigorous process of benchmarking other global non-technical skill, competency or capability frameworks and through the annual use of artificial intelligence (AI) and large language models (LLM) to run semantic analysis and continually rank and rate the top 20 non-technical, durable skills and abilities (behavioural traits and mindsets). Ultimately, while all frameworks may use different titles or sorting of skills and abilities, of them defined the non- technical skills required to be successful in a career and work beyond the 18-36 months most perishable skills can be expected to last in future (Daniel 2020). Moreover, the authors chose the HCS Framework due to their familiarity in its design and development as well as challenges in its adoption and implementation by organizations. For example, the authors investigated outcomes of the implementation of the HCS Framework in the Australia and New Zealand Bank (ANZ Bank) (Bowles, Ghosh, & Thomas 2020) and Telstra – a telecommunication company (Reynolds et al. 2023). Hence, past research work identified the need to conduct similar research work in the implementation of the HCS framework in the context of the seafaring industry to add to the findings and value created by the framework.

### *2.2. Outline of the Standards of Competence in the STCW Code*

The standards of competence in the STCW Code are grouped under seven functions (navigation, cargo handling and stowage, marine engineering, etc.) where each function is a group of tasks necessary for safe ship operations, and each function is divided into three levels of responsibility (support, operational, and management) (Ghosh et al. 2014a). Each function comprises of individual units of competence for the assessment of each individual unit of competence, the STCW Code specifies the required knowledge, understanding, and proficiency (KUP); methods for demonstrating competence; and criteria for evaluating competence (Ghosh et al. 2014b). An example is laid out in Table 1 below.

Table 1. An example of standards of competence outlined in the STCW Code.

| Competence | Knowledge, understanding and proficiency | Methods for demonstrating competence | Criteria for evaluating competence |
|---|---|---|---|
| Respond to a distress signal at sea | Knowledge of the contents of the IAMSAR Manual | Examination and assessment of evidence obtained from practical instruction or approved simulator training, where appropriate. | The distress or emergency signal is immediately recognized. Contingency plans and instructions in standing orders are implemented and complied with. |

## 3. Comparisons between the STCW Code and the HCS Framework

The previous section (Introduction) has made it clear that the functions and the purpose for which the STCW Code and HCS Framework were created are completely distinct from one another. Hence, the comparisons drawn between them are not on their effectiveness, adequacy or success but their individual characteristics which will allow the Code to incorporate the elements of the Framework. The comparison will compare the strengths and weaknesses of the Code and Framework, which if used and addressed respectively, will allow the provision of clear, unambiguous descriptors of capabilities (renamed as soft skills for the purposes of this paper) for future seafarers to fit into new roles and job descriptions.

*3.1. Does the STCW Code include the soft skills from the HCS Framework?*

The HCS Framework lists 13 essential capabilities which may be included in the STCW Code as soft skills. All capabilities are described across seven levels of career progression from school leaver to senior executive level. The lists includes Adaptive Mindset, Collaboration, Communication, Creativity, Critical Thinking, Customer Focus, Empathy, Ethics, Problem Solving & Data, and the four LEAD capabilities: Leadership, Engagement & Coaching, Agile & Innovative, and Direction & Purpose. To confirm if the capabilities were already included as soft skills in the STCW Code, a text search using the titles of the capabilities was carried out on the columns listing the 'competence' listed in the Code. The text search revealed that only Leadership and Communication was included in the STCW Code as a competence to be developed. For example, the STCW Code listed the soft skill as the competence of 'Application of Leadership and Teamworking Skills' (IMO 2011, p. 109) and 'Establish and maintain effective communications' (IMO 2011, p. 215). Although, terms like 'leadership' and 'decision-making' is also mentioned in the KUP column for the other units of competence (e.g., Maintain a safe navigational watch) (IMO 2011, p. 101), such occurrences were disregarded since they did not focus on the development of the individual soft skill. None of the other capabilities were mentioned as soft skills in the STCW Code.

The text analysis conducted for the purposes of this research also included a search for the capabilities which may have been included as soft skills under synonyms or semantics in the STCW Code. For example, Google search was used to generate the synonyms for the capability of 'Empathy' (e.g. sympathy and sensitivity); 'Ethics' (e.g. morals and ethos); and 'Collaboration' (e.g. partnership and relationship ) to find their mentions in the STCW Code as essential skills to be developed. This search revealed that the STCW Code only mentioned Relationship Development as a unit of competence [e.g., 'Contribute to effective human relationships onboard ships' (IMO 2011, p. 224)].

*3.2. Should the soft skills be defined separately?*

Based on the findings highlighted in Section 3.1 of this paper, one may argue that the lack of mention of the soft skills in the 'Competence' column of the STCW Code may be due to the fact that soft skills are essentially underlying skills and abilities that support the performance of technical skills and hence, do not warrant a separate mention. While this argument may be valid for a very narrow competency and skill approach in previous decades, it will preclude the soft skills from being well-defined at different levels of career advancement and hinder development, assessment, and recognition of these essential, durable skills. For example, the HCS Framework clearly defines each of its capability with an associated: title, description, positive and negative indicators, levels of proficiency, and criteria indicating proficiency. An example of this is provided in Table 2 below.

Table 2. An example of how a capability is outlined in the HCS Framework (IWF 2020).

| Title | Critical Thinking |
|---|---|
| Description | Able to use a range of tools or methods to critically examine and assess existing information, thinking, assumptions and issues to present well-reasoned insights or to make judgements. |
| Indicators of proficiency | Applies logic and reasoning to make judgements.<br>Moves from decisions to action. |
| Indicators of development need | Looks for the easiest to achieve solution<br>Cannot make decision |
| Levels | Level 1: Appreciates boundaries of current thinking and practice.<br>Level 2: Undertakes basic research to critically analyze existing methods.<br>Level 3: Uses evidence-based insights to make judgements. |

Table 2 provides an example of how underlying soft skills may be defined with unambiguous descriptors for development and assessment even if they are accompanying technical skills. Having clear standards for skills development will ensure uniform and consistent levels of achievement for seafarer graduates and allow employers to assess suitability of the graduates to fit into new roles or identify further training requirements.

*3.3. Does the HCS Framework fit into the STCW Code in its current form?*

Before incorporating the HCS Framework and its capabilities into the STCW Code as soft skills, it is crucial to determine if all the capabilities are relevant to the seafaring industry and its associated occupational roles. For example, one may argue that seafarers need to develop communication and problem-solving skills, but do they need to develop skills to focus on specific customer needs? The answer to this lies in the clarity that needs to be achieved in defining future roles and occupations seafarers may find themselves in, especially as different degrees of MASS emerge in the commercial space. At this stage of MASS development, when the transition of current seafarers in future roles remain undetermined, all capabilities should be considered essential and instilled as soft skills.

The STCW Code will also find it challenging to incorporate all 13 capabilities (and its associated descriptions) and add to its current lists of units of competence because doing so will make the Code too cumbersome especially when trying to prepare seafarer graduates to adapt to unknown future employment scenarios or when responding to a demanding labour market is time critical (Bowles 2023). Moreover, as stated in Section 2 (Background), the HCS Framework is based on ongoing research conducted over the last 30 years. Due to this, the Framework has undergone several revisions and modifications to ensure successful implementation in organizations and industries. Once the Framework is integrated into the STCW Code for seafarer training, it would still have to be reviewed with every generation of workers and the changing nature of the maritime industry to avoid a mismatch between the current supply and the future demand of skills.

### *3.4. Will seafarer training be able to accommodate the HCS Framework?*

The STCW Code has dictated the requirements of seafarer training by providing global, minimum standards of competence, the achievement of which need to be demonstrated through assessments before the seafarers are awarded the licence to find employment on ships. The maritime regulators (e.g., the Australian Maritime Safety Authority or AMSA in Australia and Marine Mercantile Department or MMD in India) ensure that seafarer education and training institutes deliver the required training through a structured and regimented program in a specific period of time. However, if the capabilities from the HCS Framework are incorporated as separate soft skills in the STCW Code, their instilling in seafarers may need additional training and assessment time for the educators and assessors. This may pose to be a hindrance since speed will be essential in delivering work-ready graduates to the seafaring industry which is expected to undergo major transformations due to changing technologies and MASS development.

One possible solution to integrate delivery of soft skills with technical skills is to design innovative authentic assessment pedagogies which require learning and assessment strategies in real-world context or contexts resembling professional and workplace scenarios. Contextual tasks may be found meaningful by the seafarer students due to its strong figurative context and fidelity to the situations that they may find themselves in the professional world (Wiggins 1989). Contextualised authentic tasks may not recreate all the conditions of the workplace but will replicate the complexities and challenges in different scenarios which will require students to integrate a range of competencies for problem-solving and decision-making as in the real world, providing multiple indicators of competence (Frey, Schmitt, & Allen 2012). Seafarer students may then find learning more engaging as they acquire professional skills and enhance their ability to engage in lifelong learning and, and transfer of competence to a range of authentic contexts (Ghosh & Bowles 2013). For example, past research has provided empirical evidence to show that authentic assessment (e.g. simulated emergency scenarios like man overboard), when used to assess seafarers' skills like leadership and problem-solving (Ghosh et al. 2016; 2017), correlated to higher academic achievement and better performance at the workplace (Ghosh et al. 2020a; 2020b).

## 4. Conclusion

As more MASS are launched into the shipping industry, the seafarer employees who have traditionally found employment on non-autonomous ships will find themselves to be driven away from roles replaced by automation. This will require seafarers to upskill themselves allowing them to be relevant in a fast-changing labour market. The current standards of competence for seafarers as outlined by the STCW Code may appear insufficient and require to be supplemented with skills (technical and soft skills) which will allow seafarers to adopt to new roles created due to remote control of ships from shore-based stations. This research does not question the adequacy of the STCW Code in delivering the standards of competence for the current seafarers. Instead, it aims to modify and upgrade it to future requirements of the industry which may be driven and dictated by developments in MASS, digital technologies, and internet of things. The theoretical and analytical research presented in this paper is based on the analogy drawn between the elements of the STCW Code and the HCS framework. The findings of this research paper set out to answer the future dilemma between the need to revise an existing, global standards (STCW Code), the approval of which may find a quick consensus among existing members of the International Maritime Organization (IMO) versus reinventing and building new standards which may become redundant due to possibly delayed regulatory bureaucracy (due to seeking approval from more than 170 maritime nations who are part of the IMO). The theoretical research (based on text analysis) presented in this paper highlights the advantages and challenges of assimilating the HCS Framework (and its associated capabilities) into the STCW Code. Although the text analysis searched for the current existence of the capabilities (or its associated synonyms) in the Code, the possibility of overlooking other synonyms of the search terms should be accepted. Moreover, there may be other soft skills outside the HCS Framework which may be essential for seafarer competence development but were not discussed in this paper. It was also acknowledged that adding more skills to the STCW Code may make it cumbersome. This may be managed if inputs from experts (educators, regulators, employers, seafarers, etc.) are sought in order to recognize and deliver additional training which may fall outside the realm of the STCW Code but essential for seafarers to perform tasks as expected at the future workplace. The HCS Framework, if successfully incorporated into the STCW Code does not fulfil the obligations of the stakeholders or absolve them of further actions. Regular reviews should be scheduled into regulatory practices (e.g., IMO may review the combined document every five years) to identify emerging requirements for workforce development to avoid mismatch of skills. Finally, further research work is required to shed light (through empirical evidence) on the effectiveness of incorporating the HCS Framework into the STCW Code, and on a coherent structure of education and training which may guide the instilling of the required soft skills (together with the technical skills) in seafarers allowing them to be future-ready for employment.

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# Implementing the Human Capability Standards (HCS) Reference Framework for future seafarers: Challenges and Benefits

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**Abstract:** With the rapid advancement in autonomous shipping, the boundaries between functions performed by the seafarers are increasingly blurring as automation reshapes how work is designed. The value of nontechnical, soft skills, and mindsets that cannot be automated are being rediscovered and found valuable by employers seeking new recruits and expecting their seafaring workforce to adapt, learn, and be willing to rapidly shift to fill new roles and ways of undertaking work. Based on a literature review, this paper presents an absence of a suitable framework which addressed the skills gap and aligned the competencies of the current seafarers to those required by the future workforce. This paper also highlights the need to distinguish the seafarers' current competencies from capabilities which specify the personal attributes (mindsets and behaviours) that are required to an applied standard expected in professional practice. To define the missing human capabilities, this paper applied the award winning, globally recognized, and validated Human Capability Standards (HCS) Reference Framework which is backed by over 30 years of research and accepted by Forbes 500 companies. The focus of this paper is to contextualize the framework to the needs of the seafaring industry and identify the challenges facing its implementation.

*Keywords*: seafarer; education and training; MASS; Human Capability Standards; workforce

## 1. Introduction

Since the concept of Maritime Autonomous Surface Ships (MASS) has gained momentum and technological developments related to it have been implemented worldwide in the maritime sector [International Maritime Organization (IMO) 2019], active discussion regarding the reduction of the workforce from ships (seafarers) is also taking place. For example, at Level 1 of autonomy, there will be seafarers on board to operate and control shipboard systems, but at Levels 2 and 3, ships will be controlled remotely with minimum seafarers and no seafarers onboard respectively until at Level 4, fully autonomous ships which are able to make decisions by itself are launched (Sharma et al. 2019). However, it is expected that as the level of automation increases on ships, seafarers will be rehabilitated into new roles (in shore-based control stations) to assist with ship operations for which they will need new skills (Ölçer et al. 2023). For example, unmanned navigational bridge and engine room spaces on ships may not require a seafarer's physical presence at all times but during critical periods inputs for decision-making, problem-solving, and critical thinking may be required from humans until the ships become 'smart' enough to do so on their own.

Current and past research (Bachari-Lafteh & Harati-Mokhtari 2021; Sharma & Kim 2021; Man et al. 2015; Emad, Enshaei, & Ghosh 2021; Hogg & Ghosh 2016; Emad & Ghosh 2023) has focused on identifying the technical or job-specific (information and communication technology, electronic and computer engineering, artificial intelligence, etc.) and non-technical or soft or durable (communication, leadership, and problemsolving) skills which need to supplement the current skills of the seafarers so they may transition smoothly into the new roles expected to be created in the future. However, a framework where the predicted and required skills have been integrated, structured, and validated for industry use has yet to be introduced to the maritime community.

Guided by a research question (Is there a current skills and competency framework for the future-readiness of the seafarers to operate MASS at differing levels of autonomy?), the authors of this paper conducted a systematic literature review to investigate the existence of a current framework which is being used to act as a reference for the training and upskilling of future seafarers. The focus of the search was to especially find a skills framework which outlines soft skills since the technical (or occupational skills) have already been highlighted by the Standards of Training, Certification, and Watchkeeping (STCW) Code which was introduced by the international regulatory body of the International Maritime Organization (IMO) to provide global, minimum standards of competence in 1978 (and subsequently revised in 1995 and 2010 with the latest edition being from 2017) (IMO 2011).

In the absence of an existing skills and competency framework which may be used to upskill future seafarers involved in MASS operations, the authors of this paper suggest extracting the non-technical skills from the award winning, globally recognized, and validated Human Capability Standards (HCS) Reference Framework (or HCS Framework) which has been successfully deployed by over 200 companies listed in the Australian Stock Exchange and global Forbes 500 companies across multiple industries and companies within commercial, government, and not-for-profit sectors (Working Future 2020). A capability framework is used by organisations to reveal and nurture the capabilities (skills, knowledge, and personal attributes) required by the individuals to perform the workplace tasks in a range of contexts and their future potential to adapt to changing requirements (Bowles & Britt 2023). This was proved in past empirical studies (Bowles, Ghosh, & Thomas 2020; Reynolds, Bowles, & Ghosh 2023) which found high correlation between selected capabilities from the HCS Framework and employee workplace performance in popular banking (Australia & New Zealand Bank) and telecommunications (Telstra) industries in Australia.

The HCS Framework was chosen due to the fact that it is based on more than 30 years of research and dedicated to identifying the human capabilities that are most predictive in creating a future-ready workforce, thus, making it the right fit to be used in the maritime industry struggling to guide its current and future employees towards an unpredictive future driven by fast evolving technologies. The Framework is based on the use of a data mining approach harnessing Latent Dirichlet Allocation (text-analysis model) to systematically investigate definitions of skills, behaviours, competencies, and capabilities used by organisations, educational providers, and national regulatory bodies that classify future jobs and skills. The maritime industry can use the HCS Framework as a benchmark to confirm gaps or accelerate the authoring of new additions to the STCW Code. Figure 1 depicts the HCS framework.


Figure 1. The Human Capability Standards (HCS) Reference Framework (Bowles & Britt 2023)

However, the research presented in this paper argues that although the HCS Framework has been accepted by the workforce of other industries (e.g., banking, telecommunications, community real estate, etc.) the benefits and challenges for doing so in the maritime industry needs to be discussed. This is because although the Framework provides the standards, the definitions of the capabilities and the assessment of their application needs to accommodate the expectations, culture, and values of the maritime industry.

This paper presents the findings of an analytical research conducted through a systematic literature review to shed light on the skills frameworks which are available as options for the maritime industry to adopt or contextualize to its needs for the purposes of education and training. Guided by a secondary research question (What are the challenges and benefits of incorporating the HCS Framework into seafarer training?), this research paper also reveals the findings of a theoretical study of the HCS Framework to highlight how the maritime industry can gain from the advantages presented by the Framework, and overcome the hurdles for its practical assimilation. Having a practical and usable framework which may be used directly or modified to the needs of the industry will provide an edge to the maritime industry looking to expedite the readiness of the workforce towards responding to an uncertain labour market.

## 2. Literature Review

### *2.1. Search criteria*

The first stage of the identification of the literature involved keyword searches in the databases of Scopus, Web of Science, and PubMed. To reveal the existence of a current skills and competency framework which is being used in the context of the maritime or seafaring industry to upskill its workforce, a population of published peer-reviewed papers that mentioned the key terms and Boolean operators was sampled. The Boolean operators used the key terms and phrases like skills and competency frameworks, MASS, autonomous ships, unmanned ships, maritime, shipping, and seafarer. Terms like seafarer, marine, and maritime were truncated to include all possible versions of the word. For example, the term 'maritime' generated literature from aspects of maritime business not necessarily focused on the seafaring industry (such as shipping and port logistics) and terms like marine and mariner generated literature mostly from the military because of which the terms were removed from the final search. The Boolean operators used are summarised in Table 1, along with the number of hits.

Table 1. Stage 1 of the literature review.

| Boolean Operators | Scopus | Web of Science | PubMed |
|---|---|---|---|
| "skills and competency framework" AND (maritime OR shipping OR seafarer*) AND "autonomous ships" AND "unmanned ships" AND MASS | 0 | 0 | 3 |
| "skills framework" AND (maritime OR shipping OR seafarer*) AND "autonomous ships" AND "unmanned ships" AND MASS | 1 | 0 | 0 |
| "competency framework" AND (maritime OR shipping OR seafarer*) AND "autonomous ships" AND "unmanned ships" AND MASS | 5 | 5 | 1 |

### *2.2. Inclusion and exclusion criteria*

After the systematic search, inclusion and exclusion criteria was used to select the papers for this review. Peer-reviewed papers were included if skills and competency frameworks were discussed (design, development or implementation of the framework) in the context of the maritime, seafaring or shipping industry. Conversely, the papers that did not meet the inclusion criteria were excluded. Also, the search was not restricted by year of publication, study design or any further factors, but language (only papers written in English were included for review). After removing duplicates that were identified by the three databases, the papers were screened in two phases: first the title and abstract, and second the full text of the papers. A total of four papers were included in this review, which were diverse in type of study, geographic location, approach, and field of publication.

### *2.2. Findings of the literature review*

The initial search of existing skills and competency frameworks used in the context of the maritime, shipping or seafaring industry revealed a global absence of it. Although, Popova & Yurzhenko (2019) discussed a competency framework as an instrument to assess professional competency of future seafarers, it focused only on communicative competencies in the English language course for future ship engineers. Thus, the framework was limited to a specific skill and to a specific sector of professionals within the industry which makes it hard to adapt to the broader workforce (or other skills). Skills and competency frameworks must be relevant across the entire spectrum of the profession covering all roles (Bowers & Sabin, 2023). The other papers included for the analysis revealed past research where relevant competencies were outlined for maritime professionals such as maritime business educators (Yuen, Tan &Loh 2022), container shipping logisticians (Thai & Yeo 2015), and maritime logistics executives (Li et al. 2023). However, no frameworks were found which may be used directly or as a reference to be used to upskill the future seafarers so they may adopt to new roles and occupation created due to increasing automation.

## 3. Challenges and benefits of incorporating the HCS Framework into the maritime industry

Since the literature review revealed a global absence of skills and competency frameworks for the use of upskilling the seafarers to make them future-ready, the authors of this paper chose the HCS Framework since ‘capability’, as a term, was introduced in the mid to late 1990s for workforce development so organisations may respond to rapidly changing environments to assure viable futures (Bowles 2023). Due to technological advancements in MASS, the seafaring industry is facing similar, rapid changes in ways ships will be operated and it is crucial for the employees (i.e., seafarers) to be upskilled for the maritime business to remain operationally sustainable. Since the technical skills are currently being defined by the STCW Code, the HCS Framework can be used as a guide to extract the soft skills so they may be included in the Code. Although, there have been other capability frameworks or models (for example, the Deakin Co, Professional Capability Standards), ultimately, all of them defined the non- technical skills required to be successful at the workplace. This is because soft skills are non-technical skills which may be implicit and observed in workplace contexts or social settings through interpersonal interaction only, capabilities may be defined as an innate quality of an individual to integrate, build, and reconfigure their technical and non-technical skills when performing workplace tasks (Bowles 2023). However, before the HCS Framework is incorporated into the STCW Code, it is imperative to draw up the challenges and benefits of doing so to ensure a smooth transition.

### *3.1. The need for the HCS Framework and the STCW Code to co-exist*

The STCW Code is divided into two parts where Part A provides mandatory standards and Part B contains recommended guidance intended to help implement the Code. It is part A of the Code that lays out the standards of competence in the STCW Code which are categorized under seven functions (navigation; cargo handling and stowage; controlling the operation of the ship and care for persons on board; marine engineering; electrical, electronic and control engineering; maintenance and repair; and radio communications) where each function is a group of tasks necessary for safe ship operations, and each function is divided into three levels of responsibility (support, operational, and management) (Ghosh et al. 2014a). Each function comprises of individual units of competence for the assessment of each individual unit of competence, the STCW Code specifies the required knowledge, understanding, and proficiency (KUP); methods for demonstrating competence; and criteria for evaluating competence (Ghosh et al. 2014b).

Conversely, the HCS Framework lists 13 essential capabilities which may be included in the STCW Code as soft skills. The lists includes Adaptive Mindset, Agile & Innovation, Collaboration, Communication, Creativity, Critical Thinking, Customer Focus, Direction & Purpose, Empathy, Engagement & Coaching, Ethics, Problem Solving & Data, and Leadership. Each capability is described together with its title, description, positive and negative indicators, levels of proficiency, and criteria indicating proficiency. An example of this is provided for the capability of Creativity in Table 2 below.

Table 2. An example of how a capability is outlined in the HCS Framework (IWF 2020).

| | |
|---|---|
| Title | Creativity |
| Description | Able to actively contribute to creative works, ideas or novel solutions. |
| Indicators of proficiency | Uses imagination to see things differently.<br>Flexibility in thinking and approach.<br>Is an original thinker and can think ‘outside; the box.<br>Embraces new ideas or practices.<br>Harnesses personal insights and intuition.<br>Encourages others to share creative inspirations and ideas. |

| | |
|---|---|
| Indicators of development need | Seeks to conform more than be original.<br>Lazy and unmotivated to examine new or novel solutions.<br>Doesn't see the need to be original or new.<br>Sees creativity as too risky.<br>Narrow minded and prefers to avoid using intuition or unscientific methods. Seldom promotes or encourages others to share creative ideas and inspirations |
| Levels | Level 1: Generates and captures personal ideas; Examines problems, ideas and situations from different perspectives, Works with others and seeks feedback to refine ideas.<br>Level 2: Explores different ways people think and are creative; Contributes to developing and testing new ideas and concepts; Explores and integrates new knowledge or ideas into practice<br>Level 3: Encourages imaginative and innovative solutions to problems; Develops designs, concepts or solutions that meet requirements; Appreciates and uses techniques to harness creative input from different people.<br>Level 4: Implements systematic approaches to the conduct of creativity; Establishes mechanisms for managing and reviewing creative ideas; Coordinates and cultivates creative process to bring together diverse perspectives.<br>Level 5: Creates a climate that fosters and encourages creative thinking; Promotes creative processes within and across projects or teams; Champions breakthrough solutions<br>Level 6: Challenges existing paradigms and practices; Stimulates and sponsors creative endeavours; Takes calculated risks when trialing new ideas or designs.<br>Level 7: Leads thinking and research into new designs, concepts or ways of thinking; Establishes actions to document and share creative processes; Champions a culture that embraces creativity. |

Table 2 shows that the HCS Framework provides the advantage of describing each capability to standards which may be used as benchmarks for achievement by employers, educators, assessors, and regulatory bodies and for seafarers to inculcate in themselves at different stages of career progression. The description provided for each capability may be emulated for the technical skills outlined in the STCW Code as well. This will ensure that both technical and soft skills are described to provide clear, unambiguous guidelines for future skills development. However, the challenge will be to incorporate the expansive HCS Framework as it is or expand the STCW Code to fit in new descriptions of skills as doing so will make the Code cumbersome to use. Moreover, each capability would need to be contextualized to the needs of the maritime industry and the roles to be performed by the seafarers in occupations they may find themselves in the future. For example, the nontechnical skill of 'Communication' for MASS operators may be defined (Ghosh & Emad 2023) as below in Table 3:

Table 3. Example of how competencies may be defined for MASS operators

| Title | Communication |
|---|---|
| Definition | MASS operators must evidence the ability to communicate operational breakdowns and technical specifications of machinery and equipment both onboard ships and in the Shore Control Centres. The MASS operators must be able to develop knowledge and information and share within and across locations, functions, or projects. |
| Key Behaviours | Establish mechanisms to analyse, evaluate, and report information;<br>Coordinate the management and sharing of information and knowledge across departments and across disparate geographical workplaces. |

*3.2. The need to recognize and isolate the soft skills which should be inculcated in seafarers*

Although the HCS Framework may guide the STCW Code towards the inclusion of new soft skills, it will be the duty of the educators and assessors to provide training and assess seafarers respectively to ensure the successful inculcation of the skills to expected standards. Doing so (whether separately from technical skills or in combination) will require more time and add to the workload of the people involved. An alternative would be to do a pre-assessment of the soft skills already inculcated in the seafaring students due to past professional experience, prior learning, or absorption due to social interaction at workplace or in society. For example, Reynolds et al. (2023) explains how 1477 employees in Telstra were asked to participate in a psychometric test (Telstra Future Ready Insights tool or FRIQ) to gather data on the level of capability inculcated in them before targeting the areas that needed to be worked upon through training at the workplace. In the context of seafarer training, students may demonstrate the application of 'Ethics' as a capability through past evidence collected during shipboard operations such as cargo loading and discharging or transfer of fuel oil from bunker barges while adopting practices to protect the marine environment from pollution which may be caused by unauthorized discharges from ship's tanks. This will ensure that employers are investing their resources correctly to upskill the employees and not wasting time and money on reinforcing skills which were present to levels at or beyond those required for a particular role or responsibility.

*3.3. The need for various stakeholders to contribute towards the successful implementation of the HCS Framework*

The seamless integration of the HCS Framework into seafarer training will require the involvement of maritime stakeholders (e.g., regulatory bodies, training institutes, employers, and educators). The stakeholders are positioned to provide guidance in order for the Framework to adapt to change or uncertainty expected in the future due to MASS operations. For example, employers should be motivated in the recognition of untapped or undeveloped skills and inner abilities that have not been deployed in the current role of their seafarer employees. Thornhill-Miller et al. (2023) suggested a practical solution to implement a large-scale administration of a comprehensive series of skill-measuring psychometric tests on different cross sections of the workforce. For example, the Institute of Working Futures implemented a psychometric test with the employees of Telstra, one of the largest telecommunication organization in Australia, to find the behaviours that correlated the most with high performance in the organization (Reynolds et al. 2023).

As stated in Section1 (Introduction), the HCS Framework is based on ongoing research conducted over the last 30 years. Due to this, the Framework has undergone several revisions and modifications to ensure successful implementation in organizations and industries. For example, the HCS Framework outlined in Figure 1 of this paper is the fourth version (Bowles & Britt 2023). Once the Framework is integrated into the STCW Code for seafarer training, it would still have to be reviewed with every generation of workers and the changing nature of the maritime industry to avoid a mismatch between the current supply and the future demand of skills. Regulatory bodies (e.g. IMO) and educators should play a key role in reviewing the Code and the HCS Framework at periodic intervals and delineating performance outcomes and proficiency at each level of work or career progress as they evolve.

## 4. Limitations and Future Research

Th findings of this paper are based on a systematic literature review based on the search of papers though the use of three databases (Scopus, Web of Science, and PubMed). It should be acknowledged that the decision to use certain Boolean operators and selective databases may have restricted the discovery of articles. For example, during the literature analysis, the authors discovered terms like 'models' and 'components' which could have been used along with 'frameworks' and 'characteristics' for an initial search of articles. Although, in this case, the authors attempt to retrieve more articles using these terms did not result in new results, the possibility of overlooking synonyms of search terms should be accepted.

Future research will require investigation into the soft skills that will correlate to high performance for seafarers in their new roles and occupations since past research has not done so in the context of the seafaring industry. This will be challenging until new the new roles are well-defined and the associated job descriptions are clear. So far, there have been only speculations and predictions that have not provided a clear picture on how the current seafarers will transition into the workforce which will manage and operate ships from shorebased control stations. It will also be a daunting task for researchers to correlate high performance at the workplace to selected soft skills for seafarers who will be performing functions on the ships due to issues with accessibility, and difficulty with isolating technical skills from soft skills.

## 5. Conclusion

The autonomous and unmanned systems will transform how ships will operate and the nature of work of the seafarers who currently find employment on them. Unless the current and future seafarers possess the required skills and technical expertise to identify automation failures and rectify them as required, systems built on technology may have a negative consequence on human performance. This may hold especially true for current seafarers who will have to transition (from ship-based ranks and positions) into new roles in shore-based control stations. Hence, the value of a skill and competency framework or a capability framework which will guide the development of the required skills cannot be understated. However, the frameworks cannot be considered as ends but means to ensure that the innate potential of seafarers is cultivated to perform the traditional shipboard tasks while being responsive to future opportunities and challenges arising from the advent of MASS. This is because as frameworks evolve, so will the capabilities, making it a continuous process. The aim of the frameworks should also be to enhance the adaptive capacity of the workforce and thus of the maritime industry. Capability building will also require innovative training and assessment methodologies. Attachment to archaic practices will assess skills, knowledge, and personal attributes developed in classrooms and not latent potential which should be tested using a scientific and validated instrument capable of doing so (e.g. a psychometric test). Going into the future, seafarers should not be considered merely as a source of labour but a pool of talent which needs to be aligned to the purpose and long-term strategic goals using amplified efforts. Doing so will liberate the maritime workforce capacity and accelerate the delivery of the required skills in the future.

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# Utilizing the Bayesian network in near-miss reporting at sea

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**Abstract:** Learning from near-misses is one of the possible solutions to reduce the occurrence of marine accidents to a minimum. Therefore, the near-miss reporting is necessary. According to some research, not all observed near-misses are reported in shipping, although reporting at the company level is mandatory. This paper tries to identify the most significant near-miss reporting barriers in shipping and proposes measures to improve reporting. The expert judgment was combined with the available literature review to determine the factors that prevent reporting. Then, the Bayesian network was used to develop a near-miss reporting model. The factors recognized as the most influential are *near-miss definition*, *lack of shipboard leadership support*, and *safety-related training.* The results showed that if the probability that all crewmembers know the near-miss definition, that they all had adequate safety training and that the shipboard leadership supports reporting increases to 100%, the probability of reporting increases from 55% to 75%. Accordingly, training on a near-miss definition for crewmembers and leadership training focusing on reporting, together with safety training and familiarisation with the shipboard near-miss management system, including near-miss as one of the topics of monthly safety meetings, could be beneficial and are proposed to increase near-miss reporting significantly.

*Keywords*: maritime safety; near-miss; organisational learning; reporting barriers

## 1. Introduction

To reduce the number of marine accidents and prevent their recurrence, it is necessary to discover their root causes and then eliminate them or reduce their impact (Barnett, 2005). The first steps towards reducing the number of accidents are reporting (accidents and near-misses) and investigation (Berg, 2013). The analysis of maritime accidents represents an active approach to reducing accidents. Accidents that have already occurred are investigated to discover their root causes and bring about corrective actions that would diminish the risk of such accidents in the future. According to Gnoni and Saleh (2017), near-misses are precursors to accidents; therefore, near-miss investigation and analysis present a proactive approach to reducing accidents. According to the definition of the International Maritime Organization (IMO, 2008), "a near-miss is a chain of events that could have led to some damage. Actual damage is prevented only by a lucky break in the sequence of events. The unrealized damage could be, for example, an injury, environmental pollution, or a negative impact on the company's operations" (Vepsalainen & Lappalainen, 2010; Craig et al., 2014). "Near-misses can include inadequate training, human error, flawed or poor design, management errors, flawed procedure or system, unintended outcome, or any combination of the above" (Craig et al., 2014).

Near-misses can be regarded as leading indicators of the company's safety performance (WSHC, 2016). Organizations that do high-risk jobs must not allow accidents to happen but must try to prevent them from happening. One of the ways to prevent accidents is to develop effective systems for managing near-misses. Near-misses can thus be used for learning and hence prevent the possible occurrence of accidents (Vastveit et al., 2015). The International Safety Management (ISM) Code obliges companies to create their own Safety Management Systems (SMS) to improve safety culture. According to the IMO, safety culture can be improved through continuous improvement of the SMS. In addition, reporting accidents and near-misses is one of the SMS requirements (IMO, 2010).

According to the IMO, reporting near-misses is an integral part of the continuous improvement of the safety management system (IMO, 2008; 2010). In October 2008, the Maritime Safety Board and the Marine Environment Protection Board considered the problem of reporting near-misses and promoting a just culture and issued a circular to encourage near-miss reporting. Companies should investigate near-misses as a regulatory requirement in the "Hazardous Occurrences" section of the ISM Code (IMO, 2008). All signatory countries of the ISM Code must implement it on ships flying their flag of affiliation. According to the ISM Code, near-misses must be reported from ships, and companies should investigate and analyze reports (IMO, 2008). In this way, the reporting and investigation of maritime near-misses is legally regulated.

Unfortunately, according to some studies, accidents and near-misses are not reported nearly as well as they should be (Psarros et al., 2010; Oltedal & McArthur, 2011; Hasanspahić, 2019; Hasanspahić et al., 2020). Therefore, this study aims to investigate factors inhibiting near-miss reporting in shipping and propose measures to enhance it.

## 2. Methodology

To identify near-miss reporting barriers in maritime, authors searched through existing literature. The Web of Science (WoS) and Scopus databases using the keywords "near-miss" and "maritime" have been searched. There were 27 papers found in WoS and 68 papers in the Scopus database. Then, all the abstracts were carefully analyzed, and seven papers relevant to this research topic were found in the WoS database, and six papers in the Scopus database were found. Some papers were in both databases (five of them), so in the end, there were nine papers dealing with near-miss reporting barriers in maritime. However, to broaden the search and find more literature on the topic, the Google Scholar database was searched with the same keywords, and five more papers were found. Then, the collected papers were read and analyzed to identify near-miss reporting barriers in shipping. In addition, besides barriers to reporting, the factors that aid reporting were identified and taken into account. Then, it was decided to use the Bayesian network to estimate the probability of near-miss reporting on board a ship, given the identified barriers and aids to reporting.

Bayesian networks belong to the family of probabilistic graphical models and are a powerful and adaptable tool that can be used to display models of causal interrelationships between certain variables. Such graphic structures are used to display knowledge about an uncertain area (Ben-Gal, 2007). Each Bayesian network consists of two parts: quantitative and qualitative. The qualitative part consists of nodes representing variables or factors and arcs connecting the nodes and representing probabilistic dependencies between certain variables within the model. Bayesian networks consist of nodes that can be parent nodes or child nodes (Heckerman et al., 1995). That part of Bayesian networks is a directed acyclic graph. The quantitative part consists of conditional probabilities tables (CPT), determining the exact relationships between variables (Ben-Gal, 2007; Mohammadfam et al., 2017). The probabilities of different states of a given child node are determined using tables of conditional probabilities according to the various state configurations of its parent nodes (Mohammadfam et al., 2017).

When creating Bayesian networks, it is possible to use two sources of data: expert opinion and statistical data (Langseth & Portinale, 2007). Because data on near-miss reporting is scarce, expert opinion was used as a data source. For such a system to be effective, it is necessary to determine all the factors affecting it and place them correctly within the model graphically. Assigning "a priori" probabilities to the states of the parent nodes is essential to determine the conditional probabilities of the target node (Langseth & Portinale, 2007). Therefore, after identifying the barriers and aids mentioned in the literature, six experts in shipping (all master mariners with more than ten years of experience) were interviewed to determine the most influential barriers and aids to reporting on board ships. Mutual connections between the nodes of the model were established using available literature and experts' opinions, and the probabilities of individual parent nodes were estimated using experts' opinions. The authors developed the model using the GeNIe Bayesian network modeling tool (BayesFusion, LLC). CPTs include entries for all available child and parent node state combinations. If a certain child node has *n* parent nodes, and they all have *m* possible states, the total number of combinations of the CPT becomes $m^n$. For example, if the child node has eight parent nodes, and each of them has two possible states, the number of combinations of states within CPT becomes $2^8 = 256$, making expert eliciting challenging and timeconsuming (Kokkonen et al., 2005). To facilitate that procedure, it is possible to use the parent divorcing method to split parent nodes by introducing intermediate nodes. In that way, it is possible to reduce the number of entries in the target node's CPT (Röhrbein et al., 2009).

**3. Results**

Based on a literature review, 22 factors were identified as barriers to reporting and four factors were identified as aid to reporting near-misses. After interviews with experts, eight factors (barriers and aids) were identified as the most influential in reporting near-misses on board ships. Those factors were *near-miss definition* (Erdoğan, 2011; Lappalainen et al., 2011; Hasanspahić et al., 2020), *safety-related training* (Oltedal & McArthur, 2011), *embarrassment* (van der Schaf & Kanse, 2004; Erdoğan, 2011; Lappalainen et al., 2011; Bhattacharya, 2019; Hasanspahić et al., 2020), *unwillingness to create problems for colleagues* (Köhler, 2010; Rasmussen et al., 2013; Bhattacharya, 2019), *feedback on reported near-misses* (Oltedal & McArthur, 2011; Storgård et al., 2012; Kongsvik et al., 2012; Rasmussen et al., 2013), *increased workload* (van der Schaf & Kanse, 2004; Köhler, 2010; Erdoğan, 2011; Lappalainen et al., 2011; Bhattacharya, 2019; Ghonaim, 2020), *complexity of reporting form* (Lappalainen et al., 2011; Rasmussen et al., 2013; Georgoulis & Nikitakos, 2019; Hasanspahić et al., 2020; 2021) and *lack of shipboard leadership support* (van der Schaf & Kanse, 2004; Erdoğan, 2011; Lappalainen et al., 2011; Haas & Yorio, 2019; Ghonaim, 2020; Hasanspahić et al., 2020; 2021). However, eight parent nodes and one child node, each with two possible states, make a large CPT. Therefore, the parent divorcing method was used, and four intermediate nodes were introduced (*near-miss identification*, *personal factors*, *management* and *reporting procedure complexity*, as shown in Figure 1). In that way, the number of combinations of states in CPT was reduced from 256 to 16. It makes expert elicitation much more manageable and reduces possible errors.

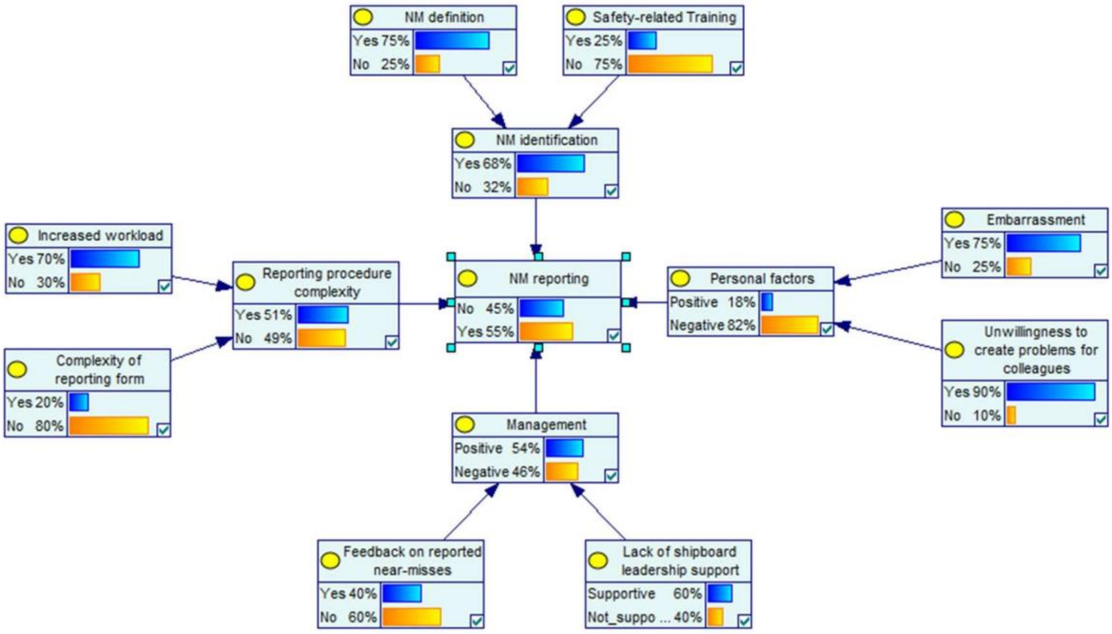


Figure 1. Near-miss reporting model.

According to expert opinions, the probability of a near-miss being reported given all chosen factors probabilities is 55% (Figure 1). Therefore, it can be concluded that valuable knowledge that could help prevent marine accidents is being lost through unreported near-miss events. There is a need to improve reporting, enable learning, and introduce preventive actions instead of corrective ones (after accidents). One way to achieve this is to analyze the proposed Bayesian network, find the most influential nodes and act on them.

**4. Discussion**

The Bayesian network performance is verified through sensitivity analysis, verifying the influence of slight changes of the network nodes (near-miss reporting factors) on the end node, which is *near-miss reporting* in this study (Castillo et al., 1997). Highly sensitive nodes have a noteworthy impact on the target node. After selecting the so-called "target node" (in our case, *near-miss reporting*), the algorithm determines which nodes within the constructed Bayesian network have the highest sensitivity (and significantly affect the target node). Accordingly, a slight change in highly sensitive node probability may lead to a significant change in the posterior probabilities of the target node. However, if the node sensitivity is small, then even significant changes in this node make insignificant differences in the posterior probabilities (BayesFusion, 2023).

Bright red color nodes influence the target node more than pinkish-colored nodes. As shades of red show, *near-miss definition*, *lack of shipboard leadership support*, *safety-related training* and *unwillingness to create problems for colleagues* are the most sensitive parent nodes (Figure 2). In addition, intermediate node *nearmiss identification* is highly sensitive as well. Therefore, acting on these nodes might significantly improve the reporting of near-miss events in shipping.

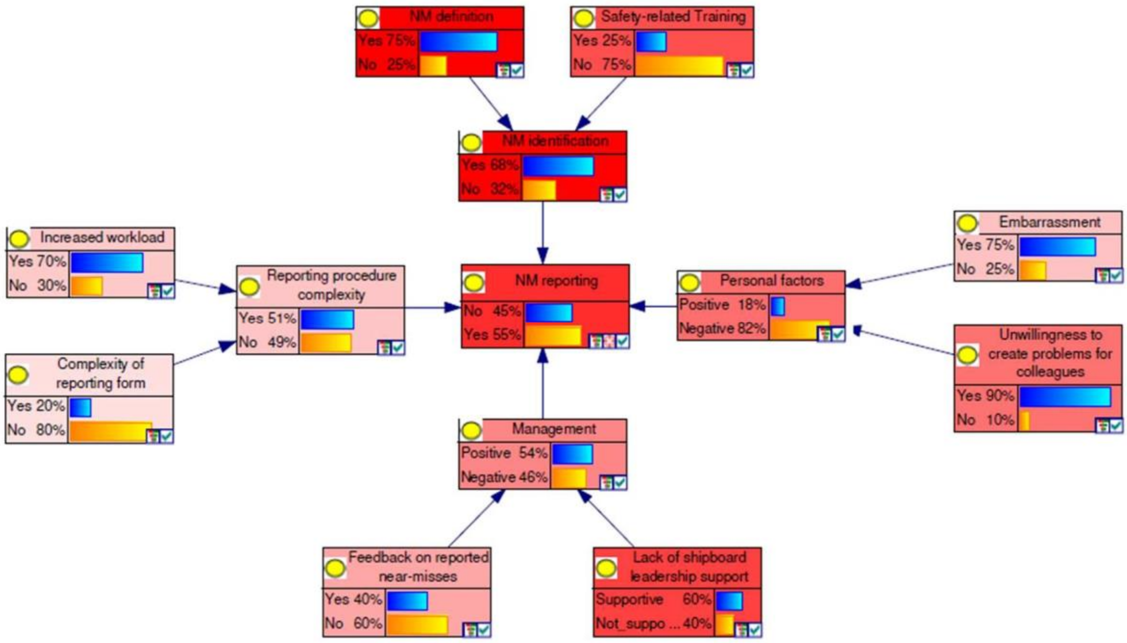


Figure 2. Sensitivity analysis for the near-miss reporting model with the selected target node *Near-miss reporting*.

To corroborate that finding, a tornado diagram is presented in Figure 3.

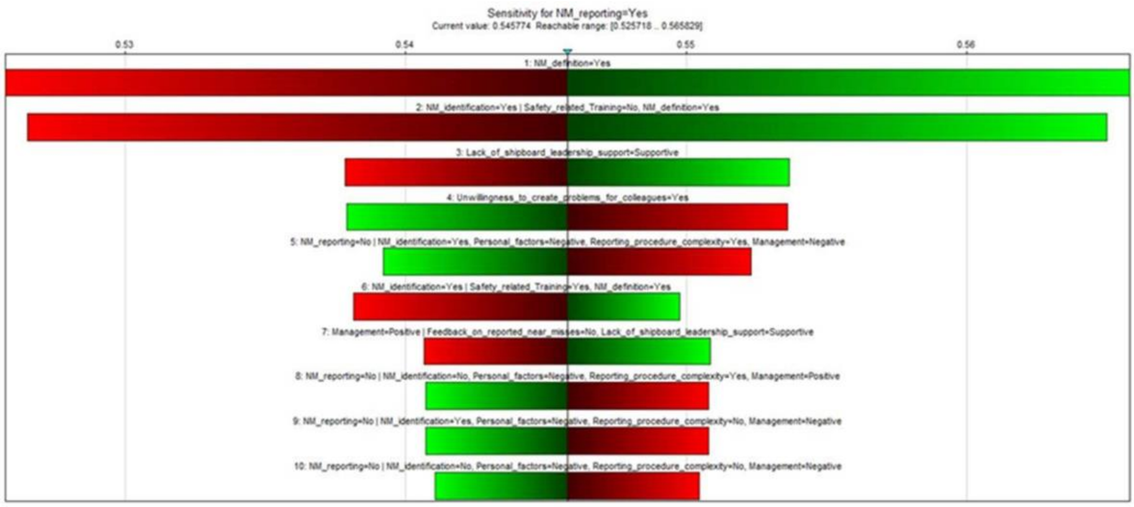


Figure 3. Tornado diagram in the sensitivity analysis.

The horizontal axis shows the change in the posterior probability of near-miss reporting when each parameter changes by 10%. The target value range shows the selected target node's minimum and maximum posterior probability values. For example, if *the near-miss definition* (state "yes") is increased by 10%, then the posterior probability of *near-miss reporting* (state "yes") will increase to 57%. Nevertheless, if the *near-miss definition* (state "yes") is increased to 100% (if all crewmembers would know what constitutes a near-miss event in all shipboard departments and areas, and they can recognize it), then the posterior probability of near-miss reporting (state "yes") will increase to 61%. In addition, if *unwillingness to create problems for colleagues* (state "yes") is reduced to zero, and *lack of shipboard leadership support* (state "supportive") is increased to 100%, then the posterior probability of near-miss reporting (state "yes") increases to 75%. However, acting on seafarers' sensitivity to their colleagues might not be easy. Therefore, if we focus on what might be more easily achievable goals, such as improving feedback on reported near-misses, in combination with making aware shipboard leadership that their engagement and role modeling might improve reporting, and conducting frequent (if necessary) safety-related training where benefits of reporting will be additionally explained, together with ensuring that all crewmembers are knowledgeable on near-misses, reporting might considerably increase. Therefore, if nodes near-miss definition (state "yes"), lack of shipboard leadership support (state "supportive"), safety-related training (state" yes") and feedback on reported near-misses (state "yes") are increased to 100%, near-miss reporting posterior probability (state "yes") increases to 74%. This significant increase in reporting probability, if achieved, could lead to a substantial reduction in the occurrence of marine accidents.

## 5. Conclusions

The experts' elicitation, in combination with the literature review, resulted in eight factors significantly affecting near-miss reporting. Based on expert elicitation, a Bayesian network was constructed, and sensitivity analysis revealed factors significantly affecting the conditional probability of *near-miss reporting*. By acting on them, the conditional probability of the target node can be optimally increased, thus improving the reporting onboard ships. Improving crewmembers' knowledge of near-misses and showing them the benefits of near-miss reporting contrary to the loss of valuable insights into near-miss root causes could significantly improve reporting onboard ships. Therefore, crewmembers' knowledge of near-misses could be improved through shorebased and onboard training focusing on shipboard near-miss management systems (NMMS), where near-miss definition together with practical examples would be given. Shipboard monthly safety meetings could be used for discussing near-misses and corrective measures that could be implemented. Maritime education and training (MET) institutions could focus more on NMMS in shipping, thus providing appropriate knowledge to their students and future seafarers. Adequately performed safety-related training, including those related to managing near-misses, could significantly improve reporting as well. Therefore, shipboard familiarisation procedures should include familiarisation with NMMS. Crewmembers should be made familiar with near-miss definition and reporting procedures (paper or electronic form). Nevertheless, it has to be mentioned that the prerequisite for reporting is implemented just culture on board the ship and within the shipping company. If blame culture exists, some other personal factors might emerge and hinder reporting. Shipboard leadership should be supportive of near-miss reporting, and therefore, near-miss training or a de-briefing before embarking on a ship for the ship masters, chief engineers, and safety officers is considered to be effective in encouraging reporting.

This study did not consider the unofficial obligation of near-miss reporting from companies, which could potentially mislead researchers as fabricated near-miss events could be reported just to fulfill the numbers of reports, and thus, wrong conclusions could be drawn. In addition, seafarers could perceive near-miss reporting as unnecessary paperwork and not as a tool for safety improvements. Therefore, future studies should continue to investigate this issue.

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# Social Entrepreneurship – a Challenge for the Maritime Business in the Republic of Bulgaria

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**Abstract:** The revolutionary transformation of the maritime industry due to digitization, decarbonization and efforts to achieve sustainability, predetermine new trends in the development of knowledge and entrepreneurship practices. In response to the new environmental, social and economic challenges, it is required to implement innovative models for the sustainable functioning of maritime supply chains, aiming to effectively increase the well-being of people, environment protection, and the wealth of companies. Social entrepreneurship has a significant contribution to achieving sustainability in the maritime sector through the cooperation between stakeholders to solve current issues in an innovative way. In accordance with the efforts of the world community to achieve the set goals for sustainable development, the article presents results and analyzes of the sustainable aspects, dependencies and contributions of the correlation "social entrepreneurship - maritime business". The research includes managers of 50 companies with many years of experience in the maritime business having a strategic role in the sustainable management of the supply chain on the territory of the North-Eastern Planning Region of the Republic of Bulgaria. The pilot study, including a survey and indepth interviews, has established the attitudes of the management in the Republic of Bulgaria towards social entrepreneurship and the mechanisms for the implementation and stimulation of the social entrepreneurship activity in maritime companies. Statistical software XLSTAT 2024 has been used to identify and analyze dependencies between the factors of interest. Analyzing the data from the study, both the contributions and the problematic aspects of social entrepreneurship have been established regarding the development of sustainable supply chains in the maritime sector of the Republic of Bulgaria through the achievement of social, environmental and economic goals. Specific guidelines for the development of the correlation "social entrepreneurship - maritime business" and for the stimulation of social - entrepreneurial activity in the maritime industry are presented in the conclusion.

*Keywords*: social entrepreneurship, social innovations, social entrepreneurs, maritime business

## 1. Introduction

The revolutionary regional and global transformation of the maritime business predetermines new trends in the development of entrepreneurship, related to the creation and implementation of innovations and contributions to the solution of significant social and economic problems (Bhide 2019). As a result of current challenges in recent decades, the issues of social entrepreneurship and innovation have gained importance among maritime business organizations in Bulgaria and around the world (Hämäläinen et al. 2007). The reasons for this are related to the phenomenon of "social entrepreneurship", acting as a mechanism to promote creativity, as well as to unlock processes of social transformation and innovation within and outside maritime organizations (Goldsmith 2010; Lumpkin et al. 2018). The accumulation of a critical mass of research on the role of social factors in the maritime business highlights the reasons for introducing new governance mechanisms to ensure the achievement of the desired sustainable social impacts in the maritime business.

In accordance with the derived prerequisites for future development, the aim of this article is to research and analyze social innovations and factors responsible for sustainable social entrepreneurship of the maritime business in the Republic of Bulgaria. The accomplishment of this objective in an empirical plan will allow a better knowledge of the object and the context in which social entrepreneurship is implemented, as well as will form guidelines for the effective encouragement of the social and entrepreneurial activity of the maritime business. In an applied aspect, the article presents a research of the rational correlations between social entrepreneurship and sustainable supply chains in the maritime business. These correlations can be studied from different perspectives, including economic, environmental and social dimensions (Dees 1998). The economic dimension explores the role of social entrepreneurship in the development of sustainable supply chains by creating innovative business models in the maritime sector that prioritize social and environmental objectives alongside economic ones (Austin et al. 2006; Zahra et al. 2009). In an environmental aspect, social entrepreneurship can promote the implementation of sustainable maritime practices within supply chains, leading to a reduction in environmental impact and resource consumption (Elkington 1997; Seelos and Mair 2007; De Bruin et al. 2023). This environmental dimension is of key importance in the modern world from the standpoint of climate change, the extinction of biological species and entire populations in the seas and oceans, and water pollution. In the third place, social prerequisites analyze the importance of social entrepreneurship in solving social problems within supply chains, such as: fair labour practices in the logistics business, poverty reduction, immigration, corruption and the development of societies (Mair and Marti 2006; Short et al. 2009; Dacin et al. 2010). Last but not least, social entrepreneurship could promote the development of sustainable supply chains in the maritime business through innovative cooperation between all parties concerned - companies, citizens, public institutions, etc. (Kamaludin et al. 2024).

While examining these dimensions and related literature, it becomes obvious that social entrepreneurship plays a key role in promoting sustainable supply chains through its economic, environmental and social contributions. Collaboration and integration between social entrepreneurs and various parties concerned is vital to achieving the long-term sustainability goals in the maritime business. In this plan, for the purposes of the present study, social entrepreneurship is defined as a set of socially responsible practices of business, or engaged in partnership with business, aimed not so much at the accumulation of profit as at the search for alternative strategies for the formation of modern sustainable approaches, principles and practices for creating social and economic goods (Dees 1998; Mair et al. 2005).

In view of the Bulgarian reality, the correlation “social entrepreneurship - maritime business” has another significant application. The European structural funds are of particular importance for the development of Bulgarian maritime companies. The targeted aspects of the structural funds for our country are related to supporting companies and regions lagging behind in their development; economic and social reforms; adaptation and modernization of policies, etc. (Narlev 2014). The possibilities for accumulating resources from the maritime business in the indicated directions should be based on innovative, as well as digital social entrepreneurial strategies and skills based on knowledge, innovation and creativity (Mednikarov et al. 2022; Stefanova and Kanev 2022; Mallam et al. 2022). The aforementioned aspects and the role of social entrepreneurship in achieving them are poorly studied in the scientific literature.

With the aforementioned challenges, knowledge on the subject “social entrepreneurship - maritime business” has been enriched and developed. However, in the scientific literature and practice there are discussions about the criteria for evaluating the correlation we are interested in and the limits of its manifestation (Wei-Skillern 2007; Nicholls 2018). The discussions are largely based on the lack of universal principles and rules for the implementation of social entrepreneurship in various sized maritime companies and the degree of development of regions, communities and societies.

## 2. Methodology of the study

The choice of methodology refers to the need to study and analyze the sustainable aspects, dependencies and contributions of the correlation “social entrepreneurship - maritime business”. The research includes managers of 50 companies with many years of experience in the maritime business on the territory of the NorthEastern Planning Region of the Republic of Bulgaria. A systematic, non-representative sample was formed based on a system of indicators - business experience and implementation of sustainable maritime practices. Specifically, the focus companies have the potential to realize the economic, social and environmental aspects of sustainable development. They have a strategic role in the sustainable supply chain management given their ability to implement green supply chain management, participate in the circular economy and realize corporate social responsibility. Limitations in forming the sample are related to organizational aspects of the study itself - time, place and resources (financial and human).

The pilot study was conducted over two years (2021 - 2023) and included two research panels. The first panel, a survey, established the management attitudes towards social entrepreneurship and the mechanisms for the implementation and stimulation of the social entrepreneurship activity in maritime companies. The second panel, in-depth interviews, aimed to establish the contributions of social entrepreneurship to the development of sustainable supply chains in the maritime business through the achievement of social, environmental and economic goals. The questions included in both panels relate to the role of management and especially intrapreneurs on sustainable practices; the problems and challenges facing social and innovation activity in the maritime sector.

The statistical software XLSTAT 2024 is used to identify and analyze dependencies between the factors of interest. This data analysis product has been chosen for its objective capabilities for appropriate analyzes to contribute to a better understanding of the role of social entrepreneurship in maritime business and the context of realization of the correlation.

## 3. Results

One of the primary tasks of the survey is to establish the management attitudes towards social entrepreneurship. The results of the conducted survey show that 100% of the managers have positive management orientations for the formation and development of social entrepreneurship in maritime companies (Table 1).

Table 1. Attitudes towards social entrepreneurship.

| | | Variable | Percentage | Valid Percentage | Cumulative percentage |
|---|---|---|---|---|---|
| Valid cases | Yes | 50 | 100 | 100,0 | 100,0 |
| Missing cases | | 0 | 0 | - | - |

More accurate indicators of the manifestation of social entrepreneurship are provided by the following sections of the study. The results shown in figure 1 indicate that 76% of the managers have established a system of rules and measures for the stimulation and development of social entrepreneurship within maritime companies, and 50% of the managers implement regular social innovations, i.e., plan, organize, lead and control the process of formation and development of social entrepreneurship.

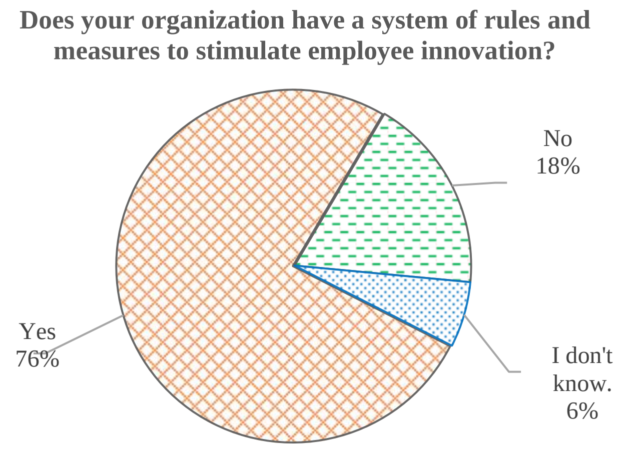


Figure 1. A system for the development of social entrepreneurship.

The next section of the social entrepreneurship research concerns the establishment of the internal social entrepreneurs within the researched maritime companies. According to this criterion, the research establishes that nearly half of the representatives of the maritime industry identify in their structures persons who act as internal social entrepreneurs. The value of the indicator is a measure of the potential of maritime companies for the development of social entrepreneurship in the future (Table 2).

Table 2. Internal social entrepreneurs.

| | Answers | Variable | Percentage |
|---|---|---|---|
| Valid cases | Yes | 25 | 50,0 |
| | No | 20 | 40,0 |
| | I don’t know | 5 | 10,0 |
| Total | | 50 | 100,0 |

The in-depth structured interviews with managers of companies from the maritime industry establish the readiness of the management to invest far more resources for the formation and development of social entrepreneurship. However, 50% of the interviewees report numerous problems accompanying the implementation of socio-entrepreneurial innovations: maritime terrorism (36%), military challenges in the Black Sea (15%), as well as the economic stability in the country (13%) (Figure 2).

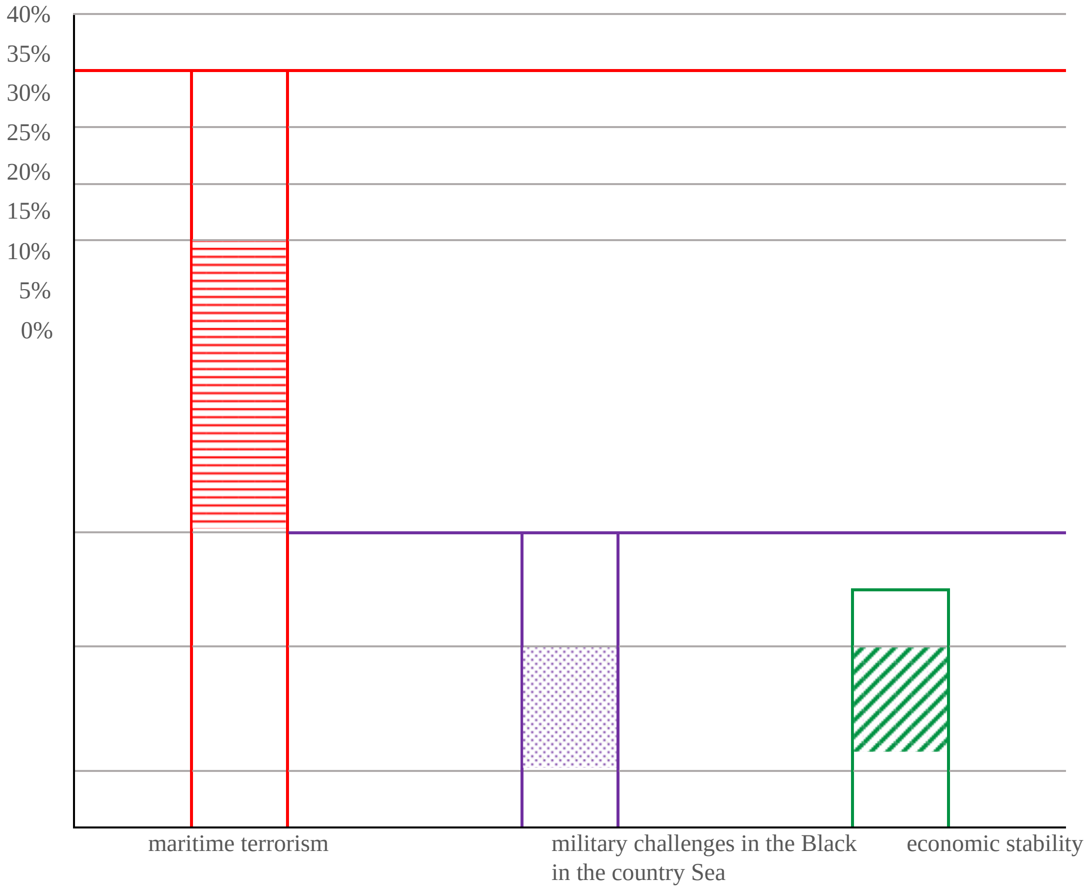


Figure 2. External problems in the implementation of social-entrepreneurial innovations.

The managers point out “deteriorated economic parameters of the organizational environment” (35%) and “insufficiently effective communications between functional specialists” (34%) as the most important internal problems (Figure 3)

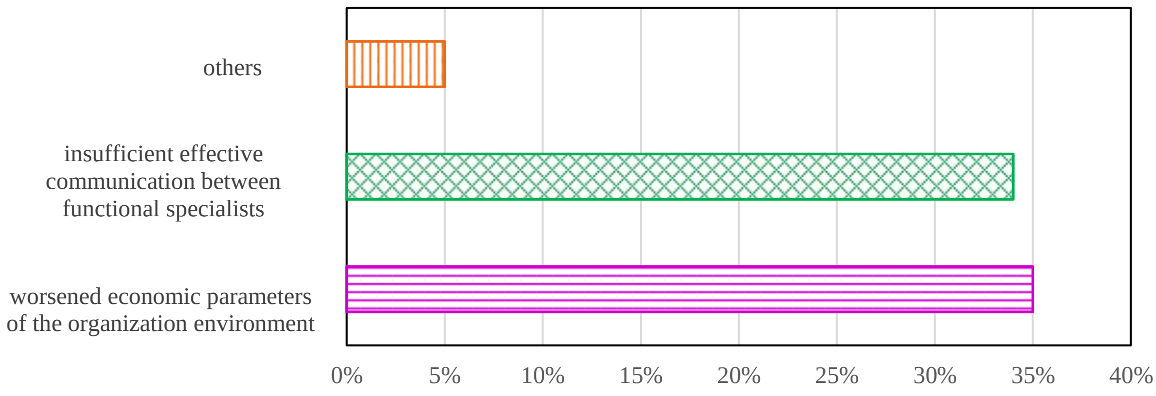


Figure 3. Internal problems in the implementation of social-entrepreneurial innovations.

In-depth interviews demonstrate the role of the internal social entrepreneurs in the creation and implementation of sustainable practices within supply chains, especially regarding the reduction of harmful impacts on aquatic flora and fauna (25%), the consumption of renewable energy sources (55% ) and green technologies in shipping (42%), recycling of waste products (15%), hybrid propulsion systems (17%) (Figure 4).

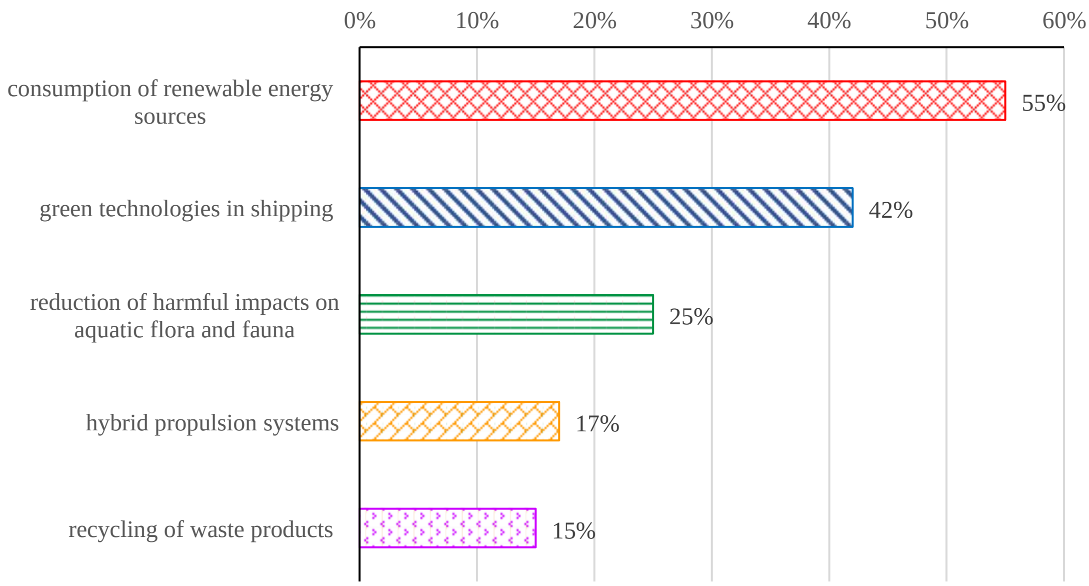


Figure 4. Impact of internal social entrepreneurs on sustainable practices in maritime logistics chains

The results of the structured interviews also identify the most important social challenges related to the social aspects of sustainable supply chains. The priority topics here correspond to increasing security and safety in the maritime sector and reducing the threats of maritime piracy (17%), as well as the need to unify fair social practices globally. According to 30% of the interviewees, such practices would encourage the development of increasingly sustainable supply chains by using social entrepreneurial networks based on the strengths and resources of different countries, regions and communities.

**4. Conclusion**

The study of the correlation “social entrepreneurship - maritime business” is an innovative approach to research the role and technologies of managing sustainable supply chains in the maritime sector for the formation of innovative contributions in environmental, social and economic aspects. The correlation can be researched from different points of view and parties concerned. This article focuses on the design of social entrepreneurship within maritime companies (attitudes of the management, internal social entrepreneurs, systems for stimulating social-entrepreneurial activity). As a result of the applied approach, the study is focused on some problem areas hindering the implementation of successful social-entrepreneurial practices in the Republic of Bulgaria.

In accordance with the formulated priorities, this article establishes the main factors that are responsible for the sustainable social entrepreneurship of the maritime business in the Republic of Bulgaria - the attitudes of the management, the role of domestic entrepreneurs and the availability of working management mechanisms for their stimulation. In addition, the study focuses attention on serious external challenges corresponding to the social and entrepreneurial activity - terrorism, military conflicts, and economic environment. Empirical studies prove the essential role of entrepreneurs and their social innovation for the development of the maritime sector in the Republic of Bulgaria: reduction of harmful effects on the flora and fauna of the waters; the consumption of renewable energy sources; green technology; the recycling of waste products, etc. In summary, the presented results establish and enrich the rational relations between social entrepreneurship and sustainable supply chains, as well as the contributions of social innovation in the maritime sector of the Republic of Bulgaria.

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# Factors affecting the time-extended evacuation on cruise ships

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**Abstract:** The safety of human life is the top priority on cruise ships. Carrying out an appropriate evacuation procedure in an emergency will prevent loss of life (SOLAS 2018). The total time to evacuate a passenger ship includes the time it takes for passengers and crew to assemble at the assembly point after the first alarm and the time it takes to abandon ship. Rushing, climbing to a greater height due to the inclination of the ship, uncontrolled movements, not responding to an alarm, turning back or going to dangerous places to collect valuables are elements that the crew should deal with when a panic occurs, as these are natural phenomena that occur with individuals or groups (Sarshar et al., 2013). Passengers follow the actions and behaviour of crew members. By observing the crew and their attitude towards safety measures on board, they get an idea of the general safety on board, which can be an important factor in avoiding panicked behaviour and thus reducing the average evacuation time (Tisseraa, 2013). There are a variety of factors that influence evacuation efficiency. The authors conducted a survey on a sample of 79 seafarers to investigate these factors. For the purposes of this article, the factors affecting the time-extended evacuation are analysed. The statements in the questionnaire that were used to try to find answers to the significance of this factor relate to the location of the lifejacket, the passengers' familiarity with crisis management, the influence of language barriers, the physical condition of the passengers and the physical condition of the crew, i.e. whether the crew members engage in leisure activities or avoid them due to long working hours (ILO MLC, 2006).
*Keywords*: cruise ship, evacuation, crisis management, working hours

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## 1. Introduction

Researching the factors affecting time-extended evacuation on cruise ships is crucial to ensure the safety and well-being of passengers and crew members in emergency situations. By understanding these factors, such as ship layout, passenger demographics, crew training efficiency and communication protocols, cruise ship operators can implement effective evacuation plans and procedures to minimise risk and improve emergency response times. This research can also help identify potential weaknesses and areas for improvement in evacuation protocols to ultimately improve the overall safety of cruise ship operations. In order to reduce the risk, it is necessary to have an organized crew that will react in a timely manner in such situations. Time to rescue is of the essence. It is necessary to check the ability of the crew to react on time in the right way in the emergency situations. The time needed for passengers and crew to assemble at the assembly stations or/and muster stations or emergency positions for the crew after the first alarm and the time required for abandonment presents is crucial time for evacuation. The IMO conventions prescribed the basic rules that designers, shipbuilders, ship's crew must meet. For the purposes of this work, we list only the basic rules that can affect the speed of evacuation. In compliance with the SOLAS regulation III/21.1.3, the embarkation and launching duration should be maximum 30 minutes from the time the abandon ship signal is given after all persons have been assembled, with lifejackets donned. Every passenger ship lifeboat shall be so arranged that it can be boarded by its full complement of person not more than 10 min from the time the instruction to board is given. The total time for evacuation of a passenger ship includes the time needed for passengers and crew to assemble at the muster station after the first alarm and the time required for abandonment plus 30 minutes time regulated by SOLAS refulation. The success of rescuing people on passenger ships is determined by the speed of the rescue and the organization of the crew. The number of different exercises and drills on passenger ships often exceeds the minimum number of exercises prescribed by the SOLAS convention. In addition to the basic and additional training prescribed by the IMO Conventions (SOLAS and STCW), the crew's readiness on cruise ships is additionally trained by the numbers of exercises prescribed by the ISM Code which is implemented through SMS requirement. Nowadays, on cruise ships it is impossible to simulate real situations. It is almost impossible to be prepared for every situation. The drills are carried out in a calm sea and nice weather, in ports or sheltered anchorages, usually without the presence or interaction with passengers. In this way, a large number of factors were not considered as an aggravating factor for rescue. The passengers and crew are told to take their time to avoid injury (Klupfel at al., 2000). Various obstacles, changes in the behaviour of the crew and passengers, the movement of the ship that can slow down the evacuation process are not easy measurable. However, the only way for the rescue to succeed is through shipboard drills. The IMO "Guidelines and Revised Guidelines for a Simplified Evacuation Analysis for New and Existing Passenger Ships" (MSC Circ. 909, 1033, 1238, 1533 recommends a maximum allowable total evacuation time for passenger ships in the range of 60 to 80 minutes, with 80 minutes for ships with more than three main vertical (fire) areas or zones and 60 minutes for two vertical zones . It should be noted that for the first time the resolution MSC Circ. 1238 referred to passenger ships. From January 2020, the Resolution MSC Circular 1533 for all new and existing passenger and ro-ro ships is in force.

## 2. Methodology

By reviewing the literature and personal observation, online survey the factors that significantly affect the speed of evacuation on a passenger ship are identified and presented. The statistical analysis for this study was conducted using Microsoft Excel spreadsheet software. Respondents answered demographic and other questions or statements through the Google Forms platform, and the data collected was then analysed using Excel. The survey consisted of introductory demographic questions, methods of conducting safety training, the progress of actions and the extension of travel time, which we later analysed in the paper. The main goal was to direct the survey to different ships and companies and to ask the most responsible people on board and collect as many answers as possible. The participants served on ships of different sizes: 26% sail on ships between 300 m and 350 m, 21% on ships between 250 m and 299.9 m, 21% on ships above 350 m, 13% on ships between 150 m and 199.9 m, 12% on ships between 200 m and 249.9 m, 6% on ships between 100 m and 149.9 m and finally only 1% on ships shorter than 100 m.

## 3. Results and discussion

The factors affecting travel time extension of the crew to reach emergency positions or muster stations analysed in this paper are the life jacket location, social identity, passenger culture impact, passenger physical condition, and physical condition of the crew. The descriptive statistics has been used to describe the research findings.

Respondents had the opportunity to indicate on a Likert scale from 0 (strongly disagree) to 10 (strongly agree) whether they agreed with the statements given. Respondents had the opportunity to make a comment after each answer, which helped the authors to analyse the results

*3.1. Life jacket location*

The number of lifejackets is determined by the SOLAS Convention, Part III, Regulations 7.2, 22.2 and 26.5. Accordingly, there must generally be a sufficient number of lifejackets on board that fulfil the requirements of LSA Code 2.2.1 and 2.2.2 for all persons on board. An additional number of lifejackets must be available for the members of the crew on watch (bridge, engine room and similar locations). Of the total number of passengers, an additional 10% lifejackets must be available for children. In accordance with Regulation 7.2 of the SOLAS Convention, lifejackets must be stowed in readily accessible locations and their location must be clearly and visibly marked. In the Annex to SOLAS 22.2, passenger ships must additionally equip 5% of the persons on board with lifejackets, which are stored in conspicuous places on deck or at muster stations so that they are available in the event of an emergency. According to regulation 26.5 of the SOLAS Convention, an additional number of lifejackets must be available near the muster stations so that passengers do not have to go to the cabins to collect them. Furthermore, CLIA (Cruise Lines International Association) association requires ships to store much more life jackets near lifeboats or muster stations so passengers can access them easily. The obstruction of corridors and stairs impairs the movement of the crew on the ship and thus the congestion of the passage. The width of gangways and stairs must comply with IMO regulations (MSC.98). At the time of the marine accident and once the danger has been recognised, danger will be signalled from the bridge and the crew will move to their positions in emergency situations. According to the instructions in emergency situations, the crew is obliged to take the life jackets beforehand if they are located in the cabins. Depending on the nature of the danger, passengers may remain in the corridors. There will be congestion in the corridors leading to the stairs if there is no crew member appointed for that emergency position. Due to their larger dimensions, lifejackets can significantly reduce visibility in front of passengers and crew members, especially in the stairways area if such ship requires life jackets to be kept in cabins.

Table 1. Life jacket location

| No | Question | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **1** | Life jackets are stored in cabins, and they are in a good working condition. | 10 | 8,397435 | 0,337144 |
| **2** | Crew members are clearly instructed to leave their life-jackets in their cabins. | 9 | 6,782051 | 0,464040 |
| **3** | Some of the crew members intentionally or unintentionally leave their life jackets in their working place. | 3,5 | 3,871795 | 0,389403 |
| **4** | CLIA imposed additional requirements for Life Jackets storage, in addition to those required by SOLAS Convention. | 9 | 7,576923 | 0,335748 |
| **5** | In a real emergency, life jackets stored in cabins may help develop congestion in corridors. | 5 | 5,461538 | 0,365737 |

The central tendency in the answers to the questions asked is that the respondents believe that life jackets are in good working condition, that the evacuation information is clear and available in more than one language. The overall impression of the sample is that these conditions are met. However, depending on the size of the ship, the lifejackets for the crew can be stored in the cabins or in other suitable places on the ship (near the assembly station). The crew often do not leave their lifejackets in the designated places, which can lead to congestion in the corridors and thus to unnecessary panic in an emergency. Respondents agree that the location of life jackets in the cabins can lead to additional congestion in the aisles.

### *3.2. Social identity*

The desire to help others influences the speed of evacuation (Von Silvers et al., 2014). It is demonstrated by individuals showing a degree of tolerance and unity and helping people who are injured or in need of help. This refers to physical efforts in opening or removing certain obstacles found in the aisles, although there are individuals who may stand out and react differently, which might seem to be a panic reaction. According to Drury et al. (2013), panic is defined as an irrational emotion, loss of behavioural control, selfishness, turmoil or disorder. Goldenston (1984) defines panic as a reaction involving fear, confusion and irrational behaviour. The reaction to danger often manifests itself in a transition to hysteria and a break in social cohesion as well as in the occurrence of panic and violent behaviour as a psychologically natural reaction to danger. In emergency situations, people look for escape routes based on their previous familiarity with the space. Mawson (2005) shows that the typical response to various physical threats is neither to run away nor to react to the danger, but to search for people in their vicinity, so that separation is a greater stressor than the danger itself. The perception of a serious threat can reduce or eliminate conscious attention in favour of three states: flight, fight or freeze. Statistical data (Sarshar et al., 2013) show that panic and panicked behaviour caused more unfortunate circumstances than the disaster itself. The occurrence of panic behaviour is influenced by many factors that have been presented by state of passage a large number of authors, namely: age, gender, culture, physical ability, experience, position of the person at the beginning or end of the queue in the crowd, feeling of time remaining, frequency of waiting, difficulty in finding the exit, etc. The panic behaviour is influenced by the understanding of the procedures by which people move towards their destination (course of action) and the extent of the consequences of an accident at sea. The experience of passengers on cruise ships depends on the number of voyages and general familiarisation with the activities on board. According to SOLAS regulation 19.2.2., passengers must be provided with the necessary information on what to do in case of emergency. On some cruise ships, digital technologies are used to familiarise passengers with procedures in the event of an emergency, while on most ships regular drills are held to gather passengers at muster stations. At the same time, during their stay on the ships, the passengers notice the behaviour of the crew members, their behaviour during the exercise and get an idea of the general safety on board. Passenger condition is influenced by physical characteristics (gender, age, height of persons, number of persons with mobility problems). In addition to physical characteristics, there are also psychological traits that affect passenger condition. According to MSC.1/Circ.1533, the speed of movement of passengers from the place where they are currently located varies depending on the position of the cabin, age, gender and people with mobility problems. On the way to the destination, passengers move through stairways and corridors, so the speed of people's movements varies.

Table 2. Social identity

| No | Question | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **6** | Records are maintained on passengers and crew members familiar with crisis management (for example retired soldiers, medical doctors, firefighters) | 5 | 4,974359 | 0,410880 |
| **7** | Passengers familiar with crisis management should be invited to participate in onboard drills. | 3 | 3,833333 | 0,415090 |

Although passengers must be trained to put on life jackets, identify their assembly points, understand emergency announcements and take the first action when an emergency announcement is made, the respondents do not agree that passengers familiar with crisis management should be invited to participate in onboard drills. The reason for these inconsistent responses is probably that passengers should not normally be disturbed, despite the requirements of the Convention. The cruise lines' policy is to make their guests feel comfortable, calm and safe during their holiday.

*3.3. Passenger culture impact*

Language confusion and misunderstandings on board can be fatal. Language barriers and lack of language skills contribute to major challenges on board ships. Passengers come from different parts of the world. In the vast majority of cases, the common language of people from different countries or regions is English. Adequate language skills are crucial in emergencies, especially when time is short. The ability to communicate with passengers in an emergency is crucial for a quick evacuation. However, there are examples of incidents where better language skills could have prevented accidents and saved lives.

Table 3. Passenger culture impact

| No | Question | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **8** | Typically, the passengers onboard cruise ships are from many different nationalities, and language barriers are a real issue. | 9 | 8,179487 | 0,257258 |

The language barrier is a serious obstacle to a successful evacuation, as not all passengers speak English. Therefore, cruise lines must pay special attention to clear communication and provide these passengers with someone to help overcome language barriers. It is good practice to provide information in multiple languages or to provide written notices through digital technology.

*3.4. Passenger physical condition*

Dynamic changes in the speed of movement in children, people who find it difficult to move or use aids, with density at the exits have already been studied in places where these people know the area they are in. In the event of a shipwreck, passengers can become disorientated, especially in an environment they are not familiar with. Their reactions, behaviour and decision making are illustrated according to Tisseraa et al. (2013), where the person who is unfamiliar with the environment they are in tries to follow the signs leading to the exit. If such a person sees no safety signs nearby one will change their behaviour and explore the surroundings in search of signs. The authors also describe three forms of human behaviour in space: the crowd follow the signs (signalled exit), search for the nearest exit (nearest exit or best predicted exit) and explore the surrounding environment (explore environment).

Table 4. Passenger physical condition

| No | Question | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **9** | Passengers are mostly up to 30 years old. | 0 | 1,846154 | 0,309187 |
| **10** | Passengers are mostly between 30 and 50 years old. | 4 | 3,923077 | 0,379182 |
| **11** | Passengers with difficulties are recorded as well as their needs (oxygen, walking chair, wheelchair). | 10 | 9,602564 | 0,120134 |

Since the statistical analysis shows that the passengers are predominantly elderly, it is obvious that their physical abilities must be taken into account during the evacuation and that special attention must be paid to their particular needs. On most ships, the so-called Disable List and Special Need Assistance Team takes care of these guests in an emergency.

### *3.5. Physical condition of the crew*

Physical fitness for work on board is demonstrated by a medical certificate issued by an authorised medical institution in accordance with the regulations and requirements of the STCW Convention (Part I/9), the MLC Convention (Section 1.2.) or the guidelines for health examinations. Compliance with the prescribed health conditions is evidenced by a valid health certificate issued by an authorised health institution in accordance with the relevant regulations for the medical examination of seafarers. Supervisors, doctors, examiners, shipowners, seafarers' representatives and all other persons involved in health examinations to determine the medical fitness of seafarer candidates or employed seafarers must comply with the ILO/WHO Guidelines for the conduct of medical fitness examinations prior to seafaring and at regular intervals for seafarers, including subsequent versions of these guidelines and any other applicable international guidelines adopted by the ILO, the IMO and the WHO. The relevant authority shall require seafarers to produce a valid medical certificate confirming that they are medically fit to perform the duties entrusted to them at sea before commencing work on board.

Table 5. Physical condition of the crew

| No | Question | Median | Mean | Standard Deviation |
|---|---|---|---|---|
| **12** | Crew members consume alcohol after working hours despite company policy requiring zero tolerance. | 4 | 4,217949 | 0,377368 |
| **13** | Crew members practice physical training in the gym | 6,5 | 6,141026 | 0,315397 |
| **14** | Crew members do not participate in physical exercises due to long working hours. | 6 | 5,653846 | 0,331912 |

The different answers to this group of questions show an inconsistent policy on alcohol consumption. Regarding physical training in the gym, the answers are also inconsistent. However, physical readiness is not a mandatory requirement for crew members, although those who are fitter make evacuation more efficient and faster. The company policy may provide for stricter measures than those prescribed by the STCW and MLC conventions. The physical fitness of the crew is affected by work fatigue and excessive exercise. Mental health is very important on ships and various social and social activities are encouraged and recommended, but should not lead to excesses.

The responses indicate that life jackets are in good condition and evacuation information is clear in multiple languages. Concerns were raised about crew members not storing life jackets properly, leading to congestion and panic during emergencies. Passengers should be trained in emergency procedures. Many shipping companies using digital technology for evacuation procedures information for their passengers, (Muster 4.0, APass, etc.) Cruise lines prioritize guest comfort, potentially hindering additional training. Finding a balance between comfort and preparedness is crucial for safety. The language barrier poses challenges for evacuations, especially for non-English speakers. Clear communication and support for language barriers are essential. Providing information in multiple languages and using digital technology can enhance communication effectiveness and safety. The analysis highlights the predominance of elderly passengers on board, underscoring the importance of considering their physical abilities and special needs during evacuations. Ships typically have specialized teams to cater to the specific requirements of elderly guests and those with special needs during evacuations, ensuring a proactive approach to managing evacuations effectively and safeguarding all passengers. The responses also identify inconsistencies in policies related to alcohol consumption and physical training in the gym among crew members. While physical readiness is not mandatory, crew members in better physical condition can contribute to quicker and more efficient evacuations. Crew members' physical fitness may be impacted by work fatigue and excessive exercise. Mental health is emphasized as crucial on ships. It is imperative for cruise ship operators to address these discrepancies to prioritize the overall safety.

## 4. Conclusion

Although the specifics may vary, all cruise ships must be designed and operated in accordance with the strict requirements of international law and must follow the established rules and regulations for the protection of all persons on board. Cruising is strictly regulated and ships often go far beyond what is required. Cruise ship safety is constantly improving as technology advances and the industry learns from the development and evaluation of best practice. Ships are also required to have lifeboats, life rafts or MES and life jackets for all persons on board, as well as additional capacity. The lifeboats can be loaded, launched and manoeuvred away from the ship within 30 minutes of the captain’s order. Safety drills or familarisation are held according to the SOLAS regulations before leaving the harbour. Regulators have updated and expanded safety requirements, including improvements to navigation equipment, onboard safety management systems, rescue equipment and training/certification standards. The survey results show that ship crews and passengers are overall well prepared for an evacuation and that ships are focusing on reducing the likelihood of accidents.

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# Current trends in the maritime education-transition and transformation from traditions to modern times

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**Abstract:** The paper examines the maritime education and training (MET) at Bachelor's degree with added value at the level of vocational training, courses for qualification and upskilling, continuous learning courses etc. The methodology is based on focus groups interviews using focus group research method. The goal is to present and propose the modern maritime education as an adaptive model. Some general factors that form the current maritime environment are presented in order to outline the trends towards dynamic, changing, more sophisticated, even unpredictable circumstances that affect the maritime business and its needs. The Bachelor education is transforming as a combination of acquiring traditional fundamental knowledge about the profession with more specialized specific skills that allows the future seamen to work in multi-connected environment. The second part of the paper presents some empirical data from two different directions: the students' dynamics in choosing their educational specialty and the corresponding needs of the employers and partners. The aim is to outline the "cross-needs" in order to combine qualifications and skills from traditionally different professional specialties. Additional feedback from the users, the maritime business and organizations is analyzed. A principle and conceptual model of curricula is proposed based on the principles of adaptive educational methods. The proposed model can be complemented and modified according to the specific requirements of various specialties and can be used as a basic idea-model for further developing catalogue of so called "boutique specialties".

*Keywords*: maritime education; tendencies in the maritime education, transformation processes in the maritime domain;

## 1. Introduction

The shipping industry is at the forefront of globalization, and it provides us with a good example of the associated challenges for various aspects like global labor market, regulations and standards. The shipping industry is on one hand "forcing" globalization by its rapid growing transport infrastructure and on the other hand it has been affected itself by the process. It has been transformed by globalization as ships have 'flagged out' and labor recruitment has been outsourced and off-shored. (Gekara, Sampson 2021, pp.2-3). With a growing automatization and digitalization variety of researchers and experts stressed on the necessity and importance of educational transformation and update to more specializations, more autonomous learning in shorter periods etc. These assumptions are true but build on different expectations, different pre-conditions, even different socio-cultural models and of varied nature. Often, these expectations are very wide: from being purely technological competent to the other end, where certain human skills and actions were expected to be central in a variety of contexts and occupations. (Manuel 2017). Furthermore, there are various additional expectations regarding future legal aspects, training aspects, economical aspects, environmental aspects, security and safety aspects, maintenance aspects etc. (Luetzhoeft, Earthy 2024, pp.1-2).

In the rapid changing environment, it is inevitable that some educational deficits must be addressed in order to prepare adequate curricula corresponding with the challenges and needs of the maritime industry. The aim of the paper is to outline some "cross-needs" in order to combine qualifications and skills from traditionally different academic and professional specialties. Some tendencies in the maritime industry and profession are presented that affect the traditional forms of maritime education and training (MET) as follows:

1. There is a global trend towards an outflow from maritime professions, especially on a European maritime labor market.

2. The trend towards an outflow from classic engineering professions is particularly clear. This is corresponding most clearly to the profession of ship engineer.

3. Taking the both observations from below, the need for skills for specific maritime positions, such as occupations on passenger ships, in the offshore industry and others, is increasing.

4. The lack of some social skills among graduates of maritime education is evident. This includes leadership skills, communication skills, and ethical models such as loyalty, empathy and dedication to the profession.

5. Parallel to these findings, the purely professional competence of the graduates definitely decreases.

6. The previous observation leads to a need to increase the employer's and the company's commitment to the process of obtaining the necessary professional competence.

7. The combination of the two trends of increasing efforts by the company to further train graduates and the lack of loyalty to the company strongly differs from the expectations of young naval officers to shorten their professional careers on board and move to onshore positions.

8. All these trends combined with the increasing automation and digitalization of almost all-shipping processes result in an increasing proportion of traditional shipping operations being "offshored" (moved to the office).

9. Again, because of all the statements below, a distinct process of "stratification" of professions appears. For example, there is a profession of a maritime specialist, physically fit, mentally tough, with moderate professional training, who works on the ship and controls the processes. At the same time, the need for a highly competent specialist, controlling and managing the same technological processes, but from an outsourced workplace in the office, is emerging.

10. The global process of increasing the need for early specialization gradually affects the results. Usually specialization started after obtaining the bachelor's degree; nowadays some specific specialization needs appear already during secondary education. Unfortunately, this trend is not sufficient recognized by the academies in their efforts to keep their curricula unified and consolidated around a common specialties framework. However, the universities intuitively feel the need for early specialization, as witnessed by the continuous efforts for increasing business involvement in education.

11. As a response to some personnel and competence deficits, as well because of the indicated trends, a publicly available version of artificial intelligence appeared. It marks a line for starting specific developments to compensate for physical deficits (shortage of personnel) with clearly outlined staff competencies through the introduction of specially prepared language models as personal advisers to specialists or even as stand-alone elements of the management network.

The presented list of trends is only indicative without completing the dynamic, detailed and inter-connected profile of the contemporary young maritime professional. The research approach is based on the principal assumption of "shared responsibilities" between the maritime industry, the academic staff and the students themselves! The Bachelor education is transforming as a combination of acquiring traditional fundamental knowledge about the profession with more specialized specific skills that allows the future seamen to work in multi-connected environment. Very important part of them are self-education and soft skills that are implemented in the current academic curricula. Currently, various disciplines which integrate practical training with soft skills are effectively integrated in the education process. (Lekakou, Vaggelas ed., 2022). Most of the soft skills content is identified in close collaboration with the maritime industry addressing current soft skills gaps.

## 2. Research

The methodology of the research is based on focus group research method using analyzed data from group interviews. Group interviews (focus groups) were conducted with students in their 4th year of study who were about to take their final exams and who had undergone practical sea practice in accordance with STCW and representatives from the business industry and maritime organizations.

The aim of the focus groups was to reveal the attitudes of the students and the business representatives towards the training, as well as after passing the sea internship, to reveal the attitudes towards career development in the maritime domain based on the above presented tendencies.

*2.1 Maritime students focus groups*

There were 10 focus groups - some of them had 10 students each, and some had 12 in accordance with the different number of students in each specialty. Two of the authors of the study conducted the focus groups interviews. To achieve the goal, seven questions were prepared. The first two related to revealing the attitude towards their training in the academy, based on the experience of practice on board ships. In this regard, the discrepancies between the training in the lecture halls and what practice at sea required of them were explored, as well as the disclosure of what was most shocking to them.

The following three questions aimed to reveal the attitude of the students towards a career at sea - how many years they see themselves on board ships and what aspirations they have to develop in the ship's crew hierarchy; what can make them interrupt their career at sea and what are the desired contract parameters and conditions for them to stay longer at sea.

Two other questions were related to the development of technologies in shipping and their attitude towards a career at sea, to reveal their perception of the necessary further education and qualification. What are the most important professional qualities and competences that should be developed and would give a chance for a successful career; how we can prepare for the challenges related to the application of artificial intelligence in shipping; and the use of autonomous and semi-autonomous ships and the necessary qualification and education.

The focus groups discussion had the the following structure: orientation to the problem; evaluating, comparing and confronting ideas; consolidation of opinions.

The summarized results: in the preparation at the higher education, there are still deficits in the practical "portion" - for the students of Navigation for working with electronic charts, and for the students of Ship Engineering - for working with some of the most modern ship systems. Most shocking for the students, however, is the culture shock and insufficient "soft skills" to work in a multicultural environment, as well as a difficult understanding of the attitudes towards them from the seafarers of the older generations. The meeting of the students from the so-called generation "Z" with senior officers and the clash of their social attitudes is shocking to the younger group.

The attitude towards a career at sea among students from all focus groups was for no more than 5-7 years, with minority of them stating an attitude to work for more than 10 years, or even until retirement. What can motivate them to interrupt their career at sea is the better pay ashore and starting a family. Students expect 1.5 to 2 months as an ideal contract period, as well as many ship-docking experiences. They consider the availability of fast internet on board as something normal and mandatory. They expect better living conditions in the living quarters of the ships, as well as more varied food.

A leading view on the development of semi-autonomous and autonomous ships is that it will not be a very fast process, because there will be issues with the safety of navigation, and by the time they spend their careers at sea, there will be no need for serious qualification or serious additional education. There is a minority of students who believe that preparations for this new age of shipping should begin now, seeing themselves as the people who would work in operational centers to manage such ships. For this purpose, however, they believe that maritime schools should provide the opportunity for master's programs with a specific theme and, if possible, remotely, as well as shorter-term courses on these issues. They believe that it is important to do this together with business and with its participation.

*2.2 Maritime business organizations focus groups*

The authors invited 25 representatives (two focus groups) of the maritime business and maritime organizations to conduct interviews in the form of a round table. The aim was to reveal the general attitudes towards the training of the future seafarers in the current dynamic maritime environment, as well as to reveal their views on career development and possible necessary post-diploma qualifications in the context of IT, artificial intelligence and communication skills. The discussion had similar structure to the previous students' focus groups: orientation to the problem; evaluating, comparing and confronting ideas; consolidation of opinions. They were briefed with the tendencies presented in the introductory part.

Regarding the first three tendencies related to the general deficits of highly prepared engineering staff all of the participants acknowledged the need for "diversification" of specific skills. They assume necessary additional training and qualification in the context of semi-autonomous and autonomous ships development, as well as various management and operational skills that will allow them to broaden the competencies according to different circumstances. This will lead to specifics that are not completely realistic to achieve only during the university education. The commitment of the maritime industry is increasing with positive direction to more engagement in the curricula development, during the onboard internships and the post-diploma qualification. There are some approaches including giving the students realistic tasks from the everyday work with mentoring, analyzing and proposing solutions, using handbooks with case studies etc.

The seventh and the eighth tendencies, as expected from the previous observations with the students' focus groups, were pointed out as major challenges. Definitely, there are shifts of some onboard activities to the shore. In this context, all focus groups assume additional training and qualification in the context of semi-autonomous and autonomous ships development as necessary. To summarize the main views after analyzing the results, the "shared responsibility" approach was recognized as eligible in the current transformation processes.

**3. Curriculum model proposal**

A synthesized model of academic curriculum for maritime specialties is presented. The options for the adapted maritime education cover three specialties: ship engineers, electrical engineers and navigators. The specifics of the three types of training are not considered in this proposal, but rather the methodological part of the training is addressed. The recommendations cover the following perspectives:

1. A **short-term perspective**, that allows to adapt and modify the existing curriculum immediately.

2. A **medium-term perspective** with a horizon of about 5 years, including guidelines for the development of new curricula in terms of content.

3. A **long-term perspective** with a horizon of more than 10 years, including ideas for changes in the event of significant foreseeable manifestations of the consequences of the revealed trends in the field of maritime professions.

It is obvious that for the perception of the proposed educational model, a brief description of the existing one is necessary. The current educational model in Bulgaria has a three-level system of a four-year bachelor's degree, a two-year master's degree and PHD degree program. The bachelor's degree prepares personnel for the operational level in the context of the accepted hierarchy in the ship's crew. A Master's degree is required for management level positions (Captain, Chief Mate, Chief Engineer, and Second Engineer). A PhD is required at academic level. Parallel to the educational degrees there is a system of certification of personnel maintained by the Maritime Administration and linked to the education. The content and general model of education is monitored by a national agency and is described in State Requirements, because in Bulgaria maritime professions fall into the category of "regulated professions" according to strict monitored state standards.

For bachelor studies, there are three types of competences: fundamental competences for engineering sciences, competences according to the STCW Convention and competences required by the European Educational

Framework. The training course integrates the preparation for all specialized certificates for practicing the seafaring profession and necessary for admission to the examination for the acquisition of a Watch Officer or Engineer certificate. Six months of practice are integrated within the four-year period of bachelor's training. After graduation follows six-month cadet internship onboard, certified by the university and, together with the acquired educational degree, serves as a basis for admission to an examination for the acquisition of certificate for Watch Officer or Engineer. The content of the studied disciplines by competencies is as follows: 20% for fundamental engineering competencies, 60% for STCW Convention competencies, 10% for European Educational Framework competencies, 10% for others. For a master's degree, the education is theoretical, does not require special certificates and the distribution of the educational content is 60% for competences according to the STCW Convention, 20% for competences according to the European Educational Framework, 20% for others.

In the **short-term perspective**, we assume as most important the consequences from the trends related to the reduction of the quality of secondary education, the deficit of social skills and the outflow from the seafaring profession. Interesting opinion was raised from the conducted interviews with the target groups, that upon entering the university, a clear concern was spread among a significant number of students that they would not be able to cope with the complexity of the taught material. The teachers and maritime specialists shall touch upon more specifically to the challenges and responsibilities of maritime professions. The cumulative effect in this regard is seriously contributing to an outflow from the seafaring profession. The proposed model foresees several important elements in the short term. The first is related to the introduction of an educational module at the very beginning of studies, the role of which is to compensate for the gaps in secondary education and to give the logical connection between the previously studied subjects and the technical disciplines that provide the basis for the engineering specialties (first and second semesters of study). In parallel, the students should increase their social competences. Among the large set of skills, popularly called "soft skills", emphasis should be placed on those skills that enable the student to learn independently (self-educational model). At the same time, communication and teamwork skills should be developed in the trainees. At the end of the first year is the annual practice in the form of a sea camp, where basic seamanship skills are mastered in the form of practical classes and specialized games.

Second and third years of training focus on the content of the competences according to the STCW Convention. As far as the interrelationship between various disciplines allows a modular program can be organized. One of the tasks is to prepare for periods in which to focus suitable study disciplines for distance learning. These periods are envisaged with the **medium-term model of education** to serve as a basis for the formation of "floating periods for practice combined with distance learning". Both at the end of the fourth semester (second year) and at the end of the sixth semester (third year) to set aside "practice windows". At the end of the second year, it is appropriate that the "window" covers the months of June, July, August, September. The respective period at the end of the third year can be extended by the months of May and October. In fact, this second period of practice takes place after completing the basic knowledge of the maritime profession. In the last year, the educational cycle completes with emphasis on two types of disciplines. The first group of disciplines addresses the professional sphere in combination with leadership training, f.ex. "Bridge Team and Resources Management" and "Engine Room Team and Resources Management". The second group of disciplines are specialized elective disciplines that emphasize training in a desired specific professional field, f.ex. for deck officers like bulk carriers, tankers, passenger vessels, etc.; and for engineers - according to the type of ship propulsion systems and equipment. The idea is in view of the fact that during the previous practice, the student is most likely oriented towards a potential desired workplace. Graduation and a cadet internship follow.

During master's degree education is assumed that first year the training focuses on the competences according to the STCW Convention required for management level with a parallel emphasis on two specific skills: leadership and skills to train subordinates. The third semester includes elective modules profiling for ship type and equipment. The last semester is devoted to the preparation for graduation with master thesis. The entire education is part-time. For the needs of specially trained personnel are conducted parallel master's degrees, f.ex. for teachers, ship agents, Superintendents, etc.

The **medium-term model** is a logical extension of the short-term transformation. In terms of undergraduate training, the model is expected to address the need to share responsibilities with staff users (shipping companies) and increase IT skills. The changes mainly concern the share of the disciplines providing knowledge according to the requirements of the STCW Convention. It is assumed to develop models of shared learning with the companies, where, performing specific duties in the company, the students have assignments to study separate blocks of disciplines, provided with materials on a remote platform. To study these disciplines under the mentorship of specialists from practice and/or university professors. In parallel, the basis of the formation of "floating practice periods combined with distance learning" presented in the short-term model should be developed and implemented. In practice, the medium-term model is a further development of the short-term model in the direction of sharing the responsibility for education with the end-users of personnel, which addresses the revealed trends of early specialization and increasing digitalization in maritime professions.

## Conclusion

In the long term, it would not be correct to propose a model because of the increasing degree of uncertainty in a long-time perspective. In general, it is envisaged to develop curricula that prepares specialists to work with remote management and control systems. It is expected that new sets of competences will be elaborated for traditional maritime professions, which will lead to a reformulation of the names of the professions into something like ‘Operator Navigator' and 'Engine Room Operator'. In addition, the growing specialization is expected to be addressed through the introduction of a "user semester", where the training is carried out on topics desired by the end- users and, of course, with their active participation. At the same time, it is appropriate to look for a model that prepares the student for both professions - Deck Officer and Engine Officer. This would allow a dynamic reorientation of personnel to different professional fields depending on the labor market situation.

In general, the need for increasing communication with end-users is clearly a fact. Insofar as the educational sphere is a real dynamic system, its adaptation is impossible on a purely local basis and should involve all system components, especially universities, shipping companies, national educational regulators, control agencies such as Maritime Administrations etc. In parallel, communication and interaction within international associations such as the IAMU is extremely beneficial.

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# Developing a Short-Term Study Tour Program: Maximizing Benefits for Host University Students

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**Abstract:** Planning and hosting a short-term study abroad tour for maritime university students requires significant effort but offers participating students a unique opportunity to build communication skills, gain intercultural experience, and deepen knowledge of the maritime industry. A program was developed for sixteen American maritime students visiting a Japanese maritime university for a short-term study abroad tour that features classroom learning opportunities, visits to local maritime industry sites, interaction with Japanese students, and cultural experiences. While planning such programs typically focuses on the learning goals of the visiting students, there is opportunity for meaningful benefits for the host students in the form of an Internationalization at Home experience. The authors identified four English classes for which the study tour program could be integrated into existing curricula and enhance original learning goals. Through classroom visits and pre- and post-tour activities, Japanese students have opportunities to develop their English communication skills with native speakers of English, gain valuable intercultural experience through joint activities, and explore new perspectives of their international field of study. The design and outcomes of the program will be shared to ensure additional tours in the future and promote the value of such programs among the community of maritime universities.

*Keywords*: Maritime Education, Maritime Training, Study Tour, Maritime English, Intercultural Interaction

## 1. Introduction

For university students preparing for careers in international fields such as those under the vast umbrella of the maritime industry, participating in study abroad programs can provide valuable intercultural experience, improve language and communication skills, and offer immersive learning environments not usually accessible in normal classroom learning (Carlson and Widaman 1988; Paras et al 2019; Smith and Mitry 2008). Study abroad programs range in type and length, from yearlong periods to much shorter spans that may last only a few weeks, or even days. Although long-term study abroad programs have traditionally been considered the norm, in recent decades, shorter programs have seen an increase in popularity due to their cost efficiency, significant educational gains, and inherent adaptability to a wide variety of learning objectives (Donnelly-Smith 2009; Iskhakova and Bradly 2022; Sachau, Brasher and Fee 2010; Sjoberg and Shabalina 2010).

One subset of study abroad programs is the short-term study abroad tour which is often a more accessible form of study abroad that typically involves a group of students led by a faculty member from their program on a visit to another country for around two to three weeks (Scharoun 2016; Sachau, Brasher, and Fee 2010). These study tours can be organized primarily by faculty members or administrators who determine the schedule, arrange site visits and other academic and intercultural activities, secure transportation and accommodations, and lead the tour. It also possible to hire an outside agency or coordinate a program or parts of the program with a host university, which is the type of study tour described in this manuscript. There are numerous examples from the literature of detailed efforts by program leaders to plan, execute, and evaluate study tours to a foreign country with their own students (e.g., Howard and Gulawani 2014; Iskhakova and Bradly 2022; Paras et al 2019; Tanoos 2019); however, this manuscript focuses on the perspective of the host university's faculty who are responsible for planning key components of a short-term study abroad tour for a group of American maritime students visiting their maritime university in Japan. Along with descriptions of the early stages of planning with the partner American university and the development of the program for the visiting students, particular emphasis is placed on the design of the program components involving interaction between the host students and visiting students.

Internationalization at Home is an increasingly popular concept promoting the view that the internationalization of a curriculum is not dependent on students traveling abroad (Crowther et al 2001; Dong, Bryant and Liu 2024; Sercu 2022). Beelen and Jones (2015, p. 69) define Internationalization at Home as "the purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students within domestic learning environments." While this definition emphasizes the value of involving all students, which was beyond the capabilities of this study tour program, the components of *purposeful integration* and both *formal and informal curriculum* were critical influences in the planning stage. In the main section of this paper, the authors describe the consideration and effort to create a program that enhances and expands upon the pre-established curriculum of their Japanese students rather than disrupts it, with the goal of maximizing benefits for both the visiting and host students.

### *1.1 Building on an Established Partnership*

This study abroad tour can be viewed as a continuation of an on-going partnership between two maritime universities that began as an encounter between faculty members at an IAMU conference and led to a variety of collaborations through distance and international short-term programs. There was a mutual desire to expand on this partnership, and in the summer of 2023, discussions were underway to seek opportunities to have our students visit each other's campuses, first with the American students visiting Japan, and later, the Japanese students visiting the U.S. The decision to proceed with the first stage of the plan and host the American students for a short-term study abroad tour was not taken lightly due to the numerous educational, administrative, and logistical issues that needed to be managed (Iskhakova and Bradly 2022; Szwed and Rooks 2014). The fact that our university had never hosted such a tour significantly complicated the challenge. Ultimately, the value of building on this important partnership and the opportunities for growth for our students in the critical areas of practical experience, intercultural interactions, and academic knowledge drove the decision to move forward.

Initial discussions with key faculty members from both institutions that summer led to a rough plan that was presented to administrators for approval. After finalizing the schedule that was deemed suitable for both parties, planning on our side extended to settling on fees and costs, arranging for housing, lining up a program of activities, and designing learning opportunities for 16 students and one professor from the United States visiting a for a 16-day long program in May 2024. Despite the brevity of the previous description, the time and effort necessary for handling the logistics of the program were substantial, but it is hoped that this investment establishes a foundation upon which future programs can be built. Dealing with these administrative and logistical issues is critical, but the centerpiece of the study tour is the program developed for the students.

## 2. Visiting Students' Study Tour Program

The goals set for the American students participating in the program target expanding knowledge in maritime science-related topics from the perspective of Japan's maritime industry, deepening understanding of the international aspects of their field, building confidence in working in international settings, developing intercultural skills, and learning more about the Japan's culture, history, and language through an immersive experience. To those ends, the program features various hands-on activities, academic lectures, instruction on Japanese language and culture, visits to maritime-related sites and cultural centers, and independent study on a maritime project that culminates with student presentations given to the host audience at the end of the tour. Importantly, there are multiple opportunities for varied interaction with the Japanese students in the maritime sciences program. As the visiting American students are in Japan for only 16 days, their tour schedule is loaded from morning to late afternoon on each day of their visit with a wide variety of different classes, lectures, site visits, and other activities.

### *2.1 Academic Activities*

In the planned program, the visiting American students receive a wide variety of lectures and instruction on academic topics ranging from learning about Japan's maritime infrastructure, major ports and port logistics, the host institution's MET system and OBT program, to a diverse set of lectures delivered by host faculty members on their own research fields. The topics the visiting students learn about in the classroom are then further reinforced by site visits to nearby ports and logistics facilities, where they take part in firsthand experiential learning and explore more about the topics that are introduced in the classroom components. Each of the academic activities the visiting students partake in is further expanded upon through daily reflection reports and their individual maritime research projects that are shared as presentations at the end of their tour.

### *2.2 Intercultural Experiences*

Intercultural experiences are usually a focal point of most study abroad programs, and this tour is no exception. The American students not only visit a variety of maritime and non-maritime related cultural sites but learn about them before visiting. The knowledge they learn beforehand helps the students to enhance the cultural immersion they experience during the tour as they incorporate experiential gains into their own research project reports and presentations at the end of the tour. The visiting American students also partake in a wide variety of activities aimed at enhancing intercultural awareness, including lectures focusing on Japanese culture, history, and language related to places and regions they visit, and perhaps most importantly, various opportunities to collaborate and interact with the host institution's students before, during, and after the tour. Through the intercultural activities implemented in this program, the visiting students learn about the daily lives, academic interests and endeavors, and career goals of the host Japanese students. They also receive suggestions about sites and activities as well as cultural expectations from the host students.

## 3. Host Students' Involvement in the Study Tour

While developing the main study tour program centered on fulfilling the goals set for the visiting American students, it was also a priority to take advantage of this unique chance and maximize opportunities for interaction and potential for learning gains for the host university's students. Because the study tour takes place in the middle of the first eight-week quarter of the university academic year, most of the Japanese students have schedules filled with classes, homework, part-time jobs, and club activities. The Japanese students are invited to participate in certain study tour activities such as a beach clean-up day and some sightseeing activities, but there are limits to how many students can participate and their full schedules likely prevent many from joining even if they are interested. Instead, attention was placed on finding ways to integrate student exchange and interaction into scheduled courses to increase the number of Japanese students that could benefit from the presence of the American students on campus. By including the visiting students in course curricula, more Japanese students can participate in the study tour program and the nature of the interaction can be better controlled to ensure meaningful benefits for both groups.

### *3.1 Selecting Courses and Adapting Curricula*

The planning stages first focused on identifying appropriate, active classes that could be included, and reviewing curricula to target activities that could be adapted. Considering that any interaction between the two groups of students would take place in English, along with the need for the authors to have control over the curricula, English language learning courses were selected for involvement. The English courses scheduled during the study tour and available to be involved in the program included two sections of a general English writing course for second year students and two Maritime English courses, one for third year students and one for fourth year students (Table 1). The timing of the study tour allows opportunities for multiple classroom visits, including one 90-minute period each for the writing classes and the 3rd year Maritime English class, two classroom periods for the 4th year Maritime English class, as well as some pre-visit and post-visit activities for all of the participating classes.

Table 1. Courses and students involved in activities.

| Course title | Student Year | Japanese Students | American Students | 90-Minute Period Visits |
|---|---|---|---|---|
| Maritime English 1 | 3 | 50 | 16 | 1 |
| Maritime English 4 | 4 | 38 | 16 | 2 |
| English Writing B | 2 | 37 | 8 | 1 |
| English Writing B | 2 | 38 | 8 | 1 |

When reviewing the course curricula for opportunities to integrate the study tour program, the priority was to enhance or expand specific existing learning goals without impeding others, or disrupting schedules and learning objectives. Ultimately, the intention was to add a new layer of functionality and motivation to the class activities so that they are no longer just 'academic exercises,' but are done with a purpose tied to the involvement of the American students. The writing course covers sentence-level, paragraph, and short essay writing skills and strategies for general academic topics rather than maritime-related themes. In the two Maritime English courses, students primarily build knowledge of English vocabulary, SMCPs, and maritime-related expressions that are connected to various maritime navigation topics that they have learned in other courses in their native language. Along with reading and vocabulary learning activities, these two courses feature class presentation projects on maritime topics of student interest. Group work, peer review, and English communication tasks are features of the curricula for all three courses. In each case, there were multiple activities that could be adapted to enhance learning through the involvement of interaction with the visiting American students. Three major areas of learning were targeted: development of English language and communication skills, provision of opportunities for intercultural interaction, and enhanced knowledge in maritime science-related topics.

Some practical considerations did influence the adjustments made to the curricula and the implementation of the activities. Google Classroom is used as a Learning Management System (LMS) for all four classes; however, due to university network security, there was no way to grant access to the system to the American students, so any activities or interactions needed to be planned with alternate applications or means. Furthermore, due to the large class sizes (37-50 students) relative to the number of American students (16 students), in many activities, the Japanese students are placed into smaller groups and one American student is assigned to each group. The two sections of the English Writing course are scheduled at the same day and time, so the 16 visiting American students are split into two groups of eight and assigned to one of the sections and then to one group of four or five Japanese students (Table 1).

### *3.2 Program Learning Goals: English Language and Communication Skills*

With the Japanese students studying in an environment where English is not a dominant language outside the classroom, the presence of the English-speaking maritime students is a unique opportunity to use English as a tool of real-world communication and interact with peers from a foreign country. For the English writing classes, three activities were identified as appropriate for adaptation—an email writing task, weekly timedwriting tasks, and a paragraph writing assignment. The email writing task has become a pre-visit first contact between a group of four or five Japanese students and one American student who is assigned to that specific group. Introduction emails are sent first by the Japanese students and then as replies by the American students. They are aware that they will later meet each other in person in the classroom and encouraged to continue email communication beyond the required initial messages.

The writing students are informed that they are preparing a travel guide for the American students at the start of the quarter with each student responsible for a single entry. The weekly timed-writing tasks, which usually center on daily life activities and interests, are focused on activities, sites, and locations of interest for the visiting American students such as features of the university campus, local restaurants, and nearby attractions. These ideas are developed into formal paragraphs along with photos and URLs introducing these points of interests that make up the travel guide. Each student is responsible for one page of the guide. During the classroom visit, the American students meet with their assigned groups and ask questions about the entries in the visitors guide that each group member wrote while providing feedback on their writing and learning more about the contents of the site or activity described in their paragraphs.

For the two Maritime English courses, students are informed about the study tour and classroom visits at the start of the quarter and how their class presentations are a key point of interaction with the American students. With minor adjustments to the original activity plans, the third-year students prepare presentations on various aspects of the maritime industry in Japan, and the fourth-year students present on specific topics of personal interest from the general field of maritime sciences. On the days the American students visit, Japanese students are scheduled into different timed sessions and give their presentations simultaneously at stations around the classroom with the American students mixed into small audience groups. The presence of American students in the audience should enhance their motivation to prepare and deliver high-level English presentations and provide question and answer sessions that are more demanding than what they would get with just their Japanese classmates. With two full class periods for visits, the fourth-year students will also participate in an interview activity with the American students and hear presentations from them about their own maritimerelated projects conducted during the study tour. Although these activities would not normally be included in the original curriculum for the course, they fit with the original course goals of encountering English maritime terms and add a layer of authenticity that is unavailable in the vocabulary learning exercises that they replaced.

*3.3 Program Learning Goals: Intercultural Experience*

With our Japanese students entering a highly internationalized industry and many headed towards careers that will have them interacting and working directly with shipmates from different countries, intercultural experience with peers in their fields is highly valued. The planned activities in the class visits are centered on building communication skills and sharing knowledge, but these interactions also have potential to provide meaningful benefits related to intercultural experience. First, this can occur as a kind of indirect experience where students share and discuss key aspects of each other's cultures. The topics featured in the class activities are designed to provide opportunities to compare perspectives on personal lives and experiences in different cultures. For example, while the American students are providing feedback on the travel guide paragraphs and asking for follow up information, there will be opportunities to chat about cultural and lifestyle differences and to learn about preconceived notions of each other's cultures. Likewise, the fourth-year students in the Maritime English class can explore cultural differences through interviews with the American students as each group learns about life of a student in a maritime studies program in a foreign country.

The planned activities also offer many opportunities to learn about cultural differences through direct experience. The students need to work to together to negotiate the execution of the various activities and take different roles along the way. During the group work tasks in the writing classes, the students must manage turn-taking, deal with differing levels of formality in communication, and resolve issues that result from miscommunication. For the presentations conducted by both groups of students in the Maritime English classes, students take on the roles of presenter and audience at different times, and it is easy to anticipate that the typically reserved style of Japanese students and more engaging style of American students will be on display during these tasks. This direct learning will likely be influenced by personality differences and chance pairings that are largely outside of the planners' control; however, the opportunities are in place and direct intercultural experience seems likely and impactful.

*3.4 Program Learning Goals: Knowledge of Maritime Science Topics*

As described in a previous section, the curriculum of the English Writing course is focused on general English topics and that of the Maritime English courses is on building knowledge of SMCPs and other English terms related to navigation topics that the students have already covered in previous courses. While the planned program does not emphasize learning new knowledge in this area, there are some meaningful opportunities included. First, it is hoped that the involvement of the American students adds a stronger motivation for the Maritime English students to learn and understand the topics of their presentations and to better explain areas of interest in their discussions. Also, through interaction with the American students, it is expected that the all the Japanese students can gain a broader understanding of their field by learning about training programs, academic and professional interests, and cultures of maritime students outside of Japan. Besides a better sense of the international flavor of their chosen field, they have the chance to reflect on their own field as it exists in Japan by seeing varied approaches taken in a different country.

**4. Future Directions and Conclusions**

The time and effort required to plan and host a study tour program at a university can be significant, but there are numerous potential benefits for both the visiting and host students as well as for the two universities involved in the collaboration. The work put into planning this program, the first of its kind at our university, has been done to create the best opportunity for growth of the participating students, but at the same time, the authors expect that this leads to opportunities for our Japanese students to travel abroad on similar tours and for future study tour visits to our university. While the development of the learning program was the focus of this manuscript, a careful and thorough evaluation of the program was also considered essential. The collection of evidence of outcomes, participant feedback, and program evaluations is necessary to pursue our plans, and it is all built into the current program. We will collect, organize, and review participation data from the various activities, student produced materials such as project reports, presentation videos, and essays, and qualitative and quantitative evaluation and feedback data from both groups of students. Through the exploration of these data, the authors hope to secure evidence that demonstrates the value of this program and others like it to administers, professors, and students.

Additionally, we hope to promote and encourage similar study tour programs among the community of maritime universities to highlight another avenue for interaction and collaboration that benefits students, programs, and our industry, particularly from the perspective of Internationalization at Home. The critical steps taken in the development process of this program and the materials that were created are being carefully recorded, organized, and stored so that they be shared, reported, and ideally adapted and reused. The nature and the results of the program will be shared to serve as a template for other institutions who may be looking to develop similar study tours or as inspiration for entirely new programs. We firmly believe that future generations of global maritime professionals will greatly benefit from the exploration and development of new educational and training techniques.

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# Training Future Marine Engineers

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**Abstract:** Today's advanced technology and digitalization allow connecting different elements of a ship such as main and auxiliary engines to the onshore remote operation centers. However, our initial analysis shows that, as the technology being used for remote control or autonomy of ships is in its infancy and standards are not fully developed there is a mismatch between the specifications of products made by different manufacturers. This creates a challenge when systems from different manufacturers are installed onboard a ship for the first time with uncertainty about the compatibility of different elements of different systems installed. This gets more challenging when different equipment receives their own individual software updates during the ship's life cycle. The marine engineers onboard ships need to be educated to be aware of these potential challenges to ensure safe sailing. These challenges may go further than onboard ships when they are required to follow distinctive regulatory frameworks leading to different levels of responsibilities, liabilities, and the assurance of safety and environmental protection. The current STCW Convention and its MET system lack the capacity to train the next generation of marine engineers. There is a gap between the skills and competency included in the STCW, especially for marine engineering, and the requirements for monitoring, controlling, troubleshooting, and maintaining the future ship's engines (Rajapakse & Emad 2019). This paper reports the initial findings of the IAMU-funded research project titled: Marine Engineering Training for the Future (ROME). The final outcome of the ROME project will help MET institutes take the initiative and make plans for the required competency developments of future marine engineers.

*Keywords*: Marine engineer, MASS, Autonomous shipping, Digitalization, SRtP

## Introduction

Industry 4.0 is disrupting all industries including maritime. Industry 4.0 with its digitalization and advanced technologies has evolved ships to a large degree over the last decades. Today, for example, there is a tremendous change between the conventional cruise ships and the latest mega cruise ships such as Icon of the Seas, built in Turku, Finland for RCCL. The evolution has already started in some sectors of the maritime industry such as automated container terminals, remotely controlled surface ships, and autonomous underwater vehicles (Emad 2020a). The evolved workplaces have a profound effect on the type of jobs the seafarers are expected to perform, and the skill and competency required to be developed (Emad & Ghosh 2023). In the process, some jobs will be eliminated, and new ones will emerge (Emad and Shahbakhsh 2022). This will also result in a new composition and level of manning on ships (Emad, Enshaei, & Ghosh, 2021). Leading marine manufacturing industries such as Wärtsilä and Kongsberg have their remote monitoring centers offering services to ships using their advanced technologies. Kongsberg Maritime and Wilhelmsen have established a joint corporation, Massterly ROC for autonomous shipping opened in Horten, Norway monitoring and remotely operating the unmanned vessels (Koivisto and Emad 2023; MSC108 12.3.2024).

Same as the other advanced industries, the maritime industry must develop a comprehensive understanding of the effects and repercussions of the implementation of advanced technologies before adopting them onboard ships. Implementation of Industry 4.0 is gradual and moves through different stages before the industry gets to the full autonomy of ships. Different classification societies such as ABS, DNV, BV, and LR try to define these

stages based on their perspectives and experiences with other industries. However, the International Maritime Organisation (IMO) considering feedback from member states and industry feedback agreed on four degrees for their description of Maritime Autonomous Surface Ship (MASS) as follows (MSC.1/Circ.1638 3 June 2021):

Degree one: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but seafarers, according to safe manning certificate, on board ready to take control.

Degree two: Remotely controlled ship with seafarers on board. The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

Degree three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.

Degree four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

**Method**

To have a better understanding of the future of work and the role of marine engineers, we designed a qualitative research project (ROME). The project provided a comprehensive understanding of the role of marine engineers in the operation and maintenance of future ships. This project is a collaboration between Satakunta University of Applied Sciences (SAMK), Finland and Australian Maritime College, University of Tasmania, Australia. The research started with performing a systematic literature review. Data was collected from different stakeholders including shipowners, seafarers, classification societies, and shipbuilders. To provide contextual data, we did an ethnographic study of the status of remote operations onboard two newly built ships M/S AURORA BOTNIA and M/S MySTAR. Additionally, data was collected during the construction of the TTline's M/S Spirit of Tasmania IV. These three ships were utilized as a case study for future shipping as all three ships have the class notation of the Safe Return to Port (SRtP). Valuable data was collected during the visits to Wärtsilä and Kongsberg Remote Service Centers. Additionally, Kongsberg's Remote Operations Center (ROC) in Horton Norway, gave us a perspective on the challenges of remote operations and additional training needed for operators working in these centers.

**Scope of the project**

The recent new and under-construction ships studied in this study are designed to operate on the regular route, Helsinki – Tallin, Vaasa – Umeå, and Geelong – Launceston. The three principles of studies about future situations are that the future cannot be predicted, and the future is not predetermined but the future can be influenced (O'Regan 2024). Nevertheless, all three shipping companies Tallink Estonia, Wasaline, Finland and TT-Line have ordered these ferries to be operated for the next 30 years. The shipbuilder has built these ships so that they will last for the same period provided proper maintenance and docking standards are followed. Although it is expected that software updates and alternative fuels will impose various challenges. These ships are/will be made future-ready and although not autonomous only some steps remain to fulfil the requirements of autonomous shipping.

M/S MySTAR is scheduled for daily two-hour sailings from Helsinki, Finland to Tallin, Estonia. It has 2500 lane meters for cars and lorries with capacity for passengers up to 2800. The usual port stay time for such a class of ship is one hour but considering the price of the fuel as a key factor for profitable sailing the port stay time is reduced to 50 minutes. The "extra" 10 minutes is used to reduce sailing time over the Bay of Finland to make it more economical. The ship has five main engines MANN 5L51/60DF (42000kW) with the ability to use LNG as fuel for three of them. According to the safe manning rules engine room cannot be unattended at any time while in operation even if it has class notation E0 (Rauma Marine Constructions: Technical specification for

SP216 Tallink Shuttle). The analysis of data from interviewing the engineers and shipping companies' representatives, shows that autonomous operations were not at the top of their priorities. Among the reasons for such consideration mentioned is the sea traffic has always been busy on their route, GOFREP (Gulf of Finland Reporting) a mandatory ship reporting system in the Gulf of Finland has been set up together with Finland, Estonia, and Russia to ensure safe navigation. Also, due to the Russian attack on Ukraine in February 2022, and terrorist activities that have taken place in the Gulf of Finland like an explosion of the gas pipeline, the cut of the electric grid between Finland and Estonia, unidentified ships are disturbing other ships and GPS positioning system spoofing is very active.

M/S AURORA BOTNIA is a 150-metre-long RoPax vessel with 1,500 lane meters of cargo and vehicle space plus room for 800 passengers. She is one of the world's most efficient and sustainable ships ever built– already compliant with the IMO's 2050 greenhouse gas reduction target and the EU's upcoming Fit-for-55 package (Rauma Marine Constructions: Technical specifications for NB 6002). M/S AURORA BOTNIA started operation between Vaasa, Finland to Umeå, Sweden in August 2021. She is sailing daily on several trips using four Wärtsilä 31DF dual-fuel engines which use liquefied natural gas (LNG) and/or biogas and hybrid propulsion solution combines engines and 2.2-MWh batteries. The ship is being used as an R&D test platform and technology demonstrator. Wärtsilä's center is monitoring the operations of engines remotely. The ship on this route faces different challenges, especially during the ice season during winter. However, so far, Aurora Botnia has performed as planned although to prevent risks such as dangerous ice pressing some sailings had to be cancelled.

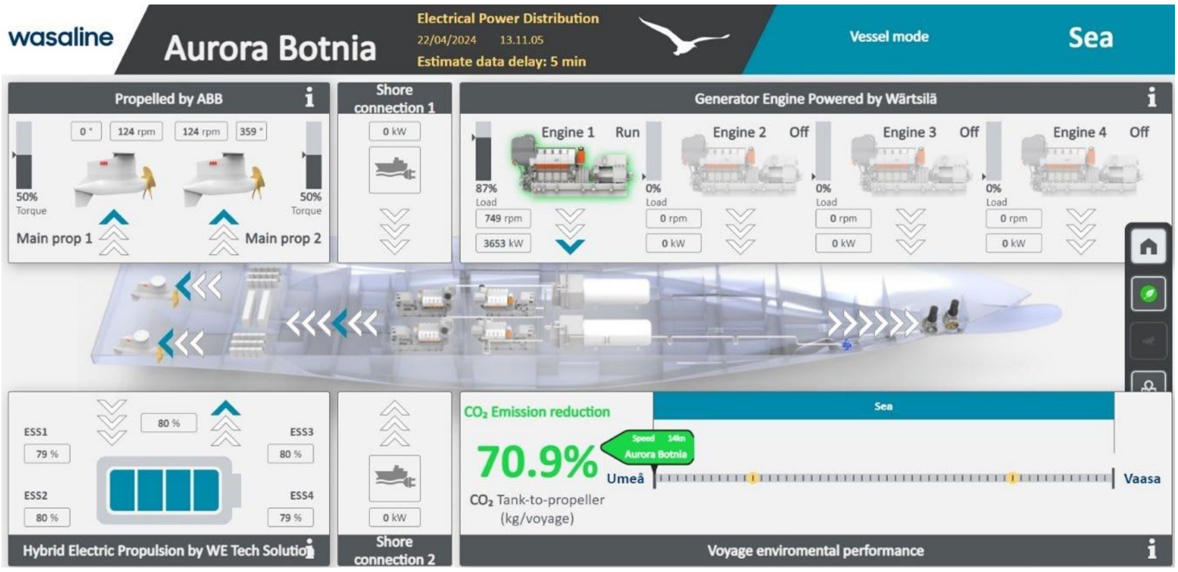


Figure 1. Example of remote monitoring M/S AURORA BOTNIA engine operation from Wärtsilä Center.

M/S Spirit of Tasmania IV and V are 212-meter-long Ropax vessels with 2500 lane meters of cargo and vehicle space plus room for 1800 passengers. They have a very important role in connecting mainland Australia to the island of Tasmania by having daily departures. Each voyage takes less than 12 hours. The ships are designed to maintain the SRtP standard's requirements. The ships' engines are not planned to be remotely monitored by any of the three Wärtsilä's centers as they will be managed by the engineers onboard (Rauma Marine Constructions: Technical specifications 2500 LM Fast RoPax Ferry NB 6009 and NB 6010).

*Safe Return to Port (SRtP)*

SOLAS (Safety of Life at Sea Convention) chapter II-2 introduced Safe Return to Port (SRtP), to ensure ships can remain operational after a fire onboard. The SRtP applies only to passenger ships with a length of 120 meters or more, constructed on or after the 1st of July 2010 (SOLAS 1974, as amended). The regulation is to establish design criteria for a ship's safe return to port under its propulsion after a fire incident, as well as to support the orderly evacuation and abandonment of the ship. The SRtP certification requires a series of operational tests such as a simulated loss of engine room due to fire that leads to failure of power generating, propulsion, and steering capabilities on one side of the ship while the ship maintains its steering capability from the special SRtP-bridge. The simulation exercise that has been utilized to test the system and assess its performance can also be used to train the ship's future marine engineers (Emad & Kataria 2022; Lokuketagoda 2017). During the simulation, the availability of essential systems for SRtP is being monitored to see if any failures occur in the part of the ship intended to be used during the incident (the main and auxiliaries' systems). The goal of the exercise is to examine whether the ship can maintain the required essential systems in operation with only one power plant. The limited scope of the assessment procedure and the fact that the test is being performed while the ship is new and in perfect working condition plus no passengers onboard is a drawback in assuring the effectiveness of the proposed SRtP system. Additionally, we foresee that during the working life of the ship, it will progress to degree two of MASS with a reduced crew and remote operation from an ROC. It is not clear to us that in that scenario with engineers as the only crew onboard, how the SRtP system will be capable of delivering the required safety features. We recommend that the administrators and regulatory bodies, in the next revision of the regulation, consider the natural progression of ships into the 2$^{nd}$ degree of MASS with a limited number of engineers onboard to operate such a system.

*MASS Projects*

Most autonomous shipping research projects investigate remote and/or autonomous operations related to ships' navigation and not the engine and machinery. Earlier projects like the Advanced Autonomous Waterborne Applications (AAWA) initiative funded by Tekes (Finnish Funding Agency for Technology and Innovation) resulted in the development of the specifications and preliminary designs for the next generation of advanced ship solutions. The lack of involvement of marine engineers in the project resulted in the absence of proper equipment design that allows ease of maintenance and repair (AAWA, 2016).

Project Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) was a collaborative research project, co-funded by the European Commission under its 7th Framework Program, with aiming to develop and verify a concept for an autonomous ship and recommended ships to avoid switching fuels as it is not technically feasible. (Porathe, 2013). It is predicted that by 2030 over 20% of ships would be able to use alternative fuels so dual fuel use is a normal practice. M/S Aurora Botnia, was one of the ships we investigated in our research. This ship uses MGO, LNG, Biogas, methanol, and batteries of 2.2 MWh. Contrary to findings from MUNIN, in our observation, she can switch between fuels so smoothly that, unless from indicators, we could not recognize the change from the bridge. On the other hand, the ReVolt project recommended a single solution for all problems that could happen with autonomous ships. Their solution was to avoid internal combustion engines and replace them with azipod thrusters with electric motors supported by a single giant battery pack (DNV GL, 2015).

The other advanced ship included in the ROME project's data collection was the Yara Birkeland. Yara Birkeland project provided a living lab in Norway. A two-year testing period of the technology started in April 2022. In this period the all-electric container ship will move from degree one to degree 4 of MASS. The ship is managed and remotely controlled by Maasterly's monitoring and operation center in Horton. In Degree 4 of autonomy, they will not maneuver the ship, but they have the possibility to stop the ship and drop anchor if that is necessary. Yara Birkeland is sailing between Heroya and Brevik. The voyage takes less than 2 hours with the total energy consumption for one trip is 1.2 MWh where the full battery capacity is 6.5 MWh. Our research includes the feedback from the crew of Yara Birkeland from these first two years. They started with five crew, now it is three and soon only two when the Electro Technical Officer (ETO) moves from onboard to ROC in Horton. The vessel is designed according to a zero-emission strategy and electric propulsion powered by batteries on board. There shall be no discharge to either air or sea. With this vessel, Yara will remove 40,000 diesel-powered truck journeys every year that eliminate the resultant NOx and CO2 emissions. In the near future, a permanent charging facility for the vessel at Yara's production plant will be available. Kongsberg Maritime is responsible for the development and delivery of all essential technologies, including uncrewed operation supervised from a Remote Operation Centre, electrical propulsion, battery, and control systems. The fallback state will be dependent on the situation that forces the vessel out of normal operation and is chosen between the available options after a thorough operational analysis (The Yara Birkeland project, Yara material). The project promised that sustainability can go hand in hand with autonomous shipping.

**Results**

The shipping industry is evolving, and the current maritime education and training (MET) system is not able to meet its requirements (Emad 2011; Emad & Oxford 2008; Emad & Roth 2007). MET needs to evolve to be able to adapt to changes introduced by Industry 4.0 (Nasaruddin & Emad 2019). The ROME project is designed to investigate the future of the maritime workplace and the role of marine engineers in remotely controlled ships. The research goal is to evaluate the future demand for the training of marine engineers and provide recommendations on how it can be materialized by maritime education and training. We studied the onboard state of some new and under-construction ships that utilize advanced technologies. The data also was collected from stakeholders such as shipbuilders, flag states, classification societies, and shipping companies with new ships in operation. Remote Operations Centers like Wärtsilä, Kongsberg and "ROC" Horten, Norway were also visited and consulted.

Based on our data analysis, the roles of marine engineers and other professionals in the maritime industry will dramatically change due to the growing digitalization and the implementation of MASS. Engineers need new sets of competencies and skills when moving to work at remote control centers. Demand for creativity and swift problem-solving abilities will replace the need for specialized knowledge in a specific area. Future mariners and related maritime industry workforce should develop a proper understanding of the design and operational aspects of MASS. Remotely controlling and troubleshooting the ships will be a challenge. To manage this well, good knowledge of image recognition techniques for the design of object identification systems is needed. Decision support systems using big data analytics and machine learning techniques are setting new challenges. Remote operators should have the capability to interact with systems employing big data and machine learning techniques used for decision-making, condition monitoring, and object identification. Engineers should understand issues related to sensor design and use as the number of sensors is growing enormously. Good skills in telecommunication and leadership are needed, in addition to knowledge related to ethical aspects of autonomous decision-making.

Previous research such as HUMANE- project (2018 – 2022) and IAMU project No.20190103 (2019-2020) emphasizes on human–centered autonomous shipping. They identified the need for developing or modifying the competence of maritime personnel and the need for reskilling and upskilling the current seafarers. They emphasize that the demand for skills will increase and require an expansion in both the width and the depth of competence profiles (Emad, et al 2022). The participants identified several key areas of competence, including maritime and technical competence, IT competence, legal and ethical competence, and core competence, which includes the ability to collaborate with people and technology, communication, and adaptability (Emad, 2020b; Lützhöft & Earthy, 2023).

The STCW Convention and Code review needs to address the current outdated training requirements (Narayanan & Emad 2022). Action is to review the tables of competence in the STCW Code to identify the need to update competencies, KUPs, and training requirements that are outdated and no longer relevant.

**Conclusion**

Emerging technologies on ships and ship operations, as well as environmental challenges, have provided the industry with new types of vessels, equipment, propulsion, energy sources, maneuvering, and operations, that require new standards of competence, functions, and levels of responsibility for their workforce (Emad, 2021). At the same time, with the experience already gained in using digitalization and emerging technologies in education and training, it is envisaged that further use of those technologies will continue. Therefore, a review of the existing provisions in the STCW Convention and Code would allow for the expansion of teaching and teaching aids to supplement and support shore-based training, methods for assessment of competence, and approval and monitoring of training programmes (Ghosh & Emad 2024).

It is important that amendments related to new training standards, particularly those emanating from amendments to other IMO instruments, consider flexibility and efficiency in the implementation of new training requirements and try to reduce administrative burdens (Emad & Meduri 2019). Of importance is that the action is needed to review the STCW Convention and Code to address the need for cybersecurity awareness for seafarers, especially as maritime operations become more reliant on digitally integrated and automated systems.

Digitalization is having an increasing role in sustainability and reducing GHG. Autonomous shipping is seen as a tool for cutting emissions. Digitalization as being tested for autonomous operations in coastal and shortsea shipping will have a great influence on future marine engineering training.

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Other Resources:

Preliminary list of specific areas identified for the comprehensive review of STCW convention and code https://www.intercargo.org/wp-content/uploads/2023/02/List-of-specific-areas-for-comprehensive-review.pdf Rauma Marine Constructions: Technical specifications for NB 6002.

Rauma Marine Constructions: Technical specification for SP216 Tallink Shuttle.

Rauma Marine Constructions: Technical specifications 2500 LM Fast RoPax Ferry NB 6009 and NB 6010.

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MSC108: Development of a goal-based instrument for maritime autonomous surface ships (MASS) ongoing MASS projects in Norway

# Testing of the HAZOP Method for a Training Ship Safety Operation

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**Abstract:** It is important to discover multiple preventive measures in the ship engine room and to take action to use them before an error or malfunction becomes a major catastrophe. The implementation of reasonable verification and safety measures in the engine room must factor in risk assessment and risk management.

The HAZOP (Hazard and Operability analysis) method was originally invented as a qualitative hazard evaluation technique by chemical industry. Recently, HAZOP is used for the design of ship engines using gas or other low-flashpoint fuel vessels.

The purpose of using HAZOP for existing training ship (Kaijin Maru) is to improve safety operations and assume two-folds benefit of student education and training. To improve safety operations, HAZOP brainstorming is conducted in the engine plant, and then safety actions are discussed and implemented. For the education and training point of view, participants conducting HAZOP will start with piping chart research, and then continue with an operation check list to consider potential risks. Even if potential risks are not found by conducting a HAZOP, brainstorming may improve knowledge of the plant understanding and improve the operation skills of participants.

*Keywords*: HAZOP Method; Engine room operation; Safety Operation; Risk Management, MET

## 1. Introduction

In ship engine plants, there are several potential risk materials such as fuel oil, liquefied gas, lubricating oil, steam, etc. When engine plants are in operation, all factors will change due to high energy materials being under high pressure and high temperature. If these high potential energy materials leak, burst, or spill out of the engine room, engineers or seafarers and the plants themselves can sustain damage. Planning and designing countermeasures from a strategic standpoint are critical actions to reduce these risks. Consequently, the implementation of reasonable verification and safety measures in the engine room must consider both risk assessment and risk management.

Risk management for vessels and the maritime field is discussed in the 2000 ISSC (International Ship and Structures Congress), which developed and established specialist committees for risk assessment. The IMO and Classification society NK (Nippon Kaiji Kyokai) have introduced FSA (Formal Safety Assessment) and established guidelines for use in the IMO rule-making process, particularly for bulk carriers and passenger ships, which face risks of loss of life and property. Additionally, ABS (American Bureau of Shipping) introduced a guide note for risk assessment application in the marine and offshore industries (ABS, 2020). The HAZOP (Hazard and Operability Analysis) method was originally invented as one of the qualitative hazard evaluation techniques by the chemical industry. It is widely used as a risk management method for offshore fuel and LNG plant construction. Recently, HAZOP has been used in the design of engines for ships using gas or other lowflashpoint fuels (IGF Code) due to the higher risks associated with gases compared to fuel oil. Cheng et al., (2022) proposed an integrated quantitative risk assessment model using the HAZOP methodology to analyze the fuel leakage risk of LNG-fueled ships. There are also several studies on how HAZOP functions as a pedagogy. Choy et al., (2004) developed a new HAZOP teaching module to encourage student interest and learning effectiveness by incorporating a number of simulation and creative interactive case-study examples. Also, there is research introduced to help students understanding barriers in learning HAZOP based on the Kolb Learning Cycle (Cheah, 2010).

The purpose of using HAZOP for the current training ship (Kaijin Maru) is to propose safety operations, and assume two-folds benefit of student education and training. To propose safety operations, the first step is to conduct research on piping charts, operation checklists, and other necessary documents to conduct HAZOP. The second step is to separate the engine plant fuel oil line into several nodes. Subsequently, HAZOP brainstorming is carried out for each node with well-trained engineers and students, and evaluated if existing safeguards are enough for potential risks. For education and training, participants conducting HAZOP engage in researching of SMS, piping charts, and operation manuals to consider potential risks. Therefore, even if potential risks are not identified through HAZOP, brainstorming can enhance the participants' understanding of plants and improve participants operational skills. The advantage of using HAZOP for training ship in this study is assuming a two-folds benefit of safety operation and pedagogical function. Compared to other risk management and evaluation methods in the maritime field (ABS, 2020), such as Primary Hazard Analysis (PHA), Fault Tree Analysis (FTA) and Event Tree Analysis (ETA), HAZOP has several advantages. PHA and Heinrich's Law, which are based on probability theories, require a big number of data to evaluate risks. The purpose of PHA is to dig up potential risks considering by consequence and frequency of events. On the other hand, HAZOP does not discuss the frequency of events and big number of data is not required. Additionally, FTA and ETA which are related to reliability theories are necessary to be carried out by well-trained participants who have an understanding and knowledge of qualitative evaluations. FTA and ETA utilize decision trees to graphically model the possible outcomes and how logical relationships among equipment failures that cause specific mishaps of interest. For these reasons, pedagogical implications such as education and training purposes for students or beginner engineers are more challenging by FTA and ETA when compared to the HAZOP method.

## 2. Methodology of HAZOP

### *2.1. General HAZOP method*

HAZOP was invented as a qualitative hazard evaluation technique by the English chemical company ICI (Imperial Chemical Industry) in 1963 as a "critical examination" technique (Lawley, 1974). The first guide: "A Guide to Hazard and Operability Studies" was introduced by ICI and the Chemical Industries Associations Ltd. (1977). The HAZOP technique is a systematic analysis that uses guide words to identify deviations from the intended process design. The technique involves a team of experts from various fields who use a brainstorming approach to identify deviations and their causes (Kletz, 1999).

In a HAZOP process, the analysis node is first defined on the piping and instrument diagram. There are two types of node definition: "Line by Line" and "Section by Section." Secondly, process parameters in the node are defined during the process, such as Flow, Pressure, Temperature, Level, etc. from their stable condition. Then "guide words" are used to help participants identify possible deviations in various plant operating conditions. Table 1 provides an example of some guide words.

Table 1. An example of guide words.

| Guide words | Meaning of guide words |
|---|---|
| none | The intended specification was not obtained |
| more | There was quantitative increase |
| less | There was quantitative decrease |
| As well as | There was qualitative increase |
| Part of | There was qualitative decrease |
| reverse | Happens opposite to intention |

HAZOP deviations from an intended specification can be identified using a combination of a process parameter and a guide word chart. For example, by combining guide word "none" with the process parameter "flow", one idea of deviation "none flow" will be suggested. Subsequently, HAZOP participants will brainstorm for possible causes that could lead to a "none flow" condition, and possible consequences that may result from "none flow" will be discussed and recorded in the HAZOP worksheet. All relevant deviations are thoroughly analyzed by the HAZOP participants combining suitable guide words and process parameters. Once all guide words and process parameters have been applied to the designated node, the assessment moves on to the next node until all nodes have been thoroughly reviewed.

### *2.2. Actual HAZOP method application for Training Ship (Kaijin Maru)*

In general, HAZOP is usually conducted during the design phase to assess safety aspects before constructing vessels. This is because it is challenging and costly to make changes or modifications to an existing vessel. As outlined in the methodology above, the HAZOP technique involves a team organized with experts from various fields. Whitty and Foord (2009) emphasized the significance of thorough planning and assembling a team for successfully conducting a HAZOP study. On the other hand, conducting HAZOP for an existing vessel, especially a training vessel, creates an opportunity of education and training for students who have a different onboard experience. From a research and education perspective, conducting HAZOP brainstorming with well-trained engineers can enhance understanding of the engine room plant operations and facilitate the transfer of operational skills among team members. Furthermore, the Training Ship (Kaijin Maru) was delivered in March 2022, and proposing safety recommendations for plant checklist and the SMS (Safety Management System) based on the HAZOP study will enhance the safety protocols for the training ship's operations.

The first step in conducting a HAZOP study is to select analysis nodes. In this study, fuel oil in the engine plant system of the training ship (Kaijin Maru) has been chosen. Piping diagrams have been prepared to select more detailed nodes of the fuel oil system. The subsystem, starting from the F.O. Settling tank to the Main Engine (M/E) and the Diesel Generator (D/G), are divided into 7 nodes as shown in table 2. Table 2. Fuel oil system.

| Subsystem Number | Detail of subsystem |
|---|---|
| 1 | F.O. Settling tank to Fuel oil Purifier |
| 2 | Purifier operation |
| 3 | Purifier to F.O. Service tank |
| 4 | F.O. Service tank to M/E |
| 5 | M/E operation |
| 6 | F.O. Service tank to D/G |
| 7 | D/G operation |

The next procedure is to prepare a detailed piping chart and the operation checklist of Fuel Oil plant as a reference and to consider existing safeguards to determine whether they are adequate or not. In addition, example HAZOP work sheets of each node are provided to conduct the HAZOP study. The purpose of the example HAZOP worksheet is to provide a brief idea for conducting the HAZOP process. Table 4 shows an example HAZOP worksheet of fuel oil subsystem 1.

Table.4. Example HAZOP work sheet of subsystem 1 F.O. Settling tank to Fuel oil Purifier

| No. | Hazard/ Guide word | Cause | Consequence | Existing safeguard |
|---|---|---|---|---|
| 1,1 | None flow | TK outlet valve shut, Strainer clogging, Tank empty | Pump gear damage, Purifier abnormal separation | Operation check list, TK low level alarm |
| 1,2 | More flow | Three-way valve miss operation | Purifier abnormal separation | Operation check list, Purifier inlet flow check |
| 1,3 | Less flow | TK outlet valve defect, Strainer clogging | Pump gear damage | Operation check list, strainer check |
| 1,4 | Reverse flow | Pump reverse operation | Purifier abnormal separation | Confirm pump revolution direction |
| 1,5 | Less pressure | TK outlet valve defect, Strainer clogging | Purifier abnormal separation | Check list, pressure gauge |

The group of two participants conducting the HAZOP process is defined by participants' onboard experiences. The purpose of the grouping is to confirm the understanding level of engine plant, knowledge of machinery and piping, risk assessment skill by difference of onboard experiences. Two participants of each group will conduct brainstorming together. Group 1 participants are both marine engineering students who have total 3month onboard experience. In Group 2, participant 3 has 12 months onboard experience and already holds a 3rd-grade engineer license. Participant 4 has only a few days of onboard training on the school training ship (Kaijin Maru). Group 2 participants are also marine engineering students who have different onboard experience.

Group 3 comprises participant 5 and participant 6, who each have actual engineering experience with 4-cycle diesel main engines and 2-cycle diesel main engine training ships. The grouping of each participant is shown in Table 5.

Table 5. Grouping of participants.

| Group | Participants and each onboard experience |
|---|---|
| 1 | Participant 1: 3month, Participant 2: 3month, |
| 2 | Participant 3: 12month, Participant 4: 0month, |
| 3 | Participant 5: 15years, Participant 6: 2years |

Before conducting the actual HAZOP brainstorming session, the general methodology of the HAZOP study is explained. Following this explanation, each group is provided with a piping diagram, an operation checklist and an example of a HAZOP worksheet. Each group conducts the HAZOP process individually on paper for each node, from subsystem 1 to subsystem 7. For each Hazard/ Guide word, causes, consequences, and existing safeguards are discussed and recorded.

## 3. Experiment result and consideration of HAZOP application for Training Ship (Kaijin Maru)

### *3.1. Experiment Result*

The results of subsystem 1, F.O. Settling tank to fuel oil purifier, shows the number of causes recorded by HAZOP brainstorming in each group, as depicted in Figure 1. The X-axis Hazard/Guide word number corresponds to the example of a HAZOP worksheet (found in table 4). Additionally, Figure 2 shows also the results of subsystem 1, indicating the number of consequences recorded by each group.

By comparing the number of causes for all Hazard/ Guide words 1,1-1,5 in each group, Group 1 had a smaller number of causes compare to the other group. The detail of causes of Hazard/ Guide words 1,1; none flow of group 1 were “Settling tank low level,” “Pipe damage and leakage,” “Tank outlet vale close,” and “Gear pump malfunction.” Group 2 detailed causes that were additionally “valve close” in other three valves in the piping line, as well as “Fuel oil high viscosity” and “Strainer clogging,” for a total of nine causes that were discussed by brainstorming. Group 3 also had a total of nine causes but compared to the details from group 2, causes of “Fuel oil high viscosity” were not included, and another cause “Settling tank and service tank communication valve keep open” was discussed as a cause of none flow. For Hazard/ Guide word 1,3 less flow in group 2 were almost the same with none flow, but did not include “Settling tank low level.”

By comparing the number of consequences for subsystem 1, group 1 and group 2 resulted in the same number of consequences for each Hazard/Guide word 1.1-1.5. However, the details of the consequences were different for each Hazard/ Guide word 1,1-1,5. For Hazard/ Guide word 1,1; none flow, group 1 mentioned “Gear pump gear damage” and “Purifier abnormal purification”, while group 2 mentioned “Gear pump gear damage” and “Resulting service tank low level.” For Hazard/ Guide word 1,2; more flow, group 1 mentioned “Piping and flange damage” and “Purifier abnormal purification”, and group 2 mentioned “Gear pump gear damage” and “Resulting service tank low level.” Group 3’s results of Hazard/ Guide word 1,1 was total of five consequences “Gear pump gear damage,” “Gear pump oil seal damage,” “Resulting service tank low level,” “Pressure gauge damage” and “Flange gasket damage due to vacuum.”

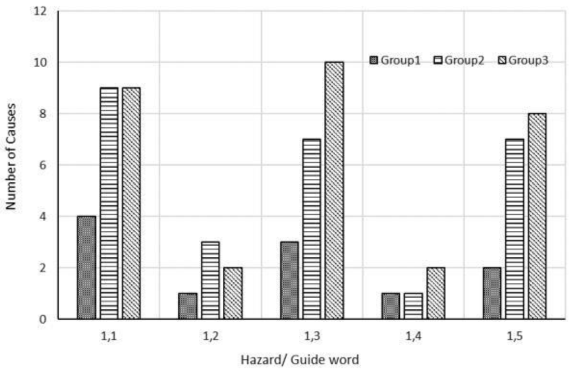


Figure 1. Subsystem 1, Number of Causes

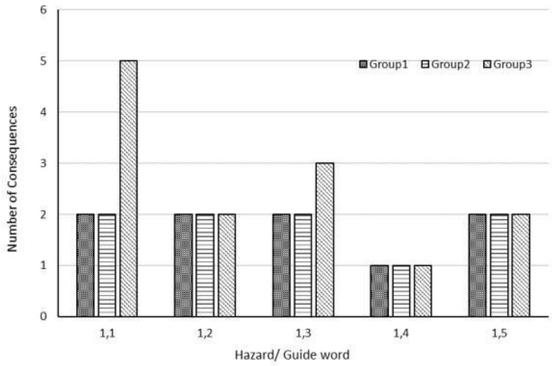


Figure 2. Subsystem 1, Number of Consequences

The results of subsystem 4, F.O. Service tank to M/E, number of causes recorded by HAZOP brainstorming in each group is as depicted in figure 3. For X axis, Hazard/ Guide word 1,6 "Pulse pressure" is added. Figure 4 displays the result of subsystem 4, with the number of consequences recorded by each group.

By comparing the number of causes for all Hazard/ Guide word 1,1-1,6 in each group, Group 1 had fewer results compare to the other group. The detail of the causes of Hazard/ Guide word 1,1; none flow of group 1 were five "valves in the line close" and "Pipe line damage." Group 2 detailed additional causes that were "Service tank low level," "Fuel oil high viscosity," "Strainer clogging," "Gear pump malfunction," and "Fuel injection pump malfunction" for a total of ten causes that were discussed through brainstorming. Group 3 causes additionally included "F.O. 2nd filter clogging," "Fuel pump pressure control valve malfunction," and Flow meter clogging." A total of 13 causes were discussed as the reason for none flow. Hazard/ Guide word 1,6; Pulse pressure cause was recorded by both group 1 and group 3, resulting in "Pressure absorber malfunction."

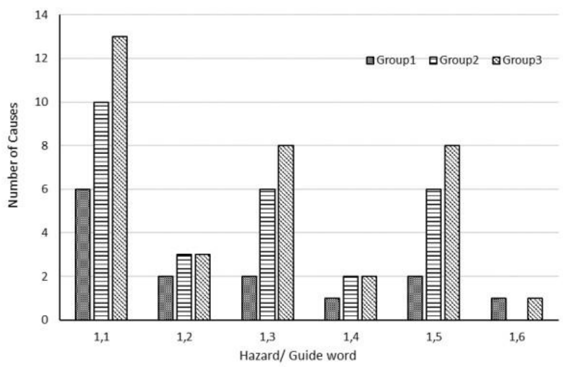


Figure 3. Subsystem 4, Number of Causes

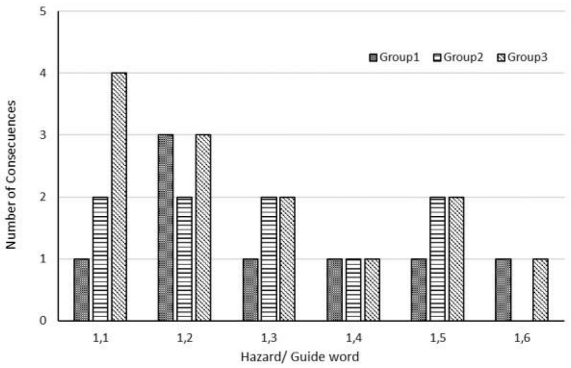


Figure 4. Subsystem 4, Number of Consequences

By comparing the number of consequences for subsystem 4 and the details of consequences for Hazard/ Guide word 1,1; none flow, group 1 mentioned "M/E emergency stop," Group 2 mentioned "M/E Emergency stop" and "gear pump gear damage," and group 3 additionally mentioned "Flexible hose damage" and "Gear pump oil seal damage." For Hazard/ Guide word 1,2; more flow, group 2 mentioned "M/E malfunction" and "Return line amount increase," group 1 mentioned "Flow meter malfunction," "M/E torque rich," and "F.O. cooler overheat." Group 3 mentioned "Return line amount increase," "F.O. cooler over heat" and "strainer clogging."

From the results of subsystem 1 to subsystem 7, not only piping lines but also the operation of purifier, M/E and D/G Hazard/ Guide word, causes, consequences, and existing safeguards were discussed using an operation checklist. Major causes and consequences are covered by the existing checklist and SMS manual, and some of the results are considered as safety recommendations. For example, regarding the valve open close indication, a checklist should include, purifier rotation direction, strainer maintenance period indication, settling and service tank temperature, and adding leakage prevention safeguards for M/E and D/G flexible pipe lines were also discussed.

*3.2. Consideration*

From the results of the HAZOP process, the onboard experience of each group affected the number of causes and consequences. These results may consider the importance of grouping. It is an obvious consideration, but the importance of group brainstorming and discussion according to variance in onboard experience was expressed in the experimental results. Group 1 participants both had 3-months of onboard experience, group 2 participant 4 had an only few days of onboard experience, but participant 3 in group 2 had 12-months of onboard experience. An analysis of the results revealed that group 2 had a higher number of causes than group 1. From the details of causes, group 2 results were not only from participant 3, but also some ideas were from participant 4. This result may suggest that the knowledge of longer onboard experience may lead to increased knowledgesharing, as well as increased new idea generation from other participants' points of view. This consideration is similar to group 3. Group 3 participant 5 had the longest onboard experience, but participant 2 had several new ideas of causes and consequences during HAZOP brainstorming. The details of causes and consequences from group 3 were ideas from a well-trained engineer's point of view compared to the other groups. On the other hand, from the results of subsystem 4, Hazard/ Guide word 1,6 "Pulse pressure" was an additional idea from group 1 and group 3. The results of this study also indicate that preparing an example HAZOP worksheet made discussion times shorter and more productive, but creating a positive discussion atmosphere will lead to new ideas from participants. After completing the HAZOP process in each group, the results and ideas of Hazard/ Guide words, causes, consequences, and existing safeguards were shared. By sharing these results, participants with less onboard experience could share and also learn from the ideas of well-trained engineer's operational skills by comparing them with their own HAZOP results.

## 4. Conclusion and future study

This study focused on conducting HAZOP for a currently active training ship (Kaijin Maru) to propose safety operations and assuming two-folds benefit of student education and training. From the results of the experiment, several considerations were proposed from each group's safety operations point of view. These results may be useful for modifying the operation checklist of the training ship. In fact, these sets of results do not mean that all recommendations have to be satisfied. Rather, based on the general methodology of HAZOP, the scope of HAZOP is to identify potential process hazards or operability concerns, not to find definite solutions to reduce or remove them. In future studies, including more engineers, navigation officers and management team members of the training ship as HAZOP members will be a more direct proposal for the modification of the safety operations of the training ship (Kaijin Maru).

From the pedagogical implication, conducting HAZOP for a currently active training ship had benefit for education and training for students. Participants of group 1 and group 2 were students who are studying in the authors' faculty. Except for participant 4, all students had on board experience, but conducting the HAZOP process was the first time for all of them. From the result, difference of understanding level regarding to engine plant, knowledge of machinery and piping, risk assessment skill by difference of onboard experiences were confirmed. From the results of the experiment, several Hazard/ Guide words, causes, consequences, and existing safeguards were discussed and proposed by each group. Conducting the HAZOP process and brainstorming improved their knowledge of plant understanding compared to before conducting the HAZOP study. Additionally, sharing ideas with well-trained engineers improved participants operation skills qualitatively and quantitatively. For future study, more nodes in the engine plant such as the lubricating oil line, cooling fresh/sea water line, exhaust line, etc., will enhance participants' understanding and knowledge of the plant. Moreover, increasing the number of participants who have various levels of onboard experience such as engine student, well-trained engineers, navigation officers and management team members may provide a more reliable and valid consideration of how the HAZOP process functions as a pedagogy.

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# Fostering Sustainable Societal Progress: Unveiling the Crucial Role of Gender Equity in Empowering Women across MTI's

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**Abstract:** Ensuring true sustainability requires addressing gender equity within society, particularly through the empowerment of women. This empowerment is crucial for the sustainable development of communities, as mentioned by the 2030 Sustainable Development Agenda. Women's economic empowerment involves their equal participation in markets, access to decent work, autonomy, control over resources, and increased decision-making power. In the maritime sector, historically male-dominated, the International Maritime Organization (IMO) has pursued gender balance through its "Training-Visibility-Recognition" strategy. While progress has been made, gender inequity persists. A survey of 150 maritime professionals in India reveals challenges, including low female cadet enrollment due to lack of support and safety concerns. With only 1.2% of seafarers globally being women, promoting gender equity is critical. The study address the further research and collaborative efforts between maritime institutions and the industry to support women in pre-sea courses, thus promoting their education and maritime sector gender equality for a sustainable future. Addressing these challenges is paramount for achieving true sustainability, where gender equity plays a central role in shaping a more inclusive and resilient society.

*Keywords* Maritime Education, Gender Equity, Seafarer, Sustainability, Women Empowerment

## 1. Introduction

Achieving sustainable development is intricately linked with ensuring gender equity within society, with women empowerment serving as a fundamental pillar crucial for sustainable development of any community. Recognizing the significance of women's economic empowerment and addressing gender disparities in the global workforce are core areas of the 2030 Agenda for Sustainable Development (United Nations, 2015). Economic empowerment of women encompasses various dimensions, including the ability to participate in existing markets equally, access to decent work, control over resources, autonomy over their time, lives, and bodies, as well as increased voice and agency in decision-making at all levels (UN Women, n.d.). This empowerment not only dealing with productivity but also fosters economic diversification and income equality, thereby leading to positive developmental outcomes. In industries such as the maritime sector, dominated by men historically, efforts to promote gender equality have gained traction. The International Maritime Organization (IMO) has been actively engaged in propelling the industry forward and supporting women in achieving a representation aligned with twenty-first-century expectations (IMO, n.d.). Through strategic initiatives such as "Training-Visibility-Recognition," the IMO aims to enhance the contribution of women as vital stakeholders in the maritime domain (IMO, 2015). Despite notable progress, gender inequity persists among maritime professionals. This study explores the challenges and barriers faced by women in the maritime sector, particularly focusing on the context of India. Employing a methodology of stratified random sampling, the research delves into the factors contributing to low female cadet enrollment compared to their male counterparts. Among the identified challenges are insufficient moral support from families and society, compounded by the struggle of balancing a maritime career with family commitments in a male-dominated industry (Vettriselvan & Leela Vinodhan, 2022). Safety and security concerns within the maritime sector further deter families from sending female candidates to pursue pre-sea courses. As the global seafarer workforce comprises only 1.2% women, addressing gender equity in the maritime sector becomes imperative for fostering inclusivity and sustainability (BIMCO/ICS, 2021). This study advocates for additional research and collaborative efforts between maritime education and training institutions and the industry to support women cadets in pre-sea courses. By actively promoting women's education and participation, these institutions can contribute to fostering gender equality in an industry traditionally dominated by men, thus steering it toward a more sustainable and inclusive future. Despite significant strides made in recent past, gender disparities in the maritime sector persist. Women continue to face numerous challenges, including limited access to training and education, bias in employment practices, unequal pay, inadequate facilities, and sexual harassment or abuse (Women Seafarers, 2019). These challenges are not only hinder women's advancement in maritime careers but also contribute to a broader lack of gender diversity and inclusion within the industry. Efforts to address gender equity in the maritime sector must be multifaceted and comprehensive. This includes promote equal opportunities for women in all aspects of maritime education and training, ensuring fair and unbiased recruitment and promotion practices, providing support and resources for women to balance career and family responsibilities, and implementing robust policies and mechanisms to prevent and address gender based discrimination and harassment. Fostering gender equality in maritime organizations is vital for innovation and talent diversity (Gender Diversity in Maritime, n.d.). With inclusive policies and support, the sector can enhance business outcomes and contribute to broader gender equity goals (Gender Diversity in Maritime, n.d.). By creating supportive environments, maritime firms enable women to excel in traditionally male-dominated fields (Gender Diversity in Maritime, n.d.). Embracing gender diversity isn't just morally sound; it's also strategically advantageous for the industry's long-term sustainability and competitiveness. This necessitates commitment from leaders, organizational responsibility, and engagement from diverse stakeholders, including governmental bodies, industry groups, unions, educational entities, and civil society organizations (UNCTAD, 2019). Beyond internal efforts, broader systemic challenges must be addressed, challenging gender norms, promoting women's leadership, and advocating policy reforms for gender equality in maritime (UNCTAD, 2019). Achieving gender equity isn't just about fairness; it's crucial for the sector's sustainability and competitiveness. Empowering women in maritime can drive innovation, diversity, and inclusion, positioning the industry for success in a rapidly evolving global landscape.

## 2. Objectives of the Study

This study aims to achieve the following objectives:

- Evaluate initiatives by maritime education institutions to foster gender equity.
- Provide a comprehensive profile of women cadets in pre-sea courses.
- Understand specific needs and challenges faced by women cadets.
- Propose recommendations to enhance gender equity and inclusivity in the maritime sector.

## 3. Methodology of the Study

This study adopts a descriptive and analytical approach to investigate the role of gender equity in enhancing maritime sustainability through the lens of Maritime Education Institutions (MEIs). The research aims to delineate the involvement of women in the maritime sector, analyze the primary challenges faced by female cadets, and propose potential strategies to promote gender parity within the field. The research methodology encompasses a review of both general and sector-specific international legal frameworks aimed at promoting gender equality in maritime industries. Additionally, it explores the process of field rulemaking and the unique aspects of implementing policies that empower women in the maritime sector. Drawing upon established principles of maritime law, the study integrates the transnational human rights perspective to provide a comprehensive analysis. Given the underrepresentation of female cadets in maritime education institutions, a snowball sampling method was employed to gather data from 150 female cadets enrolled in pre-sea training programs. This approach facilitated the identification and recruitment of participants by leveraging existing connections within the maritime community. To identify key factors contributing to the low enrollment of female cadets in pre-sea courses and to develop effective promotional strategies for enhancing women's participation in the maritime industry, factor analysis was utilized. This statistical technique enabled the research to uncover underlying patterns and associations within the data, informing targeted interventions to address gender disparities.

## 4. Review of Major Initiatives towards Gender Equity in Maritime Education Institutions

The pursuit of gender equality within ocean-related industries is a multifaceted endeavor that necessitates comprehensive legislative frameworks and initiatives. International instruments of both general and sectoral significance address various aspects of gender within the law of the sea. These instruments underscore the pivotal role of the Law of the Sea in upholding human rights, including the principle of gender equality, and advocate for gender parity in fisheries, ensuring equitable access for women fish-workers. Additionally, measures are in place to safeguard the rights of refugees, migrants, and trafficked individuals at sea, thereby promoting gender adaptation and creating safe working environments for women in maritime settings. The establishment of the Commission on Human Rights and the subsequent renaming as the Commission on the Status of Women (CSW) by the United Nations Economic and Social Council (ECOSOC) in 1946 marked a significant step towards advancing women's rights. The ensuing three-decade effort culminated in the formulation of the UN Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) in 1979. CEDAW serves as a cornerstone in the international legal framework for gender equality within marine and ocean-related industries, emphasizing equal access to education and workplace nondiscrimination for women. The International Maritime Organization (IMO) and the International Labour Organization (ILO) have played pivotal roles in promoting women's rights and gender equality within the maritime sector. Notably, the IMO's Integrated Technical Cooperation Programme (ITCP) and the Women in Maritime program exemplify concerted efforts to enhance women's participation in maritime activities. These initiatives advocate for women's inclusion in both shore-based and sea-going positions, underpinned by the principles of training, visibility, and recognition (Belcher et al., 2003). A transnational approach characterizes efforts to address gender equity in maritime industries, leveraging hybrid regulatory processes and empowering initiatives. Soft law instruments, including CEDAW, IMO, and ILO conventions, form the basis of a supranational legal framework aimed at enhancing women's roles in the maritime sector. The IMO and ILO, in particular, have assumed leadership roles in regulating underrepresented sectors, including women's concerns, through the enactment of comprehensive regulations (Goettsche-Wanli, 2019). Internal legal processes within international organizations focus on transnational law principles, facilitating the transfer of best practices across national legal systems and promoting consistency among member states. Additionally, institutional partnerships between the IMO and non-governmental organizations (NGOs) are institutionalized and regulated, further advancing gender equity initiatives (Kormych, 2020). The Maritime Labour Convention exemplifies hybrid rulemaking, incorporating guidance on eliminating shipboard harassment and bullying jointly developed by industry stakeholders. Moreover, the theme of women's empowerment has been embraced by the IMO, as evidenced by World Maritime Day 2019's focus on empowering women in the nautical community. The notion of empowerment entails granting women the freedom to pursue their aspirations and overcome societal barriers, thereby fostering gender equality and inclusivity within the maritime industry (UN Women & United Nations Global Compact, 2011). A concerted effort involving legislative reforms, international collaborations, and empowerment initiatives is essential for promoting gender equity in maritime education institutions. By addressing systemic barriers and fostering inclusive environments, stakeholders can pave the way for greater female representation and participation in the maritime workforce, thereby realizing the full potential of women in the maritime industry.

## 5. Profile of the Women Cadets in the Pre-Sea Courses

A socioeconomic survey was conducted among 150 women cadets enrolled in Pre-Sea courses across maritime colleges in Tamil Nadu, India, aiming to elucidate factors contributing to the declining enrollment of women in these courses. The findings of the survey are as follows: Regional Disparities: The level of awareness regarding the role of women in the maritime industry varies based on the cadets' state of origin. Notably, individuals from South Indian states such as Kerala (43%), Tamil Nadu (14%), and Karnataka (9%) exhibit greater awareness of the opportunities available to female cadets in the maritime sector compared to their counterparts from other regions. This underscores the need for targeted awareness campaigns to enhance knowledge about the sector and encourage greater participation among female cadets. Religious Composition: A significant proportion (80%) of women cadets in Pre-Sea courses identify as Hindu, with Christians (11%), Muslims (7%), and Buddhists (2%) comprising the remainder. These findings highlight the necessity of raising awareness among individuals from diverse religious backgrounds regarding the safety, security, and prospects for female cadets in the maritime industry. Urban-Rural Distribution: Approximately 43% of women cadets in Pre-Sea courses hail from urban areas, while 32% come from suburban regions, and 25% from rural areas. Thus, there is a need for heightened awareness initiatives targeting rural communities to increase the representation of female cadets in maritime education programs. Income Levels: A significant majority (38.4%) of women cadets in Pre-Sea courses report a family annual income of less than Rs. 4,00,000, with only 5.3% earning between Rs. 4,00,000 and Rs. 6,00,000, and a notable 26.3% earning above Rs. 6,00,000. This underscores the financial challenges faced by the majority of female cadets' families, who allocate a significant portion of their annual income towards their children's education. Dependency on Family Income: The survey reveals that 78% of women cadets in Pre-Sea courses rely on their family members' earnings, while 28.1% depend on family pensions. This reliance on a single source of income underscores the financial constraints faced by female cadets and their families, particularly in meeting tuition costs associated with maritime education.

Household Earning Structure: The majority (63.2%) of women cadets in Pre-Sea courses come from households with only one earning member, while 36.8% have two earning members. This distribution highlights the limited earning capacity within female cadets' families, further exacerbating their financial challenges in pursuing maritime education. The findings of the survey underscore the multifaceted challenges faced by women cadets in Pre-Sea courses, ranging from regional disparities in awareness to financial constraints and dependency on family income. Addressing these challenges requires targeted interventions aimed at raising awareness, enhancing financial support mechanisms, and fostering an inclusive environment within maritime education institutions.

## 6. Challenges and Needs of Women Cadets in PreSea Courses

Based on the survey findings among the Pre-Sea Courses, a significant number of cadets face challenges in organizing their tuition payments due to their family's economic circumstances. A considerable proportion of these cadets are cared for by a single parent, and a substantial majority (70.5%) come from households with only one earning member. Moreover, the majority (45.5%) of their family's annual income falls below Rs. 2,00,000, with 25% earning between Rs. 2,00,000 and Rs. 4,00,000. In response to these financial constraints, an overwhelming majority (97.7%) of women cadets in Pre-Sea Courses express the need for financial assistance from external funding agencies. Such assistance would not only alleviate economic burdens but also enable students to focus on their studies and training, thereby completing their courses and fulfilling their aspirations of becoming officers in the maritime sector. The survey also highlights the prevalent dilemma faced by many cadets, wherein their parents encourage them to enroll in regular courses with lower tuition fees, rather than maritime education, due to financial constraints. This underscores the urgent need for financial support mechanisms tailored specifically for female cadets pursuing maritime education. Furthermore, the findings indicate that financial barriers represent one of the most significant challenges encountered by female cadets in Pre-Sea Courses. To address this issue and enhance gender equity in the maritime sector, it is imperative to provide financial assistance and scholarships to female cadets. By doing so, the number of enrollments in maritime courses can be bolstered, paving the way for greater gender inclusivity in the maritime industry. Moreover, the survey respondents emphasize the importance of gender sensitization initiatives aimed at raising awareness about the maritime sector among the general public. By fostering greater awareness and understanding of the opportunities available to women in the maritime industry, gender equity can be achieved, thereby creating a more inclusive and diverse workforce in the maritime sector.

## 7. Suggestions given by the Women Cadets in the Pre-Sea Courses

The overwhelming majority (94.7%) of female cadets in pre-sea courses expressing a need for financial assistance underscores the critical importance of providing adequate support to promote maritime courses among women cadets and uphold gender equality. This finding underscores the necessity of implementing robust financial assistance programs tailored specifically to the needs of female cadets in pre-sea courses. By addressing the financial barriers faced by aspiring women mariners, maritime training institutions can foster an inclusive environment that enables equal access to educational opportunities and promotes gender parity within the maritime industry. Furthermore, it is imperative to recognize that financial assistance alone may not suffice to address all the challenges encountered by women cadets in pre-sea courses. In addition to providing financial support, maritime training institutions should also focus on creating a supportive and inclusive learning environment that addresses the unique needs and concerns of female cadets. This may include implementing mentorship programs, offering career guidance and counseling services, and fostering a culture of respect and equality within the maritime training community. Moreover, raising awareness about the opportunities and benefits of pursuing maritime careers among women cadets is essential for increasing female enrollment in pre-sea courses. Maritime training institutions should actively engage in outreach and promotional activities targeting women cadets to dispel myths and misconceptions surrounding maritime careers and highlight the diverse opportunities available within the industry. By promoting gender equality and encouraging more women to pursue maritime education and training, maritime training institutions can contribute to the advancement of women in the maritime sector and create a more inclusive and diverse workforce. Addressing the financial needs of female cadets in pre-sea courses is crucial for promoting gender equality and fostering greater participation of women in the maritime industry. By providing financial assistance, creating a supportive learning environment, and raising awareness about maritime career opportunities, maritime training institutions can empower women cadets to pursue their educational and professional aspirations and contribute to a more inclusive and equitable maritime sector.

## 8. Promotional Strategies for Gender Equity in Maritime Sector

To popularize maritime opportunities for women at the grassroots level, we can launch targeted awareness campaigns in local communities. Collaborating with local organizations and leaders, we'll spread information about maritime courses and career paths for women. Additionally, we'll create awareness among female students by implementing outreach programs in schools, organizing seminars, workshops, and career fairs.

Engaging successful female seafarers in awareness campaigns will help amplify our message through social media and public events. Publicizing the importance of maritime courses for women, emphasizing career advancement and personal fulfillment, is crucial. Setting women cadet admission targets in maritime education institutions, alongside offering financial assistance like scholarships, will further support female representation in the maritime sector. These strategies aim to enhance gender equity and empower women to pursue rewarding careers at sea.

## 9. Conclusion

In examining the pivotal role of gender equity in empowering women across maritime training institutions (MTIs), it becomes evident that the issue is multifaceted and deeply intertwined with various socio-economic factors. The study sheds light on the challenges faced by women cadets in accessing maritime education and training, as well as the potential strategies to promote gender parity in the maritime sector. One of the central findings is the stark underrepresentation of women in maritime education institutions, with female cadets accounting for only a fraction of the total enrollment. Economic barriers significantly contribute to this disparity, as many women cadets face financial constraints that hinder their ability to pursue formal pre-sea training. Societal attitudes and perceptions towards women's participation in traditionally male-dominated industries further marginalize female cadets in the maritime sector. Addressing these systemic barriers requires targeted interventions and promotional strategies. Popularizing the opportunities available in the maritime industry for women at the grassroots level is essential. Raising awareness among communities and educational institutions about the benefits of maritime education and training for women can help cultivate a pipeline of female cadets interested in pursuing careers at sea. Proactive engagement with female students at the school level is crucial to introducing them to maritime courses and career pathways. Early exposure and outreach efforts are necessary, as many women only become aware of maritime education through indirect means. Moreover, leveraging the influence of celebrities to raise awareness about maritime education among women can create excitement and aspiration around careers in the maritime sector, thereby attracting more female candidates to enroll in pre-sea courses. Maritime education institutions should also launch dedicated admission campaigns to promote the value of maritime courses for women, set enrollment targets for female cadets, and offer financial assistance in the form of scholarships to increase female representation. The study underscores the importance of addressing broader societal attitudes and perceptions towards women in the maritime sector. Fostering a culture of inclusivity and gender sensitivity within maritime education institutions and the industry at large is vital to creating a supportive environment for female cadets. Promoting gender equity in maritime education institutions is essential for fostering sustainable societal progress and empowering women in the maritime sector. By implementing targeted promotional strategies, addressing economic barriers, and challenging societal norms, it is possible to create a more inclusive and equitable maritime industry that harnesses the full potential of women cadets.

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# Analysis of Maritime Pilots' Education in the Republic of Croatia

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**Abstract:** In the Republic of Croatia, piloting is regulated by the Maritime Code and the Regulation on Maritime Piloting. To safely perform piloting duties, maritime pilots in Croatia must undergo specific education and training following the guidelines outlined in IMO Resolution A 485(XII). Due to the increasing demands of the maritime industry, additional education for maritime pilots is provided. Additional education takes place on simulators, covering various maneuvering scenarios in different weather conditions. Education is conducted at universities or specialized training centers. Although additional education is not legally mandatory in the Republic of Croatia, it is undoubtedly beneficial due to the needs of the maritime industry. The goal of the paper is to explore the implementation of additional education for maritime pilots, with a specific focus on identifying potential opportunities for improvement. For research purposes, a questionnaire on the implementation of additional education for maritime pilots was developed. The aim of the questionnaire was to obtain information about the quality of education and acquired competencies. The results of the conducted research indicate that maritime pilots believe the implementation of additional education is necessary, especially concerning specific types of vessels.

*Keywords*: education; maritime piloting; maritime pilot; education quality; acquired competencies

## 1. Introduction

Pilotage includes the guidance of a waterborne craft by a competent person (maritime pilot) and expert advice given to the master of the waterborne craft, safe navigation in ports, straits, and other areas of internal waters and the territorial sea of the Republic of Croatia (Maritime Code of the Republic of Croatia 17/19). Maritime pilots possess comprehensive knowledge of local navigation, ships, ship interactions, and meteorological conditions (Šabalja & Kos 2007). They must also have effective communication skills to interact with crew members and other individuals involved in maritime communication (Sellberg, Nordenström & Säljö 2024].

During pilotage, the maritime pilot's responsibility is to steer the ship and provide expert guidance to the master on navigation, berthing/unberthing, and anchoring. They are also responsible for issuing warnings concerning navigational conditions and regulations specific to the region in which they are operating. Given the considerable economic and environmental challenges, the role of the pilot becomes crucial, particularly when it comes to large vessels.

The principal goal of all nautical operations, including pilotage, is to prioritize the safety of ships, cargo, passengers, and the port community while also ensuring the protection of the environment (Petrinović & Matulić Sumić 2014). In fact, in complying with their duties, pilots fulfill the purpose of ensuring safe navigation in the public interest (Berlingieri 2022).

With its origins in ancient Greece, pilotage has a rich historical background and plays a crucial role in ensuring safe navigation. National laws and local port regulations have governed pilotage in European countries since the early 17th century (Amižić Jelovčić, 2022). Nowadays, pilotage is one of the oldest and least-known maritime professions. However, it stands as a vital component in ensuring maritime safety and facilitating commercial trade routes.

It is important to emphasize that maritime pilots are highly qualified seafarers who possess unique experience, extensive knowledge of the local area, and specific skills (Hontvedt 2015). They represent a unique category of seafarers since each has undergone extensive education and a seagoing service before starting a career as a maritime pilot.

The Ordinance on Sea Pilotage stipulates that pilotage can only be carried out by commercial companies (Peljarsko društvo – Maritime Pilots Association) that have received the approval of the Ministry of the Sea, Transport, and Infrastructure to carry out these activities. There are seven maritime pilot associations in the Republic of Croatia (Pula, Rijeka-Senj, Zadar, Šibenik, Split, Ploče, and Dubrovnik) in which pilotage is carried out by 35 maritime pilots. Since the Republic of Croatia requires only a small number of pilots, there are no specific educational requirements mandated by the law. As a result, companies specializing in maritime piloting provide customized training programs.

## 2. Formal education of maritime pilots in the Republic of Croatia

Shipping can furthermore be regarded as a high-risk industry with the potential to negatively affect not only those serving on board but also the marine environment and the public in case of an incident or accident (Praetorius & Sellberg 2022). Training and education are crucial in equipping mariners with the skills and tools to ensure safety in operations (Praetorius, Hult & Österman 2020). Figure 1 highlights the significance of formal education and additional training for maritime pilots.

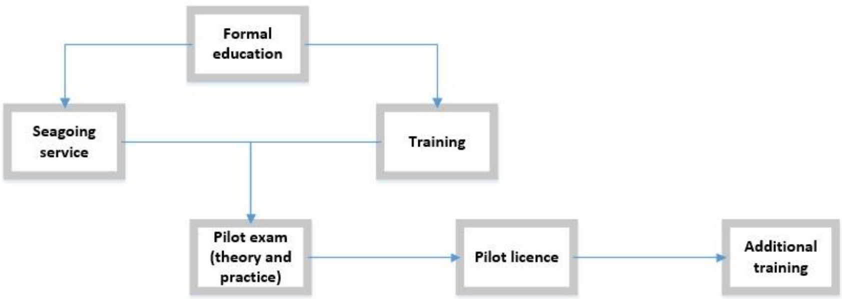


Figure 1. Education of maritime pilots.

To obtain a pilot license, one must go through a series of required steps. Seafarers can obtain a certificate of competency as Master on ships of 3,000 gross tonnage or more if they:

- attended lectures and passed all the exams of the Nautical Study Program, which included at least the content of Table A-II/2 of the STCW Code,
- passed the exam to obtain the Certificate of Competency as Master on Ships of 3,000 GT or more set forth in the STCW Code II/2,
- have a General Radio Operator's Certificate (the standard of competence specified in section A-IV/2 of the STCW Code),
- have the following certificates of competency: Basic Safety Training - STCW A-VI/1; Advanced Fire Fighting - STCW VI/3; Proficiency in Survival Craft and Rescue Boats (other than fast rescue boats) - STCW A-V1/2-1; Medical First Aid - STCW VI/4-1; Advanced Medical Care - STCW VI/4-2,
- have the following certificates of competency: Radar observer and Automatic Radar plotting aid ARPA simulation–operational level; Radar observer and Automatic Radar plotting aid ARPA simulation–management level; Operational use of Electronic Chart Display and Information System (ECDIS)-STCW A-II/1, B-II/1; Bridge Resource Management - STCW II/1; Application of Leadership and Team-working skills - operational level–STCW A-II/1, A-III/1, A-III/6; Use of Leadership and Managerial Skills - Management Level STCW A-II/2, III/2; Marine Environmental Awareness.

In addition to the above, many employers also send seafarers for additional courses and training. Some of them, which are related to navigation and ship maneuvering, are:

- Training course for a specific type of ECDIS,
- BTM - Bridge Team Management,
- BRM - Bridge Resource Management,

- Ship handling and maneuvering,
- Dynamic Positioning,
- Various STCW Ship Simulator Courses to prepare seafarers for new types/sizes of ships or for new ports.

To successfully pass the pilot exam, the Croatian Maritime Pilots Associations must make sure that candidates receive hands-on pilotage experience in a specific area, with the guidance of a mentor pilot. To obtain a pilot's certificate, an individual must pass the pilot's exam and fulfill the specified requirements. The pilot exam can be taken by any person who:

- holds the Certificate of Competency as Master on Ships of 3,000 GT or more,
- possesses the basic proficiency certificate for working on tankers, the certificate of competency as a general radio operator and additional proficiencies required to obtain the Certificate of Competency as Master on Ships of 3,000 GT or more,
- has at least 12 months of seagoing service in the capacity of chief officer or ship master after obtaining the Certificate of Competency as Master on Ships of 3,000 GT or more,
- meets the prescribed health requirements for the deck department,
- has at least 50 port pilotages for a specific port pilotage area and at least 5 coastal pilotages under the supervision of a licensed pilot; the candidate must keep a log for each pilotage, which is then verified by both the pilot and the master of the piloted ship. When applying for the pilot exam, the candidate must submit the verified log to the harbour master's office.

The pilot exam comprises a theoretical and a practical part.

The theoretical part of the exam is oral and includes the following subjects:

- Navigational safety which refers to the geographical features of the particular pilotage area (the topography of the coast and its edge, as well as of the islands, bays, channels and canals), hydrographic conditions (port access waterways, seabed, shallows, underwater obstacles on waterways, depths on certain places in the port, the structure of the sea floor at anchoring points, sea currents, the position and characteristics of the lighthouses, coastal lights and marks, buoys, port plans, nautical charts and other navigational aids), hydrometeorological characteristics of the pilotage area (types of wind, wind direction and speed in particular periods of the year, daily variations, temperatures, air humidity and air pressure, clouds, precipitation, visibility, direction and height of waves), procedures for ship berthing and unberthing (number, arrangement and characteristics of tugs, suitable places for anchoring, sea depth at anchorages, access to the coast in adverse weather conditions, pilotage regarding their size, propulsion and other navigational characteristics, use of navigational aids in pilotage), emergency incidents during pilotage (collision, impact, grounding, fire, explosion, flooding, procedure in case of listing due to cargo shifting, pollution of the marine environment from the ship, place of refuge),
- Sea pilotage refers to navigation (COLREGS - regulations for preventing collisions at sea, special navigation regulations in areas difficult for navigation, fairway regulations, buoys, navigation lights, danger alerts, assistance at sea, search and rescue, MRCC - the Maritime Rescue Coordination Center, CVTMIS - the Croatian Vessel Traffic Monitoring and Information Service), pilotage (regulations on pilotage, port and coastal pilotage, pilot's duties), order in port and at sea (entering the port, free pratique, order on board the ship at port, prohibited activities in port, ship's departure from port, rules on order in ports), custom of the port (ISPS Code - the International Ship and Port Facility Security Code, rules on the transport of dangerous or polluting goods, regulations on investigation of marine casualties, regulations governing navigation in internal waters), duties and authorizations of harbour master's offices and port authorities, medical, customs and phytosanitary inspection procedures in ports, supervision of the state border crossings and movement transit, the prevention of sea and marine environment pollution, general rules on pollution prevention, the rules of individual ports, black water, ballast water and waste management plans, procedure regarding disposal of cargo residues and human waste from ships, procedure in case of pollution, duties of the master in case of pollution from the ship, MARPOL - International Convention for the Prevention of Pollution from Ships.
- English language skills include conversational ability and a good knowledge of maritime expressions used in connection with navigation, maneuvering, pilotage, and the stay of a ship at port, as well as Standard Marine Communication Phrases (SMCP). The practical part of the exam includes:

- maneuvering the ship while entering the port, depending on the size and type of the ship that normally operates in the area for which the exam is taken, • maneuvering the ship while leaving the port, depending on the size and type of the ship that normally operates in the area for which the exam is taken,
- navigation between two ports in an area of mandatory coastal pilotage.

According to the information provided, satisfying the requirements for passing the pilot exam as a seafarer includes not only academic education but also compliance with the STCW Convention and the Ordinance on ranks and certification of seafarers, as well as the completion of additional employer-mandated courses. Moreover, a seafarer must have a minimum of 48 months of seagoing service, including the following:

- at least 12 months of seagoing service as a deck cadet,
- at least 24 months of seagoing service as an officer in charge of a navigational watch on ships of 500 GT or more, of which at least 12 months of seagoing service as a Chief Mate on ships of 3,000 GT,
- at least 12 months of seagoing service as a Chief Mate or Master after obtaining a Certificate of Competency as Master on Ships of 3,000 GT or more.

IMO (IMO: Res. A.960(23) 2003) provides comprehensive guidelines on the training, qualifications, and operational procedures for maritime pilots. These guidelines include a range of formal education programs, as well as additional training specifically tailored for maritime pilots.

## 3. Methodology

A questionnaire was used to assess the education, training, and certification procedures for maritime pilots in the Republic of Croatia.

### *3.1. Participants*

A total of 28 marine pilots from seven pilot companies took part in the research. Every participant possessed a valid maritime pilot license and prior experience working on merchant ships. Service in the merchant fleet varied between 10 and 24 years. The range of years spent in the capacity of a master ranged from 0 to 19 years of experience. Experience as a marine pilot ranged from 1 to 18 years. The respondents represented different pilotage areas along the Croatian coast.

### *3.2. Procedure*

The research was conducted using a questionnaire written in English. The survey was emailed to seven pilot companies, comprising a total of 35 pilots. Data collection involved the use of self-completion questionnaires. The questionnaire included multiple-choice and open-ended questions. Respondents were given a suggested answer format for multiple-choice questions and had to choose one of the provided options. Openended questions enabled respondents to generate their own answers freely. A sample of 28 correctly completed questionnaires was collected, representing an 80% return rate. Participation in the research was voluntary. The answers were anonymous and used only for research purposes.

## 4. Results

The pilot's responses regarding further education have been outlined below. Topics that hold substantial significance for future education have also been identified. Currently, the implementation of additional training ranges from one to four. The topics covered are Bridge Team Management, bridge simulator training, ECDIS course, Cargo operations, Pilot management simulation training including ship handling of LNG vessels, Maneuvering, Introduction and safety awareness in LNG and container industries, and Working on a simulator in handling LNG and container vessels in various berthing/unberthing scenarios.

The evaluation of knowledge and skills related to education implementation is graphically represented in Figures 2 and 3.

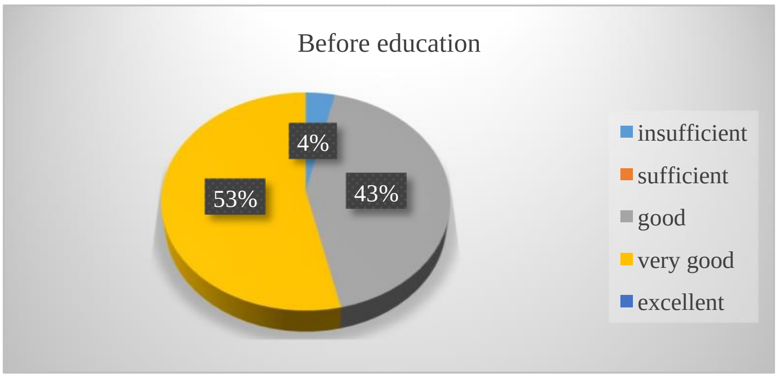


Figure 1. Evaluation of knowledge and skills before the training.

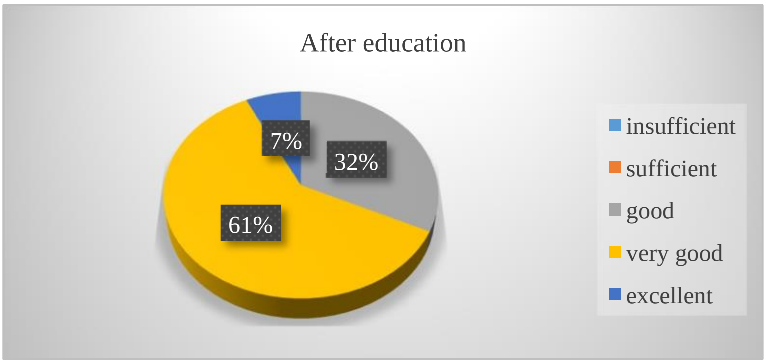


Figure 2. Evaluation of knowledge and skills after the training.

Figure 4 illustrates the connection between educational goals and the requirements of maritime pilots.

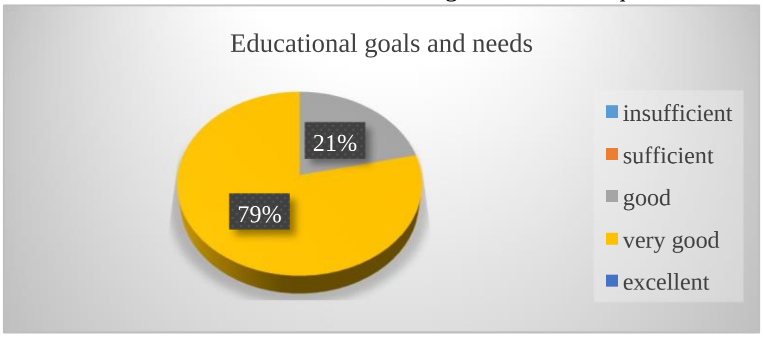


Figure 3. The evaluation of the correlation between educational goals and the needs of maritime pilots.

In an effort to enhance the overall quality of the additional education they have received thus far the maritime pilots suggest the following:

- sharing experience about how to perform and/or handle different scenarios with other pilot organizations,
- group sessions with tug masters,
- more different scenarios,
- training as recommended per IMO Resolution A.960(23),
- sea practical training on different types of ships,
- use of modern equipment.

All respondents expressed their interest in additional education. Topics that maritime pilots believe should be included in additional education are ridge team management for pilots, legal advice, pilot recovery from the sea and use of the safety equipment, manned model training, more practical work, constant upgrade of sessions with the latest rules and regulations in force, using modern technologies when handling new age vessels, ship handling with tugs, practical training, communication pilot-tug boat, hands-on training, BRM.

**4. Conclusion**

Additional education for maritime pilots in the Republic of Croatia is not a legal requirement. Nevertheless, it is crucial to highlight that the implementation of additional educational options presents a chance for professional growth. Therefore, further education is provided based on the specific requirements of each pilot company.

This research's purpose was to highlight the importance of implementing additional education for maritime pilots in the Republic of Croatia. Therefore, it can serve as a starting point for initiating additional education. A questionnaire was selected as the research instrument since it offers insight into the quality of education and acquired competence. Furthermore, it serves to identify potential areas of improvement.

Maritime pilots assess their knowledge and skills prior to and following the training. The findings demonstrate a notable enhancement in the knowledge and skills of maritime pilots after their completion of the educational program. The overall alignment of educational goals with the needs of maritime pilots is satisfactory, suggesting potential areas for enhancement.

The implementation of additional educational programs is extremely useful for maritime pilots since it allows them to improve their knowledge and skills. Suggestions for improving present and future education are of great importance. Topics like bridge team management for pilots, legal advice, pilot recovery from the sea and use of safety equipment, manned model training, more practical work, constant upgrade of sessions with the latest rules and regulations in force, using modern technologies when handling new age vessels, ship handling with tugs, practical training, communication pilot-tug boat, hands-on training, BRM, should definitely be included in future education. Introducing new subjects in additional education provides a chance to enhance the knowledge and abilities of maritime pilots, ultimately promoting maritime safety and environmental protection.

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# How to Choose the Right Lab Equipment? – A Decision Support Framework for Investment in Energy Conversion and Storage Technologies for Engineering Educations

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Abstract: The landscape of technologies for energy conversion and storage are changing rapidly in the present and coming years. Emerging and existing technologies are competing for market dominance, with great uncertainty as to what the dominant technologies of the coming decades will be. With the practice of laboratory exercises being well established in engineering educations, to familiarize future alumni with specific, relevant equipment and bridge the gap between theory and practice, universities and engineering academies are challenged in determining the most pertinent technologies and equipment to invest in. This paper presents a Decision Support Framework (DSF) to facilitate and inform investment decisions for laboratory equipment. By introducing nine constraints towards which potential investments are assessed using a numerical scale, the DSF provides a comprehensive walk-through of important considerations that is easy to use by practitioners. The constraints are divided in internal, focused on the learning environment, and external, focused on physical and economical parameters, categories. As an action-oriented framework, the DSF rests on the same foundation as decision support tools in health care and environmental management, in that it helps qualify the decision process. The DSF allows for customization of the scoring system towards specific circumstances but presents a general metric.

Keywords: Laboratory Equipment; Decision Support; Engineering Education; Learning Objectives; Life Cycle Cost

## 1. Introduction

Laboratory work is an integral and extensive part of many engineering educations, based on the general premise, that engineers are practically minded and that understanding the working principles of machinery and plants may well be supported by practical work in laboratories (Edward, 2002). Within energy conversion technologies, the increasing prevalence of renewable energy sources has thus spurred the advent of energy labs with wind turbines, photo voltaic arrays and microgrids, to facilitate competency acquisition relevant to these technologies (B. Chowdhury et al., 2013; Bosma et al., 2009).

Tomorrow's technological landscape of energy conversion and storage is markedly different and more diverse than in previous decades. Fuel cells, electrolyzers, chemical reactors, Fischer Tropsch synthesis, Haber Bosch hydrogenation, biogas, flywheels, pumped hydro, compressed air and hot rock energy storage, pyrolysis and gasification plants, large scale battery storage, hydrogen pipelines are but some of the technologies that will gain a foothold or increased presence in the energy markets.

Regardless of which technologies will emerge or prevail in the sustainability transitions, engineers will be needed to design, operate, and maintain plants and equipment. While the overall goal of obliterating the dependency on fossil fuels and the consequential emission of greenhouse gasses is clear, the route to acquire this goal is less straightforward. Rather, we are paving the road as we move forward, and while there is scattered focus on avoiding unfortunate path dependencies and failed investments in dead-end technology, it would be foolhardy to assume that the most appropriate technologies and solutions will be chosen from the start (Thaler et al., 2023).

This put institutions educating engineering and maritime professionals, in a dilemma; should course subjects be centered on currently available technologies or should a more proactive approach be adopted, in which some of the available time and resources are dedicated to technologies that may, or may not, prevail in the future? And, in the latter case, how should institutions and professors go about choosing the right focal areas? While updates to curricula for classroom settings may be time-consuming and cumbersome, the investment needed is primarily in professor working hours. Conversely, laboratory equipment requires substantial consideration towards initial investment (CAPEX), operating costs (OPEX), expected lifetime, power consumption, emissions, safety, storage, installation, and many other factors as for investment in any equipment, in addition to the academical working hours needed to qualify the purchase, author exercise instructions, gain familiarity with the equipment and ultimately use the equipment with students in labs.

Interestingly, there appears to be very little scientific literature to support institutions in choosing the right laboratory equipment. One example of potentially useful research in the area is seen in Tully & Meloni (2020), in which the authors present a thorough presentation of various 3d-printing technologies, with the stated purpose of aiding in choice of 3d-printers for laboratories. However, the article concludes: “To choose an appropriate printer, the reader should think carefully about the currently (and possibly future) intended applications and marry it with a printing technology, understanding its limitations, while balancing time and financial cost” (Tully & Meloni, 2020). Thus, ultimately, while the reader is left well informed about the technical capabilities and limitations of various 3-d printing technologies, the actual decision process is guided only by a cautionary note; to think carefully before buying.

The problem of qualifying investments in laboratory equipment is discussed by Canh et al in their 2015 case study, where the result pointed to the importance of establishing suitable strategies for investments in educational equipment and laboratories, and highlighted the positive impact that effective equipment management has for overall educational success (Tran Van Canh et al., 2015).

A specific, highly detailed decision support tool for purchase of laboratory reagents was developed by Sudsai (2011). However, due to its specific nature, where reagents and suppliers are scored to purely numerical constraints based on performance parameters, this tool cannot be used to qualify laboratory equipment in a general sense (Sudsai, 2011). While not specific to educational labs, a guide to laboratory purchases is presented in Turle (2009). Here, the author highlights the importance of considering aspects such as lead time, investment and operating costs, installation, managing and operating the equipment once installed as well as which services are needed in the form of power, ventilation, water, gasses, etc. (Turle, 2009). No guidance on how to measure these aspects is provided, however.

Although the problem of choosing the right lab equipment is far from new, we argue that it is more present than ever, given the multitude of emerging energy conversion and storage technologies competing for market dominance within the sustainability transitions. Therefore, we propose a decision support framework to aid universities, engineering colleges and maritime academies, to ensure that equipment investments are measured to a set of defined criteria and may be quantitively weighted against other technologies or solutions. Further, by establishing an objective framework, we aim to facilitate the process of fund raising, for the purpose of ensuring that laboratories meet the needs of future alumni.

## 2. Methodology - Framework Development and Classification

Frameworks are used for varying purposes in academia and by policy developers and practitioners. A decision support framework (DSF), as proposed in the present study, may well be classified as an action-oriented framework, as per the typologies defined by Cumming (2014), in which framework are classified in the five categories of: hypothesis-oriented frameworks; assessment-oriented frameworks; action-oriented frameworks; problem-oriented frameworks; and theory-oriented or overarching frameworks. According to Cumming, the action-oriented frameworks “recommend a particular course of action by an established set of actors in response to a particular kind of problem” (Cumming, 2014). The problem, in this case, is choosing the right lab equipment, and the recommended action should point to purchasing one or more piece(s) of specific equipment. In developing the framework, the first step is establishing the basis for the decision. Here, several options are available, such as technology market share, news value / publicity (for the attraction of new students), or environmental urgency, but for this DSF, our perspective is that of the teacher, who has a vested interest in ensuring his/her students achieve a set of defined learning objectives (LOs). As such, phase one in the DSF is selection of one or more LOs, see Figure 1. For the purposes of establishing a consistent approach and a basis for the decision process, LOs are considered static entries in the present study.

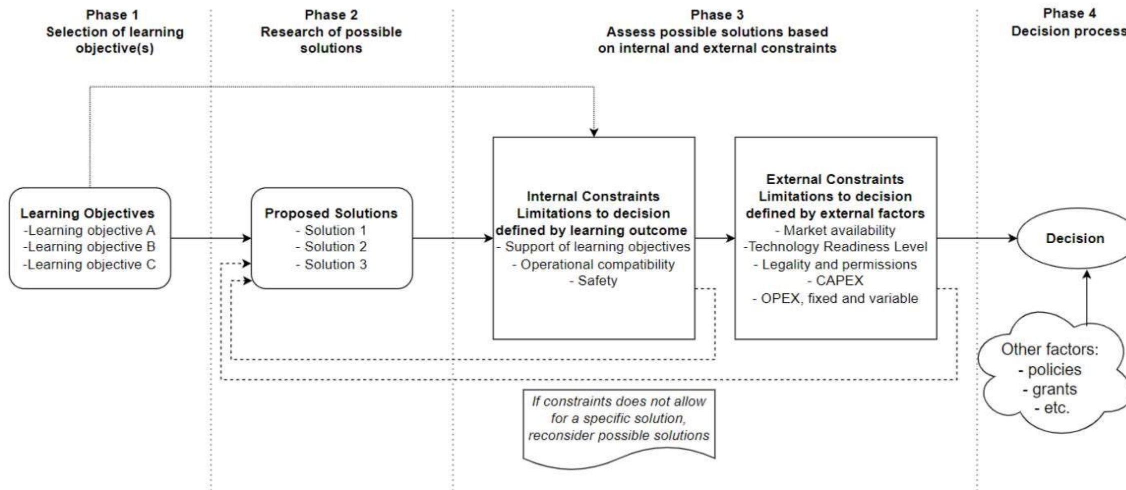


Figure 1 - Decision Support Framework for evaluating potential investments in lab equipment.

Phase two, then, considers possibly means to support students in achieving the selected LOs using laboratory equipment, from a high-level perspective resulting in a list of relevant technologies/equipment. As an example: if a selected LO from phase one is: “Describe different power-to-gas, gas-to-liquid and power-toliquid processes e.g., electrolyzers and the Fischer-Tropsch process”, items on the list might include different electrolyzer types and chemical reactors. Compiling the list should be done from a variety of data sources, such as: industry actors (suppliers, OEMs, consultants), researchers, patents, and companies specialized in lab equipment, e.g., FESTO, G.U.N.T, or TERCO. The idea is to attempt to establish an exhaustive list, which can then be qualified in phase three.

Phase three is the most comprehensive and time consuming in the DSF. Here, each item from the list of possible solutions from phase two is subjected to internal and external constraints, which inform the decisionmaking process. Compliance to each constraint is then assessed using a numerical scale, the extremes of which are defined so a higher score means higher level of compliance, whereas a low score entails little to no compliance.

The subset of internal constraints is headlined by the question “How well does the solution support the intended learning objective?” To evaluate this, three areas are assessed: degree to which access to equipment support acquiring defined skills, knowledge, or competencies (the LOs); operational compatibility with the educational environment; and concerns of student or employee safety.

The external constraints, on the other hand, considers the feasibility of acquiring, maintaining, and operating the equipment. The items of inquiry here are: market availability of equipment (access to trusted suppliers, lead times, etc.); Technological Readiness Level (a measure of the technology maturity level which act as a proxy to determine the relevance); legality and expected difficulty in obtaining permissions; CAPEX; fixed OPEX; and variable OPEX. In Table 1, the constraints are listed along with a proposed scoring metric for each constraint. All constraints are posed as questions, where investigators assign scores based on compliance to constraints, with higher scores signifying a solution that fits well within the individual constraint. Due to the expected variability of possible solutions for evaluation, only the extremes of the scale are proposed. Depending on the number and nature of specific competing solutions investigated, the definition of intermediate scores may be chosen by the investigator to allow for appropriate granularity and precision.

Finally, with the dataset from stage two and three available, the evaluated solution should be considered, preferably by a broader range of professors/teachers/investigators, against compatibility towards other LOs.

The reasoning here, is that the thorough evaluation conducted in phase three, may well have resulted in a better understanding of the prospects and limitations of the proposed solution. Thus, while the DSF is presented as a linear model, the investigation process will include naturally occurring feedback loops, where investigators become aware of synergies between potential solution for the LO(s) in question and other related LOs. Similarly, the investigation of possible solutions towards more than one LO concurrently, may result in one or more pieces of equipment being needed to support the LOs, and consequently should be scored according to this, e.g., with higher combined cost or lower availability.

Phase four is the process of comparing the proposed solutions, using the scores for each constraint and any other included factors. As for any decision support tool, the DSF presented herein does not output a specific solution, but rather informs a decision process that is, ultimately, qualitative (National Research Council, 2009).

Table 1 - Internal and external constraints with scoring metric

| How well does the proposed solution support the intended learning outcome? (Internal constraints) | Scoring metric |
|---|---|
| To what degree does access to physical equipment support acquisition of defined skills, knowledge, or competencies? | 1: Little difference from working with subject theoretically. 9: LO cannot be achieved without access to eqm. |
| Operational compatibility with learning environment and accessibility: Start-up/stopping time, lag time in regulating; how accessible is the equipment for learning purposes? | 1: Eqm. requires several hours of supervised time before start-up and/or more than eight clock hours of working time is required per experiment.<br>9: Eqm. has zero to very short start-up time. Meaningful experiments may be conducted in less than 90 minutes. |
| Safety. To what extent is the solution associated with hazards requiring mitigation and what is the residual risk? | 1: High risk – Result from preliminary risk assessment points to specific safety procedures and PPE requirements.<br>9: No or very low risk – Students can work with eqm. unsupervised. |
| **What are the main considerations in acquiring, installing, and operating the proposed solution that are outside the learning environment? (External constraints)** | **Scoring metric** |
| Availability of equipment; is it available from (trusted) suppliers, what is the lead time? | 1: Eqm. has lead time of more than 18 months and is not available from known/trusted supplier.<br>9: Eqm. has lead time of less than two weeks, available from known and trusted supplier |
| Technology Readiness Level. Is the technology mature? | Scored from 1 to 9 according to metric defined in the HORIZON work program (European Commission, 2014) |
| Legality and permissions; is it legal to install and operate the equipment in the proposed area(s) and/or are permissions from authorities required - what is the timeframe to acquire permission, if needed? | 1: No foreseeable way to obtain permission or dispensation or timeframe of more than 2 years.<br>9: No obligation to inform authorities or seek permission. |
| CAPEX; proportionally, what is the cost of the evaluated solution compared to other possible solutions? | 1: Considerable external funding is needed for initial investment.<br>9: Price of eqm. falls under micro purchase threshold, as defined by the university / academy. |
| Fixed OPEX; to what extent are recurring calibrations, yearly inspections, license renewals or similar needed? | 1: Periodically accruing license fees and/or inspections by notified body are required.<br>9: No inspections, calibrations, or periodic adjustments are needed or expected. |
| Variable OPEX; maintenance and repairs, cost of fuel and consumables | 1: High energy expense during standby and or/operation. High consumable expense. Expensive wear parts or costly repairs expected.<br>9: No standby consumption, limited material or energy usage during operation. No expensive parts in eqm. |

## 3. Discussion – Applicability and Validity of the DSF

Within e.g., ecosystem services, decision support tools are sometimes too expansive to be practically useful (Bagstad et al., 2013). In contrast the presented DSF is a relatively simple and versatile tool, wherein the investigator scores potential equipment investments to a number of internal and external constraints.

The DSF does not include specific measures to counter investigator bias when scoring potential solutions, though a possible approach could be to identify and exclude investigators biased towards specific suppliers or technologies, or softer versions where scores from biased investigators are weighted against their biases (Rabiee et al., 2021). Rather, we urge that users of the DSF themselves evaluate the need for bias management tools.

While the proposed scoring metric will result in a total number between 9 and 81 when summating scores for all constraints, we recommend that the total score is used for a very rough comparison of proposed solutions only, if at all. Each of the constraints attempt to quantify, in a single number, complex categories of potential impacts from evaluated, competing or complementary solutions; an approach that may be likened to normalization of impact assessment data when conducting Life Cycle Assessments (LCAs), where consistency is sometimes challenged (Hélias & Servien, 2021).

Rather than looking at the total score, we argue that the score for each constraint should be weighted for the intended use case and defined LO, also considering the availability of alternatives: For a LO designated to acquiring a skill in using specific equipment, purchasing said equipment may have high priority regardless of e.g., foreseeable maintenance costs. Likewise, if safe working practices cannot be internalized by students without access to potentially dangerous equipment, a low score on the "safety" constraint may have to be accepted. Again, drawing a parallel to the internationally recognized practice of conducting LCAs, this can be compared to weighting, where, based on a specific, typically political, agenda, e.g., impacts to human health may be weighted higher than impacts on global warming (Pizzol et al., 2017). Weighting in LCA practice is subject to substantial critique, in that it is "based on value choices" (International Standard Organization, 2006). Value choices, however, are hard to circumvent when determining the best way to obtain knowledge, skills, and competencies. Some terms used in the phase three scoring metric have a distinct qualitative nature; "high", "considerable", or "little" are meaningful only when used in a comparative way. There is also some overlap for several constraints, e.g., "Fixed OPEX", "Safety" and "Operational compatibility", where failure to enforce inspection regimes might cause a safety risk, just as planning and execution of recurring inspections might influence availability of the equipment. Hence, we adopt the epistemological distinction of truth claims proposed by Hertwich et al (2000), as either "factual, based on natural science; normative claims, which refer to preference values; and relational claims which address the proper relation between facts and knowledge", and assign numerical value to constraint compliance, while allowing qualitative weighting based on specific circumstances (Hertwich et al., 2000).

## 4. Conclusions and Further Research

The framework presented in this paper manifests a list of nine qualitative and quantitative considerations which should be included when investigating additions to, or replacements of, laboratory equipment. The provision of guidance towards emerging technologies is supported by the inclusion of Technology Readiness Level in the assessment criteria. Costs are considered for both initial investment and operating expenses. While fund raising for laboratory equipment often only include capital expenditures, the inclusion of both variable and fixed operating costs in the assessment ensures that the life cycle cost of the proposed equipment is made visible.

A basic prerequisite for the function of the framework is that LOs defined in the curriculum are updated and correct. In the domain of renewable energy technology and sustainability transitions, this is not always the case. While some conceptual work has been carried out to qualify curricula based on performance of technology in Life Cycle Assessments, the development of more decision support tools is needed to ensure that LOs are qualified towards sustainable technology (Kolind & Rønn, 2023). Further, previous research has indicated that laboratory work in engineering educations is not always fulfilling the learning potential of the experimental and practical exercises (Bernhard, 2018; Feisel & Rosa, 2005).

Therefore, we see that the DSF presented in this paper should be accompanied by the development of an overarching framework to qualify the curricula for the sustainability transitions, with proper attention towards optimal gain from laboratory equipment and exercises to ensure education of mariners and engineers that can not only install, operate and maintain emerging energy storage and conversion technologies, but also choose the most valid option when selecting technologies.

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# Autonomous Vessels and AutoMare EduNet – National Revolution of Maritime Education in Digivisio 2030 Platform

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**Abstract:** The autonomy of seafaring will take a huge step when IMO Maritime Safety Committee will finalize the MASS Code to be implemented as part of SOLAS. The Code will be implemented first on a voluntary basis in 2026 and it will be mandatory part of SOLAS since 1.1.2028. IMO Legal Committee has also started to renew the Maritime Conventions to meet the demands of vessels with different stages of autonomy. Technology has been developing fast in this area, especially in Nordic countries where the Maritime Cluster has been active in this field.

The Maritime cluster in Finland has built up a network for education of autonomous seafaring in order to combine the efforts of different Universities and Universities of Applied Sciences in this field. As combined effort of the Universities in this AutoMare EduNet -project (financed by Ministry of education in Finland), the universities made a survey on the needs for education and then planned the combined efforts to guarantee that the industry´s needs for well-educated workforce related to autonomous vessels are met since September 2025 and onwards. The education which will be covered by the consortium of universities is economical, legal, technical, and maritime education relating to shipping. The theoretical knowledge from scientific Universities is to be combined with Universities of Applied Sciences more practical knowledge needed at sea and in land-based organizations in shipping companies' management. As a separate part in this now permanent consortium the MET institutions will also clarify how the STCW education needs to be supplemented by the knowledge relating to autonomous seafaring when the IMO is progressing also on STCW standards.

The development of the national co-operation between MET Universities is described in the article as an example for co-operation also internationally. The research show that expertise from different MET universities which are all comparatively small institutions, can be combined in digital network. For the students it means that they can get much more elective study options when they can choose their studies from a platform or study tray inside one country when they previously had only one Universities study programme at their disposal. As a result also the teachers can concentrate on their research areas better and build their expertise.

*Keywords*: Autonomous shipping; MET; E-learning; Digivisio 2030, STCW-convention

## 1. Introduction

The autonomy of seafaring will take a huge step when IMO Maritime Safety Committee will finalize the MASS Code to be implemented as part of SOLAS. The Code will be implemented first on a voluntary basis in 2026 and it will be mandatory part of SOLAS since 1.1.2028. IMO Legal Committee has also started to renew the Maritime Conventions to meet the demands of vessels with different stages of autonomy. Technology has been developing fast in this area, especially in Nordic countries where the Maritime Cluster has been active in this field. The generation of future maritime experts working with autonomous shipping will be required to have multidisciplinary competence, which is why education should be implemented more in cooperation with higher education institutions in order to ensure high-quality teaching and competence.

The Maritime Universities of Applied Sciences from Finland are all taking steps to become IAMU members. The Satakunta University has been a member for long time, but now the Universities from Kotka and Turku which work together in the Consortium created by AutoMare EduNet project will also join the IAMU family and will work together in order to promote the results for the IAMU and invite foreign IAMU members to further develop common syllabuses orientating to vessels with different stages of autonomy according to the stages defined by IMO. Autonomous shipping makes the Maritime Universities work together to strengthen their co-operation and to gain competitive advantage for the Finnish shipping cluster and industry.

The project lasted two and a half years and during the project a platform for dividing the studies was found. As a government project Digivisio 2030 was initiated during the project, in which all the Finnish Universities have joined. This platform makes it possible for all university students to choose studies from all other universities since September 2025 and join the studies virtually, from wherever they are studying. The AutoMare EduNet consortium offers studies which have been determined by the needs of the maritime industry in relation to MASS vessels different levels of autonomy (IMO 1-4 levels). The Consortium makes it possible for MET Universities to allow the teachers to specialize deeper in their own research fields as the MET institutions can benefit from each expert’s knowledge nationally. The MET institutions can also offer their students a large variety of expertise and professors can teach maritime students in hole nation at the same time in their courses. Students can also pick up the courses they are interested in, wherever they are studying and all possibilities are offered by Digivisio 2030 platform when they register their topics of interests in the digital system. This will certainly be a revolution of MET education that changes the future even more than autonomous shipping itself.

The Maritime cluster in Finland has built up a network for education of autonomous seafaring in order to combine the efforts of different Universities and Universities of Applied Sciences in this field. As combined effort of the Universities in this AutoMare EduNet -project (financed by Ministry of education in Finland), the universities made a survey on the needs for education and then planned the combined efforts to guarantee that the industry´s needs for well-educated workforce related to autonomous vessels are met since September 2025 and onwards. The education which will be covered by the consortium of universities is economical, legal, technical, and maritime education relating to shipping will be offered in a single digital vision platform. At the European level, Finland is recognized as a forerunner and pioneer in digitalization, producing digital solutions safely while ensuring interoperability with European solutions. Finland is also a forerunner in the development of maritime automation. A highly educated nation and Finland as a model country for flexible learning play an important role in strengthening Finland's image, as the advancement of maritime automation changes the educational needs of the maritime cluster both nationally and internationally.

Strong national digital expertise has enormous potential to utilize digital innovations to promote education exports in shipping and the entire maritime cluster. The platform, which is based on the digital vision, enables the Finnish education offering to be opened up to international target groups extensively and with significantly more competitive digital services. This will support, for example, the digital and sustainable mobility models being developed in EU cooperation in education and training. Maritime experts trained in Finland are in demand and sought-after partners regardless of national borders. In this way, the digital vision also contributes to innovation development, export opportunities and economic growth for the entire maritime cluster.

## 2. AutoMare EduNet -project

The project lasted two and a half years and during the project a platform for dividing the studies was found and the common goals for the Universities division of expertise was targeted according to the needs of the maritime cluster, which was benchmarked by the EduNeed -part of the project. The theoretical knowledge from scientific Universities is to be combined with Universities of Applied Sciences more practical knowledge needed at sea and in land-based organizations in shipping companies’ management. As a separate part in this now permanent consortium the MET institutions will also clarify how the STCW education needs to be supplemented by the knowledge relating to autonomous seafaring when the IMO is progressing also on STCW standards or equivalent standards for the personnel in Remote Operation Centre´s (ROC). The Satakunta University of Applied Sciences as the only IAMU member from the project will also promote the results for the

IAMU and invite foreign IAMU members to further develop common syllabuses orientating to vessels with different stages of autonomy according to the stages defined by IMO.

*2.1 Why do we need autonomous shipping?*

The age groups of young people will quickly start to shrink after 2030. According to the population projection, the number of persons aged 19 to 21 will be at its highest in 2030, nearly 65,000 on average for each age group. After that, the decline will be quite rapid and by 2040 the size of the 19 to 21 age group would only be good 52,000. Finland needs students and labour to be directed towards the needs of autonomous shipping, as there is less and less labour going to sea available in Finland. Finland's shrinking age groups, as well as the shortage of experts in the maritime cluster, which, due to the global forces of change in autonomous shipping, is hitting high-skilled experts in particular and highlighting the need to raise the level of competence and education of the entire maritime cluster, as well as the need to invest in skills and the growth of human capital. Through the continuous learning provision of higher education institutions in AutoMare EduNet consortium, it is possible to produce tailor-made solutions for achieving the competence and educational level objectives necessary for national and international autonomous shipping. Finland has followed closely the developments and efforts of Japanese maritime cluster which has recognized the future needs of autonomous shipping already for at least a decade. Technical co-operation has been extensive and now it should be time for co-operation in education. Japan is also a country which is highly dependent on maritime transportation like Finland. In both countries the lack of seafarers is leading to catastrophe if maritime transportation is not automized rapidly as the young generations are not so willing to go to sea anymore and spend months at sea away from their families and friends. Young people now are more used to computing and playing games – and they might be interested to operate vessels from a remote-control station ashore instead, if they are paid well for their efforts.

Responding to the rapid changes in the world of work in the maritime sector is essential for the sustainable growth of maritime transport and for ensuring security of supply. Increasing the productivity in the maritime sector requires an increase in the knowledge capital of the maritime cluster as a whole. The increase in the level of skills cannot be met only by measures aimed at younger age groups and future maritime professionals, but measures are needed to complement them by measures already targeted at those already working in companies and government positions in the sector. Through these continuous learning measures, the high skills requirements of the labour market can be met and the skills of low-skilled adults already working in the maritime sector can be put to effective use in new jobs requiring new skills. This is a specific target in AutoMare EduNet.

*2.2 The evolution and revolution of education in MET*

The AutoMare EduNet consortium offers studies which have been determined by the needs of the maritime industry in relation to MASS vessels different levels of autonomy (IMO 1-4 levels). The Consortium makes it possible for MET Universities to allow the teachers to specialize deeper in their own research fields as the MET institutions can benefit from each expert’s knowledge nationally. The MET institutions can also offer their students a large variety of expertise and professors can teach maritime students in hole nation at the same time in their courses. Students can also pick up the courses they are interested in, wherever they are studying and all possibilities are offered by Digivisio 2030 platform when they register their topics of interests in the digital system. This will certainly be a revolution of MET education that changes the future even more than autonomous shipping itself. The education which will be covered by the consortium of universities is economical, legal, technical, and maritime education relating to shipping will be offered in a single digital vision platform. Mixing the students together according to their interests creates new kind of expertise when lawyers, economists engineers and mariners are finding common solutions to challenge based problems using CBLmethodology as well as Problem Based Learning (PBL) methodology to challenges and problems created by autonomous industry and seafaring. And it is not the only revolution in education – Combination of experts from the Universities and Universities of Applied Sciences create new kind of expertise when they work on educational solutions and teach together. Now nationally – but in future also internationally in co-operation with Universities worldwide according to their expertise without limitations. This will certainly increase competition, but it will lead to increase sharing of expertise between the Universities which have trust in cooperation between each other. IAMU would be a perfect organization to promote this.

## 3. Digivisio 2030 for sharing – All Universities in one nation forming one platform of education

The cornerstone of the continuous learning provision of maritime schools is research and RDI expertise, the needs of which must be able to continuously serve the development of autonomous shipping. Internationally competitive and effective RDI activities need a sufficient level of competence to meet the development needs of autonomous shipping and the availability of a skilled workforce with a maritime background capable of RDI activities. Digivisio 2030 enables the AutoMare EduNet brand to be built as a separate part of the Digivisio 2030 entity, and it enables the visibility and differentiation of the special expertise of the Finnish maritime cluster from the higher education offering also internationally.

The aim of the Digivisio 2030 project for higher education institutions is to create an internationally respected learning ecosystem, which in the first phase will be based on Digivisio's digital services, the joint study offering of higher education institutions and interaction with companies and society. Through the ecosystem's digital services, lifelong learners can flexibly and continuously complete studies that suit their individual needs across higher education institutions and develop their skills through open course offerings. The continuous and flexible learning tray to be developed in Digivisio 2030 is a single service that is visible to the user and that integrates seamlessly with other national services. The key elements of the continuous and flexible learning tray are course offering, learning, personalization, guidance and enrolment. Digivisio 2030 aims to implement its own brand, which will strengthen the own brands of higher education institutions and higher education networks in accordance with the Digivisio 2030 scenario.

Society and business are expected to provide solutions to the challenges of autonomy, the maritime world and security of supply. Strong confidence in Finnish maritime and shipbuilding expertise acts as a strong incentive for universities and universities of applied sciences operating in the maritime sector through public investment. Strong public resources for higher education and RDI activities in maritime and marine technology have been a recipe for success, the effects of which are significant for society as a whole and its security of supply. The AutoMare EduNet project and the consortium built in it intensifies and clarifies this cooperation, but the effective functioning of the cooperation network will require significant additional funding in the future in order not only to make the training provision in the maritime sector more efficient, but also to be developed to meet the requirements of the future. This is where international co-operation should be targeted – to make this work, which is already nationally revolutionary inside one nation, internationally revolutionary. To make it work internationally needs also international funding and sharing of expertise. This can make it really revolutionary in shipping and MET.

### *3.1. Digivisio 2030 and MET in Finland*

As a rule, the training provided by the training network can be divided into two different categories: Training regulated by the International Convention and national law and the freely planned provision of training. Maritime training for seafarers is regulated by the STCW Convention, which regulates the training requirements for sea captains and marine engineers currently employed on board ships. Compliance with these requirements is monitored by the national maritime administrations.

In Finland, the education in question is carried out by universities of applied sciences, which have the right to award the degrees in question. The degrees are bachelor's degrees. Their content is thus largely governed by an international convention, for which the changes brought about by autonomous shipping will be implemented at IMO level in the next few years. There are no corresponding restrictions for master's degrees, and universities of applied sciences have already been able to change their training content to meet the training needs of autonomous shipping during the AutoMare EduNet project. In addition, the training provided by universities does not have the corresponding requirements set by legislation, so the training is free to take into account the needs and challenges brought about by autonomous shipping. Universities of Applied Sciences in Finland (Novia, SAMK, Turku UAS and XAMK UAS) prepared a report for the AutoMare EduNet project in the Eduneed work package, which purpose is to present a holistic view of the study offering in the maritime HEI´s.

The offering of UAS is divided into two categories. Universities providing maritime education whose bachelor's degrees are based on the STCW Convention (Seafarers' Training) form their own group, and other UAS:es whose education is based on marine technology and shipbuilding/design form their own.

The STCW Convention, which regulates the training of seafarers, is a mandatory convention that strongly regulates the content of maritime bachelor's degrees. Compliance is monitored by national authorities and training is audited periodically by them. The development of this training in autonomous shipping is strongly linked to the expected changes to the STCW Convention, the work which has just begun. The training of seafarers will change between 2025 and 2028 as a result of the amendments to the Convention, and the changes to the training can be expected to enter into force and apply around 2028. The work of the MSC has still several large problems to be solved – like the training of the land based organizations in ROC:s. At its meeting in June this year in IMO, there was still no clarity will the training of the ROC be regulated by STCW or some other instrument of the IMO. These issues still slow down the process of the work of the Maritime training institutions in planning the future work of the consortium. At the moment we need follow the IMO work closely in order to be ready when these important decisions have been made. New requirements to respond MASS Operations can be determined thereafter. Inclusion of MASS-related subjects in the STCW is still therefore waiting for the work of the MASS Code to be finalized by spring 2025.

For Master of Maritime Management degrees, the situation is very different. Master's degrees act as a bridge from sea to land, so that in the future, a growing number of people with experience at sea will work in the land organizations of the maritime cluster. For these, the skills requirements will increase in line with the requirements of increasing autonomy, and the role of these persons as shipping companies adapt to the changes brought about by autonomy is essential for the development of the maritime cluster as a whole. AutoMare EduNet project describes the existing Master's studies offering, the emphases of which vary in different UAS future offering will be built in such a way that students can choose studies from several UAS´s and thus build a diverse competence package that meets their needs and those of their employer. The upcoming legislative work at the IMO will be taken into account in the development of Master degrees in 2024–2026 so that they together meet the future needs of shipping companies and maritime administrations. At the same time, cooperation enables higher education institutions to concentrate and specialize.

### *3.2. Follow-up of the development in autonomous shipping*

General follow-up and monitoring responsibility are divided between partners and their organizations. The group consists of representatives from all partner organizations (University of Turku, Åbo Akademi University, Aalto University, Turku University of Applied Sciences, Novia University of Applied Sciences, Satakunta University of Applied Sciences (SAMK) and South-Eastern Finland University of Applied Sciences (XAMK)). Monitoring groups responsibilities include: 1) Follow the technical development of MASS. 2) Follow the legal and economic development of MASS. 3) Follow the development of Digivisio 2030 and its implementation in partner organizations. 4) Planning and organization of stakeholder/partners' work. 5) Determining the process to identify the gap between education needs from the maritime cluster and educational organizations. 6) Determining how to collect and analyze feedback from the maritime cluster to measure the impact of education.7) Determining the ways to follow the needs from the maritime cluster in non-mandatory education. 8) Organization of website maintenance. 9) Organization of group meetings 4-5 times a year, some of them together with stakeholders.10) Decision-making on initiatives required to finance activities (internal and external). 11) The group elects a chair and secretary (which can be other than member of the group) for each calendar year. 12) Monitoring group can decide to establish other working groups under its auspices if needed for effective work of the partner group.

The STCW Convention monitoring group, (Novia, SAMK, XAMK) is responsible for monitoring the development of the Convention and development of IMO/ILO work on Roles and regulation of employees of ROC´s (Remote Operation Center) and jointly prepare future changes in training as the work progresses in respect of autonomous shipping and the increasing autonomy of shipping. Monitoring groups responsibilities include: 1) Monitoring the development of the STCW -Convention. 2) Monitoring the development of the relevant Conventions related to STCW/MASS. 3) Determining the way to follow the Convention drafting process where the demand for seafarers and ROC employees are determined. 4) Determining the process to identify the gap between education needs from shipowners and educational organizations relating to seafarer education. 5) Determining how to collect and analyze feedback from the shipowners to measure the impact of education. 6) Decision-making on initiatives proposals required to finance activities (internal and external) in co-operation with the Partners Monitoring group. 7) Organisation of group meetings 4-5 times a year, some of them together with stakeholders. 8) Group elects a chair and secretary (which can be other than member of the group) for each calendar year.

## 4. Conclusion

In AutoMare EduNet the higher education institutions have committed to create and maintain a lasting structure for co-operation to develop their offering through common platform, which is identified and decided to be Digivisio 2030 starting at September 2025 to offer courses in degree program education. The offering of the AutoMare EduNet project is designed as part of the future digital vision 2030 cooperation of higher education institutions, and the cooperation is built on the rules of the game and technical solutions of the Digivisio 2030 platform.

The future of both shipping and education is changing, and in 2030 both will have changed radically compared to 2023 when the government funded project ended. In terms of degree education in 2030, Finnish higher education institutions will participate in the Digivisio 2030 offering, in which sharing information between higher education institutions guarantees students the opportunity to flexibly tailor the education package they need from the offerings of different higher education institutions. AutoMare Edunet implements this model of the national higher education strategy through networking, which means that the education offering is already compiled in a coherent manner, making it easy for students and companies to utilise. At the same time, higher education institutions can focus on strategic core competence, as they do not have to produce all the expertise required for autonomous shipping themselves. This, in turn, makes it possible to raise the national level of education and allow students to specialize flexibly and sufficiently.

Autonomous shipping is increasing in parallel with the above-mentioned development. Technological development is advancing, and there are no significant slowdowns in the development of autonomous shipping. In the future, co-operation between higher education institutions will be further deepened by the network, as maritime legislation will enable autonomous shipping globally as of 1.1.2028. The work of the network secures Finland's position as an international trainer of autonomous shipping and enables a flexible transition from conventional vessels to autonomous vessels also with regard to the training needs of the maritime cluster.

As a conclusion to the aforesaid, the consortium has prepared well in advance for the format of cooperation in relation to the two relevant changes of the training needs of the industry. The Digital future of education and Digivisio 2030 coincided well with the timing of AutoMare EduNet project. Some participant clearly did not see in the beginning of the project how revolutionary the co-operation will be before connecting the autonomous shipping and Digivisio 2030. For a small country the results are turning out to be crucial so that we are able to maximize the capacity of all Maritime HEI´s by combining our efforts to build the future of maritime education. The aim of this article is to draw together the situation where we have come. After a short standstill period while waiting for the Code and lining the STCWs position in relation to ROC crews, we are now gathering forces which are well needed when the Code is ready and the development – Either based on changes to STCW or some other instrument – continues next spring. Then this work will be hastened by the entry into force of the mandatory MASS Code in 1.1.2028 as by then we have to have already seafarers and ROC crews trained according to the demands which we are still waiting for. By then also international efforts in meeting the needs should be discussed internationally in co-operation. We aim that the model we have built and which has been presented in this article, could be of value also for international co-operation.

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# Harmonization of non-STCW short-learning courses

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**Abstract:** Seafarers' education is always a combination of formal education and short-learning courses. During their navigational experience, seafarers on board sophisticated ships participate in numerous courses required by shipping companies. The number of such short-learning courses and their contents differ not only in relation to different types of vessels but also with regard to the same type of vessel owned by the particular companies. Outcomes, contents and duration of these courses are often unknown. The main goal of this research is to develop methodology for assessing and monitoring current situation and future needs of the maritime industry with regard to the short-learning courses. The research activities in this paper refer to number, type and time frame of additional courses in maritime industry needed to perform various duties on board LNG carriers, tankers and cruise ships. In order to collect data about additional short-courses for the seafarers, a specific seafarers' form has been created. This focused on data about seafarers' level of education, nationality, rank and vessel type, STCW certificates, additional non-STCW certificates, and online courses required by their shipping companies. Since the competencies acquired through such courses are unknown, the results of the research will serve to develop methodology for their recognition and validation.

*Keywords*: STCW Convention; micro-credentials; short-learning courses; non-formal education; maritime competencies

## 1. Introduction

Acquiring competencies is an ongoing process for seafarers that lasts throughout their working life, thus emphasizing the importance of lifelong learning in maritime industry. Short courses for seafarers, conducted at accredited educational institutions or privately owned training centers, play a crucial role in seafarer's education. The courses can be divided into courses prescribed by the STCW Convention and courses that are the result of the requirements of shipping companies. Since seafarers' education is partially standardized at the international level through the application of the STCW Convention, short courses prescribed in the STCW Convention usually have similar contents and learning outcomes, recommended by the IMO Model Courses. However, it is not uncommon for the topics and schedule of these courses to vary across different countries and educational institutions.

Another type of short courses for seafarers are the courses that are the result of the requirements of shipping companies, and are not prescribed by the STCW Convention. These short courses are the result of companies' needs and requirements. For the purpose of the additional training of their seafarers, shipping companies usually have cooperation agreements with training centers where their seafarers attend courses, or they have their own training center as a separate unit of the company. Furthermore, it is not uncommon for shipping companies to finance short courses the seafarers have to attend.

The number of courses required for seafarers sailing on different types of vessels is unknown. In addition, contents, outcomes and duration of these courses are also unknown, i.e. there is no review of the current situation.

One of the few research that deals with this topic was carried out in 2015, and it was concluded that masters on board LNG carriers need to attend more than 60 additional courses required by the shipping companies (Gundić et al. 2015). Another research dealing with this topic was carried out in 2021. In that research, short courses on cruise ships were analyzed and it was concluded that masters on board cruise vessels needed to attend more than 40 additional courses (Gundić et al. 2021). There is no database on the number of short courses needed for different types of vessels of different companies, and there is no comparison among short courses on different types of vessels. Maritime industry has a great advantage having internationally recognized standards for seafarers' education. This may mean that cooperation between the Maritime Education and Training Institutions (hereinafter: METI) and shipping companies on improving educational and training programs for seafarers is at significant level. Unfortunately, this is not the case. The main problem regarding this topic is the lack of cooperation between METI in different countries, as well as the lack of cooperation between METI and training providers and shipping companies. Due to the lack of cooperation between maritime higher institutions and training centers, especially from different countries, there is no insight into the content and the number of courses that seafarers have to attend. This information remains between seafarers and their companies/training centers. Therefore, it is important to analyze additional courses for different types of vessels in order to get an overview of their course requirements. Since many of these courses are identified for certain technologies, some of them may become standardized and incorporated in the STCW Convention and the undergraduate study programs, which can positively affect MET.

LNG carriers, cruise vessels and tankers are selected type of vessels in this research as these types of vessels are the leaders in the shipping industry when it comes to technology implementation, safety, and focus on environmental protection. It is expected that these trends will step up in the next period with more stringent regulations placed forward by administrations.

Global trade in LNG expanded slightly in 2023 with prices staying above historic averages. All this has an impact on the existing fleet of LNG vessels, order book of newbuilds in the near future, and the level of technology involved in building a new LNG vessel (Shell LNG Outlook 2024). Number of ordered newbuilds in the yards, entered in another growth stage and has reached close to 54% of the total LNG carrier fleet. Increasing number of commissioned Floating Storage Regasification Units (FSRU) in Europe particularly in Baltic and North Sea region clearly indicate the trend of diversifying importing source of LNG and natural gas to Europe (Riviera 2024).

Cruise industry proved to be resilient industry expected to surpass record the numbers from pre-covid time. Unlike LNG vessels where their size is limited and thus determined by terminal acceptance criteria, draft of the vessel, and Capacity and Capital Expenditure (CAPEX), cruise "mega vessels" are facing resistance from the ports, cities, and environmentally sensitive maritime areas, which are banning mega ships due to the "over-tourism" (Goodwin Recruiting 2023). Additionally, CLIA (Cruise Lines International Association) put a strong effort into development and statistics, with regards to cruise industry sustainability initiatives resulting in some of the key points showing what cruise companies are doing to improve responsible tourism (CLIA 2023). These points include the following: offering to cruise travelers' choice of cruise based on environmental impact; following path to decarbonization with advancement in technology, infrastructure, and technology; using LNG as a transitional fuel while sustainable and renewable marine fuels and propulsion technologies are explored, and new built vessels need to have "cold ironing" capabilities.

Regarding the tankers, significant surge of contracted newbuilding in 2024 is attributed to rise in order of VLCC's (BIMCO 2024). Freight rates have remained high since the beginning of the war in Ukraine. Due to the fact that the environmental regulations have become more stringent, the ageing fleet in the tanker industry is becoming a problem. Due to safety challenges and the protection of the marine environment, most of the oil majors have imposed an age limit on vessels, ranging from 15 to 20 (DNV 2024).

Therefore, additional courses for seafarers' sailing on these types of vessels are analyzed in this paper. The article is structured as follows: after the introduction, the methodology description is presented in Section 2, whereas the results are presented in Section 3. Section 4 provides conclusions and proposals for future research.

## 2. Methodology

The research conducted in this paper is part of the "Micro-qualifications in seafarers' education and training – MICROMET" project. This project is funded under the Erasmus+ program – Key Action 2 for higher education. The project activities are supposed to last from December 1, 2023 to May 31, 2026. The project activities aim at developing standardized programs for undergraduate maritime studies and short learning programs for seafarers.

Research methodology in this paper refers to an identification process on number, type and content of additional short courses for seafarers at LNG carriers, tankers and cruise ships. The number, type and content of additional short courses for seafarers serve to identify the area of the competencies contained in STCW and nonSTCW short courses, are referred to.

In order to compile data on courses a dedicated seafarers' form was created, containing the following information on the seafarers: level of education (high school, undergraduate faculty level, graduate faculty level), nationality, rank and vessel type, STCW certificates, additional non-STCW certificates, and online courses required by their shipping company. The seafarers' form was distributed on the project and faculty websites, as well as on the faculty's social media platforms (LinkedIn and Instagram). It was also sent to some seafarers via email. Furthermore, masters, chief officers, and shipping companies were interviewed about the additional courses needed for their seafarers. The local officer training centers have also supported the survey conducted. Consequently, all the responses have been gathered and categorized in the data base dedicated to the project being carried out.

**3. Results** Through the analysis of the seafarers' forms submitted by seafarers as well as interviews with masters, chief officers, and representatives of shipping companies, additional non-STCW courses needed for seafarers sailing on LNG vessels, cruise vessels, and tankers were defined. To date, a total of 233 seafarers' forms were collected. The results presented in the following text are preliminary since this research is to be conducted until August 1, 2024. Figure 1 represents the level of education of the seafarers who participated in the research.

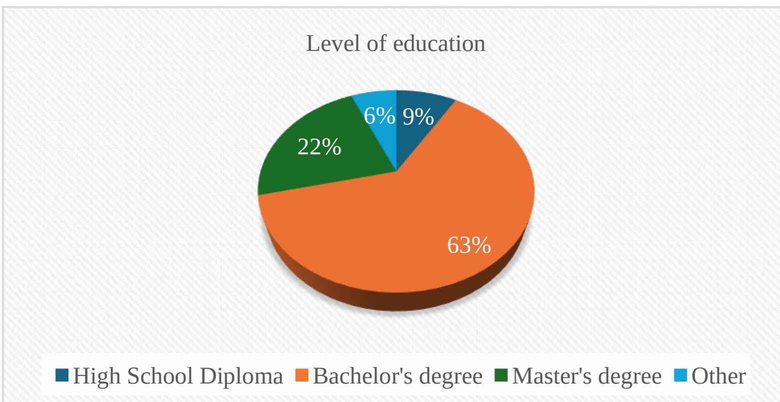


Figure 1. Level of education of the seafarers who participated in the research.

It was found out that the majority of seafarers have completed bachelor's study level, which is expected, since this level of education is sufficient for obtaining the highest ranks on board. The smallest number of seafarers who took part in this research have only graduated from high school, which is also expected considering that advancement to the highest ranks is limited and less and less companies employ deck officers who have only completed high school.

Figure 2 represents nationalities of the seafarers who have participated in the research so far.

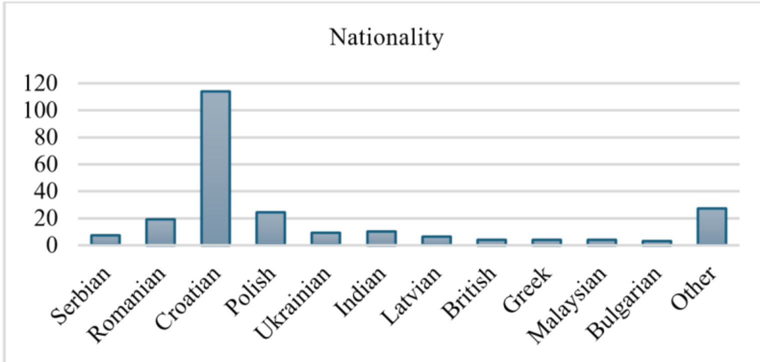


Figure 2. Nationality of the seafarers who took part in the survey.

Most of the seafarers who participated in this research were of Polish and Croatian nationality. Other nationalities participated in the research were: Bosnian, Montenegrin, Norwegian, Mexican, Filipino, Georgian, Belarusian, Egyptian, Russian, Bangladeshi, Portuguese, Nigerian, Spanish, British, Panamanian, Indonesian, Iraqi, Italian, Argentinian, Irish and Lithuanian.

Considering that project participants are two higher education institutions from the Republic of Croatia (University of Zadar, University of Split), one from Poland (Gdynia Maritime University), one from Spain (Polytechnical University of Catalonia), as well as one shipping company from the Republic of Croatia (Tankerska plovidba Inc.), and one training center from Malta (Mediterranean Maritime Research and Training Centre Coop. Soc. Ltd.), such results have been expected.

Furthermore, Figure 3 represents the rank of the seafarers who participated in the research.

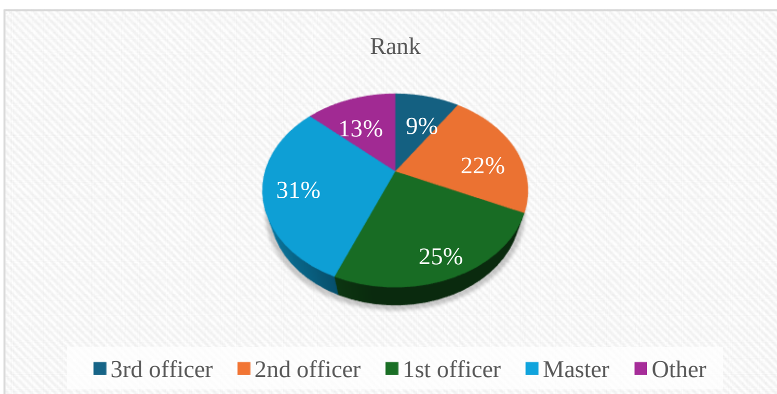


Figure 3. Rank of the seafarers who participated in the survey.

Most of the seafarers who participated in this research are masters and senior officers, i.e., seafarers with years of experience and higher ranks. This implies that they have attended a greater number of additional courses throughout their careers, making the results more representative.

Next, Figure 4 represents data on the vessel type the seafarers who participated in this research are sailing on.

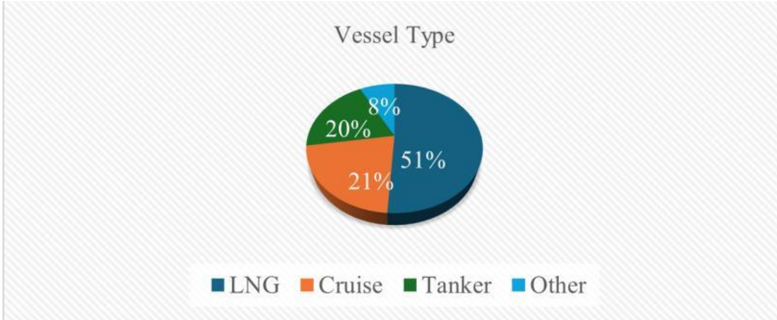


Figure 4. Vessel type of the seafarers who took part in the research.

Most of the seafarers who participated in this research are currently sailing on LNG carriers. Considering that these are technologically advanced ships, that the LNG fleet is currently expanding, and that LNG carriers generally enable good living conditions and salaries to seafarers, these vessels are appealing to them.

In the research, the seafarers listed the STCW certificates they had obtained. The results also include the STCW certificates the seafarers sailing on other types of vessels have obtained. However, these results are not the subject of the current study. Some of the STCW courses are the same for all three types of vessels and depend on the seafarers' ranks. The senior officers have generally obtained more STCW courses' certificates than the junior officers.

It is important to emphasize that seafarers sailing on different types of vessels have obtained different STCW courses' certificates. Therefore, the seafarers sailing on LNG vessels have obtained the following certificates: Basic Training for Liquefied Gas Tanker Cargo Operations, Advanced Training for Liquefied Gas Tanker Cargo Operations. Seafarers sailing on tankers have obtained the following certificates: Basic Oil Tanker Cargo Operation, Basic Chemical Tanker Cargo Operation, Advanced Oil Tanker Cargo Operation, Advanced Chemical Tanker Cargo Operation. Seafarers sailing on cruisers have obtained the following certificates: Crowd Management Training, Crisis Management & Human Behaviour and Passenger Safety, Cargo Safety & Hull Integrity.

As far as non-STCW courses are concerned, according to the collected data these courses should be analyzed according to the vessel type: LNG carriers, cruisers and tankers. For the future research it is necessary to categorize the non-STCW courses based on their content. Due to different operation on these types of vessels (primarily cargo operations), the same categories are not suitable, so it is suggested that courses for LNG and tankers to be divided into the following categories: Navigation & Radio Communication, Safety & Security, Cargo Operations, Soft Skills and Other. For cruisers, slightly different categories are proposed: Navigation & Radio Communication, Safety & Security, Soft Skills and Other. Additionally, if possible, it is suggested to conduct an analysis of courses per rank, for the Master, Chief Officer, Second Officer and Third Officer.

In addition to face-to-face courses, seafarers often attend online courses as well. The examples of some online courses for seafarers are STS Operations Training, Mental Health and Wellbeing, Marine Risk Assessment, The 2020 Sulphur Regulations, Accident and Incident Investigation, Behaviour Based Safety, Company SMS etc. These courses are different and cover a wide range of topics generally referring to safety on board, seafarers' mental health, work in specific ship environments, specific operations on certain types of vessels, environmental protection measures, and more. Online courses attended by the seafarers who participated in this research can be divided into the following categories: Navigation & Radio Communication, Operations, Safety & Security, Cargo Handling & Stowage, Soft Skills. These are, as a rule, CBT courses provided by companies like Videotel, Seagull, iLearn, and MINTRA e-Learning. Companies categorize online courses into mandatory courses that seafarers of a certain rank are required to take and pass, and those that are recommended for a particular rank. Additionally, for some courses, a refreshment is recommended, typically every three to five years.

## 4. Conclusions

Short courses for seafarers, whether prescribed by the STCW Convention or resulting from shipping companies' requirements, play a crucial role in seafarers' education. While the courses prescribed by the STCW Convention are usually standardized at the international level with similar contents and learning outcomes recommended by IMO Model Courses, the STCW Convention does not cover courses required by shipping companies. The lack of collaboration between educational institutions, training centers and shipping companies' results in a lack of information about the courses seafarers attend.

The analysis of additional courses for different types of vessels is crucial for understanding the training requirements for various types of vessels. Internationally recognized standards for seafarers' education in the maritime industry enable collaboration among educational institutions in order to improve educational programs. However, the lack of collaboration between educational institutions and shipping companies poses a major challenge.

The number of additional non-STCW short courses and their contents differ not only in relation to different types of vessels but also in relation to the same type of vessel owned by different companies. Once the number of courses has been determined, one can analyze the content and competencies acquired through these programs. These results can be used for the identification and validation of competencies acquired through additional non-STCW short courses and to improve MET at HEI by integration of these competencies in the study programs.

Based on the presented research results, it can be concluded that there is a need for standardization of additional non-STCW courses for seafarers on LNG vessels, cruise ships, and tankers. The planning of future research should include mapping of competencies contained in STCW and non-STCW short learning programs.

Recognition and validation of seafarers' competencies acquired through additional non-STCW short courses will contribute to the standardization of seafarers' education and training process and cooperation among maritime higher institutions from different countries, as well as between maritime higher institutions and other key stakeholders.

## Acknowledgements

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# Popular representations of the seafaring profession: A corpus assisted discourse analysis (CAD)

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**Abstract:** With the merchant fleet's ongoing expansion, there is a growing mismatch between labor demand and supply, leading to a shortfall in the seafaring workforce and concerns about its sustainability. In tackling this challenge, the public perception of the seafaring profession emerges as a critical factor. Fostering a positive image of seafaring careers is essential for attracting and sustaining a robust labor force. This paper presents a corpus-assisted discourse analysis (CDA) of the popular discourse surrounding seafarers and their profession. It investigates how language use may influence public perceptions and, by extension, the attractiveness of a seafaring career. Using a general linguistic corpus and a purpose-built seafarer corpus, the analysis identifies prevalent linguistic and thematic patterns in seafaring discourse. It delves into the implications of these linguistic findings, exploring whether certain narrative constructs in the seafaring discourse could contribute to a negative image of the profession, deterring potential entrants. The findings indicate that seafarers are portrayed stereotypically in the popular media, and as victims in need of support in maritime publications. The paper discusses how a nuanced understanding of this discourse can inform strategies to more effectively promote seafaring careers, including the role that the IAMU community can play in cultivating a positive public image of seafarers

**1. Introduction** With the merchant fleet's ongoing expansion, there is a growing mismatch between labor demand and supply, leading to a shortfall in the seafaring workforce and related concerns about its sustainability. The latest *Manning Annual Review and Forecast* report by Drewry (2023) shows that the availability gap in the global seafaring labor pool has widened, equating to a deficit of about nine percent, and similar deficit levels are predicted for 2023 to 2024. The Drewry report calls attention to the impact of the COVID-19 pandemic on crewing shortfalls and, significantly, on the overall appeal of jobs at sea, citing the effect of negative stories of crews stranded on vessels in deplorable conditions.

This is not the first time that shipping's image problem has been raised in connection with recruitment issues. In 2008, the International Maritime Organization's (IMO) Go to Sea campaign sought to promote three objectives in response to the global shortage of seafarers, the first being "to instil an enhanced, more favourable public perception of the maritime industry" (IMO, 2008). This was echoed in 2010 in the Final Act of the Conference of Parties to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, Resolution 12 Attracting new entrants to, and retaining seafarers in, the maritime profession, which recommends that concerned stakeholders *do their utmost to promote among young persons a career at sea* […] *by: 1. engendering a more favourable public perception* […] *of the maritime industry; 2. promoting a greater awareness and knowledge among young people of the opportunities offered by a career at sea.* Most recently, IMO's new Secretary General, Arsenio Dominguez, set "[…] changing the public perception of the shipping industry" as a key agenda item for IMO ("IMO Secretary-General", 2024).

A number of studies have examined the image of shipping and the seafaring profession among young people (e.g., Jensen et al. 2015; UK DfT 2021), with some findings suggesting that it is no longer seen as an obvious career choice. On this background, the public perception of the seafaring profession emerges as a critical factor. Fostering a positive image of seafaring careers, particularly among the younger generation, is essential for attracting and sustaining a robust labor force (Jensen et al. 2015). Understanding the representation of seafarers in popular public discourse, including media coverage and social media discussions, becomes imperative in this context.

This paper presents a corpus-assisted discourse analysis (CDA) of the popular discourse surrounding seafarers and the seafaring profession. It aims to investigate how language use may influence public perceptions and societal attitudes and, by extension, the attractiveness of a seafaring career. Using a general linguistic corpus (enTenTen), and a specialized purpose-built seafarer corpus, the analysis identifies prevalent linguistic and thematic patterns in the seafaring discourse that potentially contribute to a negative image of the profession, deterring potential entrants. The paper discusses how a nuanced understanding of this discourse can inform strategies to more effectively promote seafaring careers, including the role that maritime universities and the IAMU community can play in cultivating a positive public image of seafarers.

## 2. Literature review

Public discourse, including various forms of media, has the power to shape attitudes, beliefs and behaviors. According to Fairclough (1989), "language is a form of social practice" (p.20). Its use is not random; rather it simultaneously reflects and perpetuates prevailing societal norms and narratives, including dominant ideologies and power structures. On that basis, critical discourse studies treat discourses as models of the world that help to explain how people perceive events and how they behave. The importance of industry image is increasingly cited in the literature. For all industries, a positive image is critical for attracting investors, customers and a qualified and motivated workforce (Burmann et al. 2007). Industries, such as shipping, that suffer from image problems struggle to attract young people, especially in developed nations where non-economic factors are strong motivators in career decisions (Caesar & Fei, 2018). From a shipping industry perspective, identifying and understanding the factors that contribute to positive and negative perceptions of seafaring is critical to recruitment efforts.

When discussing perceptions of shipping and those working on ships, the absence of media representation is also significant. Studies of how shipping is perceived in the media have revealed that the industry in general, and seafarers, in particular, are either ignored or negatively represented. Theotokas and Bissias (2014) and Sanchez-Beaskoetxea and Coco Garcia (2015) explored the image of shipping and seafarers as communicated by selected newspapers in the UK and Spain. The authors examined news reports following shipping accidents and found that shipping companies and crews, especially captains, were portrayed negatively in the media. Both studies noted that, with the exception of major accident reporting, the shipping industry and seafarers receive very little attention in the media. This invisibility in the public discourse can, in part, explain the lack of awareness and knowledge about seafaring revealed by a study of young people's perceptions of maritime careers (UK DofT, 2021). The study surveyed young people between the ages of 16 and 24 and found that 51% knew almost nothing about jobs in the maritime sector. Their lack of awareness, along with lack of interest, was found to be one of the main reasons for not considering a career in the sector.

Further factors influencing young people's perceptions and career decisions around seafaring have been discussed in the literature. A survey of secondary school students in Sweden, Norway and Greece (Jensen et al., 2015) revealed that monetary compensation, and working and living conditions on ships were important image constructs when considering a career in shipping. When considering the overall image of the shipping industry, corporate social responsibility (CSR) scored highly, showing that young people are concerned about the environmental and social behavior of the industry and consider it as a factor in their career decisions. This aligns with the findings of the UK DofT (2021) in which young people expressed impressions of the maritime industry as lacking equality and diversity and, therefore, being potentially inhospitable to women, minority ethnic groups, LGBTQI+ individuals and people with disabilities. Other perceived characteristics of maritime jobs that served as deterrents were related to the nature of seafaring work, and included concerns about loneliness, irregular and inflexible work hours and potentially unsafe and dirty conditions. While good pay was mentioned as an attractor, it was not considered a priority for most. Crucially, the study found that the perceived characteristics of maritime careers do not align with what is important or attractive to young people in planning their career paths.

## 3. Methodology

The research methodology is based on corpus-assisted discourse analysis (CDA), which combines methods from corpus linguistics and critical discourse analysis. Data-driven linguistic analysis using corpora can benefit from critical discourse analysis, which focuses on drawing out broader narratives. The study draws on two different corpora, which are the sources of data for the study, a reference corpus and a specialized corpus both obtained through SketchEngine (Killgarriff et al., 2004), an online text-analysis software and corpus manager.

The reference corpus is the general English language corpus (GC), enTenTen2021, made up of texts collected from the internet and currently consisting of over 52 billion words. The enTenTen 21 corpus was selected because it contains data from a similar timeframe as the purpose-built corpus and is, therefore, an appropriate reference corpus for comparison purposes. The second is a specialized, purpose-built seafarer corpus (SC) consisting of online articles focusing specifically on seafarers. The articles were sourced from IMO's Current Awareness Bulletin, which is published monthly and contains a list of headlines of online news and publications on key subjects related to the Organization's work. Each issue is divided into thematic sections. The section on *seafarers* was the source for this corpus. Baker (2023) notes that when building a specialized corpus for the purposes of investigating a particular subject, the quality of content of data takes precedence over issues of quantity. The size of the SC was limited by the number of texts allowed by the corpus building tool on SketchEngine's platform.

The seafarer corpus was built according to the procedure described by Baker (2023). At the time of the research, 27 issues of the IMO Current Awareness Bulletin were available on IMO's website, covering January 2022 to March 2024. To obtain a random sample of publications focusing on seafarers, the total number of publications in the *seafarer* section of each of the 27 issues was counted, resulting in a total of 808. Each publication was assigned a number in chronological order; for example, the publications listed in the January 2022 issue were numbered 1-21. Subsequently, ChatGPT4 open AI was prompted to provide a random list of 100 numbers between 1 and 808. The URLs of the publications corresponding to the 100 numbers provided were added to a spreadsheet. The next step was to copy the text from each online article to a Google document in order to clean it. Cleaning the text involved removing advertisements, images and hyperlinks. The cleaned text was then uploaded to the SketchEngine corpus builder. In the event that a publication was not accessible, due to a broken link, paywall or requiring a subscription, the next publication in numerical order was substituted. When all 100 texts were uploaded, the resulting 62,316-word seafarer corpus was compiled by Sketchengine.

To analyze the data using the text-analysis software, the following three core corpus linguistics techniques (Brezina & Gablasova, 2018) were applied. 1. Frequency list: A frequency list, as its name suggests, provides a list of the most frequently occurring words in a corpus. Frequency lists for both corpora were examined and compared to identify the most salient themes in the seafarer discourse. Words that stood out for some reason (e.g., were unexpected) in the frequency list, were examined more closely by looking at their concordances. 2. Concordances: A concordance is a list of all the occurrences of a selected word or phrase in the corpus, including a few words to either side. It is displayed in a format called 'key word in context' or KWIC. Concordances were examined to understand the ways in which words are actually used in the corpus, and to identify discourse patterns and categories with respect to seafarer representation. One type of pattern that was useful in achieving this was related to the presence and frequency of collocates. 3. Collocations: A collocation is a co-occurrence of words in discourse. It shows which words occur frequently next to or near each other. In this study, words occurring frequently with *seafarer* were analyzed to make 'meaning connections' (Brezina & Gablasova, 2018) between words by identifying linguistic and thematic patterns and representations.

While the text-analysis software quickly and accurately processes large amounts of linguistic data to produce quantitative analyses presented as frequency lists, concordances and collocations, qualitative analysis needs to be employed to interpret, explain and hypothesize about the linguistic and thematic patterns discovered (Baker, 2020). This study applied a bottom-up iterative approach in analyzing the corpus. The researchers moved back and forth between the quantitative data and identification of salient patterns, themes and categories in the representation of seafarers in order to understand the representation of seafarers in the popular discourse.

## 3. Results and discussion

### *3.1. Frequency*

In any corpus the most frequently occurring words tend to be articles (the, a, an) and prepositions (of, at). In order to obtain information about the main themes and focus of the corpora, the frequency analysis focused on nouns to the exclusion of other grammatical categories. The top 40 nouns from the seafarer corpus are categorized into themes in Table 1 and the frequency count for each word is shown in parentheses.

Table 1: Categorization of 40 most frequent nouns in the SC

| Maritime Industry | Actor | Time | Issues | Support |
|---|---|---|---|---|
| Ship (347)<br>Crew (325)<br>Vessel (226)<br>Industry (212)<br>Sea (206)<br>Maritime (149)<br>Shipping (148)<br>Port (112)<br>Board (91)<br>International (89)<br>World (87)<br>Sector (67) | Seafarer (835)<br>Crew (325)<br>Company (112)<br>Government (105)<br>Family (102)<br>ITF (92)<br>UK (91)<br>Member (90)<br>Worker (90)<br>Woman (85)<br>People (79)<br>Country (78)<br>Owner (69) | Year (112)<br>Time (103)<br>Day (96)<br>Month (80) | Issue (90)<br>Case (88)<br>Right (73)<br>Safety (73)<br>Condition (73)<br>Harassment (66)<br>Health (60) | Welfare (111)<br>Support (68)<br>Service (65)<br>Training (58) |

Many of the most frequent nouns are unsurprising given the source of the seafarer corpus. They represent core elements and actors in the maritime industry. References to time are also expected given that ‘’time’’ and ‘’year’’ are the two most frequent nouns in the GC and “day” is the fourth. More interesting for the purposes of this research are the nouns categorized as “issues” and “support”. Many of the “issue” nouns are, in and of themselves, neutral, having no intrinsically negative meaning. However, when their concordances are examined, another picture emerges. They acquire what Baker (2020) refers to as negative discourse prosody. That is, they are negative by association. When the concordance lines for “issue” are examined (Figure 1), the context reveals a host of problems facing seafarers, including mental health issues, harassment and bullying, lack of support, and unfair treatment. Similarly, the term *rights* is neutral in and of itself, but rights are rarely discussed in a positive sense; rather they are most frequently discussed when they are being infringed or defended. The GC, for example, shows that the term *rights* is frequently collocated with the verbs *infringe, violate, defend and protect.* The frequency count, therefore, reveals a representation of seafarers as victims of negative treatment and conditions for which they are in need of support.


Figure 1: Sample of concordance lines for nouns *issue* and *right*

### *3.2 Collocation*

Collocations were obtained for *seafarer* and *sailor* from both the GC and the SC. Sailor was included in addition to seafarer to test the hypothesis that sailor is more commonly used in the popular discourse than seafarer. In fact, *sailor* appears almost 10 times more frequently than *seafarer* in the GC (47,176 instances for *seafarer* compared to 409,739 for *sailor*). Sailor is frequently associated with stereotypical images and analogies through collocations such as “drunken sailor” and “make a sailor blush”, a phrase used to describe a crude person who uses extremely profane or vulgar language. *Sailor* is also frequently associated with the armed forces, through collocation with “soldier”, “navy” and “marine”. Historical images and those associated with fiction and recreation (i.e., sailing as a hobby or sport) also appear frequently. In comparison, *sailor* appears only 35 times in the SC. Collocations with *sailor* in this corpus are largely the same as those for *seafarer* (Figure 2).

Using SketchEngine, collocates of *seafarer* were generated. Modifiers of *seafarer* are shown in the first column in Figure 2, and can be grouped into three main categories: nationality, gender and condition. The nationality modifiers (Filipino, Ukrainian, Indian and Russian) are not surprising considering that the Philippines is the largest supplier of seafarers to the global merchant fleet, while Ukrainian and Russian seafarers are likely to be impacted by the ongoing armed conflict and, therefore, mentioned frequently in recent news articles. The modifiers *woman* and *female* might give the impression that women make up a large proportion of the seafaring population. However, a close examination of the concordances for the collocations *woman seafarer* and *female seafarer* show that *women seafarers* are most frequently associated with receiving or requiring support, while the collocation *female seafarer* is most often used in comparison with male seafarers, highlighting the disparity between the two in terms of representation and treatment. The condition modifiers *abandoned* and *vulnerable* are strongly representative of negative experiences of seafarers and reinforce the image of seafarers as victims.


Figure 2: Word Sketch of seafarer generated by SketchEngine

Verb collocates are shown in the second and third columns of Figure 2. The collocates with seafarer as object present an interesting dichotomy. Verbs with seafarer as object are strongly associated with two categories mirroring the two significant word categories in the frequency analysis. On one hand seafarers are recipients of support, as evidenced by collocation with the verbs *protect, support, help* and *treat*. On the other hand, seafarers are portrayed as victims, particularly of abandonment as suggested by collocation with *abandon, leave* and *strand*. Representations of seafarers receiving help can be considered positive. The fact that there is a desire and willingness to help seafarers and that organizations are taking action in that regard is perhaps positive. However, there are two alternative interpretations that contribute to the image of seafarers as victims. On one hand, seafarers are requiring of help due to dire situations they are facing. One example is shown wherein concordance lines are examined to reveal what seafarers are protected from (Figure 3). On the other hand, this representation of seafarers suggests that they are not empowered. This interpretation is reinforced by an analysis of collocations in which seafarer is the subject of a verb.

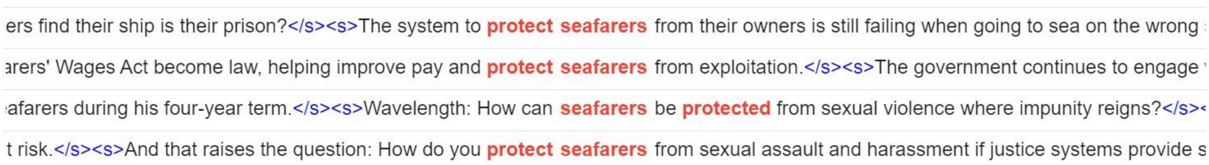


Figure 3: Sample of concordance lines for *protect*

In the study of linguistics, thematic roles are assigned to noun phrases, depicting the various roles that they play in relation to the action described by a verb. Two common roles are those of agent (the doer of the action) and patient (the recipient of the action) (McRae et al., 1997). In the present analysis, seafarers are relegated to the patient role with respect to the support verbs (*help, protect, support*) and the victim verbs (*abandon, leave, strand*), having something done to them or for them. It is significant to note that all of these verbs can be classified as dynamic verbs, meaning that they describe actions. In stark contrast, the majority of verbs that have seafarer in the subject position (i.e., *be, have, feel, experience, face, remain and need*) are classed as stative verbs, meaning that they refer to a condition or state that is unlikely to change. Since stative verbs express a state rather than an action, they are not typically associated with a patient and also do not demonstrate agency. Duranti (2005) describes agency as the property of entities that "[…] have some degree of control over their own behavior [and] whose actions in the world affect other entities." The collocations with seafarer as subject of a verb meet neither of these requirements. By this definition, the representation of seafarers is one of passive actors lacking agency. They are unable to act intentionally, exert control over their own actions or to affect the world around them.

**4. Conclusion**

The study found that seafarers are portrayed stereotypically in the popular media, and as victims in need of support in maritime publications. The result has an implication to MET that such seafarers' representation as passive actors without agency could relate to traditional and quasi-military MET where cadets are expected to be passive and obey orders from senior members of the crew under the ship's strict hierarchy. There will be a role of MET institutions that can empower young seafarers to make positive contributions to the industry through new transitions, like digitalization and decarbonization. MET institutions are not listed as the most frequent nouns in the category of actors in SC, which indicates that MET institutions could be more active in relation to seafarers than now. In this regard, the IAMU community can share good practices in promoting positive and active images of seafarers in solidarity and highlight their contributions to the industry. The promotion of Global Maritime Professionals (GMP) will also help understand the positive and professional nature of seafarers. Future research is considered to investigate the public discourse of selected IAMU member universities from their websites, academic handbooks and other publications and to identify patterns of their discourse about seafaring as a career choice.

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# Research on improvement possibilities of using E-Learning in Maritime Higher Education (case study of Republic of Croatia)

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Abstract: The aim of the research, carried out and presented in this paper, was motivated by creating guidelines for distance learning, and the use of Information and Communications Technologies (ICT) in Maritime Higher Educational Institutions (MHEIs). After the COVID-19 pandemic, teachers and students gained experience in online teaching, face-to-face teaching and hybrid teaching of both, International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and non-STCW courses. Although, ICT is used worldwide in MHEIs (at variable rates), conducted researches clearly indicate both positive and negative side facts of its implementation. Therefore, attitudes of Croatian MHEIs students were analyzed, based on their experience during the COVID-19 pandemic, on the ways of acquiring prescribed competencies and their verification, as a key component and as crucial pathway for their proper implementation, as they can contribute to developing guidelines for distance learning and using ICT in MHEIs.

*Keywords*: online, e-learning, maritime, higher, education, COVID-19

## 1. Introduction

The paper analyzes the results of the research conducted within the E-NAUT project, which aims to promote inclusive and functional distance learning and e-learning, while respecting the basic features and specificities of the seafarers' education and the standards of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention. However, so far, STCW (IMO, 2010) has not yet determined which competencies can be acquired through distance learning, which can be acquired exclusively through face-to-face teaching, and which can be acquired through a hybrid model of teaching. Therefore, research presented in this paper involving Maritime Higher Educational Institutions (MHEI) students in Republic of Croatia was carried out to gain more detailed insight into discussed topic and was based upon evaluation of the opinions and perceptions of the students. Research was performed using survey and quantitative data analysis to conceive the students' perception with special focus set on e-learning regarding maritime specific courses. The results of the research indicate the possibility of improving teaching materials by using interactive contents and solving certain teaching units by using e-learning platforms and as such have proven to follow results from other conducted researches (Arslan, Özkan, 2023; Demirel, 2021; Lloyd's List, 2021; IAMU Secretariat 2021,2022; Paixão, Ramos, 2022; Renganayagalu et al., 2022; IAMU Secretariat 2021,2022). However, results presented in this paper clearly indicated one should be careful when applying them, especially regarding professional/practical courses, and as such are aligned with results from other authors' researches.

## 2. Methodology

STCW Convention (i.e., the STCW Code part B-I/6) foresees the possibility of applying e-learning and distance learning, but acquiring certain STCW competencies is almost impossible through distance learning (e.g., acquiring competency referring to survival at sea where it is necessary to abandon the ship). There are also competencies that cannot be acquired without Information and Communications Technologies (ICT). As previously mentioned, so far, it has not been determined which competencies can be acquired through distance learning, which can be acquired exclusively through face-to-face teaching, and which can be acquired through a hybrid model of teaching. Altogether, it has not been defined which competencies can be partially or fully acquired through these learning models. Additionally, the STCW Convention has not defined which tools and technologies can be used to acquire the prescribed competencies.

Before the COVID-19 pandemic, distance learning was minimally represented in Higher Education Institutions (HEIs), including MHEIs, especially in STCW courses. A similar situation existed in other higher education institutions as well. There are numerous obstacles to the introduction of distance learning and ICT usage in higher education systems. One of them is the readiness of teachers to use these technologies. This fact is supported by the research conducted in 2018 by the Organization for Economic Co-operation and Development (OECD), which revealed that less than 40% of the teaching staff in the European Union (EU) was ready to use digital learning technologies. However, since March 2020, after the declaration of the pandemic, the situation has changed significantly (Arslan, Özkan, 2023; Demirel, 2021; IAMU Secretariat 2021,2022). All education institutions in Croatia closed on March 19, 2020, and transitioned to online teaching. Organizational changes that occurred under the influence of the COVID-19 pandemic had an effect on all key aspects of higher education, primarily on the ways of acquiring competencies and their verification. All higher education institutions, including the maritime ones, faced a wide range of problems primarily regarding the digital skills of the participants in higher education. Moreover, questions were soon raised about which competencies in nautical maritime study programs could actually be acquired through online teaching, especially competencies acquired through STCW courses. A systematic response and guidelines were lacking due to objective reasons. However, today all teachers (both, those teaching general educational courses and those teaching the STCW courses) have experience in delivering online, face-to-face, and hybrid teaching. Teachers' attitudes based on their experience gained during the COVID-19 pandemic regarding the ways of acquiring prescribed competencies and their verification, can contribute significantly to the development of guidelines for distance learning and the usage of information and communication technologies in MHEIs. However, significant contributions also come from the viewpoints and experiences of students who have experienced all three teaching models (online, face-to-face, and hybrid).

The research, whose results are presented in this paper, aims at promoting inclusive and functional distance learning and e-learning, in accordance with the Digital Education Action Plan (2021-2027) (EU, 2020), while respecting the fundamental characteristics and specificities of maritime education, the STCW Convention standards, and the Ordinance on Ranks and Certification of Seafarers. The research was conducted at MHEIs in the Republic of Croatia. Surveys were conducted physically (on paper) with the assistance of interviewers, and the questions were a combination of open-ended and closed-ended ones. The survey was purposely conducted in physical/paper form due to the experience showing low student response rates when conducting online surveys. A total of 320 students were surveyed. The aim of the survey questions was to gain an insight into the attitudes and experiences of students in the nautical field regarding e-learning platforms, as well as their views and experiences regarding the application of e-learning and distance learning. The following text provides survey questions as well as graphical representations of the analysis of the responses obtained.

## 3. Results and Discussion

The aim of survey was to determine the structure of students, or platforms' users, especially at the undergraduate level where the number of STCW courses increases with the years of the study, and is inversely proportional to the number of non-STCW (general) courses with the increase in years of the study. Furthermore, teachers' years-long experience in higher education system indicates the fact of an inverse proportional relationship between the number of students and the complexity of educational contents, as well as their expectations in higher years of the study. Briefly put, it can be concluded that students in higher years of the study have higher expectations and demands towards the content of courses compared to those in lower years of the study. This conclusion is also supported by the data shown in Table 2 and Figure 2, i.e. by a noticeable number of dropouts, especially in the first year of the study. The most common reason for abandoning studies is the students' insufficient understanding of the characteristics of the maritime profession.

Table 1. Question #1: Which study program are you attending?

| Answer choices (single choice allowed) | Responses % | # |
|---|---|---|
| Undergraduate nautical studies | 85.00 | 272 |
| Graduate nautical studies | 15.00 | 48 |
| Σ | 100 | 320 |

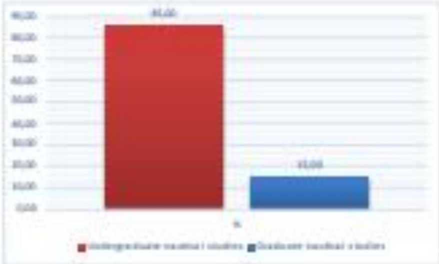

Figure 1. Graphical representation of the answers to the first question

Table 2. Question #2: Which academic year are you attending?

| Answer choices (single choice allowed) | Responses % | # |
|---|---|---|
| 1st year of undergraduate studies | 40.00 | 128 |
| 2nd year of undergraduate studies | 33.13 | 106 |
| 3rd year of undergraduate studies | 11.88 | 38 |
| 1st year of graduate studies | 5.31 | 17 |
| 2nd year of graduate studies | 9.69 | 31 |
| Σ | 100 | 320 |

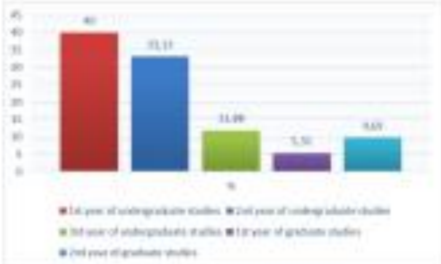

Figure 2. Graphical representation of the answers to the second question

Table 3. Question #3: Which online platforms/video conferencing tools did you use during the COVID-19 pandemic?

| Answer choices (multiple choices allowed) | Responses % | # |
|---|---|---|
| Microsoft Teams | 48.44 | 155 |
| Zoom | 59.69 | 191 |
| Merlin (Moodle) | 45.31 | 145 |
| Google Classroom | 11.56 | 37 |
| Google Meet | 12.50 | 40 |
| Other | 11.56 | 37 |
| Σ | 100 | 320 |

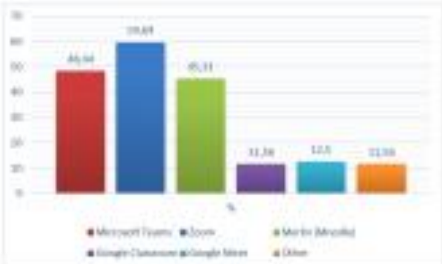

Figure 3. Graphical representation of the answers to the third question

Table 4. Question #4: Rate the satisfaction with the online learning platforms used during the COVID-19 pandemic

| Answer choices (single choice allowed) | Responses % | # |
|---|---|---|
| Extremely unsatisfactory | 5.00 | 16 |
| Unsatisfactory | 10.00 | 32 |
| Neither satisfactory, nor unsatisfactory | 39.38 | 126 |
| Satisfactory | 39.38 | 126 |
| Entirely satisfactory | 6.25 | 20 |
| Σ | 100 | 320 |

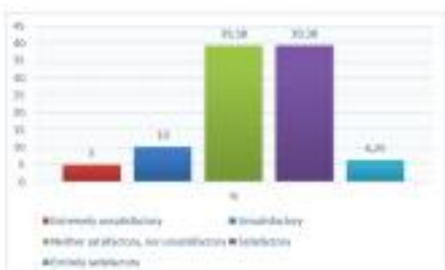

Figure 4. Graphical representation of the answers to the fourth question

Table 5. Question #5: Did you use online learning tools before the COVID-19 pandemic?

| Answer choices (single choice allowed) | Responses % | # |
|---|---|---|
| Yes, as a hobby | 19.06 | 61 |
| Yes, for studying | 12.19 | 39 |
| Yes, as a hobby and for studying | 17.50 | 56 |
| No, I did not use them | 51.25 | 164 |
| Σ | 100 | 320 |

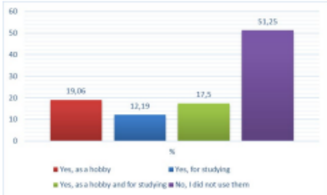


Figure 5. Graphical representation of the answers to the fifth question

Table 6. Question #6: Do you agree with the following statements? (single choice allowed)

| Answer choices | A | | B | | C | | D | | E | | F | | G | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | # | % | # | % | # | % | # | % | # | % | # | % | # | % | # |
| I disagree completely | 3.13 | 10 | 5.94 | 19 | 17.19 | 55 | 11.56 | 37 | 9.69 | 31 | 15.58 | 50 | 18.44 | 59 | 8.13 | 26 |
| I do not agree | 14.06 | 45 | 16.56 | 53 | 29.06 | 93 | 24.69 | 79 | 16.56 | 53 | 26.17 | 84 | 20.63 | 66 | 13.13 | 42 |
| I do not agree, nor disagree | 42.81 | 137 | 36.25 | 116 | 30.63 | 98 | 29.38 | 94 | 33.75 | 108 | 28.35 | 91 | 28.75 | 92 | 32.19 | 103 |
| I agree | 30.10 | 96 | 31.56 | 101 | 17.19 | 55 | 24.69 | 79 | 28.44 | 91 | 22.74 | 73 | 22.50 | 72 | 32.50 | 104 |
| I agree completely | 10.00 | 32 | 9.69 | 31 | 5.94 | 19 | 9.69 | 31 | 11.56 | 37 | 7.17 | 23 | 9.69 | 31 | 14.06 | 45 |
| Σ | 100 | 320 | 100 | 320 | 100 | 320 | 100 | 320 | 100 | 320 | 100 | 320 | 100 | 320 | 100 | 320 |

Choices:

A. Despite the passing grade, there is a lack of part of the competencies related to general courses.
B. Despite the passing grade, there is a lack of part of the competencies related to professional, STCW courses.
C. Online learning is appropriate for courses that encompass competencies related to the *Navigation* category.
D. Online learning is appropriate for courses that encompass competencies related to the *Cargo Handling* and *Stowage* category.
E. Online learning is appropriate for courses that encompass competencies related to the *Controlling the Operation of the Ship and Care for Persons on board* category.
F. Online learning is appropriate for courses that encompass competencies related to the *Fire-Fighting* category.
G. Online learning is appropriate for courses that encompass competencies related to the *First Aid* and *Medical Care* category.
H. Online learning is appropriate for courses that encompass competencies related to the *Safety and Social Responsibility* category.


Figure 6. Graphical representation of the answers to the sixth question.

The most frequently used platforms for e-learning during COVID-19 pandemic were Zoom, Microsoft Teams, and Merlin (a version of the Moodle system used in all higher education institutions in Croatia). Google platforms and other e-learning platforms had a significantly smaller frequency of usage (24.06%) and (11.56%).
From the obtained results, it is evident that platforms of companies with well-known products prevail; however, it is worth noting that they also represent platforms (Microsoft Teams and Merlin) whose usage the Ministry of Science and Education of the Republic of Croatia has enabled to all participants in higher education system in Croatia. It is also important to emphasize the differences between the above-mentioned platforms. Microsoft Teams (Office365) provides teachers and students with a wide range of e-learning tools, intended for e-learning (video, audio, textual, interactive, etc.), in one place at no additional costs. However, at the beginning of the COVID-19 pandemic, due to the large number of users, significant difficulties in platform availability were noticed, especially in the area of streaming, i.e., a larger number of simultaneous users which interfered greatly with the normal functioning of the platform. Furthermore, although Office365 platform offers great possibilities, it is not intuitive for usage by teaching staff, i.e., the adaptation is needed to fully utilize everything it offers. This fact is probably the main reason why the Zoom platform took the leading position with a usage share of
59.69% for online teaching (streaming) purpose along with Merlin (Moodle) for online sharing of teaching materials, and the possibility of conducting quizzes and exams, and various other teaching activities requiring interaction between teachers and students. Considering the relatively limited range of services offered by Google e-learning platforms, this data is in accordance with the obtained results.

The research results presented in Table 4 and Figure 4 show a generally neutral attitude of students regarding their satisfaction (user experience) with the e-learning platforms used during the COVID-19 pandemic. The distribution of responses shows characteristics of a Gaussian curve, which validates the reliability of the responses, with a significantly higher percentage of satisfaction (39.38%) than dissatisfaction (10.00%) among students, along with a normal presence of a certain percentage of complete dissatisfaction (5.00%) or complete satisfaction (6.25%) among students. It may be worthy to mention that the students' complete dissatisfaction with online teaching platforms was largely caused by their previous non-usage of elearning platforms, as indicated in Table 5 and Figure 5, and by their insufficient previous usage by teaching staff (as shown in Table 6 and Figure 6). Teachers' "unpreparedness" for the sudden transition to a new form of learning without the possibility of adapting teaching materials and methods of teaching to e-learning platforms may have contributed to the complete dissatisfaction of the students.

The analysis of the responses presented in Table 6 and Figure 6, shows the students' prevailing attitude that e-learning platforms did not facilitate their personal contact with teaching staff, and that teaching materials were not adapted to e-learning platforms. Furthermore, it is apparent that students encountered technical difficulties while using e-learning platforms. However, there is a more significant and prevailing result indicating that students experienced problems with regular attendance of classes and the availability of teaching materials. Students' dissatisfaction with technical support for the platforms used for e-learning is also evident, and it confirms the previously mentioned fact that both students and teaching staff were insufficiently informed and prepared for the "sudden" transition to e-learning platforms. This result, in the context of seafarers' education, is not so unexpected because their education includes elements that, due to their nature (STCW courses), cannot be adequately presented/passed on to students through e-learning platforms.

## 4. Conclusion

Based on the conducted survey whose results were presented in the previous chapter, it is possible to draw several conclusions about the advantages and disadvantages of using e-learning platforms in MHEIs in Republic of Croatia. The advantage identified is the possibility of improving teaching materials by using interactive contents and solving certain teaching units by using e-learning platforms, i.e., increasing the "classic" teaching materials and methods that cannot be applied in traditional lecture-style teaching. The fact that certain courses referring to the STCW Convention, or practice-oriented courses, already have teaching materials adapted for delivery through e-learning platforms (e.g., VideoTel) support this conclusion.

According to results presented as well as results obtained from previous researches (Arslan, Özkan, 2023; Demirel, 2021; Lloyd's List, 2021; IAMU Secretariat 2021,2022; Paixão, Ramos, 2022; Renganayagalu et al., 2022; IAMU Secretariat 2021,2022) it can be concluded that the usage of e-learning platforms in (Croatian) MHEIs represents a positive practice towards improving learning outcomes. However, one should be careful when applying them, especially regarding professional/practical courses, since previous empirical experiences gained from using e-learning platforms for teaching have shown certain drawbacks. These include the inability to conduct online classes for most practical courses, the students' loss of concentration in isolated online learning conditions, potential technical difficulties that teaching staff and students may encounter during their usage and poorly prepared teaching materials available through e-learning platforms. Therefore, to achieve optimal effectiveness when using e-learning platforms in MHEIs, it is important to consider all the abovementioned conclusions. Neglecting them can lead to unwanted effects, while their proper/moderate application can have positive effects on the educational process.

The research results in this paper are intended as starting point for further improvement and exploration of additional possibilities and methods of using e-learning platforms in MHEIs as well as their (possible) future inclusion and detailed specification through STCW Convention. Further research should include extended survey(s) to gain even more detailed insight into possible specifics related to both MHEIs and seafarers' education in general, although, given that the research is based on the international standards of the STCW Convention, the conclusions, guidelines and recommendations resulting from the project and compliance with other conducted researches, authors strongly believe findings can be applied within any study program in the nautical field, worldwide. Additionally, further research should include mapping STCW competencies in nautical study programs that can be acquired through distance learning, e-learning, and face-to-face teaching.

### Acknowledgements

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# Acquisition of business communication skills among students of maritime studies

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**Abstract:** Business environment in the modern maritime industry involves many participants from all over the world. The globalisation process and internationalisation of the contemporary world have brought into focus the importance of communication among all parties involved. English being the official language of the trade, this research has focused on the communication skills in English of the students of maritime studies, taking into account the specific terminology and discourse in this specific business area. The paper aims to provide an insight into communication skills of students of maritime studies and their attitudes on acquisition of these skills. The research was carried out among undergraduate and graduate students of the University of Dubrovnik, Maritime Department. For the purpose of this research, a questionnaire was compiled by the author to ascertain the students' attitudes on the communication skills and also their application of the basic skills in business communication. The data gathered was analysed by using the statistical package SPSS 26. The research results obtained can be used as guidelines when developing new programmes and/or syllabuses for students of maritime studies but also of other business studies.

*Keywords*: *business communication, maritime industry, English, students, attitudes*

## 1. Introduction

Contemporary world is undergoing frequent changes in all fields of life and work, caused and influenced by modern technological advances providing various means of communication and travel. The ongoing globalisation process has brought into focus the importance of communication in social, cultural and educational context. Business environment in maritime industry involves participants from all over the world and it is based on prompt, clear and efficient operation of all parties involved. Thus, communication should be clear and smooth. Educational institutions for future professionals in maritime business offer programmes aiming to provide for acquisition of the specific knowledge required in this area of business. English is the official language of the trade, therefore, communication skills in English are the prerequisite for successful employment, necessary in performance of everyday work as well as for training and specialisation purposes. Students of maritime studies are learning the specific terminology and basic grammar skills in educational environments in countries where English is not their mother tongue (English for Specific Purposes – ESP). According to Dudley-Evans and St John (1998) the demand for ESP continues to increase and expand throughout the world. They claim ESP is designed to meet the specific needs of the learners, it makes use of the underlying methodology and activities of the specialisation it serves and it is centred not only on the language (grammar, lexis, register), but also the skills, discourse and genres appropriate to those activities. In English speaking countries (e.g. at the

Massachusetts Maritime Academy) there are various elective courses in oral and/or written communication. However, at the University of Dubrovnik, Maritime Department, for example, English is a mandatory course and mainly focused on vocabulary and grammar. Students are offered elective course in Business Communication in Shipping on their fifth year of study. This research aimed to provide an insight into communication skills of university students of maritime studies and their attitudes on acquisition of these skills.

There has not been much data or research on the students' attitudes on acquisition of business communication skills, and only few on the attitudes of students of maritime studies. The pilot study by Rees, Sheard and Davies (2002) is among the first studies that developed a new scale to measure attitudes towards communication skills learning (Communication Skills Attitude Scale – CSAS). Their research resulted in a 2-factor scale representing positive attitudes and negative attitudes (Rees et al., 2002:141) of medical undergraduate students.

Kovač and Sirković (2017) explored attitudes towards communication skills among engineering students in Split, Croatia. They used CSAS on a sample of 62 students to collect data. The research results showed noticeably positive attitudes towards learning communication skills.

Al-Musalli (2019) carried out a research in 2015 exploring communication skills of new employees in Canadian companies in an effort to shed light on bridging the gap between the kind of training offered in business communication courses and expectations from new graduates at the job market. Research encompassed 32 representatives of business companies focusing on written and oral skills of new graduates employed at the companies. The results indicated that communication skills training should not be left for the employers to handle on their own and courses should aim to adjust to work market needs in order to provide adequate communication skills training prior employment.

## 2. Research Methodology

### 2.1. Aim

This research aims to provide an insight into attitudes of university students of maritime studies on business communication skills and acquisition of the basic skills in oral and written communication.

### 2.2. Participants

The research was carried out at the University of Dubrovnik, Maritime Department, Croatia, focusing on 95 full-time undergraduate (Year 1-3) and graduate students (Year 4-5) of the Maritime Department.

Table 1 shows the frequency and percent of the participants according to year of study.

Table 1 - Participants

| YEAR OF STUDY | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | YEAR1 | 26 | 27,4 | 27,4 | 27,4 |
| | YEAR2 | 29 | 30,5 | 30,5 | 57,9 |
| | YEAR3 | 22 | 23,2 | 23,2 | 81,1 |
| | YEAR4 | 7 | 7,4 | 7,4 | 88,4 |
| | YEAR5 | 11 | 11,6 | 11,6 | 100,0 |
| | Total | 95 | 100,0 | 100,0 | |

### 2.3. Instrument

The research instrument consisted of two parts. In the first part demographic data was collected: gender, age and year of study. The second part consisted of a questionnaire compiled and adapted for this particular research, containing 17 statements. Validity and reliability of the questionnaire was tested and confirmed. The participants were asked to indicate their degree of agreement with individual statements on a 3-point Likert scale (1=disagree, 2=neither agree nor disagree, 3=agree).

### 2.4. Data collection and analysis

Research data was collected in Croatian educational context during regular classes at the Maritime Department of the University of Dubrovnik. Participants were guaranteed anonymity and voluntarily participated in the research. All data collected was analysed using the statistical package SPSS 26, more precisely, using descriptive statistics and inferential analysis. Analysis of Variance – ANOVA was used for finding differences in attitudes in relation to the year of study.

## 3. Results and Discussion

In order to ascertain whether there are any statistically significant differences in students' attitudes on business communication skills with reference to the year of study, ANOVA test for independent samples was used.

Table 2 shows descriptive statistics for each statement.

Table 2 – Descriptives

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| Statement | N | Min | Max | M | σ |
| 1. I am ready to speak in front of a group of familiar people. | 95 | 1 | 3 | 2,81 | ,445 |
| 2. I am ready to speak in front of a group of strangers. | 95 | 1 | 3 | 2,62 | ,605 |
| 3. I can understand oral instructions and complete a task. | 95 | 1 | 3 | 2,87 | ,393 |
| 4. I do not hesitate to ask for clarification if I did not understand someone. | 95 | 1 | 3 | 2,76 | ,477 |
| 5. I can understand written instructions and complete a task. | 95 | 1 | 3 | 2,83 | ,429 |
| 6. I need to have good communication skills to be successful at work. | 95 | 1 | 3 | 2,88 | ,353 |
| 7. Developing my communication skills is as important as developing my knowledge. | 95 | 1 | 3 | 2,80 | ,475 |
| 8. Communication skills help facilitate team-working skills. | 95 | 1 | 3 | 2,94 | ,285 |
| 9. I can't see the point in learning communication skills. | 95 | 1 | 3 | 1,20 | ,497 |
| 10. I do not need good communication skills to do my job properly. | 95 | 1 | 3 | 1,34 | ,538 |
| 11. My oral communication skills are good. | 95 | 1 | 3 | 2,60 | ,554 |
| 12. My written communication skills are good. | 95 | 1 | 3 | 2,47 | ,599 |
| 13. I easily participate in discussions in English. | 95 | 1 | 3 | 2,53 | ,616 |
| 14. It is easier for me to write than to speak English. | 95 | 1 | 3 | 1,72 | ,710 |
| 15. Non-verbal communication is important in business communication. | 95 | 1 | 3 | 2,59 | ,574 |
| 16. Grammar is important in business communication. | 95 | 1 | 3 | 2,43 | ,709 |
| 17. Vocabulary is important in business communication. | 95 | 1 | 3 | 2,76 | ,520 |
| Valid N (listwise) | 95 | | | | |

**M** = Mean; **σ** = Standard Deviation

As shown in Table 2, taking into consideration the trend of mean values, the highest mean values (M=2,94) have been found for statement 8, i.e. the participants in the study largely agree that communication skills help facilitate team-working skills. This is particularly important when speaking of maritime industry and work on board vessels where, due to confined working area, it is of utmost importance for the crew to work as a team. This applies not only to communication onboard but also from ship to shore and vice-versa (company headquarters, shipping agents, ship chandlers, manufacturers and their services, etc. High mean values have been found for statements 3 (M=2,87) and 6 (M=2,88) – the students have largely agreed that they can understand both written and oral instructions to complete a task.

On the other hand, the lowest mean value has been obtained for statement 9 (M=1,20) where students largely disagree with the statement that there is no point in learning communication skills, which shows their awareness of the importance of learning these skills. Low mean values have also been recorded for statement 10 (M=1,34), indicating that the participants believe they do need good communication skills to do their job properly. Such results may be due to the fact that students of maritime studies prepare for an international and multi-lingual working environment, where English was declared as official language just because of the variety of nationalities working on board same vessels and the resultant need for a common language to be used in communication.

Table 3 – Differences in attitudes with reference to year of study

| Dependent Variable<br>**Statement 2** | Year of Study | **M** | **σ** | **p** |
|---|---|---|---|---|
| YEAR5 | YEAR1 | 2,81 | ,402 | **,002*** |
| | YEAR2 | 2,66 | ,614 | **,016*** |
| | YEAR3 | 2,68 | ,568 | **,016*** |
| | YEAR4 | 2,57 | ,535 | ,404 |

***p<0,05; **p<0,01**

**M =** Mean; **σ** = Standard Deviation

In order to explore whether there are any differences in students' attitudes with reference to the year of study, ANOVA test for independent samples was used. Statistically significant differences have been observed for statement 2 only (*I am ready to speak in front of a group of strangers*), between Year 5 students and Year 1, 2 and 3 students. No statistically significant differences have been observed for this statement between Year 4 students and other years. This might be due to the fact that Year 4 students do not attend courses in English or Business communication. The study programmes do not provide for either obligatory or elective courses concerning communication in English on this year of study at the University of Dubrovnik. Also, this group of participants was the smallest one – only 7 students completed the questionnaire. Mean values indicate that the students of the first year (M=2,81) agree with this statement more than their peers from other years of study. The lowest mean value has been observed for the Year 5 students (M=2,00), where the students neither agreed nor disagreed with the statement. These results should be further explored on a larger sample. However, a possible explanation for these results might be that the Year 5 students have had a one year pause from learning English and business communication in English. Furthermore, older students, having attended more professional courses during their study, might be better aware of the imminent employment and their future work environment and its requirements.

Cleland et al. (2005) noted in their research carried out among undergraduate students in Aberdeen, Scotland, that there were significant differences in attitudes to communication skills by year of study and gender. Positive attitudes scores for Year 1 were significantly higher than those for higher years. The authors concluded that attitudes towards communication skills learning are positive initially and stated that it may be the increasing experience of clinical practice lead to a change in attitude. This might be similar in Croatian context in maritime studies. Namely, on Year 5 the students are at the end of their study, about to seek employment and perhaps being vary of working in a predominantly international environment where language/communication skills are of major importance.

Another research paper carried out by Harlak et al. in Turkey in 2008 on medical students, in two phases: before training and after training, indicated that in the pre-test 49% of students had positive attitudes but in post-test the positive attitude group decreased significantly, whereas there was not change in the negative attitude group. Students' attitudes toward communication skills learning significantly changed in a negative direction after training. The authors suggested that Turkish curriculum might need further examination and modification in order to create positive changes in students' attitudes toward communication skills.

Research study carried out in Croatia among engineering students (Kovač and Sirković, 2017) obtained results showing that senior students had higher positive attitudes compared to the students at the beginning of their undergraduate studies. The authors explained their results by noting that the senior students gained an additional awareness during their university education regarding the significance of communication skills.

## 4. Conclusion

The purpose of this study was to analyse attitudes of undergraduate and graduate students of maritime studies toward business communication skills and their acquisition. Results of the study have shown that there are statistically significant differences in attitudes in only one statement, referring to readiness to speak in front of a group of strangers. The lowest means were obtained for Year 5 students, while the highest means were obtained for Year 1 students.

It may be concluded that students of maritime studies at the University of Dubrovnik tend to develop lower positive attitudes toward their business communication skills than the freshmen. The results are in accordance with some studies carried out among medical students (Harlak et al. 2008; Cleland et al. 2005).

However, one of the rare studies in Croatia, among engineering students, obtained the results indicating higher positive attitudes of students of higher years of study in comparison with younger students, quite the opposite from our research. More research in different contexts and on different and larger samples should be carried out to learn more about students' attitudes toward communication skills.

Research study carried out in Silicon Valley among employers in 2005 by Stevens underlined that employers considered communication skills of new graduates needed improvement in several areas, including vocabulary and self-expression. Students needed stronger writing skills and additional education on business communication.

Educational institutions in Croatia, but also worldwide, should take their recommendation into consideration and refresh study programmes having in mind that students need to achieve business communication skills as a preparation for the international market. The global labour market needs good communicators and employees with good skills in oral and written communication. Maritime universities worldwide might have recognized the need for good communicators, but have they prepared their study programmes accordingly? Has enough attention been given to the issue of business communication in shipping?

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# Opportunities and challenges of part-time studies in Maritime Education and Training

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**Abstract:** The maritime industry is changing quickly thereby affecting the educational requirements of seagoing personnel. Within this context, nautical officers are taking part in lifelong learning programmes at universities to keep up with new requirements or to better prepare themselves for a shore-based job. This article advocates distance learning approaches for seafarers at post-graduate level which can be studied alongside work at sea in part-time mode. What opportunities does this approach offer and what hurdles need to be overcome? A case study analysis was carried out using boundary theory. The requirements for this target group are examined and conditions for success are discussed. Central for successful participation in further education alongside work at sea is the ability of seafarers to deal with both the integration and segmentation of activities of different life domains. This constitutes a unique demand compared to most occupational groups and part-time students.

*Keywords*: boundary theory; lifelong learning; maritime education and training; distance learning; microcredentials

## 1. Introduction

The international shipping business transports more than four fifth of the global trade by volume (UNCTAD 2023). According to the Seafarer Workforce Report (BIMCO 2021) "1.89 million seafarers currently serve the world merchant fleet, operating over 74,000 vessels around the globe." It also warns of a shortfall of approximately 90,000 officers by 2026. Besides, climate change and decarbonisation, digitalisation as well as cyber-security are the most important drivers of change in the shipping industry and have a major impact on its technical and regulatory development (Stopford 2022; UNCTAD 2023). It is not only the industry but also the jobs on board ships that change and require further training (IAMU 2019), which goes beyond the high demands a workplace at sea as such puts on ships' crews (MacLachlan 2017; Li et al. 2022). A job at sea is often seen to be not compatible with private life or family planning in the long term. Many seafarers spend only a few years at sea before looking for adequate employment opportunities ashore (Albert et al. 2016). Therefore, they are interested in further learning activities that can be studied alongside work in part-time mode in order to not only adequately prepare themselves for a second career but also to keep up with aforementioned demands.

Accordingly, this article promotes "Social/Maritime Education & Training" and advocates for its consideration in further education and lifelong learning (LLL) approaches for seafarers which are in line with their demands. Based on this, the following research questions are in focus from a nautical officers' perspective: How can LLL help to cope with the demands mentioned? Which chances but also risks are associated with such LLL activities? Which approaches and strategies seem to be appropriate in order to balance obligations related to work, private life and part-time studies?

To answer those questions, this article consists of four chapters. The introduction (chapter 1) includes the research objectives and research questions. Following on from that, related work and definitions of this study are briefly elucidated (chapter 2). Chapter 3 presents nautical officers as lifelong learners, which includes, due to limited scope, the methodology, the presentation of a case study and discussion. The article ends with a summary, conclusion and outlook (chapter 4), which also shows potential for transferability to other IAMU member universities. Although single aspects of this text are discussed in more detail elsewhere (Nause 2022a;

b), this discussion goes beyond and constitutes an expansion of aforementioned works, especially as the findings may be used as blueprints by others and opens up opportunities for cooperation.

## 2. Related Work and Definitions

### *2.1. Lifelong Learning and Maritime Education and Training*

In the first half of the 1970s concepts and policies on LLL and lifelong education were published, for example, by the Council of Europe. In line with that, the European Commission (2001) defines LLL as "*all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences within a personal, civic, social and/or employment-related perspective.*" (p. 9, emphasis in original) People learn throughout their whole life in order to keep up with the changes that are taking place and to adequately address complex issues they face in their working lives.

In the light of this, Maritime Education and Training (MET) evolved from a practical and on-the-job training paradigm with a focus on the education of seafarers to a university-style and tertiary education scheme (Manuel 2017). Therefore, MET concepts have to be updated constantly by considering relevant future aspects but at the same time address social issues and developments (Ahmad Fuad et al. 2024). The aim is to educate maritime experts who operate ships with highly innovative technical systems and sail them around the world but also organise global transport chains (Bauk & Ilčev 2021). Thus, concepts of part-time studies and learning at work programmes are increasingly gaining in importance (Parry et al. 2023).

### *2.2. Boundary Theory*

People regularly have to fulfil and balance several roles at the same time. These roles can be assigned to different areas of life, for example, obligations related to employment, private life, studies, etc. To explain their relationship and interaction, the boundary theory is used in this article (Ashforth et al. 2000; Nippert-Eng 1996).

The basic understanding of the boundary theory is based on the assumption that boundaries exist between activities of different life domains. These boundaries can be permeable or impermeable in one or both directions. People can separate or mix the activities of different areas of life; the resulting roles are arrayed on a continuum from segmentation to integration (Figure 1):

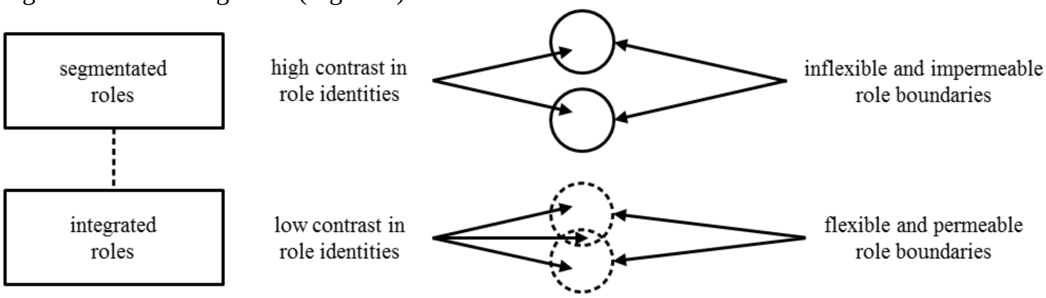


Figure 1. Segmentation versus integration, source: own illustration following Ashforth et al. 2000, p. 476.

The two approaches have different advantages and disadvantages respectively: The advantage of segmentation is that it is always clear which role someone is in; requirements are always clear and the behaviour shown by the person is appropriate. On the other hand, the disadvantage is a higher resource consumption when switching between roles. The number of role changes is usually rather small and predictable (rituals), for example, twice on working days while commuting to work and home. In terms of integration, the advantages and disadvantages are reversed. Moreover, integration can lead to contradictions and conflicts.

Ashforth et al. (2000) give examples of both poles: On the one hand, these are people from occupations that refer to 'dirty work' (Hughes 1951), for example, exotic dancers or garbage collectors. They try to keep their work secret from their personal environment. On the other hand, these are members of 'total institutions' (Goffman 1961), for example, seafarers or members of a religious order living, who both live and work at the same place, namely on-board ships or in monasteries. Here, the activities of the different domains almost merge into one another without boundaries (Nippert-Eng 1996).

Most people combine both strategies and find themselves somewhere in the middle of the continuum ('mixed types'). They have different tendencies, with a general mixing, the mixing of single aspects only as well as different directions of mixing being possible. According to Kreiner et al. (2009), people use so called "Work-Home Boundary Work Tactics" (p. 716 f.) as strategies for coordination, transition between roles and setting their preferred level/style of segmentation or integration. People perceive a situation as stressful when preference and default are in contradiction due to the situation in terms of segmentation and integration. Especially integration becomes a burden to those people who prefer segmentation (Kreiner et al. 2009).

## 3. Nautical Officers as Lifelong Learners

### *3.1. Methodology*

In the following, the methodology of a case study design as a research method is used and the reasons for its choice are briefly given. According to Clark et al. (2021) "[t]he basic case study design involves detailed and intensive analysis of a single case." (p. 59) The term case study research does not stand for a specific study design or methodological approach, but rather for a complex, open research design. Accordingly, there are different definitions of case study research, with the respective approach or design being decisive (Yazan 2015). The idea is to understand the case in-depth, shed light on a new or given problem or reveal important features about the case (Clark et al. 2021; Yin 2018). The specific methodology used here is the discussion of the group of nautical officers in the context of LLL, MET as well as the boundary theory. This approach is promising as the detailed analysis will lead to new findings and knowledge. These results contribute to the understanding of the challenges and opportunities discussed and constitute the basis for measures and strategies to address the problems explained. Besides, as the methodology used here attributes to the qualitative research paradigm it paves the way for further (quantitative) studies, comparative insights and empirical support.

Emphasis is put on the different roles of seafarers as nautical officers, family members and lifelong learners as well as the associated challenges and opportunities which go along therewith. The discussion considers their typical obligations and infers which strategies seafarers as part-time students apply in order to manage/balance their roles in their different life domains. Within this discussion, the distance education M.Sc. degree course of International Maritime Management (IMM), offered at Jade UAS (n.d.) in Germany, serves as example in this article to show one way to tackle the hurdles, demands and developments mentioned above. The author of this text is the co-ordinator of the degree course presented. Therefore, data presented and information used within this case study also includes experience from everyday business, evaluation results and conversation with students and lecturers. Other maritime institutions and universities also have implemented similar distance learning degree courses or Diploma programmes on post-graduate level, for example, the IAMU members Australian Maritime College (n.d.) or World Maritime University (n.d.) to name but a few.

In terms of limitation, due to limited scope, this discussion does not take into account these further programmes. Besides, it does not include results from Covid-19 pandemic or the (negative) impact of (new) geopolitical conflicts. In addition, this discussion disregards the influences of different cultures, stress factors and initial conditions in the countries of origin of seafarers. Some of these aspects will somewhat be addressed but should be discussed in more detail in future discussions.

### *3.2. Case study: International Maritime Management (M.Sc.) distance degree course*

MET programmes lead to the acquisition of the STCW Deck Certificate of Competency (CoC) for officer in charge of a navigational watch. This may be studied along with an under-graduate university degree (depending on country-specific characteristics and types of institutions). As a next step, such new graduates can start working on board sea-going vessels as nautical officers *or* continue their education with further studies (on post-graduate level) in order to prepare themselves for highly qualified jobs in the maritime industry. Social, cultural and other reasons but also structures and processes created by politics result in the fact that seafarers from different countries typically spend only a few years at sea before looking for employment opportunities ashore while a minority work at sea until retirement. Irrespective of reasons and details, from a seafarers' point of view a job at sea is often seen to be incompatible with private life or family relations. Due to the characteristics of the workplace at sea (long and irregular phases of work and holidays, ships sail in different and changing time zones, with limited access to the Internet), the combination of seagoing service – with the aim of acquiring a CoC in capacity of Master –, whilst *simultaneously* continuing formal learning in university education seems particularly attractive for this group of people.

While implementing the IMM distance degree course (Jade UAS n.d.), a didactic concept was developed which puts the unique target group characteristics stated above into the fore. The distance learning approach is supplemented by a kick-off event at the beginning of the course which serves familiarisation purposes. IMM encompasses seven learning modules plus thesis which in total equals one and a half years full-time studies. As almost all IMM students study while working, three years part-time studies is more or less the average duration. The didactic concept contains different elements of flexibility, which especially are: flexible course duration, flexible places of learning (this explicitly includes ships as places of learning) and integration of professional real-life projects into the studies (learner-centred approach).

*3.3. Discussion*

Seafarers are either at sea or at home for long periods of time. The alternating situation within these two 'worlds' is completely different and this contrast is predetermined and inextricably linked with the seafaring profession; it resembles a situation of *segmentation* according to the boundary theory. On a lower level, we find the following two contradicting situations: while at sea, seafarers work and live at the same place, namely ships; working hours and rest periods alternate and (almost) merge into one another. In line with that, crew members are both for each other, colleagues and social partners even though crews typically constitute a non-consensual community. Irrespective of this, seafarers can hardly separate between these roles during a service on board, and therefore this resembles a situation of very high or even complete *integration* according to the boundary theory; this situation is predetermined and inextricably linked with the seafaring profession, too. On the other hand, the holiday period is fundamentally different; work plays (almost) no role for seafarers as there are no phone calls from the employer or colleagues. This predetermined polarity is a non-changeable characteristic which has to be accepted by seafarers: here a rhythm of life at sea externally determined by ship operation, and there a self-determined life at home (which is more or less determined by the social environment). Within this framework, nautical officers may have an interest in further education and are asked to organise their further learning activities in terms of when, where, how and what they prefer to study. Accordingly, the ship can become a place of working, living and learning, which makes the aforementioned situation more difficult or easier (see below) and requires a high level of self-organisation and motivation.

In this context the aspect of support is important, for example, family support, employer support, strategies to balance the different requirements (O'Shea et al. 2024; IU 2023; Nause 2022a; b). In addition to employment, private life and studies, particularly family involvement and other obligations at home or care work are in focus.

'Ordinary' part-time students concentrate on studying, while partners manage the household. Partners regularly provide time for support or relief while part-time students take this time. The situation for seafaring part-time students is the opposite: they give time while at home and take over tasks in the household or to relieve their partners; this approach is understandable in light of absence times. Besides, employment and compulsory schooling often take place between nine and five. Therefore, 'ordinary' part-time students study primarily on weekdays during the evening hours (from 5 p.m.) and on weekends. Meanwhile, seafarers on vacation may be waiting for their family and friends to be available for leisure activities. The situation for seafaring part-time students is the opposite again here: if they prefer to study at home, they can study on working days between nine and five in order to keep evening hours and weekends free for leisure activities with family and friends; aforementioned 'waiting times' can be used or potentially be allocated for their studies from whatever former activities. If they prefer to study on board their studies do not have any impact on their vacation as the situation/routine at home remains unchanged.

Work at sea is reported to be very stressful for several reasons (MacLachlan 2017; Li et al. 2022), while work at sea is characterised also by routine and monotony (Devereux 2021). Taking this into account, it should be further clarified, by considering the role of motivation, whether LLL activities at sea further exacerbate the stressful situation and are seen as a burden on top accordingly which is, for example, seen and therefore accepted as a chance/pre-requisite for better job opportunities in the future (extrinsic motivation). Or whether the opposite turns out to be more important as seafarers primarily study as they are interested in the learning experience itself, see studies as a possibility to overcome the routine and monotony on board as they see studies as 'meaningful leisure activity' (intrinsic motivation). In line with that, Hirimbure and Lutzhoft (2014) report that seafaring students would welcome a greater use of distance studies in their future learning while at sea.

The discussion shows that seafarers have to be able to cope with both segmentation and integration due to the characteristics of their workplace. It should be analysed in the future whether and to what extent the personal preference regarding integration or segmentation correlates with the perception of the situation on board in general as well as years of employment spent at sea before changing to a shore-based career, etc. In this context another argument follows from aforementioned discussion. Leaving the job at sea behind is the only alternative to accepting the situation with both segmentation and integration. Especially in terms of integration, all seafarers need to have or develop skills that enable them to deal with such given situation at sea.

Moreover, the discussion shows that further investigation is necessary to understand seafarers' needs and decisions. Distance learning approaches are one way to tackle the hurdles identified as the distance between the workplace and the university is very high. At the same time, distance learning approaches give the learners a very high level of flexibility in terms of when, where, how and what to study and therewith bear potential for broader implications in MET, such as the ethical dimension, autonomy on an individual level, the potential to strengthen well-being at sea, promote digitalisation, careers at sea and ashore as well as educational needs on a broader level. On the other hand, such opportunities require key competences and motivation from seafarers.

**4. Summary, Conclusion and Outlook**

The article analyses the role of nautical officers as lifelong learners who would like to use their voyages at sea for further education. So far, very little is known about this student group. The article provides information about how nautical officers could organise their further education alongside their work at sea and what influence seagoing ships as place of learning have on the organisation and learning behaviour.

As a result of developments in the maritime industry the demand for highly qualified personnel is becoming apparent (IAMU 2019). In line with this, BIMCO (2021) warns of a shortfall of seafarers and encourages ratings to become officers which is important and positively linked to personal development, among other reasons. Therefore, distance learning approaches in MET constitute possible ways to tackle the skills gap and deficit in the number of seafarers. Besides, distance learning approaches turn out to be a suitable possibility as they are in line with seafarers' demands. The industry but especially seafarers themselves can keep up with the changes that are taking place and acquire the skills needed or qualify themselves in single fields of special interest. Post-graduate degree courses but also smaller formats, for example, post-graduate diplomas or microcredentials (European Commission 2020), are increasingly becoming more important, particularly due to dynamic developments and current needs to which educational institutions can respond quickly and specifically. Such smaller formats also address people who, for various reasons, have no interest in or no time for studying (another) entire degree course. This topic is even more important as different areas of life are increasingly interconnected. Thus, the boundary theory posits that individuals differ in the way they separate or integrate activities from different life domains and provides strategies for coordination. This debate is particularly relevant for seafarers, as life at sea is very much determined by the on-board routine.

Moreover, the aspect of gender diversity should be included in this discussion as it bears a great potential for improvement from various viewpoints, for example, individual perspectives but also the economy in general and gender equality in particular as the "percentage of female STCW certified seafarers is estimated to be 1.28% of the global seafarer workforce […]" (BIMCO 2021). Although there is a positive trend in gender balance, women in the maritime domain mainly work in jobs which do not require STCW certification, for example, in hospitality or hotel roles on cruise ships. Therefore, LLL and distance learning approaches could be used as one possibility in the whole process from recruitment to retention to long-term employment of women in the maritime domain, especially to strengthen gender equality and their role as STCW certificated officers.

In summary, LLL activities are essential requirements today and offer good opportunities for seafarers who cannot attend 'classic' degree courses due to the characteristics of their workplace. Moreover, the combination of work experience and part-time studies present great opportunities and could be an instrument for personal development but also for companies in order to promote and keep their staff. On the other hand, we find an area of tension between the desire and demand for LLL and multiple commitments from different roles at the workplace, private life and studies. Therefore, distance learning approaches require a very high level of motivation, coordination and perseverance from a learner's viewpoint which might be perceived as barriers. Those who have already learned how to learn can particularly benefit from learning opportunities offered in part-time mode. Central for successful participation in further education alongside work at sea is the ability of seafarers to deal with both the integration and segmentation of activities of different life domains. This constitutes a unique demand compared to most occupational groups and part-time students.

Details and possible solutions to the questions raised were presented. So far, the discussion is limited to experiences of this case study but future research should consider further case studies but especially expand the empirical basis and provide a deeper contextualisation with the collection of quantitative data. This is especially noteworthy as similar degree courses and smaller formats on post-graduate level have also been implemented by other maritime universities which make comparative studies possible. Moreover, this allows different institutions to benefit from each other and opens up opportunities for cooperation across the IAMU community.

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# Use of lightboard videos in Maritime Education and Training

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**Abstract:** This article presents an update of the didactic concept of a post-graduate maritime distance degree course, which now includes lightboard teaching videos as a didactic element. What potential do they bring but also what challenges may be encountered? A case study analysis was carried out taking dual coding theory into account. The analysis shows that the teaching and learning of abstract relationships or dynamically developing processes repeatedly result in difficulties. Lightboard teaching videos with step-bystep explanations as well as verbal and visual presentations can especially facilitate such learning occasions. Such videos also offer possibilities as a form of examination because they allow a more realistic depiction of situations than, for example, written examinations. In addition, this approach contributes to the general concept of Open Science which strengthens collaboration and sharing of knowledge within Maritime Education and Training. On the other hand, successful implementation requires different pre-requisites, such as procurement of technology, teacher support as well as resources for detailed planning and recording of the videos.

*Keywords*: lightboard videos; distance education; active learning; approaches to learning; dual coding

## 1. Introduction

Seaborne trade is a catalyst for the global economy. It is the people at sea and ashore who serve the fleet around the world and organise global transport chains. Currently, shortage of labour, decarbonisation, digitalisation and cyber-security are the drivers of change that have an impact on the industry (Stopford 2022) and Maritime Education and Training (MET) accordingly. This discussion focusses new teaching and learning opportunities for students in self-paced distance learning programmes. To support their learning, the possibility of implementing lightboard teaching videos (LTV) with a maximum of five minutes length is discussed.

This article refers to the conference's "Social/Maritime Education & Training" general theme category and advocates for its consideration in terms of implementing technological advances in distance learning approaches. The following research questions are in focus: In how far can LTV facilitate learners at a distance? Which chances but also risks go along with the implementation of such videos?

The article starts with the introduction which includes the objectives and research questions (chapter 1). Following on from that, related work and definitions are briefly outlined (chapter 2). Chapter 3 discusses the use of LTV in concepts of MET in general and presents also an application, namely a concrete case study. The article ends with a summary, conclusion and outlook (chapter 4), which includes key learnings and beyond shows potential for transferability and collaboration across the IAMU community.

## 2. Related Work and Definitions

### *2.1. Motivation and Active Learning*

Motivation is a 'force' that engages individuals to do something in a goal-oriented manner (Heckhausen & Heckhausen 2018). Central for intrinsic motivation is an activity itself which is carried out for its own sake, for example, pursue a hobby. No control instrument is required as the experience of the action motivates. In contrast, central for extrinsic motivation is an external factor that acts as control instrument, for example, obtaining rewards or avoiding punishments. Once the control measure is not given any more, the activity will no longer be carried out.

The term active learning (AL) is widely used and has emerged as an alternative to traditional pedagogical methods in universities. Bonwell & Eison (1991) argue that the use of the term relies rather on an "intuitive understanding than a common definition." (p. iii) Moreover, it is often misunderstood and assumed accordingly that all learning is inherently active. This is not the case. It is the learners' task to do more than attending lectures and listen to them, instead they are asked to apply learning processes: "They must read, write, discuss, or be engaged in solving problems." A mandatory pre-requisite for this is, that teachers make use of teaching approaches that promote AL and enable students to engage in doing and learning things as well as reflecting on what they do, for example, in terms of analysis, synthesis and evaluation (see also Clanton Harpine 2024). There is also evidence that AL leads to a more positive learner attitude, reduces the risk of dropping out and strengthens interpersonal skills and teamwork (Harrington & Zakrajsek 2017). AL is based on five basic principles according to Kosslyn (2021; see also Kosslyn & Nelson 2017): 1) deep processing: initiate (deep) mental engagement with the learning content, 2) chunking: organise learning content in smaller and larger parts (chunks), 3) building associations: use association networks to establish connections between contexts, concepts/theories and examples, 4) dual coding: provide information means of word/text and picture/video, and 5) deliberate practice: use exercises specifically to improve performance. The two concepts of 'deep processing' and 'dual coding' in particular are important for this discussion and will therefore be introduced briefly below.

### *2.2. Deep Processing and Dual Coding*

Approaches to learning are regularly identified and described in the literature on learning theories. Students use a deep and understanding-oriented approach or a superficial and reproducing approach; both approaches are associated with different learning outcomes (thorough understanding versus factual knowledge). This concept was introduced by Marton and Säljö (1976a; b). It was cited and applied and further developed many times and is considered to be empirically well proven (Biggs 1987). This duality was also systematically linked to motivation related to the learning object or result: deep-level-learning is associated with intrinsic motivation, surface-level-learning with extrinsic motivation.

Human cognition theory assumes that combining verbal and non-verbal (visual) information is very useful. Based on this, the principle of 'dual coding' assumes that having the same information in both formats, namely textual and visual presentation, promotes the acquisition of knowledge and long-term memory more than just textual information presentation. This assumption constitutes the dual coding approach (Paivio 1986). Noetel et al. (2021) carried out a meta-analysis and found that providing learners with supplemental videos led to strong benefits for the learners ($g = 0.80$), compared to the use of videos alone ($g = 0.28$). The values were calculated using Hedges's $g$ and interpreted by applying Cohen's rule-of-thumb (small = 0.2; moderate = 0.5; large = 0.8) which allows comparability with other studies in the field. They also refer to the fact that the median effect size for meta-analyses in higher education is 0.35 (benchmark) which underlines aforementioned relevance.

## 3. Lightboard Teaching Videos in Maritime Education and Training

### *3.1. Methodology*

In the following, the methodology of a case study design as a research method is used and the reasons for its choice are briefly given. According to Clark et al. (2021) "[t]he basic case study design involves detailed and intensive analysis of a single case." (p. 59) The basic idea is to understand a case in-depth, shed light on a new or given problem or reveal important features about it (Clark et al. 2021). In line with that, a brief introduction of the International Maritime Management (IMM) degree course including its didactic concept will be given. Then, LTV as measure for further development will be discussed. First, the general idea of LTV is shown. Thereafter, an exemplary example/case is presented. In addition, the case presented should serve as a blueprint or template for others not only at Jade University but also across the IAMU community.

Besides the information provided and stated respectively, experience from day-to-day business is considered as the first author of this article is the co-ordinator of the IMM degree course and he also had been involved in developing and evaluating the overall degree course's didactic concept. In addition, the second author is the lecturer of the Maritime Business and Logistics (MBL) learning module which is in focus here.

In terms of limitation, due to limited scope, this discussion does not take into account the following difficulties or hurdles: first of all, the appropriate technology must be available so that recording LTV is possible. Furthermore, teachers must be open to new approaches and (would like to) take on the task outlined. In this context, we encourage people ‘simply’ to start and, if necessary, to cooperate.

### *3.2. International Maritime Management Degree Course and Trigger for Change*

IMM is a distance-education, post-graduate degree course offered at Jade UAS (n.d.) in Germany. It is a cooperative programme of work and study which targets graduates of bachelor’s degree programmes working up their way to the management-level at sea or on land and who wish to acquire a master’s degree *simultaneously*. IMM enables further education for those who would like to study besides the job and who are not able to attend ‘classic’ on-campus degree courses for several reasons, for example, family commitments or reasons which are inextricably linked with jobs at sea (Nause et al. 2018). Therefore, the course was designed in distance education format and in line with the needs of nautical officers (Means et al. 2014; IAMU 2019).

Experience from teaching and student feedback of the IMM degree course in general and the MBL learning module in particular show that students face different challenges with regard to content while studying. Barriers which can be subsumed under the heading of organisational aspects are disregarded in this discussion, for example, lack of employer support. The focus is on module-specific reasons as well as ‘practical’ hurdles while studying, for example, how to deal with extensive datasets and databases, calculate freight and utilization rates, or interpret economic principles, numbers and statistics in maritime contexts. Some feedback from students is: “The minimum world scale calculation should be explained in more detail.”, “Calculations [are] sometimes difficult to comprehend.”, “[...] it would be better [to have] detailed calculations with more examples.”, “I would appreciate learning videos or webinars to supplement the scripts in the future.” Thus, short and succinct LTV of up to five minutes length should be introduced. These videos facilitate teaching and learning, serve to enhance the understanding of practically relevant issues, reflect experience, consider social cues, initiate discussions, problem-solving skills, self-efficacy and self-regulation, strengthen online community engagement as well as enhance users’ understanding and interaction (Perkins & Woods 2023; Gleason 2018). Once recorded, students can use these videos asynchronously and as often as needed. On this basis, learners can work on their own questions, projects and examination as well as interact and discuss with their peers and lecturers.

### *3.3. Lightboard Teaching Videos*

A lightboard is a writeable screen or glass board which is placed between the lecturer and a camera. It allows to record LTV and therefore it is used in an asynchronously manner but allows direct interaction between teacher and learners as in a classroom. LTV provide a more personalised experience as learners see the lecturers’ gestures, body and eye movement besides the content. The tool is mostly used in science, technology, engineering, and mathematics disciplines (Fallas-Ramírez et al. 2022; Jose et al. 2021; Lubrick et al. 2019).

Specific planning and a concept for the use of LTV as teaching and learning methodology are required prior to the recording of the videos (ibid.). A concept starts with general information (for example, degree course, learning module, topic, author, presenter, date), preparation and file management (for example and if applicable, background display, script file name to be transferred to teleprompter, embedded videos). The planning then becomes more detailed and creating the script is similar to creating a presentation or lecture. The content to be presented is divided and each individual slide is created one after the other. It is possible to use background images and texts (which resembles a presentation or lecture with projector and presentation software) or hand-written images and texts with pens (which resembles a presentation or lecture with blackboard); combinations are possible, too. It is also possible to include more than one page as the presenter can include short breaks for board cleaning (‘wipe’ the screen or change the background image).

The LTV is then recorded on this basis and followed by the post-production of the video or the transcription of the audio track, etc. It is very important to consider several aspects that seem banal at first glance: clothing (no stripes or checks, lighter or darker colours compared to background), facial expressions, gestures, arrangement of speaker, images and text, quantity of content per slide, number of slides, etc. Several takes are also regularly required for one video but over time a routine sets in and experience makes it easier.

### *3.4. Lightboard Teaching Video in the Maritime Business and Logistics Learning Module*

In the further course, the implementation of LTV in the MBL learning module of the IMM degree course is outlined. Experience has shown that the calculation of key performance indicators, freight rates but also numbers in general again and again lead to problems. As a measure to overcome this barrier, the calculation of a container terminal capacity including the impact of a shorter/longer dwell time is illustrated using the concept of inventory management and the sawtooth model; an extract of the concept is shown in figure 1 below:

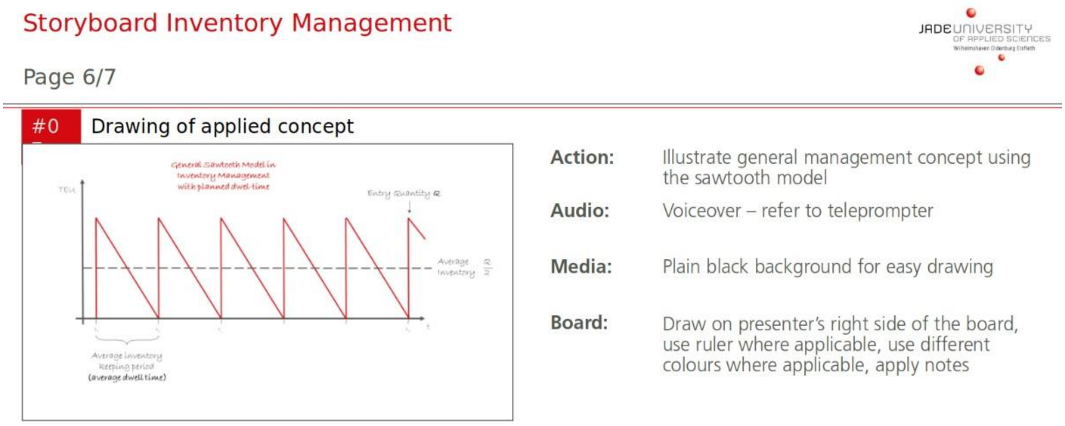


Figure 1. Screenshot of 'Storyboard Inventory Management' for a LTV, source: own picture.

As a next step the video was recorded. It has a length of 4:24 minutes. For illustration purposes one picture of the aforementioned LTV from the MBL learning module is shown in figure 2 below:

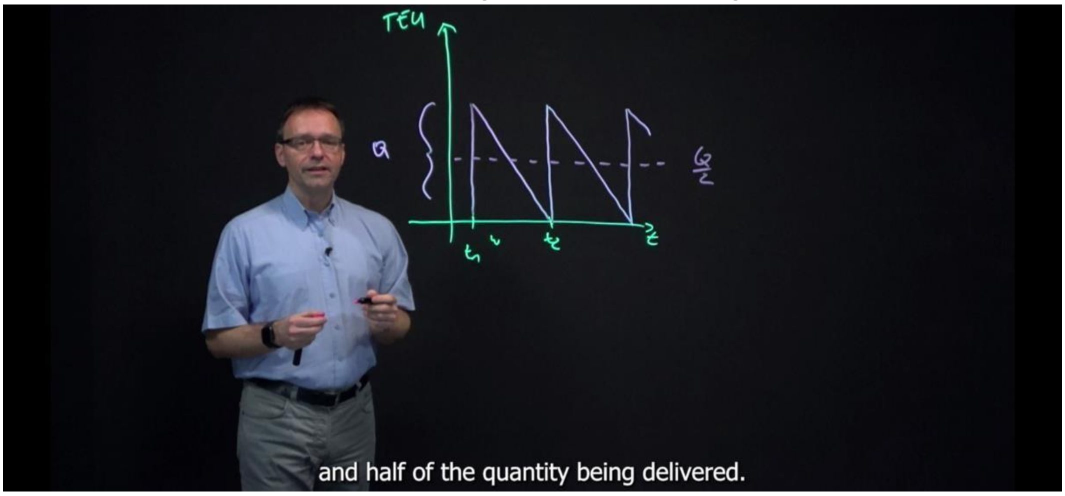


Figure 2. Screenshot of a LTV, source: own picture.

Both pictures show the same sequence in order to illustrate the step from the concept to the video. Moreover, another LTV was recorded which provides an explanation of the bullwhip effect in supply chains, among others.

### *3.5. Discussion*

Digitalisation is an educational trend but this development goes also together with the fact of its high level of acceptance – mainly as an outcome of Covid-19 pandemic (IU 2023). Thus, further advances in technology also lead to new teaching opportunities, which refer to education in general, but especially to MET with its target groups that are difficult to reach at sea. Digitalisation leads to new possibilities for improvement and teaching trends but also to higher demands from a learner's viewpoint. Moreover, technology on-board ships becomes more complex and this constitutes a driver of change (Stopford 2022). From a maritime university's viewpoint, this results in a continuous review process which necessitates adjustments of teaching-learning concepts and content from time to time whenever appropriate.

Based on this, LTV as newly implemented didactic element in the IMM degree course has to be evaluated as a next step. The existing evaluation instrument is currently updated with the aim to collect empirical data that allows not only the evaluation of this measure but also comparative studies to directly assess the impact of LTV on student learning outcomes. It is planned, for example, to compare the learning outcomes, student satisfaction, examination scores and effect sizes using LTV with those collected before (using traditional teaching methods without LTV). In addition, from the learners' as well as teachers' perspectives, it is desirable that the use of the videos results in measurable effects (pre- and post-comparison). Examples (key performance indicators): 1) The MBL learning module contains calculation/numeric tasks in which the content presented is applied. These tasks resemble a formative evaluation instrument and are implemented in the learning management system as self-directed online tests whereby the computer provides instant feedback upon students' submissions. It is desired that the number of test attempts should decrease, which would increase the perceived satisfaction of the learners at the same time. 2) A high number of test attempts goes hand in hand with a high number of queries regarding the calculation of freight rates, use of databases, etc. In line with that, the number of these questions should decrease, too. Reduced numbers of test attempts and queries in turn can be interpreted as an improved teaching-learning environment, didactic approach and presentation of the content.

Graduates today face situations in their (maritime) jobs where they are asked to work in an environment and solve problems in an area of tension that is driven by ecological, economical, technical and administrative factors. Therefore, they need skills for critical thinking and problem solving, communication and collaboration as well as creativity and innovation (Kivunja 2014); for further information on what competencies will be needed by the maritime workforce see IAMU (2019; the IAMU working group is working on an update as per April 2024). This is just one example to underline the importance of lifelong learning and of how education and education demands are changing. In this context, LTV show only one possible approach that can certainly be used in many other learning settings. Even if an example from the field of economics is presented here, the use of LTV in other maritime fields is conceivable, for example, navigation (e.g. collision regulations), technical contexts (e.g. how fuel cells work) or basics in mathematics/physics (e.g. wave function). Regardless of the subject, LTV contribute to AL, interaction between the lecturer and learners as well as an active presentation. Besides, they help to transform the role of lecturers away from being repetitive presenters of the learning content to being moderators (this idea is not new but still an issue). At the same time, AL requires students to change their behaviours and prepare themselves (better) for the lectures and become involved *actively* in the lectures/discussions. This is seen as a key opportunity for developing core competences, higher-order thinking skills as well as intellectual development which go beyond content knowledge.

Besides the discussion of deep processing (see above), this approach shows that LTV can help to promote AL in more ways. It, for example, contributes to the aspect of chunking as one video targets one aspect/topic of the learning module. We see also an association between a concept (here: inventory management and the sawtooth model) and an example (here: container terminal capacity). Furthermore, based on the presentation of the content by means of the video (approach of dual coding by its definition), students are asked in the learning module to apply the concept introduced by carrying out a calculation (deliberate practice) immediately thereafter. Thus, interaction with students is achieved as the explanation is supplemented by a task.

The use of LTV may not only be used for teaching and learning as shown so far. It could, for example, also be used as a mode of examination by asking students to record videos. This seems promising as it strengthens active modes of teaching, learning and assessment and especially puts learners in the foreground. This enables the implementation of examination situations which face students with situations during examination which are far closer to reality as traditional written examinations do, for example.

## 4. Summary, Conclusion and Outlook

The article analyses the possibility of using lightboard teaching videos in maritime education and training with a focus on distance education. The discussion starts with a brief literature review before it provides the trigger for change, what measures have been taken and how the approach chosen has been implemented.

In this case, students' feedback constitutes triggers for change. A strategy for a demand-oriented further development of the IMM distance degree course was initiated and its implementation is carried out with a sense of proportion that continues to meet the requirements of the target group, namely nautical officers as part-time learners. The newly implemented LTV constitute a teaching method which aims to provide a better presentation of learning content, but also improves learning processes, interaction between lecturer and learners and examination arrangements. As a next step, empirical data will be collected in order to increase research depth, reflect and validate the concept, the effectiveness of the approach, namely the introduction of LTV, thereby enhancing the persuasiveness and reliability of the research. Besides, such evaluation allows to compare the concrete results that were achieved after the introduction of LTV with these before. Feedback could also lead to a more comprehensive understanding of the application effects and therefore further improve the use of LTV.

Even if the approach is promising from a didactic point of view and can improve AL, on the other hand, various aspects have to be taken into account when introducing LTV. In addition to ‘typical’ barriers, for example, resistance to change and lack of resources, other conditions also must be met, such as the procurement and provision of the technology or the enthusiasm of the teachers involved.

The LTV and experiences gained here serve as an example of good practice which should be transferred to other modules, degree courses and universities. Therewith, the concept constitutes a blueprint for further projects in MET across the IAMU community which also has the potential to strengthen collaboration between different universities. Recorded videos can also be uploaded to video platforms. Therewith, lecturers and their videos respectively can contribute to the general concepts of Open Educational Resources, Open Science and Creative Commons licences in order to share knowledge and contribute to worldwide education. This discussion gains in importance in general but might be relevant for the maritime domain in particular, for example, in terms of international conventions, worldwide uniform standards or the Global Maritime Professional Initiative.

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Stopford M (2022) Maritime governance: piloting maritime transport through the stormy seas of climate change. Marit Econ Logist 24:686-698. https://doi.org/10.1057/s41278-022-00227-9

# Reviewing Gender Related Experiences in Maritime Education in some of the Black Sea Neighbourhood Countries (Georgia, Turkey, Bulgaria and Ukraine)

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**Abstract:** This article discusses the maritime industry, which traditionally has been characterized by imbalances in gender-related experiences, resulting in women's underrepresentation in the field. The study aims to review gender-related experiences of maritime education in several of the Black Sea Neighbourhood Countries (Georgia, Turkey, Bulgaria and Ukraine). By reviewing gender-related experiences in these countries, the study provides existing views on the status quo of gender equality and inclusivity in the areas of maritime education.

The method of study is based on secondary data obtained from the partner maritime universities in the above-listed countries. The literature around the topic has been reviewed, and primary data has been collected via an online survey with qualitative and quantitative information from partner institutions; in particular purposive sampling method was applied by selecting representatives from partner universities in the Black Sea region to share their experiences in the gender-related issues in maritime education. The primary data was analysed to draw assumptions on the existing trends and changes in gender-related experiences through the women empowerment regional campaign. The study was based on reviewing various dimensions, in particular female and male alumni enrolment rates, career opportunities, and gender-related experiences in the maritime field.

In this article, we identify the key factors resulting in gender imbalances, as well as social factors, cultural perceptions, and institutional practices. We have explored the effect of the “women empowerment” regional campaign at the partner universities.

In the conclusion of the article, we underscore the importance of raising awareness about gender-related experiences within the scope of educational institutions and offering new insights to industry stakeholders and policymakers. Thus, the study fostered diversity and equity in maritime education in some of the Black Sea neighbourhood countries.

***Keywords***: *Gender-related experiences; Inclusivity; Maritime education.*

## Introduction

The maritime industry conventionally has been characterized by imbalances in gender-related experiences, which results in women's underrepresentation in the field. The status of female representation in the maritime sector has different causes starting from historical background, traditions and their physical readiness to success in the maritime sector due its masculine stereotype as ascribed from ancient times. Traditionally, women have served a submissive role in society which prevented them from pursuing their career goals and landing dream jobs. Women generally were not considered to be equal to men in many cultures due to religious reasons, cultural experiences and strictly defined roles in the family which forced them to divert from career goals and reject the opportunities offered by the maritime industry (Grimett, 2024)). In the 21st century these practices may no longer be followed and are deemed to be archaic according to Grimett, who also cites United Nations Sustainable Development Goal

5 which calls to, "achieve gender equality and empower all women and girls." Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world. There has been progress over the last decades, but the world is not on track to achieve gender equality by 2030 (United Nations, 2022). As we see from the report and existing practice faced globally and locally there is less chance of achieving Goal 5 despite significant efforts and educational campaigns run to achieve women empowerment in maritime education and training.

With this purpose, we have decided to initiate a study to review gender-related experiences within Black Sea Neighbourhood Countries (Georgia, Turkey, Bulgaria and Ukraine), which share common cultural and historical heritage in the context of engaging women in maritime education and industry. The study intends to obtain existing views on the status quo of the gender equality and inclusivity of women in maritime education through obtaining data from Higher Educational Institutions from Black Sea Neighbourhood countries via filling a mixed online survey. The study was based on reviewing various dimensions, particularly female and male alumni enrolment rates, career opportunities, and gender-related experiences in the maritime field. Through analysing the obtained data and identifying key factors resulting in gender imbalances, as well as social factors, cultural perceptions, and institutional practices, we have explored the consequences of the women empowerment regional campaign BSMA (Batumi State Maritime Academy) partner universities and have defined the necessity for further fostering diversity and equity in maritime education in some of the Black Sea neighbourhood countries.

**Literature Review Gender Stereotypes**

Gender stereotypes and cultural attitudes have historically hampered women from fulfilling tasks or taking positions that were considered traditionally masculine in both the formal and informal maritime subsectors. This has led to the establishment of a culture where discrimination against women is accepted. A result of the historical and cultural barriers in the maritime sector has been that many women do not consider the maritime environment to be an attractive field of employment (Institute for Security Studies, 2020).

Several gender-related discriminatory issues were found in the shipping industry during the International Labour Organization's review of the sector. Among these were instances in which female candidates with the necessary qualifications were turned down in favour of male candidates. These are some of the additional barriers facing women who attempt to start a career in seafaring (UNCTAD, 2019) (Pike, 2021). Discrimination, legal obstacles, and workplace harassment were identified as some of these barriers.

Protection of women's rights has been advocated internationally from the mid 1900's. Since the mid1900s, there have been many international charters, action plans and conventions adopted to improve the status of women globally. The United Charter 1945, the Universal Declaration of Human Rights 1948, World Population Plan of Action (WPPA) adopted at the 1974 World Population Conference on Population (Bucharest), International Conference on Women 1975, 1980, 1985, International Women Year 1975, the Decade for Women, Convention on the Elimination of All forms of Discrimination Against Women (CEDAW) (United Nations, 1995) were all introduced to highlight the plight of women and address the issue of gender inequality.

While policies advocating for women, gender equality and women empowerment have been developed and implemented, they have not been as effective as anticipated. Women still face challenges of unequal access to employment and education, high levels of violence against women and underrepresentation in decision making roles (Hannan, 2008).

According to the World Bank Statistics of 2021 women account for only 2% of the world's 1.2 million seafarers and 94% of female seafarers work in the cruise industry (The World Bank, 2021). The maritime transportation industry has a huge potential for women's empowerment. Women make up only 2% of workers in the global maritime transport industry, according to the International Transport and Workers' Federation. These few women also hold only 7% of management positions and make an average salary that is 45% less than that of men. Thankfully, data shows that more and more women are working in the shipping sector across all functions, including seafaring, operations, chartering, insurance, and law. More women are also enrolling in maritime-related studies, which will be critical in ensuring that women will have the technical expertise to enter this workforce (United Nations Conference on Trade and Development. 2018. Review of Maritime Transport 2018. Geneva: UNCTAD).

There is ample evidence showing that the best way to improve communities, businesses, and even entire nations is to invest in women. Economic growth is higher in nations with higher levels of gender equality. Businesses with more female executives do better overall and women-led peace accords have a longer lifespan. More women in parliaments mean more laws on important social issues like child support, education, health, and anti-discrimination. The evidence is clear: parity for women means progress for all (IMO, 2021).

**Women in the Maritime Education**

Historically, the maritime industry has been and continues to be dominated by males. In the recent past, it was commonly assumed that professional occupations in the maritime sector were exclusively occupied by men with job titles such as "helmsman", "seaman" and "fisherman". Until the 1900s, women were not always encouraged to engage in seafaring jobs and activities due to cultural beliefs and gender stereotypes. In some cultures, the presence of a woman on board a ship was sometimes seen as a bad omen (Institute for Security Studies, 2020); (Grimett. 2024).

The proportion of women entering the maritime industry through maritime training academies remains low. The International Chamber of Shipping reports that in 2015, women represented 6.9% of global officer trainees Furthermore, the numbers do not improve over time, with fewer women remaining in the industry long enough to obtain management-level licenses (Grimett, L. 2024).

The limited number of female students enrolled in Marine Engineering and Maritime Navigation studies, coupled with the lack of gender policies in most MET institutions, is becoming an increasing cause for concern in the maritime education sector. The gender imbalance in higher education is a significant issue that requires attention. The ratio of male to female students is starkly disproportionate, with a clear majority of male students. This presents a challenge in understanding the current situation and developing effective solutions to address the imbalance and eliminate gender bias.

Numerous initiatives have been undertaken at both the institutional and international levels with the objective of increasing the participation of female students in higher education. At the international level, the IMO's program on the Integration of Women in the Maritime Sector (IWMS) is the primary initiative with the objective of "to encourage IMO Member States to open the doors of their maritime institutes to enable women to train alongside men and so acquire the high-level of competence that the maritime industry demands" (IMO 1989).

In 1988, IMO launched its Women in Maritime gender program, under the slogan: "Training VisibilityRecognition". This program enhances the contribution of women as key maritime stakeholders and supports their participation in both shore-based and sea-going posts (IMO 1988).

During that period, a limited number of maritime training institutions admitted female students. In order to include a gender perspective in IMO policies and procedures, an institutional framework has been established with the assistance of the organization's gender and capacity-building program. This has facilitated women's employment prospects and access to maritime training in the maritime industry (IMO, 2021).

Some policies for gender equity have already borne fruit, we are still far from the intended equity expectations. According to the BIMCO/ICS 2021 Seafarer Workforce Report, women currently make up just 1.2% of the world's seafaring workforce. With 24,059 women estimated in the report to be serving as seafarers - a 45.8% increase, this indicates a positive trend in gender balance.

At national level public authorities must take measures to increase the percentage of women in sectors or professions in which they are currently underrepresented. Furthermore, they shall promote greater professional diversification of women in the labour market. They shall adopt the necessary measures to facilitate not only the incorporation of women in sectors of the economy that are traditionally masculinised, but also that of men in traditionally feminized sectors. In addition, they shall ensure that the feminized sectors are revalued socially and have the same recognition and the same working conditions as the others. These regulations and guidelines are also extended to the educational sector (Claudia, 2020).

There are currently only two female seafarers in Georgia, with a third soon to commence her training. Six young women were trained for employment on cruise ships as was agreed according to the Memorandum of Understanding between UN Women and the Maritime Transport Agency, 2019. However, there are already women employed at the Maritime Agency whose professionalism and tireless work is unlocking the potential that the sea can bring to the country. It is necessary to educate and raise awareness of not only stereotypes but also the potential of the maritime field, with a particular focus on school-age girls considering their career options (UN Women, 2021).

To achieve this goal, it is necessary to take coordinated action. For example, Georgia works closely with universities, schools, NGOs and international organizations. In addition, the maritime authorities established the Women's International Shipping and Trading Association - Georgia in 2016 and co-authored a document of the International Maritime Organization's Gender Equality Network. Since 2018, in partnership with UN Women, the country has initiated several promising initiatives, including a gender audit and the development of an action plan based on the results. It has also initiated the introduction of tools to combat sexual harassment and the training of girls and women in maritime professions. The Maritime Transport Strategy document, currently being developed for the first time in Georgia, will also include support for strengthening the role of women in the maritime sector. This will mainstream the process into the system, which will undoubtedly promote women’s participation (UN Women, 2021).

**Maritime Education in Georgia**

The history of Maritime Education in Georgia is something we are proud of. Maritime education and training in Georgia dates to the 1920s and starts with opening of evening courses for seafarers in Batumi. In 1929 based on evening courses Maritime Industrial Technical Secondary School was founded. On March 5th 1944 Maritime Industrial Technical Secondary School was reorganized into Batumi Maritime College and later in 1994 by decision of the Georgian Government the College was reorganized into Batumi State Maritime Academy.

Historically Georgian women in maritime contexts were involved in family-run fishing and trading enterprises along the Black Sea coast and their roles were crucial in supporting local maritime activities. It is not surprising that there was a gender imbalance/inequality concerning the maritime sector in Georgia like in other countries in the past. Since ancient times, Georgian people have been respecting the value of old traditions, customs, and culture, where the men were seen as superiors and were placed in a dominant position in all areas of economic, social and political life. The traditional belief that women’s roles were tightly intertwined with expectations around motherhood and domestic responsibilities, largely expected to obey their husbands, the existence of gender gap and well-established stereotype in society that the Maritime industry was accepted as a male dominated environment and the maritime industry was a job for men only. This stereotype was broken down for the first time by four women graduated from Batumi Maritime College in 1940, the first female sailors (Nina Kalandadze, Vaide Gvarishvili, Shushana Tumanishvili, Iulia Pailodze) in the history of Georgian maritime education. There was the need for education and training to encourage females into the maritime sector and change the human perceptions that only males ought to pursue careers in the maritime industry, with the provision of knowledge maritime education also involved the change in attitude (Bezhanovi, 2021).

In 1936, four Georgian women were enrolled on navigation speciality program at Batumi Maritime College which they graduated with honours. After graduating from college Nina Kalandadze and Iulia Pailodze were employed in the Far East shipyard, Vaide Gvarishvili and Shushana Tumanishvili on board a ship in the Caspian Sea. Their involvement in maritime sector contributed to the social changes and promotion of gender equality in maritime education and the greater push to the gender equality in maritime professional fields at that time in Georgia. The first Georgian female sailors demonstrated that gender did not dictate one’s ability to perform effectively in the maritime sector and these jobs required skills, intelligence, resilience and expertise rather than gender. Overall, the first Georgian female sailors serve as a role models, inspiring future generations of women in Georgia to pursue careers in the maritime industry (Bezhanovi, 2021).

Nowadays, support for women in Georgia’s maritime sector is growing, in order to promote gender equality and encourage women in the maritime sector to increase access to relevant education, the Maritime Transport Agency has also started cooperating with maritime schools. It is planned to allocate quotas for female students at Batumi State Maritime Academy, particularly at its faculties of navigation and engineering, as well as to finance tuition fees and establish other scholarships to encourage more female representation in the maritime education and training.

**Method of Study**

The method of study was based on secondary data obtained from the partner maritime universities in the above-listed countries. The literature around the topic was reviewed, and primary data was collected via an online mixed survey with qualitative and quantitative information from partner institutions; purposive sampling method was applied by selecting representatives from partner universities in the Black Sea region to share their experiences in the Gender-related issues in maritime education. Application of the above-mentioned sampling method, which is also referred to as selective or judgemental sampling was pre-conditioned due to the intention of targeting partner University representatives from Turkey, Bulgaria, Georgia and Ukraine who have expertise in relation to gender-related issues. It is noteworthy that the latter have expressed readiness to share official statistics on the close-ended questions and provide valuable contributions on open-ended questions. Therefore, the purposive sampling method significantly contributed to obtaining comprehensive insights and justified opinion on the topic through reaching relevant representatives from targeted Institutions.

The survey was filled by the representatives of the following nine HEIs in target countries which are leading centres in the maritime education and training in the field of tertiary education:

- Georgia - Batumi State Maritime Academy; Batumi Navigation Teaching University.
- Turkiye - Maritime Faculties of Karadeniz Technical University; Istanbul Technical University; Yildiz
- Technical University; Dokuz Eylul University; Bandırma Onyedi Eylül University.
- Bulgaria - Nikola Vaptsarov Naval Academy.
- Ukraine - Kherson State Maritime Academy.

The survey comprised of 7 close and 5 open-ended questions, which was shared online via the following link: CLICK HERE.

The quantitative part of the survey was used to gather the data on approximate ratio of Female and Male student ENROLMENT rates in the last 5 years, approximate ratio of Female and Male GRADUATES employment rates in the last 5 years; main Female Career Opportunities in MARITIME INDUSTRIES in your region; assessment of Women Empowering Campaign at corresponding institution; whereas qualitative part of the survey enabled us to the situation changed in related to Gender related experiences in target regions; obtained data about ORGANIZATIONAL strategies or initiatives that have been implemented to encourage more women to pursue maritime education and careers over the past five years as well as he GOVERNMENT policy and strategies for encouraging more women inclusion in maritime education and careers over the past five years; It also asked for future expectations of corresponding institutions concerning the overall changes in target countries about gender equality in the maritime industry. Generally, all partner HEIs have maritime navigation and engineering educational programs, but they also run maritime field related programs, thus the statistics on enrolled students are applicable for the whole university.

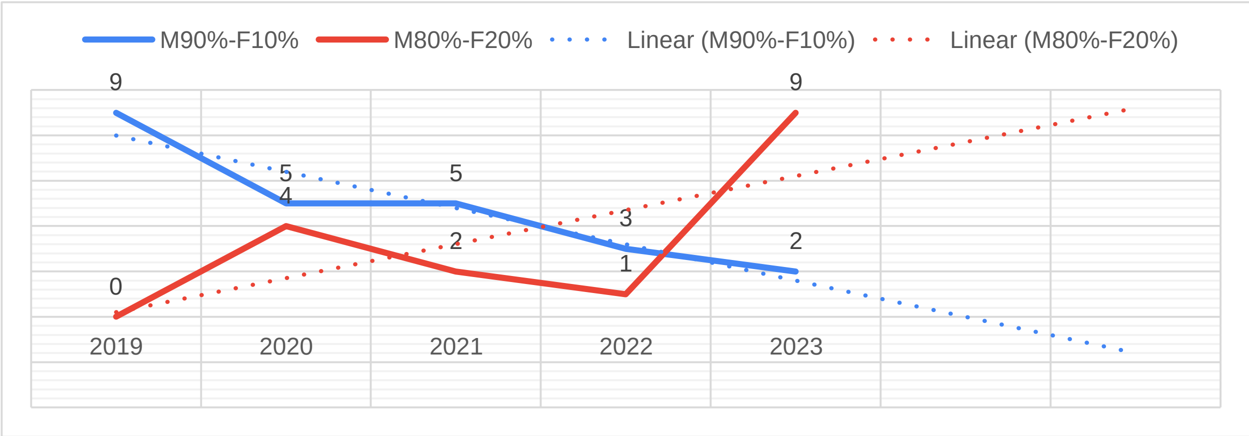
All partner institutions promptly responded to the surveying and in total 9 replies were received on the abovementioned mixed type of survey, which was valuable content for analysis, drawing assumptions and conclusions and finally developing recommendations and implications to be taken into consideration locally and in Black Sea neighbourhood countries.

**Discussion of Results**

Generally, all partner institutions believe that they provide equal opportunities for both genders in terms of admission to maritime education. Out of nine HEIs, 44.4% of them believe that they provide “excellent” opportunities for both genders. Another 44.4% think that their institution is in the range “above satisfactory” and 1 institution thinks it is “Average”.

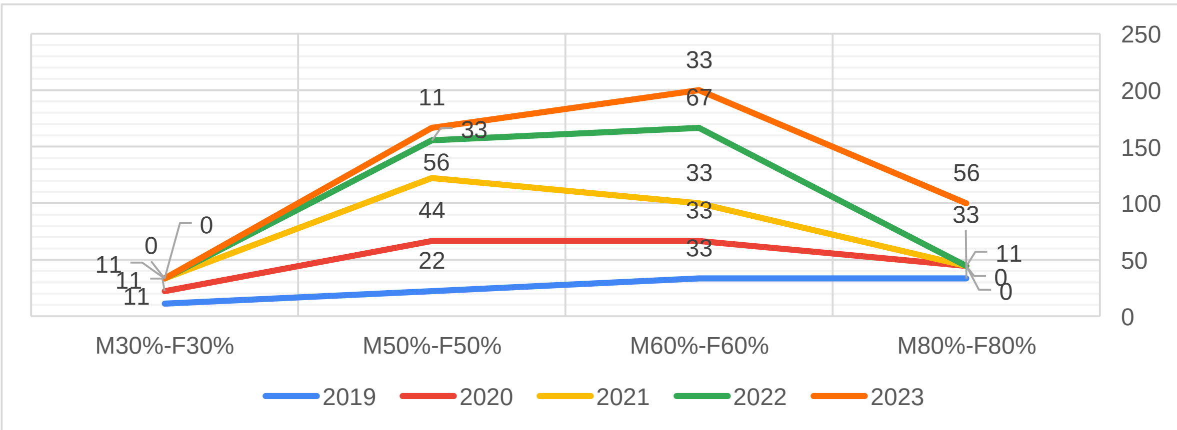
In chart N1, estimates of female (F) student enrolment as a percentage of total enrolment with male (M) students for the past five years (2019-2023) are provided. The chart specifies a major overview of gender equality in enrolment at nine maritime higher education institutions (HEIs). The obtained data clearly shows that mostly male students dominate in most institutions and represent (M90% - F10%) but in 2023 the proportion has been slightly changed (M80% - F20%). The linear forecast demonstrates a positive trend and opportunity to increase the enrolment of women in some universities compared to previous years.

**Chart N1. An approximate ratio of Female and Male student ENROLMENT rates in the last 5 years (%)**




*Source: The results of the primary source are processed by the authors. Batumi 2024*

**Chart N2. An approximate ratio of Female and Male GRADUATES employment rates in the last 5 years (%)**

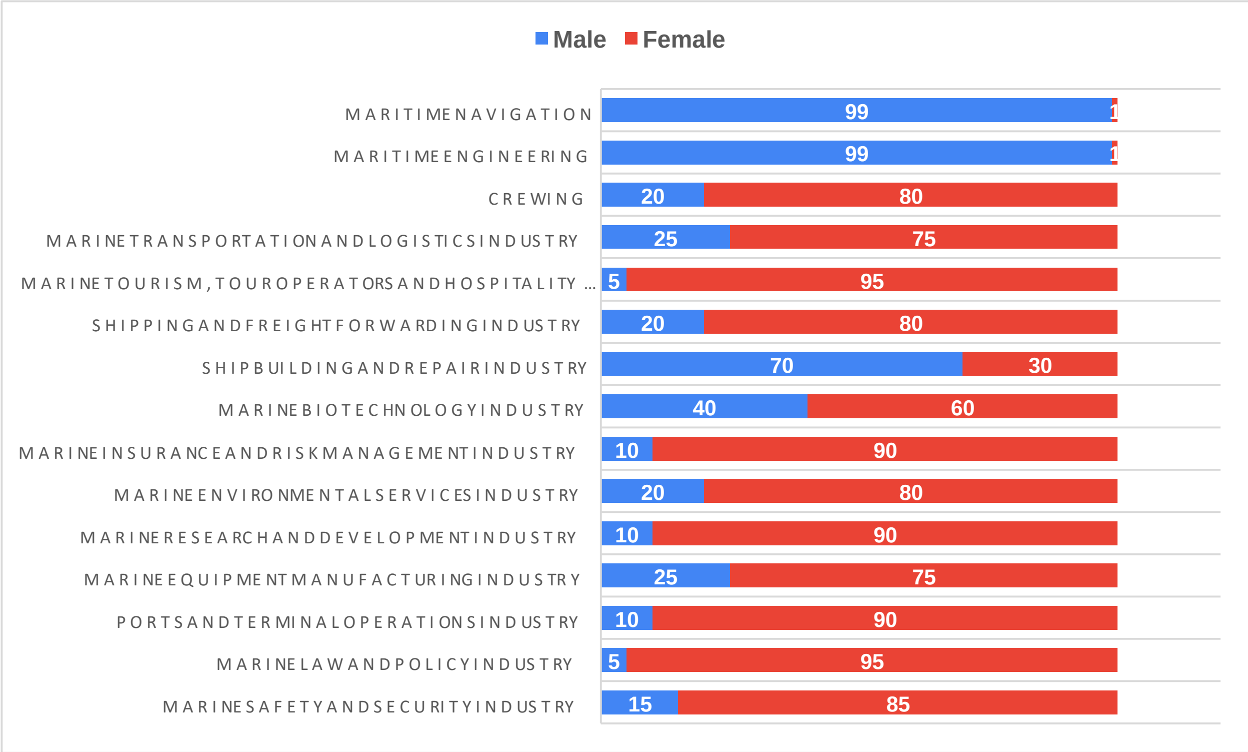



*Source: The results of the primary source are processed by the authors. Batumi 2024*

Chart N2 shows the graduation percentage of students in the last 5 years. For better view we took the highest point for 9 universities, as 100%. The chart presents the flow of students by year. That is, in chart N1, we asked how many students were enrolled in 2019, but in the chart N2, graduate refers to students enrolled before 2019.

In 2019, 66% of universities had graduates in the range of 50-80%. In 2020-21-22, on average 4 out of 9 universities have 50-60% graduation rates, this low rate is mainly due to the pandemic period, as half of the students were unable to study online and suspended status. And in 2023, after the post-pandemic period, the situation is better, and 56% of universities have graduates in the 80% range.

**Chart N3. The main Career Opportunities in MARITIME INDUSTRIES by GENDER in Black Sea region (%)**

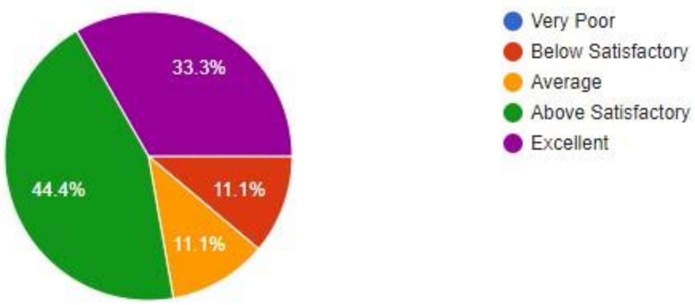



*Source: The results of the primary source are processed by the authors. Batumi 2024*

In chart N3, we have determined the ratio of main career opportunities in maritime industries by gender in black sea region.

The answers of the representatives of the universities were distributed as follows: male graduates is mainly employed in marine navigation, marine engineering, shipbuilding and partly in biotechnological direction, 70-99%. And 60-80% of female representatives are employed in the maritime industry: crewing, maritime transport and logistics, maritime tourism, insurance, environmental protection, research, ports and terminals, maritime law and maritime safety and security.

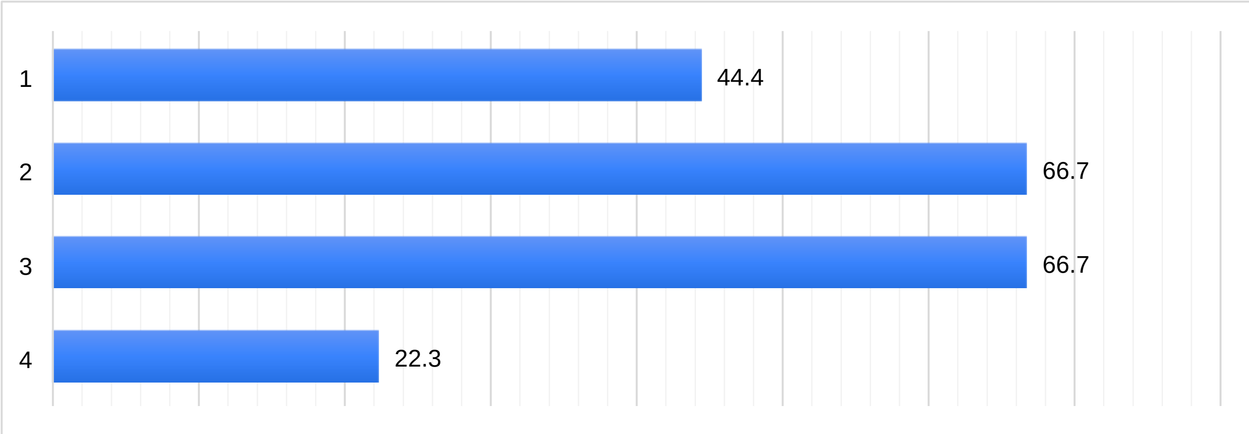
**Chart N4. Women Empowering Campaign rate at your institution**




On the question of how universities evaluate the Women Empowering Campaign at your institution, the answers were distributed as follows: 33% Women as an Empowering Campaign was implemented Excellent and result female enrolment increased in 2022-23, 44.4% think Above Satisfactory, 1111%, each university Below Satisfactory and Very Poor. We are also interested in if there have been any updates or revisions to the curriculum to incorporate topics related to gender equality, diversity, and inclusion in maritime education over the past five years. Only two universities completely updated and revised the curriculum related to gender equality, diversity. Partially updated 5 (55.6%) universities and did not update 2 universities.

We tried to study if any of the universities have introduced any support services or resources to address instances of discrimination, sexual harassment or gender-related issues among students or faculty members over the past five years. Some of the universities have established a special unit (department) which is responsible for such issues, to resolve these issues, a psychological service operates at the academy. They are guided by the documents and policies of the Ministry of Education in the field of these problems. Also, some HEIs have informational meeting implementation and a scholarship program for women cadets in coordination with several maritime companies. One institution mentioned that they had sexual harassment or gender-related issues, but the university promptly fixed it.

**Chart N5. CULTURAL or TRADITIONAL barriers and challenges affect gender roles for the recruitment, retention, and promotion of females in the maritime industry (%)**




*Source: The results of the primary source are processed by the authors. Batumi 2024*

In the chart N5 the results were distributed as follows:

1. Cultural norms discourage females from pursuing maritime careers, leading to limited recruitment, retention, and promotion opportunities 44.4%.
2. Traditional beliefs about gender roles perpetuate stereotypes, making it difficult for females to advance in the maritime industry 66.7%.
3. Societal expectations prioritize male-dominated professions, hindering female participation and career progression in maritime fields 66.7%.
4. Lack of support from family and peers reinforces traditional gender roles, creating barriers for females entering or advancing in the maritime sector 22.3%.

The partner organizational strategies or initiatives they have implemented to encourage more women to maritime education and careers opportunities are: organizations are implementing strategies to promote gender equality in maritime education and careers. These include promoting sustainable gender equality through scholarships for women cadets, increasing awareness of gender equality issues, and maintaining changes in behaviour and attitudes. Mentorship programs are also being established, pairing experienced female professionals with aspiring women in the field. Scholarship programs are being created and connected with international fleets. Work is being done to increase awareness of gender equality issues, maintain changes in behaviour and attitudes, strengthen organizational capabilities, and promote gender-responsive culture. Participants are provided with skills to integrate gender equality issues into educational programs, and the promotion of gender equality is popularized in the Ukrainian maritime sector and the world. Women seafarers are preferred in many maritime companies.

To the next question “generally how has the situation changed in relation to gender related experiences in your region”, 78% of HEI’s responded that in the last 5 years it has “slightly improved” and 22% “significantly improved”.

All the partner universities have future expectations in the maritime sector, operation of autonomous surface vessels shall significantly improve gender issues, the more women are working day by day and increasing the empowering ratio. Some institutions expect to see continued progress in promoting gender equality in the maritime industry within their country. This includes increased participation of women in maritime education and careers, improved representation of women in leadership roles within maritime organizations, and the establishment of supportive policies and initiatives by both public and private sectors to foster an inclusive and diverse maritime workforce. They anticipate that these efforts will contribute to a more equitable and thriving maritime industry in the future.

Most of the universities believe there are no serious obstacles to the implementation of gender rights in the Black Sea region. Women, like men, have the right to take part in all economic sectors, but at the same time, women are more inclined to traditional fields of activity, since in our countries traditionally a woman is, first, a mother and a wife. At the same time, radical changes in gender stereotypes have been observed over the past 10 years; military operations on the territory of Ukraine (especially after a full-scale Russian invasion) became a kind of impetus. Women are intensively joining all military structures, and the types of employment in the sphere of "peaceful" economic activity are also changing. They believe that this will help increase the number of women in the maritime industry.

The data reveal a significant gender imbalance in enrolment at maritime universities, which are still largely dominated by male students, but in recent years there has been an increase in women's interest and representation potential. We believe the role of women in the maritime field should be developed and promoted through gender policies and practices within regional organisations. Continuously monitor and assess the progress towards achieving gender parity and make necessary adjustments to strategies and actions.

(The above-provided discussion is a concise analysis of the results, due to the length of the paper, more comprehensive information could not be given. For detailed information visit link - **CLICK HERE**).

## Conclusion

At institutional level, namely, considering all the findings of the study we can observe a positive shift towards female representation in maritime education and logic in the maritime industry. The data indicates a slight increase in female student enrolment at degree level, with a stabilization of the falling tendency at master and doctoral level. These results are not encouraging and demand further work on gender equality to be carried out.

To boost the proportion of women in fields or occupations where they are currently underrepresented, governmental authorities at the national level must take action. Additionally, they should encourage women in the workforce to be more diverse in their professional backgrounds. They should implement the required policies to support men's entry into traditionally feminized fields of the economy as well as women's integration into traditionally masculinized sectors. They should also make sure that the feminized sectors have the same recognition and working conditions as other sectors and are given a social worth equivalent to that of the others. The field of education is likewise covered by these rules and laws.

By exposing stereotypes and elevating good role models, educational initiatives can increase public understanding of the contributions and skills of women working in the marine industry.

Increasing gender diversity in the marine industry may be achieved via implementing focused recruiting methods that actively encourage women to seek professions in the field. In addition, by fostering inclusive and encouraging settings for women in jobs that have historically been held by males, support networks and mentorship programs can increase retention rates.

In order to promote gender parity through legislation and regulation, governments and maritime organizations/institutions are essential. Setting goals for gender diversity and putting into practice laws that guarantee fairness and equal opportunity for all people, regardless of gender, can lead to significant change in the sector.

Promoting gender balance in the marine industry requires cooperation amongst industry players, including maritime unions, employers, and educational institutions. The industry can provide more equal opportunities for everyone by collaborating to identify and resolve inclusion impediments.

All parties involved must work together to change outdated perceptions about women at sea and advance gender parity in the maritime sector. The sector can unleash the potential of its workforce and promote sustainable development and innovation by addressing underlying prejudices, putting supporting regulations in place, and cultivating an inclusive culture.

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# The Use of Artificial Intelligence Applications in Maritime Education and Training

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**Abstract:** The use of Artificial Intelligence (AI) applications, which are continuing their development, is gradually increasing in areas such as economics, finance, medicine, and education. While some consider the use of artificial intelligence by both teaching staff and students beneficial, some have the opposite view. Although it is thought that artificial intelligence is a very efficient tool for scientific research, those who hold the opposite view say that it prevents students from developing their critical thinking abilities. It is also a fact that the opportunities offered by AI will increase even more soon, and its harmful aspects will be eliminated while the opportunities it provides increase.

The maritime profession has to follow the constantly developing technology and, accordingly, Maritime Education and Training (MET) has to follow this pattern. The MET has to benefit from AI in terms of both improving education and training as well as contributing to scientific research.

This research aims to investigate how to use AI applications to develop MET by considering AI applications in other professions and providing suggestions on what to do about this.

The study starts by examining AI applications in different business areas and continues by evaluating how to apply them to the MET under the current and future needs of the MET. The study covers the needs of both teachers and students concerning this.

At the end of this study, the author presents recommendations on how to use AI for MET programmers, lecturers, and learners.

*Keywords*: Artificial Intelligence (AI); Maritime Education and Training (MET); Education Technologies; Adopting New Technologies

## 1. Introduction

Artificial Intelligence (AI) applications, which are continuing their development, are gradually increasing in areas such as economics, finance, medicine, and education. While some researchers consider the use of artificial intelligence by both lecturers and students beneficial, some have the opposite view. While it is accepted that the use of artificial intelligence is a very efficient tool for scientific research, those who hold the opposite view say that it prevents students from developing their critical thinking abilities. It is also a fact that the opportunities offered by AI will increase even more soon, and its harmful aspects will be eliminated while the opportunities it provides increase. The maritime profession has to follow the constantly developing technology and, accordingly, Maritime Education and Training (MET) has to follow this pattern also. The MET has to benefit from AI in terms of both improving education and training and contributing to scientific research.

AI is a broad field now encompassing areas such as robotics, natural language processing, vision and sensory systems, expert systems, and decision aids. Generally, AI refers to the ability of a machine to learn from experience, adjust to new inputs, and perform human-like tasks. There is no commonly accepted definition of AI because the definition has changed as this technology has evolved. Business interest in AI has been increasing (Yapo & Weiss, 2018).

Organizational interest in artificial intelligence (AI) projects has steadily grown in recent years. Just 14% of organizations had deployed AI in 2019; however, that number rose to 19% in 2020 and is expected to reach 24% in 2021, according to Gartner research AI can encounter unpredictable or unexpected occurrences in the data, and correspondingly generate unpredictable or unexpected results, including biased output, because of the complex nature of AI solutions. Bias in AI systems can “affect the brand value of the organization” (Sau, 2021). Thus, a consideration of bias as well as unpredictable or unexpected results in AI is essential. Machine learning-based systems currently in use may encounter vastly different data, reflecting the changed circumstances of life imposed by the coronavirus lockdowns (Heaven, 2020).

Repurposed AI may be susceptible to producing unpredictable, unexpected, or biased results as the model was initially trained for the original purpose. Repurposed AI is not new but may offer promise in an environment requiring rapid responses to find quick solutions. (Sreeharsha, 2020). AI uses vast quantities of historical data, with known outcomes, to discern patterns in that data and make predictions. The accuracy of those predictions depends upon the quality of the data set used to train the model, the quality of the data set used to produce the prediction, the design of the algorithm, and the performance of the system using real-world data (Silverman, 2020). Nonetheless, 96 percent accuracy “is suspiciously high for any machine learning problem” and realworld deployment nearly always degrades system performance (Engler, 2020). With the potential for unpredictable, unexpected, and biased results in an environment within which development and deployment are hastened by necessity, future research to increase this understanding becomes critical (Duan, Edwards, & Dwivedi, 2019).

In April 2021, the European Commission proposed the first EU regulatory framework for AI. The commission stated that AI systems used in different applications are analyzed and classified according to the risks they pose to users. The different risk levels will mean more or less regulation (Topics European Council, 2020). As part of its digital strategy, the EU wants to regulate artificial intelligence (AI) to ensure better conditions for the development and use of this innovative technology. AI can create many benefits, such as better healthcare; safer and cleaner transport; more efficient manufacturing; and cheaper and more sustainable energy. Anneke et al (2021) published an article on “Implications of the use of artificial intelligence in public governance”. They call for the development of solid, multidisciplinary, theoretical foundations for the use of AI for public governance, as well as investigations of effective implementation, engagement, and communication plans for government strategies on AI use in the public sector. Bermejo et al (2019) stated that value can be created in multiple government functional areas, such as decision support, transportation, public health, and law enforcement (Sousa et al, 2019). Compared to the private sector, there is less knowledge concerning AI challenges specifically associated with the public sector (Aoki, 2020).

In ship management, it is important to use data collection in many resources and use of this data for quick decision-making. Automation and remote control systems are becoming widespread on ships. Remote monitoring on board ships involves the use of advanced technology and communication systems to continuously track and collect data from various shipboard systems and equipment, which can be transmitted to onshore locations for real-time analysis. This practice enhances the safety, efficiency, and performance of vessels and is an integral part of the maritime industry's digital transformation. Here are some key aspects of remote monitoring on ship.

## 2. Method

The maritime profession has to follow the constantly developing technology and, accordingly, MET has also to follow this pattern. The MET has to benefit from AI in terms of both improving education quality and contributing to scientific research.

This research aims to investigate how AI applications can be used for the development of MET by considering AI applications in other professions and providing suggestions on what should be done in this regard.

The study starts by examining AI applications in different business areas and will continue by evaluating how they can be applied to the MET under the current and future needs of the MET. The needs of both teachers and students. Meta-synthesis used to explore the literature on a particular AI topic and synthesize the literature to inform future research. In this study, the literature related to the use of AI in other fields was reviewed and the findings of different researchers were discussed and their applicability to the MET was evaluated.

## 3. Research

### *3.1. Artificial Intelligence*

Artificial Intelligence, computers, and anthropomorphic ability to think and make decisions enable technologies. Artificial Intelligence works using a combination of data mining, modelling, and machinery learning techniques. Artificial Intelligence technology, humans imitate neurons in your brain carry out transactions, and decide.

AI is based on three essential applications: Big Data, Machine Learning, and Deep Learning.

- Big Data: Much of big data's true value is only able to be realized using AI techniques. Big data offers AI an immense and rich source of input data to develop and learn through. In this sense, AI and big data strongly intertwine.

- Machine learning: Machine learning is a computer science technique that allows computers to 'learn' on their own. It is often taken as AI, but that is only one element of it. The characteristic that separates machine learning from other forms of AI is its dynamic ability to modify itself when exposed to more data.

- Deep learning: Deep learning is a subset of machine learning, most commonly used to refer to deep neural networks. In generalist terms, a neural network processes data through a layered approach, where each successive layer takes its input from the output of the layer before it.

Currently, AI is again on the frontier in the form of (self-) learning systems emerging in robot applications, intelligent centers, intelligent data analytics, etc.

The introduction of Artificial Intelligence (AI) in research studies has ushered in a new era of possibilities, transforming the way researchers approach data analysis, experimentation, and problem-solving across diverse fields. AI, a branch of computer science that simulates intelligent behavior, has proven to be a powerful ally in addressing the complexities and challenges inherent in research. AI empowers researchers to sift through vast amounts of data rapidly and accurately, uncovering patterns and insights that may be challenging to discern manually. This efficiency is particularly crucial in fields where datasets are extensive, such as genomics, astronomy, and climate science. AI excels at recognizing complex patterns in datasets thanks to machine learning algorithms. Researchers can utilize these capabilities to predict outcomes, anticipate trends, and make informed decisions based on historical data. AI technologies automate routine and repetitive tasks, allowing researchers to focus on the more complex and creative aspects of their work. This not only increases efficiency but also reduces the possibility of human error.

AI is the frontier in the form of self-learning systems emerging in robot applications, intelligent centers, intelligent data analytics, etc. In fields such as medical research and environmental science, AI also improves image and signal processing capabilities. It enables images such as medical scans or satellite images to be automatically analysed and complex signal data interpreted. NLP (Neuro-Linguistic Programming), a subset of artificial intelligence, is effective in extracting meaningful insights from large amounts of textual data. Researchers can analyse academic articles, books, and other textual sources to identify relevant information, trends, and connections.

AI facilitates the creation of realistic simulations and models, allowing researchers to test hypotheses in virtual environments before conducting physical experiments. This speeds up the research cycle and minimizes costs.

AI contributes to the field of personalized medicine by analysing individual patient data, including genetic information and medical history. This enables personalized treatment plans and more precise and easy medical interventions.

There are also AI-powered robots, which are used in research environments for tasks such as laboratory automation, sample handling, and experiments. This not only increases efficiency but also ensures precision in experimental procedures.

Researchers are leveraging AI to analyse climate data, study environmental changes, and model the impact of various factors on ecosystems. This helps to understand and address pressing environmental challenges. As AI continues to evolve, its integration into research endeavours holds the promise of accelerating scientific discoveries, increasing the robustness of findings, and pushing the boundaries of what is possible in various research areas.

Artificial Intelligence, computers' anthropomorphic ability to think and make decisions one that enables is technology. Artificial Intelligence will make human life easier. It is known as one of the most important technologies today.

*3.2. Applications of AI in Research Studies*

AI is applied in a variety of research fields, empowering traditional methodologies and enabling scientists to solve complex problems with unprecedented efficiency and precision. In the field of health and medicine, AI algorithms analyse large amounts of genomic data to identify patterns associated with diseases, facilitating personalized treatments and drug discovery. Moreover, AI-powered diagnostic tools are improving the accuracy of medical imaging, helping in the early detection of conditions such as cancer.

In environmental science, AI models are used to analyse satellite imagery and sensor data, providing valuable insights into climate patterns, deforestation trends, and biodiversity hotspots. By utilizing machinelearning algorithms, researchers can predict natural disasters, monitor air and water quality, and develop strategies for sustainable resource management.

AI also plays an important role in advancing fundamental research in physics, chemistry, and astronomy. High-performance computing combined with AI algorithms enables the simulation and analysis of complex systems, leading to ground-breaking advances in materials science, quantum mechanics, and astrophysics. For example, AI algorithms are being used to process data from particle accelerators, resolve cosmic phenomena, and model molecular interactions with unparalleled accuracy.

*3.3. Benefits of Artificial Intelligence in Research Studies*

The integration of AI into research offers numerous benefits by accelerating the pace of discovery and fostering interdisciplinary collaboration. One of the main advantages is that AI algorithms can scan large datasets and extract meaningful patterns, thus accelerating hypothesis generation and experimental design. Moreover, AI-powered predictive models streamline the research process by allowing researchers to predict outcomes, optimize parameters, and identify potential research areas.

In addition, AI facilitates the automation of repetitive tasks and data analysis, freeing up researchers' time to focus on high-level problem-solving and creativity. Collaborative platforms powered by AI algorithms facilitate knowledge sharing and interdisciplinary collaboration, encouraging innovation and cross-pollination of ideas across different fields.

*3.4. Maritime Education and Training (MET) and Digital Technologies*

To achieve effective Maritime Education and Training the maritime personnel with the skills to prevent accidents, respond to emergencies, and ensure the safety of crew, passengers, and cargo. The role of the MET is not just about developing professional skills; it should also cultivate a mind-set of responsibility, sustainability, security, and safety.

Digital technologies enable realistic simulations of maritime scenarios, allowing students to experience and respond to various situations in a controlled virtual environment. Digital platforms offer a wealth of educational resources, including e-books, online courses, and multimedia materials, providing students with dynamic and interactive learning experiences.

E-learning platforms in support of maritime operations provide a realistic education environment for maritime transportation, marine engineering, port and maritime management, and naval architecture programs. E-learning platforms provide an effective education at a low cost.

Additionally, digital technologies allow for the collection and analysis of data related to students' performance for the assessment of professional and soft skills as well as the identification of areas that need to be improved based on the analysis of performance assessment. Providing digitalization reduces the administrative and academic workload.

The shipping industry has experienced significant growth in the adoption of digital technologies, transforming various on-board and at-shore applications that highly affect the safety, security sustainability, and efficiency of maritime operations. The following areas are highly affected by digital technologies in the maritime sector Navigation and Communication Systems, decision-making, Environmental Monitoring and

Compliance, Smart Ports and Logistics, Automation, Remote Control, Maintenance Monitoring, Cyber Security, IoT (Internet of Things), Digitalization of Administrative and Financial Application.

The simulation of real-world applications is highly important in the MET contributing to highly effective and comprehensive learning experiences. The simulation system facilitates practical training in a risk-free environment. Nowadays, Bridge, Engine Room, Cargo Operation, Communication, Ship Handling, and Emergency Response simulators are available in support of MET programs.

*3.5. Use of AI for Teaching and Learning*

Educators are interested in using AI-powered capabilities to support students with disabilities and multilingual learners. AI in education offers personalized learning, task automation, smart content creation, adaptable access, and closing the skill gap. AI in education has the potential to revolutionize learning and teaching. AI in education can address challenges, accelerate progress, and promote inclusion and equity. UNESCO has developed guidance for policymakers to ensure the responsible implementation of AI in education. Plagiarism and ethical concerns are raised regarding AI-generated content and the use of AI in education. AI technology in education includes communication, personalization, assessment, administrative tasks, and virtual assistants. The significant AI systems in support of education are as follows: *Artificial Intelligence - Office of Educational Technology (https://tech.ed.gov/ai/)*

The Office of Educational Technology is working on policies and supports for the use of AI-enabled educational technology. Educators are interested in using AI-powered capabilities like speech recognition to support students with disabilities and multilingual learners. Educators are exploring how AI can help with writing and improving lessons, as well as finding and adapting learning materials.

*Impact of AI in Education in Transforming Learning Industry( https://appinventiv.com/blog/10-waysartificial-intelligence-transforming-the-education-industry/)*

AI in education is transforming the industry by offering personalized learning, task automation, smart content creation, adaptable access, determining classroom vulnerabilities, closing the skill gap, customized data-based feedback, 24/7 assistance with conversational AI, secure and decentralized learning systems, and AI in examinations.

*AI in Education ( https://www.educationnext.org/a-i-in-education-leap-into-new-era-machineintelligence-carries-ris ks-challenges-promises/)*

AI in education has the potential to revolutionize how students learn and how teachers work. Recent advancements in AI technology, such as Chat GPT, have enabled interactive and intelligent tools that can generate text, images, music, and video in response to natural language instructions.

*Artificial intelligence in education (https://www.unesco.org/en/digital-education/artificial-intelligence)*

Artificial intelligence (AI) in education has the potential to address challenges in teaching and learning, accelerate progress towards education goals, and promote inclusion and equity. UNESCO is committed to supporting Member States in harnessing the potential of AI while ensuring its application is guided by core principles.

*ChatGPT and Beyond: How to Handle AI in Schools (https://www.commonsense.org/education/articles/chatgpt-and-beyond-how-to-handle-ai-in-schools)*

AI application in education involves the use of AI technologies, such as adaptive learning and facial recognition, in schools. One concern is the use of generative AI writing tools that can create essays based on simple prompts, leading to potential issues with plagiarism.

*5 Essential Applications of AI Technology in Education (https://www.carahsoft.com/community/carahsoft-5-applications-of-ai-tech-in-education-blog-2023)*

AI technology in education has evolved and expanded to include new and more advanced AI systems. It is assumed as an essential tool in the learning process for various types of learners across K-12 (education from kindergarten to 12th grade) and higher education. Some of the applications of AI in education include communication, personalization, assessment, administrative tasks, and virtual assistants. *AI In Education: 5 Practical Applications (https://www.v7labs.com/blog/ai-in-education)*

AI-assisted learning methodologies have already affected education by automating tasks, providing personalized learning experiences, improving accessibility, offering outside-the-classroom tutoring, and automating administrative tasks. The use of AI in education aims to ensure inclusive and equitable quality education for all.

Gwendolyn (2023) published an introduction on Introduction to Generative AI. The resume of “AI can be used as a Lecturer Tool” is as follows:

- Creating Interactive Learning Materials (Prepare quizzes, assignments, and research studies, interactive assessment questions and Define dissertation (research) subjects and prepare assessment criteria
- Preparing Lecture (Designing Syllabus teaching aid including assessment criteria, reference, and teaching aids)
- Language Support (Multilanguage schools)
- Improvement of Interactive Teaching Methods
- Supporting Research Studies
- Student Support
- Preparing Course Material (Preparation of Presentations, Creating textbooks, Creating Videos, etc.)
- Preparation of quizzes, assignments, research, and case studies

## 4. Discussion

### *4.1. Challenges and Cautions*

Artificial Intelligence (AI) is reshaping the landscape of education, ushering in a new era of personalized learning experiences for students around the globe. In an increasingly interconnected world, AI holds the promise of democratizing access to quality education and leveling the playing field for learners of all backgrounds. With AI at the forefront, education is undergoing a profound transformation. By harnessing the power of AI, educators can create tailored learning pathways that cater to the unique needs and preferences of each student. This personalized approach not only enhances student engagement but also fosters deeper understanding and mastery of complex concepts (ITmunch, 2024).

Despite its transformative potential, the widespread adoption of AI in research endeavours is not without challenges and considerations. Chief among these is the need for robust data governance frameworks to ensure the quality, privacy, and security of datasets used to train AI models. The biases inherent in training data can lead to algorithmic errors and perpetuate inequalities, requiring careful validation and calibration of AI algorithms.

The integration of AI into IT is a powerful transformational force that provides new capabilities, increases productivity, and creates new business opportunities. The development of AI's capabilities and the start of its use in different fields will enable the development of applications in business life and scientific studies. Besides these opportunities, there are also important challenges such as ethical concerns and concerns such as data privacy protection. Therefore, as we look to the future, it is necessary to adopt these technologies responsibly, to believe that AI and IT will benefit society as a whole, and to recognize that they are a reality of our future.

Moreover, the interpretability of AI models remains a major concern, especially in areas where decisions have far-reaching consequences, such as healthcare and criminal justice. Ensuring transparency and accountability in AI-driven research requires interdisciplinary collaboration between scientists, ethicists, policymakers, and stakeholders.

### *4.2. Solutions*

Ultimately, the use of AI in research efforts represents a paradigm shift in scientific endeavours, empowering researchers to solve complex challenges and open new frontiers of knowledge. AI accelerates the pace of discovery across disciplines by enabling rapid analysis of large datasets, prediction of results, and automation of tasks by leveraging machine learning, data analytics, and computational modelling capabilities. However, realizing the full potential of AI in research requires addressing challenges related to data management, algorithmic bias, and illustrating interpretability. Through joint efforts and interdisciplinary collaboration, AI holds the promise to revolutionize research methodologies and catalyse innovation in the pursuit of scientific understanding and societal progress.

Artificial Intelligence (AI) has become the cornerstone of progressed research efforts across numerous disciplines, offering unprecedented capabilities to analyse data, model complex systems and uncover patterns that were once beyond human capability. This extensive integration of AI into research methodologies has not only increased the speed of discovery but has also fundamentally changed the way scientists approach problems and generate insights.

In healthcare and medicine, AI has emerged as a powerful ally, revolutionizing everything from drug discovery to patient care. By leveraging machine-learning algorithms, researchers can analyse large pools of genomic data to identify genetic markers associated with diseases, paving the way for personalized treatments tailored to individual patients. AI-powered diagnostic tools such as image recognition algorithms are improving the accuracy of medical imaging techniques such as MRI and CT scans, facilitating early detection of conditions such as cancer and neurological disorders. In addition, natural language processing (NLP) algorithms are used to review medical literature and electronic health records, extracting valuable information to improve clinical decision-making and patient outcomes.

Beyond healthcare, AI is reshaping the landscape of environmental science and sustainability research. By analysing satellite imagery and sensor data with machine learning algorithms, scientists can monitor environmental changes, track deforestation patterns, and assess the health of ecosystems with unprecedented detail and accuracy. AI-powered predictive models allow researchers to forecast climate trends, estimate the impact of human activities on biodiversity, and inform policy decisions aimed at mitigating environmental degradation. AI algorithms are also instrumental in optimizing resource management strategies such as energy distribution, waste management, and water conservation, thus contributing to global efforts towards sustainability and resilience to climate change.

In basic research, AI is driving innovation in disciplines such as physics, chemistry, and astronomy. High-performance computing combined with AI algorithms allows researchers to simulate complex systems, model molecular interactions, and predict the behaviour of materials with unparalleled accuracy and efficiency. In particle physics, for example, AI algorithms are used to analyse data from large-scale experiments such as the Large Hadron Collider, helping to discover new particles and events. In astronomy, AI-powered algorithms are revolutionizing the analysis of cosmic phenomena, enabling the detection of exoplanets, gravitational waves, and transient events with unprecedented precision and speed.

Despite its transformative potential, the widespread adoption of AI in research endeavours is not without challenges and considerations. One of the main concerns is the ethical and responsible use of AI, especially in sensitive areas such as health and criminal justice. Ensuring fairness, transparency, and accountability in AIdriven research requires robust governance frameworks, interdisciplinary collaboration, and continuous dialogue between researchers, ethicists, policymakers, and the public. In addition, issues such as algorithmic bias, data privacy, and interpretability remain important challenges that should be addressed to realize the full potential of AI in research.

As a result, the integration of AI into research studies represents a paradigm shift in scientific endeavours, offering unique opportunities to accelerate discovery, optimize processes, and address the complex challenges facing humanity. By leveraging the capabilities of machine learning, data analytics, and computational modeming, researchers can unlock new frontiers of knowledge and drive innovation in a variety of fields. However, realizing the transformative potential of AI in research requires careful consideration of ethical, social, and technical challenges, as well as a commitment to responsible innovation and interdisciplinary collaboration. Through collaborative efforts and thoughtful management, AI holds the promise to revolutionize research methodologies and catalyse scientific progress for the betterment of society.

### *4.3. Maritime Education and Scientific Research*

Maritime education has to combine both STCW-regulated training and the country's academic education system. It combines academic and vocational training, including long-term sea training utilizing ships of different flags. It is very difficult to meet this internal different requirement. In addition, it has to prepare dynamic programs that consider the rapid technological developments in the maritime sector. The use of artificial intelligence in the preparation of MET programs, which is a complex task, will be very useful.

On top of that, the mission of MET institutions is not only to educate but also to research. For a tertiary education to flourish, lecturers need to be involved in scientific studies. The most important function of tertiary education today is to produce individuals who are capable of critical thinking, which requires them to be familiar with scientific research from the very beginning.

Artificial intelligence (AI) is integrated into scientific discovery to augment and accelerate research, helping scientists to generate hypotheses, design experiments, collect and interpret large datasets, and gain insights that might not have been possible using traditional scientific methods alone. Here we examine breakthroughs over the past decade that include self-supervised learning, which allows models to be trained on vast amounts of unlabelled data, and geometric deep learning, which leverages knowledge about the structure of scientific data to enhance model accuracy and efficiency (Wang et al, 2023).

AI is more credible when compared with other search engines. AI sources are more precise and facilitate reaching the exact information needed by the learner. Therefore, it saves time to obtain reliable information without vesting time, provides credible data, and enables the learner to gain new skills and have a conceptual approach.

*4.4. AI in Support of Student Learning:*

Numerous trends in the global economy, like the aging workforce, diversity, and the adoption of digital technologies pose constant pressures for change in the management of human capital (Stone and Deadrick 2015). Although the digitalization of businesses requires a holistic restructuring of human resources management, it enables a wide range of activities, from basic human resources functions such as recruitment and training to more strategic and developmental roles (Theotokos et al, 2024).

The maritime industry is being digitalized rapidly. In this transition, human resources need to keep pace with this transformation.  To cope with the problems that maritime human resources management will face in this transition, young people receiving MET education should rapidly adapt to digitalization. MET learners, the prospective seafarers need to be well prepared to adopt digitalization in the maritime industry.

## 5. Conclusion

There are plenty of reasons enforce us to follow the technological developments in the maritime business and also related to Maritime Education and Training (MET) which is encouraging the use of such technologies. This can be achieved by providing the necessary tools to adopt these technological developments in the MET. The maritime industry and MET are in a situation to use innovative technologies. Using AI provides MET program-makers, lecturers, and learners with many advantages.

*5.1. MET programmers*

Maritime education combines academic and vocational training, including long-term sea training. It is very difficult to ensure the compatibility of the training programs issued by STCW with academic programs and to ensure this within a certain period. To achieve this, matrices are established to harmonize the requirement with the course scope, and the most appropriate programs are determined by considering the suitability, applicability, and acceptability criteria. This very difficult task requires the use of analytical methods. The use of AI in the preparation of MET programs will be very useful in making a comparative study and finding realistic solutions.

*5.2. Lecturers*

The lecturers may use AI in the following issues:

- Creation of interactive learning materials including additional references, learning tools, and simulator support
- Creation of assessment methods and materials (Assignments, practical studies, examination, case and research studies)
- Revising the syllabus in particular learning outcomes, assessment criteria, content, and references
- Delivering Lectures in different forms that facilitate learners’ understanding (movies, articles, conferences, laboratory work, workshops, etc.)
- Using AI tools for teaching
- Assist in translating for multinational students
- Facilitate research studies providing suitable analytic method application and better information from AI sources
- Teaching in a multilingual school environment using AI language support

- Inclusion of AI in support of blended teaching methods

*5.3. Learners*

The learners may use AI in the following issues:

- Interactive lessons will be easier to access
- They will be able to access more accurate and reliable sources when preparing their research assignments.
- They will be able to access the information they are curious about from more reliable AI sites that are focused on those topics instead of mostly unreliable websites.
- The learner will be able to access this information in a shorter time as the online resources of educational organizations will develop more thanks to AI.
- Will be able to use simulators easily and participate in some laboratory activities from home
- Learner will be able to compile information on specific topics
- Learners may have guidance for preparation for class lectures, assignments, research, and case studies

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# E-Learning Capacity-Building – The Case of IMO's Integrated Technical Cooperation Programme

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**Abstract:** The International Maritime Organization (IMO) is augmenting its Integrated Technical Cooperation Programme through self-paced and blended learning courses. This study aims to showcase the usefulness of the e-learning course modalities to build the capacity of maritime professionals. The report is a case study of how the officers at IMO's technical cooperation division and specialized departments worked with e-learning specialists at the World Maritime University to develop and deliver the courses. The findings show how the self-paced learning modality works in a range of lower to higher intended learning outcomes. The courses are divided into e-lessons and e-exercises to give the learners an understanding of the course concepts, and then have them apply their knowledge and analyze the outcome. The blended learning was used to prepare for and support the instructor-led activities (onsite or online) to achieve additional higher learning outcomes related to a flipped learning approach. The IMO e-learning courses show how e-learning can enhance training for the safety, security, and environmental performance of international shipping. The development illustrates cutting-edge e-learning technology applications such as self-paced gamified and adaptive learning in Massive Open Online Courses on the one hand, and blended learning based on constructivist principles on the other.

*Keywords*: Capacity-building, Self-paced learning, Blended-learning, Participatory Design, IMO

## 1. Introduction

On 12 October 2023, the IMO Member State Audit Scheme (IMSAS) e-learning course was launched for the IMO member states. The IMSAS e-learning course is the final and most comprehensive one in a pilot project that was started by IMO in 2020 to develop e-learning to augment the training and capacity-building programmes under its Integrated Technical Cooperation Programme. The other e-learning courses in the pilot project were on Oil Pollution Preparedness, Response and Co-operation (OPRC) and Marine Biofouling: Impacts and Management of Risks. . In addition, before being completed, the pilot project was extended to include e-learning courses on Maritime Single Window, International Safety Management, Ballast Water Management, Counter Wildlife Trafficking in Maritime Supply Chains, and the London Protocol Implementation, as well as translating the developed courses to the UN official languages. With its e-learning courses, IMO joins other UN e-learning initiatives, including UNSDG Learn, OpenWHO, UN CC:Learn, and ICAO's e-learning training packages, amongst others. This study aims to showcase the usefulness of IMO's elearning course modalities to train maritime professionals. Furthermore, the aim is to analyze the participatory development process and how to sustain it. The first set of objectives is to (1) evaluate the open enrollment selfpaced course modality for training at a scale and (2) and the possibility to reconfigure the courses in a blendedlearning modality to achieve additional higher intended learning outcomes. The second set of objectives is to (3) understand the need for educational, technical, and subject matter experts to collaborate to develop the courses and (4) how their collaboration entailed application and infrastructure development that was informed by usage.

## 2. Related Work

The research objectives address a research gap noted by Bonk and Wiley (2020) and Reeves and Lin (2020) in an introduction and conclusion of a special issue of the Journal of Educational Technology Research and

Development with systematic reviews and synthesis of the current state of research. They note how, regrettably, many reports address learning technologies as "things" in a decontextualized manner instead of detailing their use and development in an educational setting. In addressing this gap, the study on the first set of research objectives includes cutting-edge learning technologies in the special issue, such as adaptive and gamified education technologies and Massive Open Online Courses, but the analytical focus is on their use and the education-related problems and issues that they address. With the second set of objectives, this study further moves from an analytical focus on "things" to "thinging" – a conceptualization that is found in Participatory Design literature about infrastructuring to denote the need for multifaceted learning processes that are bridging usage and in-situ, application, and infrastructure development (Karasti 2014). For this purpose, the analysis makes use of Bolmsten and Manuel's (2020) framework to understand the educational and technical learning processes that were required to develop the self-paced and blended learning modalities.

**3. The IMO case of self-paced and blended learning training modalities**

This is a case study that synthesizes the development and delivery experiences from the different IMO elearning courses. The IMO member states requested the new e-learning modalities as there were personnel, financial, and time-related constraints on the number of onsite regional training courses the IMO secretariat could offer. There are 175 IMO member states, and only a few learners have the chance to participate in onsite training every year. IMO's ambition was to build internal e-learning capacity. The case study reports on the work of IMO's Integrated Technical Cooperation Programme (ITCP) in developing and delivering the courses, with pedagogic and technical support from the World Maritime University's (WMU) Outreach department.

*3.1 The self-paced e-learning course*

The pilot project specified a self-paced e-learning modality to cater to training scale needs. The challenge was to develop an instructional design that maintained the same Intended Learning Outcomes (ILOs) as the onsite regional training courses. The design was divided into e-lessons and e-exercises to achieve the ILOs of the established lectures and exercises so that the learners could understand the course material and then apply their knowledge and analyze the outcome.


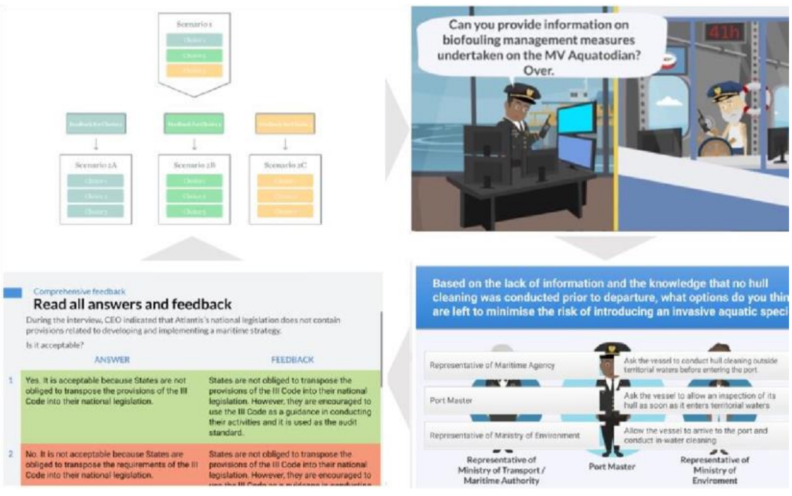


Figure 1. E-lesson

Figure 2. Scenario-based and role-play exercise with multiple decisionmaking pathways (based on Articulate's 2018 best practices)

Figure 1 showcases examples of the IMO self-paced e-lessons. The e-lessons combine recorded lectures with interactive features such as click-and-real functionalities and multimedia elements, enhancing learners' comprehension and fostering a deeper understanding of the content. Additionally, self-assessment knowledge checks are incorporated to reinforce learning.

Following the e-lessons, students use exercises to apply their understanding. Figure 2 is an example from the Biofouling course where scenario-based and role-play learning is employed to present a challenging situation where a vessel risks introducing invasive aquatic species via biofouling to a hypothetical country. The learners then are tasked to explore various stakeholders' perspectives in biofouling management and identify optimal strategies considering the country's legislation and IMO biofouling management guidelines. Similarly, in the IMSAS course, role-play scenario e-exercises are developed to allow students to apply their knowledge of IMSAS from the perspectives of both an auditor and an auditee. These scenarios are designed to reflect realworld complexities, where decision-making is multifaceted and correct choices may not always be obvious. Learners encounter challenges and consequences for each decision they make within a hierarchy of decisionmaking interactions. For instance, learners may assume the role of the audit team leader, tasked with gathering evidence about compliance by interacting with various stakeholders. Feedback is provided after each query, enriching the learner's understanding and reinforcing key concepts.

IMO's different self-paced learning courses are calculated to take two to five days to complete and range from awareness-raising to comprehensive introductory courses. For example, the IMSAS e-learning course belongs to the latter category. It was divided into five modules, with 21 e-lessons and 15 e-exercises totaling 800 and 425 "seat time" minutes, respectively.

As of July 2024, the self-paced learning courses have about 12000 registered learners from 188 countries. The completion rate is between 30-60%, which exceeds industry standards for these types of courses that typically average between 7-10% (Fu et al. 2021). Survey data from 443 learners who have completed the course shows that over 90% of them recommend the course and are likely to use the knowledge gained in their work.

*3.2 Additional blended-learning options*

Initially, the pilot project did not include plans for blended learning options. The development of blended learning modalities started with the IMSAS team and their additional need for alternative training delivery methods as the project progressed. The first blended-learning delivery was developed during the COVID pandemic for a regional training course for auditors in the Asia-Pacific region in March 2022 when onsite delivery of the IMSAS course was not possible. The IMSAS team augmented the developed self-paced elearning course package by integrating it into the regional online teaching and workshops. This was the first test of how the self-paced e-lessons and e-exercises could be blended with the instructors' lectures and exercises. The students first worked with the e-lessons and exercises at their convenience and repeatedly (asynchronously). The instructor-led lectures and exercises then took place entirely online (synchronously), with additional discussions and interactions using a forum (asynchronously).

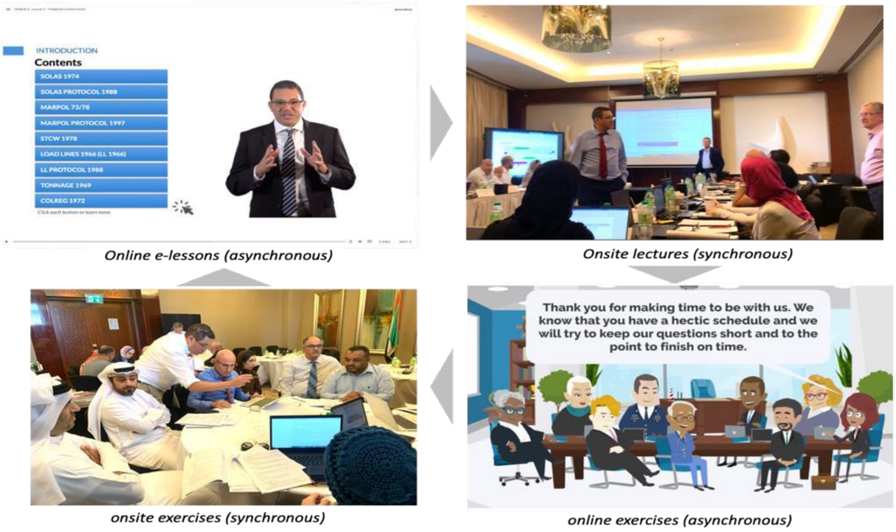


Figure 3. Blended learning delivery

The second blended learning delivery was developed into a flipped classroom approach for a regional auditors training course in Dubai, UAE, in November 2022 (see Figure 3). The intention was to use the e-lessons and eexercises to prepare and augment the instructor-led activities to achieve additional higher learning outcomes compared to the original onsite regional training. In this way, the instructors could spend less time explaining basic concepts to the students and more time engaging them in discussions of cases and scenarios during the lectures. In a related way, the students used the e-exercises for practice and preparation, enhancing their interactions when doing the exercises in the classroom.

## 4. The learning processes during the development

This section maps the educational and technical learning processes that took place to develop the self-paced and blended-learning course modalities between 2020 and 2023. The mapping is outlined in Figure 4 and is based on Bolmsten and Manuel's (2020) framework of sustainable and participatory learning processes. It shows the evolutionary and multifaceted learning processes required to develop the courses. On the one hand, educational knowledge and knowledge about technical options need to be brought together to learn about education technology development (vertical layers). On the other hand, learning processes need to transition the development of standards and applications with input from usage/in-situ development (horizontal layers). The mapping using the framework shows what Bødker et al. (2017) refers to as *"knotworking*" in how the educational and technical learning processes integrate through enactment.

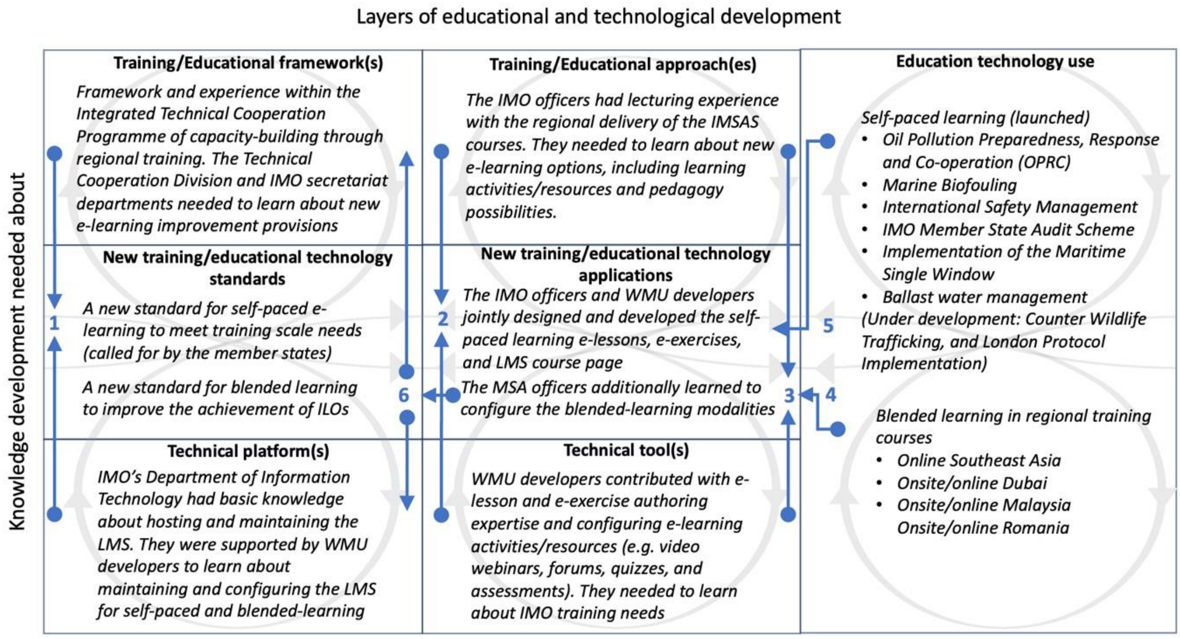

Figure 4. Learning processes during the development of the self-paced and blended-learning courses

The mapping is outlined in Figure 4, and the key findings regarding the learning processes are summarized in the following:

1. **Starting with probing, not determining the standard**: Using e-learning to build the member states' capacity constituted a new IMO training standard. The officers at IMO's specialized divisions and Technical Cooperation Division (TCD) had established frameworks and experience delivering onsite regional training courses. Through the pilot project, they intended to learn about the usefulness of new online modalities. Furthermore, enhancing the IMO Learning Management System was a prerequisite to adopting new delivery modalities. The decision to start the standard development with a pilot project allowed for assessing the feasibility of developing the Intended Learning Outcomes (ILOs) of the established onsite regional training courses in a self-paced e-learning modality. At the same time, it left room for the following learning processes to scrutinize their assumptions.
2. **The value of participatory learning processes**: The main learning processes to develop the self-paced courses took place on an application level, and the mapping shows how they intersect. The IMO officers had experience developing and delivering the onsite regional courses. WMU provided pedagogical support to review the existing training materials and to develop the e-learning activities and resources. The design and development activities were based on an iterative approach, where the IMO officers and the WMU developers first developed high-level design sketches – in a process referred to as storyboarding - that then were prototyped and developed using an e-learning authoring tool. The challenge was to develop the same ILOs from the onsite courses into self-paced e-learning. Especially creating the higher learning outcomes of the exercises where the students need to apply their knowledge and analyze the outcome was challenging and time-consuming. In the onsite training, these scenario-based role-play exercises were based on discussions and group work between the students and instructor. The storyboarding of the exercises in the

self-paced learning format was extensive work, where the IMO officers and WMU developers first designed interactive and multi-threaded auditing role-play scenarios between different stakeholders. In the next stage, specifics such as the dialogue scripts and detailed feedback needed to be developed. Finally, everything had to be technically animated and authored. To arrive at the result illustrated in Figure 2, including testing and revisions, took more than 200+ hours for every hour of exercise developed. This close collaboration and feedback in the educational and technical development are essential to develop the self-paced learning courses, and the value also extended beyond the project specifications.

3. **The result of participatory learning processes transitioning beyond the project:** As described above, starting with the IMSAS project, the development processes went beyond the individual pilot project and also resulted in the IMO officers learning how to improve their established onsite regional training with blended learning options. During the self-paced course development process, they learned about the utility of the e-lessons and exercises and what type of learning outcomes they could achieve compared to their onsite training. In addition, they inquired about using additional learning activities and resources, such as video webinars, forums, and new assessment and quiz tools. It resulted in the IMO officers configuring a blended learning modality of their IMSAS course in the Learning Management System, as illustrated in Figure 3. The configuration of the blended-learning modality took place in conjunction with the IMO officers' review of their teaching materials and delivery manuals in preparing for their regional course delivery. For this first delivery, the WMU developers supported the IMO officers with setting up and delivering the course by conducting workshops and technically configuring the course in the IMO LMS. This shows the potential of continuous participatory learning processes that are triggered by a project and connecting to day-to-day work.
4. **The possibility of continuous updates by incorporating experience from usage:** The experiences from the first delivery furthermore showed how the IMSAS team could continue to develop the blended-learning modality into a complete flipped classroom approach, where the intention was to use the e-lessons and eexercises to prepare and augment the instructor-led activities to achieve additional higher-learning outcomes. The IMSAS course was delivered a second time in a blended-learning modality using a comprehensive flipped classroom approach in a regional training course in Dubai. The delivery combined onsite and online delivery through the e-learning course package. This time, the IMSAS officers had the primary responsibility, themselves, of setting up the course page. When writing this report, the IMSAS course has been delivered for the third and fourth time in a blended-learning modality in Malaysia and Romania. This possibility for instructors to carry on the development themselves based on their input from usage shows the sustained value of a participatory development processes (and a supportive technical infrastructure) to ensure the usefulness and the possibility to enhance e-learning courses over time.
5. **The benefit of making use of usage data**: The consecutive launches of the IMO e-learning courses between 2020-2023 in the IMO LMS generate data about their usage. Basic data about the number of learners, their completion rates, and geographical distribution informed the decision to continue to invest in e-learning. But there is additional untapped potential in a detailed data analysis that can also provide insights into how the e-lessons and e-exercises are used to optimize their design. Together with, for example, learner surveys, it complements the participatory learning process by offering additional data about the usefulness of the courses.
6. **The process of establishing an e-learning standard**: The development of the pilot project’s self-paced courses and the additional courses show how a new standard is established and disseminated. In this way, a standard is not an abstract construction, but requires enactment. The IMSAS blended-learning development furthermore shows the importance of ongoing and participatory learning processes to develop the standard, which in this case informed the possibility of augmenting the self-paced e-learning modality originally specified for the IMO e-learning projects. Blended learning modalities are now highlighted as a new strategic priority for IMO’s Integrated Technical Cooperation Programme. Finally, the self-paced learning and blended learning modalities have opened up new capacity-building partnerships. For example, the launch of IMSAS to the member states spurred an inquiry into new educational collaborations between WMU and the International Maritime Law Institute regarding integrating the IMSAS e-learning course in their educational offerings. The development of IMO courses, such as the Maritime Single Window Implementation and Counter Wildlife Trafficking course, also included a close collaboration between IMO,

WMU, and other NGOs such as WWF and IPCSA. In summary, this shows how the development of an elearning standard is a participatory learning processes that evolve through enactment (beyond ex-ante specifications)

## 5. Conclusion and future work

IMO is expanding its capacity-building offerings and reach with its new e-learning solutions, thereby joining other UN specialized agencies in developing e-learning for these purposes. This study has shown the possibilities of self-paced and blended learning modalities to train maritime professionals. Self-paced e-learning was the original modality specified in the pilot project to complement the established regional onsite training courses. The resulting e-lessons and e-exercises show the possibility of retaining similar intended learning outcomes in the range of understanding course concepts, learning how to apply them, and analyzing the outcome. Furthermore, the study shows the possibilities of flexible e-learning development and deployment, where it was possible to reconfigure the self-paced learning course in a blended learning modality. The experiences illustrate how e-lessons and e-exercises can augment the quality of the onsite regional training courses to achieve additional higher Intended Learning Outcomes. The instructors progressively learned to develop a flipped classroom delivery approach where they got more time to engage with the students in for example case-based discussions. These results address the research gap noted by Bonk and Wiley (2020) and Reeves and Lin (2020) by showing the usefulness of e-learning beyond isolated research projects and developing technical “things”.

In addition, the study shows the participatory learning processes necessary to achieve the results, which additionally contributes to moving the research agenda from “things” to “thinging” (ibid), and relates to a contemporary research agenda of infrastructuring (Bolmsten and Manuel 2020; Karasti 2014). The educational and technical learning processes focused on developing the new courses and informed underlying frameworks and infrastructure. The mapping using the sustainable and participatory process framework reveals how the learning processes evolved and intersected. It shows how the dynamic and continuous learning processes unfolded beyond the projects’ specifications. When starting the development, the IMO officers had topical knowledge and knew how to deliver the regional training courses, but they needed to learn about new e-learning options. The participatory development approach with WMU’s developers built their pedagogical and technical expertise and IMO’s institutional e-learning capacity. In previous work, we established the participatory and sustainable development framework by synthesizing e-learning development issues across different case studies. The results presented here, focusing on development, strengthen the evidence of the value of a participatory approach and the need for ongoing learning processes, informed by usage, to sustain e-learning development.

This study has presented a first overview of IMO’s work - as a UN-specialized agency with a key mandate for maritime international capacity-building - to develop new e-learning solutions. Going forward, our research includes a detailed analysis of both the development and delivery processes using actor-network theory to understand further how IMO’s e-learning builds learners’ professional capacity. In addition, we are studying other UN agencies’ e-learning initiatives. The results also open for research and development in communities such as IAMU by showing the potential of e-learning and development partnerships but indicate the need to go beyond individual projects to sustain the results.

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# Maritime Society 5.0: Embracing Newly Emerged Skills and Career Pathways

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**Abstract:** Society 5.0 initiative aims to position human intelligence at the core of maritime systems and to emphasize the collaboration between humans and technology, instead of focusing solely on emerging technologies. This initiative is widely recognized in both scientific and professional communities for providing maritime professionals with new sets of skills, with the aim of enhancing economic, ecological, and societal well-being.

The new skills are the focus of this research and represent the first level of the research. The second level of the research examines the transformation of maritime career development, driven by global changes in labor market and the evolving nature of maritime profession. The study explores the common generational characteristics of the target workforce group in maritime industry, specifically millennials and Generation Z. This study is a conceptual study based on qualitative methodology, which utilizes systematic literature review and document analysis as primary methods. The study relies on an established frame of reference and a threestep methodology: scientometric analysis, systematic literature review, and conceptual framework development.

The study results include the identification of the skills necessary for Maritime Society 5.0, referred to as the "8 fusion skills" as well as an overview of the key generational characteristics of the current and future maritime workforce. The integrative outcome of this study is a conceptual model for envisioning Maritime Society 5.0 skills and career pathways, which are fundamentally based on the balance between the supply and demand for human resources in maritime sector. The research findings highlight three areas that require further adaptation: education 5.0, human resource management 5.0, and marketing 5.0.
The main contribution of this paper is the identification of the common ground across the fields of human resource management, engineering sciences, and marketing. Additionally, the paper offers integrated solutions for the challenges of transitioning from previous maritime societies to Maritime Society 5.0.

*Keywords*: Maritime Society 5.0; skills; career; conceptual framework; Gen Y and Z

## 1. Introduction

The Industrial Revolution profoundly influenced maritime society and shaped its evolution from the late eighteenth century until present. While Industry 4.0 emphasizes digitalization and automation, Industry 5.0 reintegrates human intelligence into industrial processes. This transition challenges maritime professionals to adapt to technological advancements and a human-centered approach. As a result, there are newly emerged concepts like Maritime 5.0, Shipping 5.0, Seafarer 5.0, and MET 5.0 that promote the collaboration between intelligent systems and humans in maritime operations (Autsadee et al., 2023; Mehrangiz et al., 2022).

Global labor market is characterized by a persistent gap between the skills demanded and the skills that are available, which is a paradox, considering a significant increase in educational achievements over recent decades. According to the International Labour Organization (ILO, 2015), there are over 73 million young and unemployed people worldwide. Numerous factors contribute to the mismatch between the supply and demand of skills, including demographic and climatic changes, educational achievements, changes in work organization, the globalization of markets, trade liberalization, technology, and innovation.

Every industrial revolution leads to an appropriate educational model. The era of Society 5.0 demands a technologically and informationally literate workforce capable of thinking and solving problems from diverse perspectives, applying flexible skills, thinking "outside the box," and developing synergy with colleagues from different disciplines. In that sense, new maritime skills should be well defined, while educational programs and career pathways of maritime professionals worldwide need to be adjusted and aligned with the needs of new generations and labour market. The paper therefore addresses two research questions (RQs):

*RQ 1: What are the skills necessary for Maritime Society 5.0?*
*RQ 2: What are the characteristics of Generations Y and Z that require adjusted career and educational pathways?*

The paper aims to develop a new conceptual model for Maritime Society 5.0 and to introduce new skills, needs and key characteristics of the emerging workforce, comprising Generations Y and Z. Additionally, the concept aims to find a balance between supply and demand in the maritime labor market from three aspects: education 5.0, human resource management (further HRM) 5.0, and marketing 5.0. The purpose of the paper is the theoretical contribution to the examination of new MET models for Maritime Society 5.0 and the provision of support for the youth in terms of developing and promoting their careers in the environment of global economic, social, technological, and ecological transitions.

## 2. Methodology

The primary frame of reference is based on relevant literature and documents issued by globally recognized maritime institutions. The conceptual foundation for researching literary sources and documents is based on the initiative known as "Society 5.0," introduced by the Japanese Government as part of the Fifth Basic Plan for Science and Technology (2016–2020). Two key documents referenced for maritime skills include “GMP Body of Knowledge” (IAMU, 2019) and “Anticipating and Matching Skills and Jobs” (ILO, 2015) for career pathways. The methodology is designed at three levels:

1. A scientometric analysis by means of Google Scholar, which preceded the paper title conception and involved the examination of the most important journals, research topics, and quotations;
2. A systematic literature review of the Scopus and Web of Science (WoS) databases, which was conducted through an advanced search: TS=(("society 5.0" OR "maritime society 5.0") AND (skill* OR maritime competence OR knowledge AND Millennials OR Generation Z career)); and
3. The development of a conceptual framework that postulates the relationships between key global drivers of maritime industry, key representatives of the supply and demand for maritime workforce as well as other areas of maritime education, HRM, and marketing, which need to be adapted to the requirements of Society 5.0.

## 3. Results and discussions

The research of the Scopus database provided 21 relevant literature sources, while the Web of Science (WoS) database provided 36. The study therefore relies on a refined approach based on 57 papers in total. The papers were subsequently analyzed to address two research questions. A structured methodology led to the identification of two sets of results, accompanied by a discussion and the definition of a conceptual framework.

### *3.1. Newly Emerging Skills for Maritime Society 5.0*

Previous research shows that future engineering graduates will need the skills that radically differ from the professional profile of the engineers form the 20th century. Fusion skills are a helpful starting point in developing engineering education (e.g. maritime engineering) in future. There are eight *fusion skills* that literature sees as crucial for Maritime Society 5.0 (Guile and Mitchell, 2022; Daugherty and Wilson, 2019):

- *Rehumanising time* – devoting more time to creative research that addresses pressing issues;
- *Responsible normalising* – responsible shaping of the purpose and perception of human-machine interaction and its impact on individuals, businesses and societies;
- *Judgement-integration* – the judgement-based ability to decide on the course of action when a machine is uncertain;

- *Intelligent interrogation* – optimal questioning of Artificial Intelligence (AI), across levels of abstraction with the aim of gaining the necessary insights;
- *Bot-based empowerment* – effective collaboration with AI agents to augment human capabilities and enhance business processes and professional careers;
- *Holistic (mental and physical) melding* – the creation of functional mental models of machine operations and learning, with the use of machines that capture user performance data to refine interactions;
- *Reciprocal apprenticing* – the work alongside AI agents that allows individuals to learn new skills and receive on-the-job training to excel in AI-enhanced processes; and
- *Relentless reimagining* – the rigorous discipline of inventing new processes and business models from scratch, rather than merely automating existing processes.

Additionally, the analysis of the critical competencies required by global maritime professionals in the digital era indicates that *cognitive* competencies are of the utmost importance. The second place was occupied by *operational* competencies particularly significant for the seafarers who need to manage, process, and understand increasingly complex data and digital processes of handling and optimizing operations. The third critical competency is *individual*, which represents human ability to work under pressure. The fourth essential competency is *social*, where communication and various leadership skills stand out as significant subcompetencies relevant for the multicultural work environment and effective decision-making in complex and computerized environment (Emad and Ghosh, 2023; Ceylani et al., 2022; IAMU, 2019).

### *3.2. Generation Y as Emerging Maritime Workforce*

The development of workforce is related to the several generations and time intervals (Dobrova and Rubtsova, 2020): baby boomers (1940-1960), Generation X (1961-1980), Generation Y (1981-1995), and Generation Z (1996-2017). Generation Y (Millennials) is the first technological and global generation. Their population rate, compared to the global population, is 23.9%. There are several essential characteristics that are indicative of the work operations of millennials. For instance, millennials quickly perform various tasks, prefer multitasking jobs, easily operate in multicultural environments, and lean towards teamwork to achieve personal goals at work. Generation Y employees are adept at filtering and synthesizing information from different sources to solve problems, as they have been exposed to an "information overload" since birth.

Generation Y constitutes the majority of maritime workforce. Studies confirm that millennials are generally kind, open-minded, conscientious, innovative, creative, cooperative, disciplined, and prefer working under mentorship (75% of Generation Y employees desire a mentor). The positive aspects of this generation should be encouraged by maritime companies through the adoption of the management styles that are open to new ideas. Participatory management, for example, provides opportunities for everyone to share and contribute in a complementary manner, which is suitable for millennials as they rather avoid orders and hierarchy. Generation Y enjoys learning, and adapts quickly to new companies. However, research has shown that the introduction of internal measures would efficiently strengthen the emotional stability of this generation by developing strategies to handle and resolve stressful situations that could negatively impact the efficiency and effectiveness of maritime operations (Estimo et al. 2020; Berkup, 2014).

Maritime company managers emphasize that an early career abandonment has begun with the arrival of Generation Y. The results of previous studies confirmed a low level of organizational and professional commitment of millennials (retention in a lower position rather than dropout). The negative characteristics attributed to millennials include a weak sense of belonging and low work motivation. Overtime work demotivates them and negatively affects organizational commitment. On the other hand, Generation Y is considered the most educated.

### *3.3. Generation Z as Emerging Maritime Workforce*

Generation Z is characterized by increased hyperactivity, infantilism, multimedia literacy, loop reading, social autism, consumerism, a lack of analytical evaluation of communication and text, etc. Generation Z, however, has an additional advantage in overcoming the problems of maritime industry regarding the overload of information. The young generation has the potential to be early trained to quickly filter a plethora of information and properly process navigational information, unlike older generations (Sencila and Kalvaitiene, 2018). Furthermore, this generation is considered the most connected one.

"The children of the internet" have a short attention span, interest in multiple things at once, but also the highest synchronization of motor skills of hands, eyes, and ears in human history. Regarding motivation as a function of HRM in maritime industry, Generation Z is characterized by a dose of dissatisfaction and a narrow focus on results - they have high self-confidence, expect to live under better living standards longer, and be wealthier than previous generations thanks to advanced technology. Generation Z was educated earlier, acquired advanced and planned education, enjoys practical training, and appreciates attending online courses (Berkup, 2014). The members of this generation demonstrate characteristics such as multitasking, efficient use of technology, individualism (lower preference for teamwork), creativity, global outlooks, and a tendency towards non-standard and personalized tasks at work. Marketing of maritime professions for this generation needs to be rebranded while maritime industry should be presented as *sustainable, human-centered, and resilient*.

**4. Conceptual Framework for Envisioning Maritime Society 5.0 Skills and Career Pathways**

A systematic anticipation of skills needed for Maritime Society 5.0 is of the utmost importance for the alignment of competency standards, curricula, and programs. The ILO claims that the anticipation of the skills needed in future is a key preventative measure to avoid skills mismatch, and the basis of a strong training and skill development system. For the process of the anticipation, the involvement of stakeholders, enterprises, training organizations, and governments is necessary for decision making about future investments in education and training (ILO, 2015). This paper, at the conceptual level, considers a possible model for the development of future skills in maritime industry, as well as the key partners and ways to develop the required skills under the influence of global drivers (see Fig. 1).

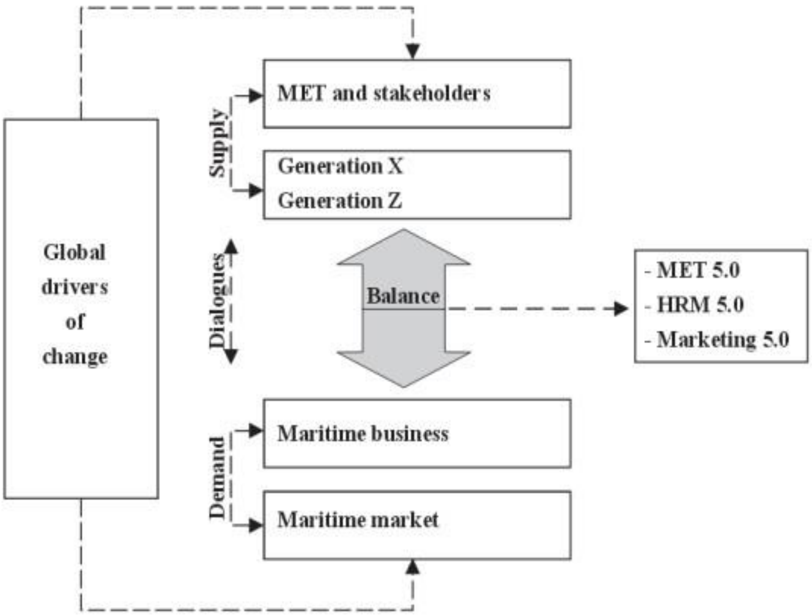


Figure 1. A conceptual framework for envisioning Maritime Society 5.0 skills and career pathways

(Source: Authors)

Figure 1 shows two elements that have to be balanced in the Maritime Society 5.0: *demand and supply of the skills and competences of workforce*. Effective HRM practices in overcoming the challenges of demanded skills include better skill usability, employee retention measures, improved working conditions, business strategies based on capabilities and human capital investment, and national/sectoral policies and regulations. On the other hand, managing skills supply should be based on national/sectoral education and training policies and regulations, lifelong learning, activation measures, skilled migration and workforce mobility, as well as skills matching and retraining through employment services (ILO, 2015).

Figure 1 shows that at this stage of maritime community development, *social dialogue* is a necessary basis for the anticipation of the required skills. There are several methods for anticipating skills beneficial for the maritime community 5.0 (ILO, 2015):

- ✦ quantitative employment projections by maritime sectors and occupations, known as „forecasts";
- ✦ qualitative methods (focus groups, roundtable discussions, expert interviews, scenarios);

- surveys among employers, institutions or enterprises; and
- tracer studies of school/training graduates and school-to-work transition surveys.

*MET 5.0* focuses on the cultivation of essential skills such as teamwork and collaboration with intelligent non-human agents, the promotion of innovation and creativity, rapid adaptation to dynamic maritime environment, and synergistic adaptation to ongoing technological advancements (Mehrangiz et al., 2022). Research indicates that future maritime education and training programs should encompass the following competencies of seafarers: information technology systems, electronic and computer engineering, satellite communication technology, artificial intelligence, machine learning, troubleshooting, and integrated systems between shore-based and onboard operation (Emad and Ghosh, 2023). The development of maritime industry requires new directions in training of both basic and soft skills to meet the complexity of Maritime Autonomous Surface Ship (MASS) operations. A recent examination of the existing MET curricula and programs indicated that they do not include new knowledge and technologies related to MASS, which should be urgently changed (Bhardwaj, 2023; Bogusławski et al., 2022). Engineering research indicated that progress towards *integrated/interdisciplinary* educational programs is highly beneficial since reformed programs would be more compatible with the newly emerging skills. Additionally, new programs promote a genuine integration of workplace practice through collaboration with industry stakeholders. The ultimate goal of reformed educational programs is holistic and theoretical understanding merged with practical experience, while the traditional framework of programs is based on mere theoretical understanding of a specific discipline with only a partial dose of practical awareness (Guile and Mitchell, 2022). Therefore, it is necessary to transform traditional educational paradigm and revise existing approaches and learning models (Dobrova and Rubtsova, 2020).

The aging maritime workforce in several developed countries exhibits the need for succession planning initiatives and *strategic HRM 5.0 interventions*. The unattractive nature of maritime jobs stems from poor working conditions and demanding contracts which deter future generations, especially Generation Y and Z, who are starting their careers. Moreover, many seafarers leave the sector and opt for onshore careers in various industries. This migration is a primary cause of the shortage of maritime workforce and jeopardizes the sustainable supply of highly skilled professionals. Different age groups exhibit different characteristics, which means that a one-size-fits-all approach to managing expectations will not yield efficiency.

As a part of HRM strategies and practices, maritime companies will need to focus on critical areas such as talent attraction (seafarers), training and education, recruitment and retention. Maritime companies need to resort to the strategies that extend seafarers' working years on ships or in maritime industry on land in order to prevent the shift of professionals to other sectors. Employers in maritime businesses must adeptly manage differences across generational categories (X, Y, and Z) to consistently attract and retain talent (Caesar, 2024). Additionally, current motivational models in maritime industry should also be reconsidered. Research has shown that the younger generations of maritime students define the best job offers through high salaries and short voyages (1-3 months). In addition to the primary factors, young generations also desire healthy crew interpersonal relations, suitable accommodation and employment contracts, pleasant working and vessel conditions and navigation area, quality food, facilities for rest and sports activities, good company reputation and employee care, good internet connection, and promising career opportunities (Sencila and Kalvaitiene, 2018).

The literature suggests several strategic principles for human resource management that are aligned with the challenges of Society 5.0: making strategic value decisions, the strategic integration of HRM policies and procedures, recognition of employees as the most valuable asset, emphasis on staff support management, enhancing the commitment of both management and employees, effective communication, decentralization that empowers employees, promotion of flexibility and adaptability, focus on creativity and innovation, and maintenance of unwavering focus on quality (Misbah & Budiyanto, 2020).

The need for *Marketing 5.0* of the maritime industry emerged with the introduction of autonomous vessels and other technological advancements that allow seafarers to reduce the time spent at sea and increase shorebased work time. The ability of maritime industry to effectively respond to the changes, without hindering trade, largely relies on the resilience of the workforce. Therefore, the industry's marketing positioning must urgently ensure long-term sustainable maritime transport based on a *resilient and highly skilled workforce*. Additionally, research showed that digital marketing is efficient in attracting young individuals to maritime education due to the omnipresence of digital marketing channels. In particular, social media marketing significantly influences cadets' decisions to enroll in maritime programs (Rajasekar and Aithal, 2022). Measures to position maritime careers should be planned based on the principles of transformational management rather than transactional management. In that regard, marketing of maritime professions should be based on the promotion of not only material motivation (as was the case with previous generations) but also on the benefits of non-material motivation: personal development, networking opportunities, and a higher degree of autonomy.

## 5. Conclusions

Contemporary maritime industry witnesses an economic and political shift from extractive economy to regenerative economy, which paves the way to Maritime Society 5.0. In present dynamic environment, maritime business representatives are compelled to deeply understand and adapt to the evolving and upcoming generations. The understanding is crucial to the maintenance of the motivation of new generations and enhancement of efficiency through learning and aligning business models with the generational traits. The maritime workforce shortage and the labor market dynamism call for the improved conditions for the supply of maritime labor. Similarly, the new generations must be prepared to find a balance of interests and to adapt to work environment and changes.

Maritime Society 5.0 heralds the advent of new skills, known as fusion skills, which are expected to revolutionize the industry. While cognitive, operational, individual, and social skills remain essential, the introduction of fusion skills promises to enhance the potential of the industry. Maritime industry is on the verge of a transformative shift, which requires the reconsideration of the HRM 5.0 practices and strategies for innovative motivational models. The new ways of career promotion should be identified and complemented with marketing repositioning 5.0 based on a resilient and highly qualified workforce. The Maritime Society 5.0 will also need a new digital marketing paradigm and better use of marketing instruments to make this industry more attractive and sustainable.

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# Word list of research in decarbonization in the maritime industry – a case study on lexical analysis of technical corpora

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**Abstract:** This study examines a suite of software tools for lexical analysis tailored to the emerging field of decarbonization in maritime transport. Given the technical nature of this domain, mastering its terminology poses a challenge, especially for non-native English speakers.

Conducted within the framework of the national project "Decarbonization of the Maritime Sector – Green Boka Bay, DeMS – GBB," led by the Faculty of Maritime Studies Kotor (University of Montenegro), the study aims to delineate the specific English terminology of this area. To achieve this, a corpus of 21 relevant scientific papers, comprising 251,114 running words or tokens, was compiled.

Our analysis is aimed to extract specialized lexicon pertinent to decarbonization. Through the exclusion of commonly occurring General English (GE) terms from further examination, we present a refined word list encompassing 47 technical headwords or word families from research papers on decarbonization in the maritime industry. Moreover, we measure the prevalence of academic vocabulary and explore alternative features offered by lexical analysis software.

This paper concludes with a reflection on the study's constraints, its educational implications, and outlines avenues for future research.

*Keywords*: decarbonization; corpus; word list; technical vocabulary; software

## 1. Introduction

Given that English serves as the official *lingua franca* of the maritime industry, delving into new areas of maritime research or any global industry typically entails familiarizing oneself with new technical terminology, and sometimes even mastering a specialized form of English for Specific Purposes (ESP). Introducing young researchers to new areas within the maritime industry, particularly if they are non-native English speakers, presents a dual challenge. To address this, global trends in education, such as Content and Language Integrated Learning (CLIL), have emerged, where technical subjects are taught alongside language acquisition. Recognizing the importance of language proficiency in technical fields, we incorporated a focus on specialized terminology into the project titled "Decarbonization of the Maritime Sector – Green Boka Bay, DeMS – GBB", led by the Faculty of Maritime Studies Kotor at the University of Montenegro. This project brings together researchers from diverse fields, including a PhD student new to the maritime domain.

Decarbonization in maritime transport is a relatively novel research area, demanding a nuanced understanding of technical terminology. This poses a significant challenge for novice researchers, particularly those who are not native English speakers. Consequently, one of the primary goals of our project is to identify and clarify the specific English terminology relevant to this field. With this objective in mind, we have formulated the following research questions:

1. Is there a statistically justified method for compiling a list of the most frequent technical terminology for a specific area of research?
2. What would be the practical implications of using corpus linguistics methods in technical research and technical language teaching and learning?

## 2. Corpus and Methodology

To obtain the list of technical vocabulary from our focus area of research, we adopted corpus linguistics methods and some contemporary software solutions for lexical analysis of text. In particular, we utilized the programs developed, updated, and freely offered by Laurence Anthony, a linguist and researcher (https://www.laurenceanthony.net/). These tools have been widely used in corpus linguistics research, especially in English for Specific Purposes, thus allowing for relevant comparisons of methods and results (e.g. Nation 2016; Đurović 2021; Vuković-Stamatović and Živković 2022).

To start with, the experts from the technical aspects of the project selected the relevant research papers published in scientific journals. The complication of research papers collected for further research under the DeMS-GBB project comprised the corpus of 21 relevant scientific papers presented in Table 1 (full references given under the section References).

Table 1. Target corpus composition

| No. | Paper | Tokens | Word types |
|---|---|---|---|
| 1 | Alzahrani A. et al (2001) Decarbonization in seaports: A review of directions for future research. | 18,314 | 3,767 |
| 2 | Amer A. M. et al. (2023) Exploring the regulatory framework of maritime decarbonization to achieve IMO GHG emission targets. | 4,304 | 1374 |
| 3 | Ampah J. D. et al. (2021) Reviewing two decades of cleaner alternative marine fuels: Towards IMO's decarbonization of the maritime transport sector. | 21,575 | 4,022 |
| 4 | Armstrong V. N. (2013) Vessel optimization in low carbon shipping. | 5,366 | 1,595 |
| 5 | Balcombe P. et al. (2019) How to decarbonize international shipping: Options for fuels, technologies and policies. | 16,327 | 3,674 |
| 6 | Chermariski E. et al. (2020) Decarbonization of maritime transport: Analysis of External Costs. | 5,778 | 1,721 |
| 7 | Diaz-Secades L. A. (2024) Enhancement of maritime sector decarbonization through the integration of fishing vessels into IMO energy efficiency measures. | 10,099 | 2,327 |
| 8 | Dong J. et al. (2022) A review of law and policy on decarbonization of shipping. | 10,999 | 2,237 |
| 9 | Dos Santos V. A. et al. (2022) The maritime sector and its problematic decarbonization: A systematic review of the contribution of alternative fuels. | 15,740 | 3,103 |
| 10 | Ezinna P. C. et al. (2021) Decarbonization and sustainable development goal 13: a reflection of the maritime sector. | 6,200 | 1,855 |
| 11 | Halim R. A. et al. (2018). Decarbonization pathways for international maritime transport: A model-based policy impact assessment. | 17,601 | 2,781 |
| 12 | Inal O. B. (2024) Decarbonization of shipping: Hydrogen and fuel cells legislation in the maritime industry. | 7,315 | 1,854 |
| 13 | Jeong B. et al. (2022). Decarbonization trend in international shipping sector. | 4,441 | 1,306 |
| 14 | Mallouppas G. and Yfantis, E. A. (2021) Decarbonization of shipping industry: A review of technology development, and innovation proposal. | 24,053 | 4,199 |
| 15 | Ngyen S. et al. (2023) Blockchain – Powered incentive system of JIT arrival operations and decarbonization in Maritime Shipping. | 16,062 | 2,789 |
| 16 | Psaraftis, H. N. and Kontovas, C. A. (2021) Decarbonization of maritime transport: is there light at the end of the tunnel? | 12,039 | 2,316 |
| 17 | Urban F. et al. (2024) Sector coupling for decarbonization and sustainable energy transition in Maritime shipping in Sweden. | 14,602 | 2,801 |
| 18 | Wang S. et al. (2023) Decarbonizing in the maritime transportation: Challenges and opportunities. | 9,805 | 2,534 |
| 19 | Wan Z. et al. (2018) Decarbonization in international shipping industry: Solutions and policy recommendations. | 6,965 | 2,037 |
| 20 | Zanobetti F. et al. (2023) Decarbonization of maritime transport: Sustainability assessment of alternative power systems. | 12,676 | 2,298 |
| 21 | Zis T. P.V. et al. (2020 ) Decarbonizing maritime transport: A Ro-Pax case study. | 12,754 | 2,296 |
| | Total | 253,114 | 17,314 |

As announced earlier, for the lexical processing and analysis of the papers, we used a set of software solutions developed by Laurence Anthony (https://www.laurenceanthony.net/). Firstly, we used AntFileConverter, version 2.0.2, and converted the selected papers into plain text format (.txt). In that way, we obtained the raw files totaling 253,114 tokens or running words, or 17,314 word types (Table 1). We then cleaned the corpus from irrelevant parts and elements, such as generative titles and subtitles, references, names, acknowledgments, journal data, and similar, for higher relevance of the results.

Preparing a corpus can be very demanding and time-consuming, but is a very important and necessary set of steps to achieve the adequate relevance of the results. For example, once we got the first results from the software, we noticed that some of the journals applied hyphenation for breaking words between lines. We then had to go back to the initial .txt version of the text and remove all the hyphenated segments so that we have complete words for further analysis. In final, the technical corpus for lexical analysis was reduced to 201,576 words or 43,068 word types for further analysis.

Considering that the focus of our analysis was on the specialized vocabulary of the area, we used AntWordProfiler, Version 2.1.0, to eliminate the most frequent General English (GE) words. For that purpose, we assigned the lists of the first 2,000 GE words from the British National Corpus and Corpus of Contemporary American English (BNC/COCA) developed by Paul Nation (Nation 2016). These 2,000 GE words are considered the most frequent words in the contemporary English Language, thus expected to be initially acquired by a language learner (Nation 2013: 18).

In addition, we tested the coverage of Academic Word List elicited by Averil Coxhead (2000) against our technical, but also academic papers. Further on, we presented additional possibilities of utilizing AntConc Version 1.2.1 for further analysis of terminology and phrases, as well as possible pedagogical implications.

For practical reasons, and taking into consideration the learning effort, word lists are generally presented in the form of headwords or word families. Considering that by initial conversion we obtain tokens or running words and that the programs generally provide results in word types or lemmatized forms, we used the Familizer+Lemmatizer Ver. 2.5 online program (https://www.lextutor.ca/familizer/) for converting the corpus vocabulary material and the results as required and recommended by the software and similar research.

## 3. The Most Frequent Technical Vocabulary of Research in Decarbonization in the Maritime Sector

After finalizing our technical corpus for further analysis, we used the AntWordProfiler Version 2.1.0, to obtain the frequency word list. Considering that we aimed at technical vocabulary, we assigned the first 2,000 GE words (BNC/COCA) to be deduced from further analysis, as they are generally anticipated to be familiar, as it is determined that we acquire vocabulary by its frequency. In addition, as it is generally the procedure in this kind of research for building word lists, we also eliminated the most frequent abbreviations, proper names, marginal words, and transparent compounds, also by assigning them as BNC/COCA word lists to the program settings.

Finally, we obtained a list of 47 headwords (word families) given alphabetically in Table 2.

Table 2. The word list of research papers on decarbonization in the maritime industry

| | | | |
|---|---|---|---|
| achieve | consumption | HFO | propulsion |
| alternative | data | hydrogen | regulations |
| ammonia | decarbonization | impact | review |
| analysis | diesel | implementation | sector |
| assessment | efficiency | index | solutions |
| biofuels | emission | international | sources |
| blockchain | factor | liquid marine | strategy |
| capacity | fossil fuel | maritime | sustainable |
| carbon | global | methanol nox | target |
| cargo cell | greenhouse | potential | technical |
| climate | GHG | | transport |
| | | | vessel |

Additionally and for curiosity reasons, we are also giving the first 10 words from the list ranked by their frequency (Table 3):

Table 3. The most frequent technical headwords from papers on decarbonization in the maritime industry

| Headword | Frequency | Headword | Frequency |
|---|---|---|---|
| fuel(s) 2,214 GHG 517 emission(s) 1,059 international 516 | | | |
| carbon maritime | 833 | hydrogen sector | 515 |
| marine | 697 | alternative | 465 |
| | 521 | | 445 |

We can conclude that the list of headwords obtained from research papers on decarbonization in the maritime industry is quite an attainable one in its simplest form of headwords. Considering the academic nature of the genre we focused on, we were also tempted to test the coverage of the Academic Word List (AWL), developed by Averil Coxhead, in our target corpus. For this purpose, we also used AntWordFile program (Version 2.1.0) and this time the assigned lists for testing the coverage were General Service List by West (1953) and AWL (Table 4).

Table 4. Coverage of GE and AWL lists in the target corpus

| Word list | Tokens | % |
|---|---|---|
| GSL | 135,635 | 67 |
| AWL | 26,802 | 13 |
| Out of the lists | 39,139 | 20 |
| Total | 201,576 | 100 |

Considering that our target genre is comprised of academic i.e. scientific papers, the significant level of academic words was expected and we can see that it is as high as 13% (Table 4). This makes it a higher than the average coverage in research articles and textbooks where it is measured at about 10% (Coxhead 2010).

## 4. Additional analysis and possibilities

Considering that the meaning of words is context-dependent, we delved deeper into our target corpus by exploring the most frequent collocations and n-grams. For this purpose, we used the AntConc program (Version 1.2.1). This software tool enables us to scan the corpus in search for word strings or patterns. We can do so by specifying the size(s) of the grams we seek to count and compare, while the program detects them within the corpus, as well as the number of occurrences.

It is noteworthy that n-grams are prevalent in our target corpus, indicating a significant frequency of occurrence. This observation reinforces the conclusion drawn from the size of the technical list obtained (Table 3), suggesting a shared terminology among the papers. This phenomenon contrasts with some other types of corpora (e.g. Đurović et al. 2022). For example, a 10-gram *international convention for the prevention of pollution from ships* is found with 4 occurrences, and as a 9-gram (without the acronym) even 7 times. The most frequent 5-grams, for example, are: *the international maritime organization IMO* (22 occurrences), *GHG emissions from international shipping* (19 occurrences), and similar. For practical reasons, we will not go into detail on this aspect, let us just mention that 3-grams such as *the shipping industry* has a frequency of 119, *the shipping sector* 87, and similar.

As we announced earlier, we wanted to explore words from our list in the context. To do so, we used the same program to see how our technical words collocate within our genre. If we set the program for collocations to the left, we find that the most frequent collocations are *dual fuel, marine fuel, heavy fuel, fossil fuel,* etc., with dozens of occurrences. The most frequent collocations to the right would be *fuel consumption, fuel cells, fuel oil, fuel savings,* etc. If we note that *fuel consumption* repeats 202 times in our data set and that we analyzed 21 research papers, we can once again confirm the high frequency i.e. overlapping of technical terminology, which is partly to be expected in a related area of research. We can further explore word clusters according to the number of assigned members (2+). For example, the most frequent cluster with *emission* is *emission(s) reduction(s)* with 196 occurrences.

All the above options are readily provided by the software tool, mostly available on the display ribbons. It requires familiarization with the program and its options, as well as close attention to the obtained results and their meticulous analysis.

Furthermore, the methodology has been proven as an efficient method in building dictionaries, especially practical for generating technical glossaries that can be made bilingual or multilingual in combination with any other language (Vuković and Živković 2022, Đurović 2021), as well as indexes accompanying technical textbooks (Đurović and Dlabač 2024).

## 5. Limitations of the study

The limitations applied to our study are those generally pertaining to similar research involving lexical analysis of corpora (e.g. Nation 2016, Brown 2010, Đurović and Dževerdanović 2023). The first constraints would refer to the size and composition of the corpus. Taking into consideration that some corpora count over a million or even several million running words, we can consider our research a smaller-scale one, or a case study, as implied by the title. This, in turn, has provided us with more practical results to handle and "cleaner" results, since we could be more dedicated to the details of the corpus and better prepare it for the analysis, which resulted in fewer conversion errors.

Also, our corpus was (intentionally) pretty uniform, i.e. we used only research papers published in scientific journals. A corpus that would incorporate additional textual material, such as conference papers, reports, manuals, relevant legislative material, and similar, would provide for somewhat different results. That is why the methodology applied and decisions made on the way must be indicated and justified (Nation 2016, Đurović 2021).

In addition, we need to bear in mind that Maritime English is characterized by polysemous or cryptotechnical words (Fraser 2009) that, taken out of maritime context, can be deemed as GE words, missing their actual contextual meaning. For example, we have *average* among the first 2,000 most frequent GE words, but as a part of the maritime syntagm *general average*, it carries a different, maritime-specific meaning. Bearing in mind that the most frequent content GE words are also the most prominently polysemous (Ravin and Leacock 2000), this is one of the aspects requiring additional attention when maritime corpora are in question. Also, the words we obtain beyond the first 2,000 GE words are not necessarily technical (e.g. *review*), but are still specific for the target corpus.

For the above reasons, this type of analysis is considered very useful, but never perfect since it cannot be reduced to merely statistical production of data. In addition, the methodology itself is constantly updated and upgraded, with an array of newly appearing software and AI tools at hand. Nevertheless, as we can see from the above, human intervention i.e. involvement of both language and technical professionals is still indispensable in the process.

## 6. Conclusion

Corpus linguistics methods impelled by contemporary software solutions enable us to conduct an array of lexical analyses of texts. In this case, we were challenged by the requirements of the national project dedicated to the decarbonization of the maritime sector in a specific area. Since the project anticipated the focus on technical terminology, especially for young researchers familiarizing themselves with the area of research in English, we used the software solutions for obtaining the technical word list from our target corpus of scientific papers on decarbonization in the maritime sector. We provided a very practical and attainable word list of 47 technical words with generally high frequency in our target corpus. Additionally, we demonstrated further possibilities of the software tools for lexical analysis of texts that can be of use to language instructors and researchers. One of the specifics detected in the analysis was highly repetitive technical vocabulary in a single area of research, which enabled us to obtain the list reflecting highly concentrated i.e. frequent vocabulary. Also, we meticulously presented the applied methodology that can be replicated and the results of which can be compared to other relevant findings from various technical areas of English for Specific Purposes.

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# Advanced CFD Fire Model in Ship Engine Room with VR Integration

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**Abstract:** An onboard fire is a multiparameter event that depends on various factors. Due to safety concerns, conducting live fire hazard training experiments is not a feasible option. The advent of virtual reality (VR) technology has provided a viable alternative for training individuals in hazardous situations.

The data and procedures presented here are research results aimed at improving fire hazard marine training. An innovative fire spread model for a ship's engine room has been developed. Employing computational fluid dynamics (CFD), the behavior of fire and smoke is represented accurately, thus enhancing the overall realism and effectiveness of the VR training simulations. The developed VR environment mimics the dynamic nature of onboard fires, reflecting the complex and evolving nature of such events. This level of immersion enables trainees to get a firsthand understanding of the challenges associated with firefighting, evacuation procedures, and emergency response protocols.

A scenario of a fire originated at the ship engine was developed. The results of the CFD analysis for this specific scenario are represented in the VR environment. Developed interface ensures the complex data from the CFD model is accurately transferred into the virtual reality environment, making the simulation more practical for real-time interaction and analysis. An initial user survey was conducted to determine the level of realism and validity of the VR model and the results are presented here.

*Keywords*: ship engine fire model; CFD; VR engine room fire

## 1. Introduction

Addressing fire hazards on marine structures and vessels is crucial as it significantly impacts ship design, engineering decisions, and training methods (Sim et al. 2019). The likelihood of a fire onboard involves multiple factors, and due to safety concerns, conducting live fire training is not practical. However, virtual reality (VR) technology offers a promising alternative for training in hazardous conditions (Smutny 2023).

A recent literature review (Vukelic et al. 2023) by the authors focused on applying VR technology in maritime firefighting and evacuation training. They identified a lack of evidence-based research in VR firefighting scenarios. Often, fire dynamics in VR are simplistically modeled, relying on the capabilities of video game development software. This approach can distort the realistic appearance of fire, affecting the authenticity of VR training. A proposed solution is to develop an evidence-based model of fire spread within VR, combining it with computational fluid dynamics (CFD). CFD tools can accurately simulate the initiation and spread of fire, including temperature changes and smoke behavior. By incorporating CFD results into VR, fire dynamics can be depicted more authentically, enhancing the training experience and providing more effective firefighting training.

This paper presents a model using CFD principles to simulate fire spread (temperature and smoke density) in a ship's engine room. A specific script transfers the CFD results to the VR environment, creating a detailed fire scenario in a ship engine room's VR setting. The goal is to develop an advanced, evidence-based maritime firefighting training scenario. The model was preliminarily validated by professional firefighters, demonstrating a perceptual difference between generic and CFD-based fires in the VR simulation of a ship engine room.

## 2. Methodology

The general approach and main steps taken to perform this study are given in Figure 1.

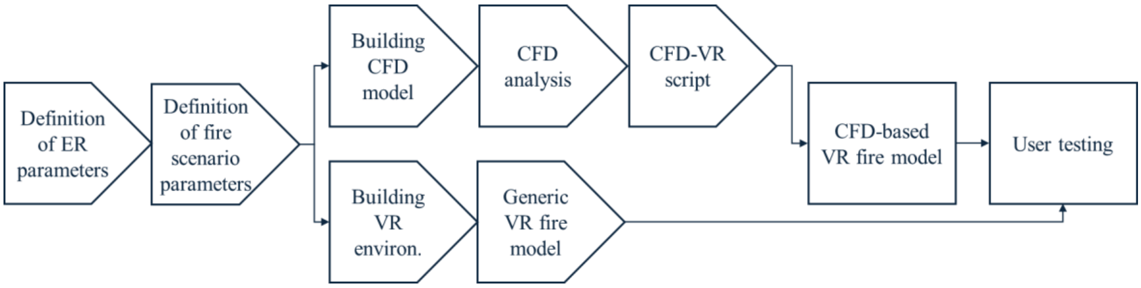
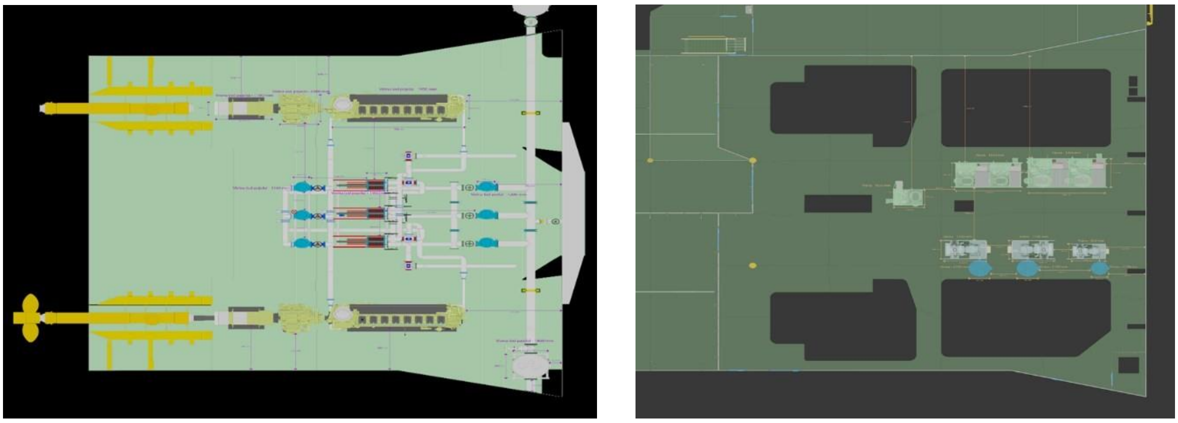


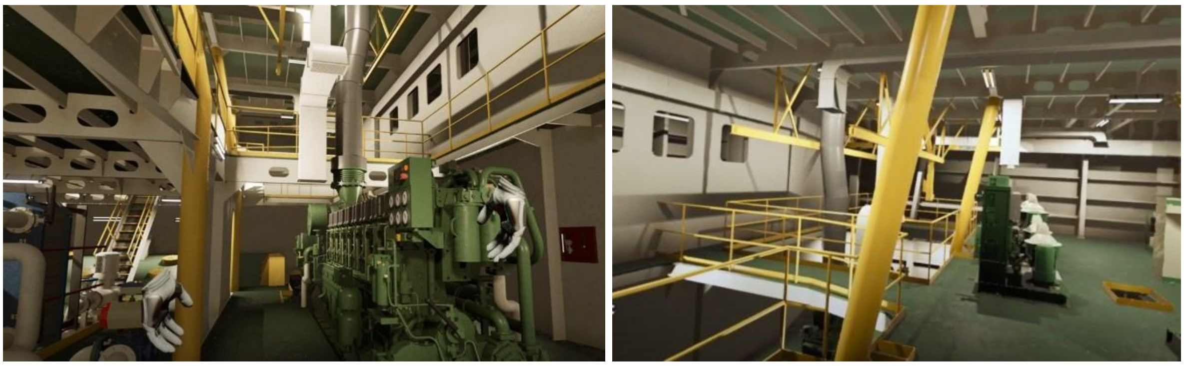

Figure 1. Flowchart of the study.

A model of the engine room was developed from the blueprints of an actual RO-RO ship's engine room, provided by the design office with authorization from the shipping company. This double-decked engine room measures 16.1x19.6 meters and features two main four-stroke diesel engines with shaft generators, along with three diesel generators, as illustrated in Figure 2. The lower deck houses the main and auxiliary engines, propeller shafts, sea, and freshwater cooling systems, along with pumps and valves. The upper deck includes two heavy fuel oil purifiers, one diesel oil purifier, two start air and one service air compressors, alongside fuel and lube oil tanks and other essential auxiliary equipment, valves, and pipelines. The ventilation system extends throughout the engine room, comprising 16 ducts that function either as delivery or reversible systems, with a stipulation that air exchange rates must be no less than 30 exchanges per hour (Mihai et al. 2022).



a) b)

Figure 2. Engine room layout: a) lower deck, b) upper deck.



a) b)

Figure 3. View of the engine room in virtual reality: a) lower deck, b) upper deck.

Virtual reality content is crafted using a specialized software framework, Unreal Engine, which comes equipped with essential libraries and support programs. Unreal Engine was chosen due to previous familiarity, its availability to non-commercial users, and its ability to deliver exceptional graphics, realistic lighting, and impressive visual effects, which significantly enhance the immersive experience. Additionally, it integrates smoothly with the Oculus Quest2 VR headsets used in subsequent applications. Images of ER in VR are given in Figure 3.

*2.1. CFD fire spread modelling*

For the CFD modeling, the engine room layout was simplified. Auxiliary rooms were omitted, and the main bi-level space was rendered as a simple square, excluding the two triangular "wings." These modifications result in less than a 1% difference in the total area but significantly improve the cell efficiency in the CFD simulation. Machinery was represented by cuboids of comparable size, as shown in Figure 4. Purifiers on the upper deck were not modeled as their impact on smoke behavior is minimal; however, the ventilation to these areas was included due to its significant influence on smoke stratification and the characteristics of hot smoke movement (Lan et al. 2023). Ventilation inlets and outlets were incorporated throughout the room according to technical specifications. The entire process of creating geometry, meshing with finite volumes, and fluid dynamics analysis was conducted using the CFD software Smartfire (Ewer et al. 2013), which is specially designed for fire modeling and simulation.

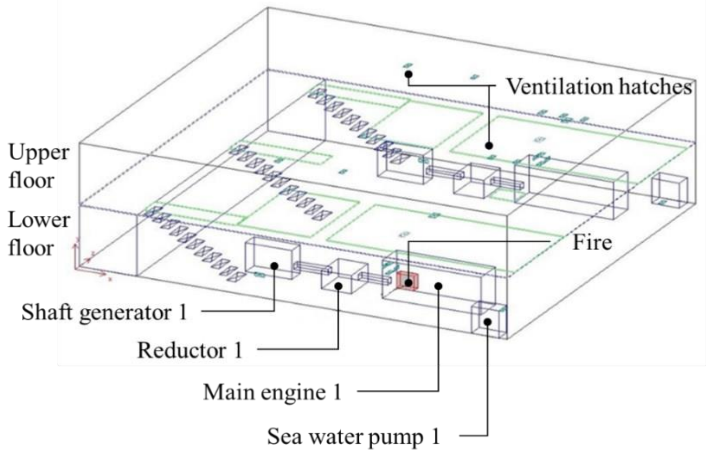



Figure 4. 3D model of the engine room.

The simulation procedure begins by selecting a scenario in which a fire originates from the main engine fuel oil pipeline. Previous research on ship engine room fires primarily examined pool fires. However, in practice, leaked liquid fuel often forms dynamically changing spill fires, which have not been extensively studied (Liu et al. 2023). The fire's starting point is positioned near one of the two main engines, as software constraints prevent placing the fire within the engine representation itself. The fire zone has dimensions of 0.76x0.75x0.33 m, as shown in Figure 3. The fire is modeled as a simple fire, and fuel generation is determined by the equation:

$$P = C \cdot t^2, \tag{1}$$

where C is a constant $6 \cdot e^{-7}$and the simulation runs for $t$ = 600 seconds. This scenario produces a maximum fuel output of 0.215568 kg/s, totaling 43.1352 kg of fuel involved in the fire. This amount of fuel, with a combustion heat value of 40 MJ/kg, leads to a maximum heat output of 8622.73 kW and an overall heat release of 1725.41 MJ.

*2.2. Transferring CFD results to the VR environment*

While both Smartfire and Unreal utilize voxels, transferring CFD analysis results directly into the game engine is not natively supported. This issue primarily arises because CFD results are stored in “.vtu” or “.vtk” formats, which are incompatible with the game engine's native file types. However, the Unreal Engine can import data from “.vdb” files, which are somewhat similar to “.vtu” files. This implies that conversion between these formats is feasible but requires a custom C++ script to be written.

### 3. Results and discussion

The outcomes of the conducted CFD fire spread analysis are displayed as the progression of smoke and temperature changes over time. Images from the final time step (600 seconds) showing smoke and temperature iso-surfaces are illustrated in Figure 5.

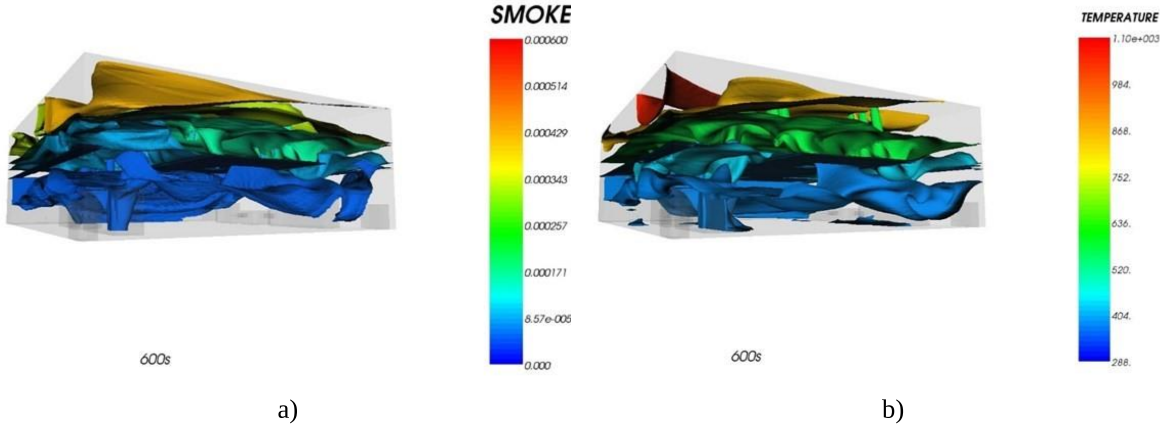



Figure 5. CFD analysis results presented at the last time step (600 s) in a form of iso-surfaces representing: a) smoke, b) temperature.

Fire can be realistically simulated within a VR environment using the native tools of a game engine. The Unreal Engine offers a suite of tools for fluid effects simulation which, according to the developers, employ physics-based methods to achieve realistic representations of fire, smoke, and other phenomena. In these simulations, fluid data can be depicted either through grids or particles. Specifically, gas simulations utilize a grid where each cell contains variables representing the medium's density, temperature, and velocity at that point (UnrealEngine5 2024). During smoke simulation rendering, the density grid is used to display areas of varying opacity based on density levels. In fire simulations, the color of the fire in each grid cell is determined by its temperature, with higher temperatures causing the gas to rise more swiftly due to buoyancy. According to the technical documentation, Unreal Engine employs 3D FLIP (Fluid-Implicit-Particle) simulations, where particle data is used to solve Lagrangian moment equations on a grid (Brackbill and Ruppel 1986).

The results were validated by replicating the Steckler's experiment (Steckler et al. 1982). The comparison results are shown in Figure 6.

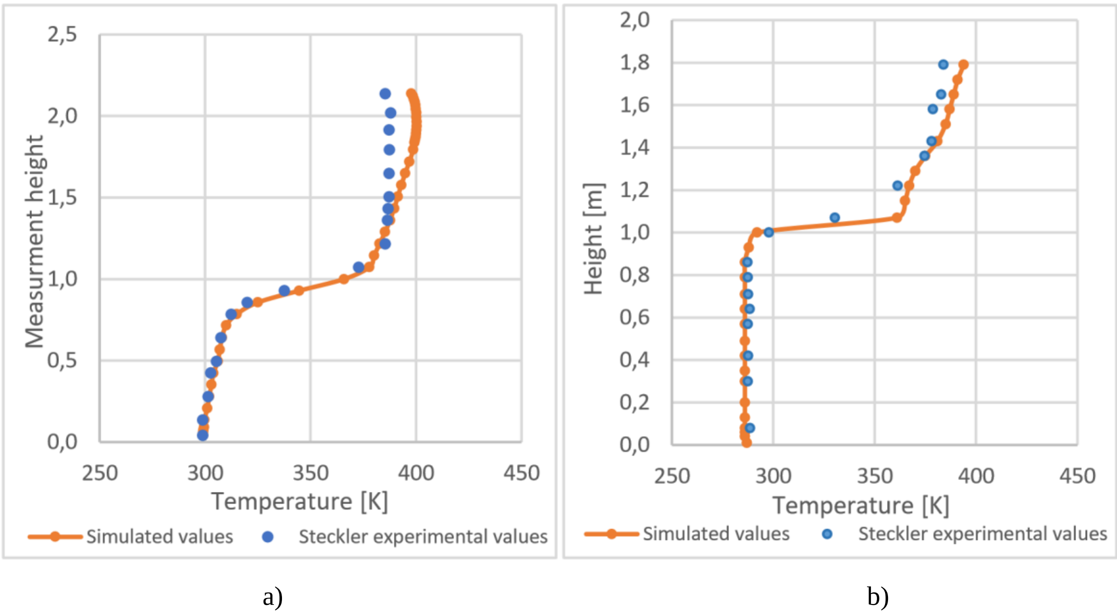



Figure 6. Comparison of the corner (a) and door sensors (b) for the Steckler's experiment and simulation.

As shown, the results of the corner sensor are very similar between experiment and simulation. The deviance is not greater than 3%. The deviance of the door sensor is not so simple. Although the similarity in the result graph is very high, the deviance graph shows discrepancies of more than 8 %. The discrepancy appears at the point in the air layer where there is a transient layer between two temperatures – low and high. The trend in the results graph is good, but this point deviates from the experimental results by more than 8 %. Since the experimental results are from the original graph, which was not in digital form, there may be deviances when converting the data due to the thick graph line, and since these points are in the thin transient layer, even a minor error in the height of the sensor position leads to significant temperature deviation. Another possible reason for such a deviance is that the door sensors were not completely still during the original experiment, which affected the measurement accuracy. All other result points are within a deviation of 3%, which is acceptable.

The authors leveraged this built-in feature of the game engine to model fire in the VR engine room environment, as depicted in Figure 7a and Figure 8a. These images are presented alongside those generated by integrating CFD and VR, as previously described, shown in Figures 7b and 8b.

a) b)

Figure 7. Fire and smoke on the lower deck of the engine room: a) VR generic, b) CFD-based.

a) b)

Figure 8. Smoke on the upper deck of the engine room: a) VR generic, b) CFD-based.

The images in Figures 7 and 8 capture the same moment within the fire spread scenario, revealing noticeable differences in smoke behavior. On the lower floor, depicted in Figure 7, variations in the appearance of the fire plume are observed, likely because of the ER ventilation system. The generic smoke typically rises directly above the fire source, whereas the CFD-based smoke is blown sideways. On the upper floor, shown in Figure 8, the generic smoke forms a distinct mushroom cloud with clear boundaries, whereas the CFD-based smoke disperses more uniformly across the area, with most of it concentrated above the floor opening.

VR technology allows mariners to experience realistic fire scenarios in a safe, controlled environment, enhancing their preparedness without the risks associated with live fire drills. By simulating various types of fires and emergency situations, VR can expose them to a wide range of scenarios that they might not encounter during traditional training, broadening their experience and response strategies. The immersive nature of VR helps improve the retention of firefighting techniques and procedures by providing a hands-on, interactive learning experience. VR training can be repeated multiple times, allowing participants to practice and perfect their skills, leading to increased confidence and competence in actual emergency situations. The technology enables real-time feedback and assessment, allowing trainers to identify and address any weaknesses or mistakes immediately, ensuring continuous improvement in firefighting effectiveness.

## 4. Conclusion

VR technology is increasingly utilized in firefighting training, and it's gradually being integrated into maritime firefighting training specifically. To enhance the uptake of this technology and bolster the authenticity of VR firefighting scenarios, the authors have developed an advanced VR model for fire spread in ship engine rooms. This model is grounded in evidence-based research, initially using computational fluid dynamics (CFD) to simulate fire spread, with the results subsequently imported into the VR environment. This approach marks a significant improvement over previous models that relied heavily on the game engine's built-in tools, which often produced exaggerated or inaccurately shaped fires.

In this study, a scenario involving a fire in the ship's main engine was crafted, considering factors such as airflow, temperature, and smoke density. The results are then rendered through VR technology, providing a more immersive and accurate depiction of fire spread. A key achievement of this research is the development of a script that seamlessly links the CFD outputs with the VR system. This integration allows for the complex data from the CFD model to be precisely conveyed into the VR environment, enhancing the simulation's utility for real-time interaction and analysis. Early user experience testing has yielded positive feedback, with participants noting that CFD-based smoke in VR appears more realistic than traditional VR smoke.

## Acknowledgements

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# Educating Global Maritime Professional: An Action Research to Implement Courses Regarding Effective Communication

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**Abstract:** This study aims to strengthen the interpersonal communication skills of future global maritime professionals through a collaborative e-learning initiative focused on effective communication, which is related to one of the focus areas of the Body of Knowledge (BoK) of the Global Maritime Professional (GMP) Initiative (IAMU, 2019). Specifically, this research explores the potential of collaboration among IAMU member universities in delivering the learning outcomes stated in the BoK as a teaching and learning strategy. Employing an action research methodology, instructors and students from different Maritime Education and Training (MET) member universities participated in determining the content and educational approaches needed to improve students' interpersonal communication skills. Subsequently, a collaborative e-learning course incorporating the content and various teaching and learning activities (TLA) emerged and underwent testing and evaluation with students representing three different MET institutions. These findings underscore pressing educational needs within the MET, particularly in verbal and written communication skills. The study highlights the value of implementing communication courses with students from different nationalities, revealing that despite time-zone disparities, culture, and language barriers, students not only enhance their communication skills but also cultivate essential social skills crucial for a Global Maritime Professional. IAMU member universities have faced numerous challenges in implementing the GMP and BoK. This study proposes alternative ways for GMP implementation, emphasizing the potential of member universities coming together to deliver BoK's focus areas and their learning outcomes effectively.

*Keywords*: Global Maritime Professional; Body of Knowledge; Interpersonal Communication, Action research, E-learning

## 1. Introduction

Seafarers' competency is regulated by the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), which sets basic standards for them to safely perform their responsibilities on ships. The present day has witnessed significant disruptions, such as technological advancement, political turmoil, and climate change, which are challenging the existing maritime education and training paradigm (Alop, 2019; Simmons & McLean, 2020). The requirements of seafarers are on the rise to deal with increasingly complex problems stemmed from such disturbances. Therefore, the method of training is unlikely to be the same.

In the contemporary era, maritime education emphasizes not only the technical expertise needed for seafarers to perform duties at sea but also soft skills and lifelong learning abilities, such as critical and analytical thinking. These skills help individuals tackle the growing challenges posed by disruptions and support their transition to a shore-based career (De Água et al., 2020; Manuel, 2017; Stefani & Apicella, 2022). Interpersonal communication is a crucial ability for seafarers that helps them perform jobs effectively and influences their overall nautical careers.

In that context, the International Association of Maritime Universities (IAMU) designed the Body of Knowledge (BoK), which outlines specific learning objectives necessary for future maritime professionals, highlighting interpersonal communication as a crucial soft skill. The document outlines several levels of outcomes in both cognitive and affective areas (IAMU, 2019, p.31 & p.42). The former's achievement level ranges from remembering to creating. The latter involves receiving and internalizing a value system. The instrument specifies learning outcomes for communication skills that are missing in the present maritime regulatory framework.

Maritime Education and Training Institutions (METIs) are the key stakeholders to incorporate new training requirements to their current curricula. Considering the international characteristic of the shipping industry, it is beneficial for METIs to collaborate with each other in this regard. For example, one METI can refer to other good practices of other METIs to adapt them to their program. However, Bolmsten et al., 2021 indicated that many maritime universities tend to operate in isolation and the lack of resources are one of the main challenges that hinder the collaboration.

The study analyzed the current status of learning and teaching activities (TLA) related to communication by focusing on stakeholders directly involved in these activities, such as students, lecturers, and curriculum developers. The researchers then work together with them to create a collaborative e-learning course, put it into action, and assess its effectiveness. This attempt not only experiment online learning approach to complement crucial skills for future seafarers but also enhance the collaboration between different maritime universities.

## 2. Aims and objectives

This study aims to enhance the collaboration between maritime education institutions by initiating joint elearning courses targeting "Effective Communication" topic, aligning with the focused area in the Body of Knowledge published by IAMU in 2019). To reach this aim, the following objectives are established:

1. Understand the needs of maritime academic institutions regarding the topic of interpersonal communication.
2. Identify and create e-learning course content that could complement the institutions' curriculum.
3. Determine the learning outcomes of the course based on the Body of Knowledge (BoK) and specific context of participating institutions.
4. Deliver and evaluate the outcomes of the course in collaboration with partnered institutions.

## 3. Methodology

The study employed action research as the primary methodology. Action research is a research methodology that puts theories into practice to produce practical knowledge or solutions for addressing urgent issues within social entities or communities. The strategy focuses on the collaboration between researchers and practitioners directly involved in and affected by the situation targeted for improvement by action research (Robson, 2002). For the scope of this study, the authors are researchers, and practitioners refer to lecturers, curriculum developers, and students participated in the action research.

In this case, the research sought to enhance collaboration between maritime academic institutions by developing joint e-learning courses. The research activities took place at three universities: Ho Chi Minh University of Transport (UTH), Maritime Academy of Asia and the Pacific (MAAP), and Batumi Navigation Teaching University (BNTU). The study builds upon the work of Bolmsten et al. (2021), which investigated the use of collaborative e-learning course to implement IAMU's BoK in different educational institutions.

The researchers designed, delivered, and evaluated the course together with directly involved people (i.e., lecturers, curriculum developers, students, and academic supervisors). The research team established a threestage action research cycle to guide the research process rigorously (Dittrich, 2008): **Phase 1:** Understand the context of participating maritime academic institutions (e.g., their curriculum, the perspectives of lecturers and students about the course, available resources); **Phase 2:** Develop and implement the e-learning course together with participants (e.g., lecturers, students, academic supervisors); and **Phase 3:** Evaluate the outcomes of the course. The cycle is depicted as follows:


Figure 1. Action research cycle

The qualitative data solicited from lecturers and students in the interviews in phase 1 and phase 3 were analyzed using thematic analysis. Braun and Clarke (2006) developed this approach, putting forward different steps to analyze and present qualitative data. The three main step includes: 1. Familiarize and code the data; 2. Generate basic and overarching themes; and 3. Write up.

## 4. Findings

### *4.1 Phase 1: Understand current status of maritime communication training and the needs of participants*

In this phase, researchers conducted semi-structured interviews with lecturers and students in three participating maritime universities to explore their perspectives on communication training and gain deeper understanding about participants' needs regarding communication subjects.

#### *4.1.1 Communication is essential both in daily life and at sea*

Although the contexts are different—interviews were conducted in different institutions in various countries—students and lecturers appreciate the importance of communication in general and specifically at sea. Some lecturers pointed out that good communication is vital not only to conduct duties onboard but also to form relationships between seafarers, thereby reducing loneliness and work stress.

The lecturers also indicated that communication onboard is not about perfection in terms of language but about being assertive and willing to talk and exchange ideas. In line with this, some students agreed that perfect English speaking does not always facilitate conversations; it is more important to pay attention to who you communicate with and adjust your speaking style so that both speakers and listeners are on the same page.

#### *4.1.2 Students lack confidence in their communication skills*

When researchers asked students to measure their communication skills from one to ten, most of them evaluated their ability with a score ranging from five to seven. No one assessed their skills at nine or ten. They highlighted some challenges, such as controlling emotions when speaking, struggling to find the proper words to convey their ideas or feelings, and lacking chances to practice regularly. Some lecturers also mentioned the influence of previous education of students. Enhancing communication is a continuous process. Inadequate training of students at the primary or secondary level makes it difficult to address this deficiency in higher education.

#### *4.1.3 The communication subjects in curriculum are not sufficient*

The communication training in different institutions varies: one of them does not have a specific course for communication but integrates communication outcomes in other subjects, while others have separate general English courses and maritime English subjects. Some students indicated that these courses lack adequate emphasis on practicing communication skills. Thus, there is a need for opportunities where learners can communicate with each other.

#### *4.1.4 Participants' interest in multinational learning experience regarding communication*

One of the objectives of the study is to create a collaborative learning experience for participants. All students and lecturers supported this idea. Some lecturers valued this opportunity, giving students chance to practice communication, especially with students from different nationalities and cultures. Similarly, some students appreciate the course considering their future multinational working environment.

*4.2 Phase 2: Develop and implement the intervention*

*4.2.1 Course development process*

After doing the needs analysis in Phase 1, the researchers started Phase 2 with course development. In developing the course, the following were considered: intended learning outcomes (ILO), content, modality, equipment and resources, duration, teaching and learning activities, and assessments. The researchers collaborated with the course developer participants to obtain their input in the development of the course. Finally, a timetable was developed and used during the implementation, as shown in Table 1.

Table 1. Course timetable

**Course title:** Maritime Interpersonal Communication

**Intended Learning Outcomes (ILOs):**

ILO1. Identify the components of a successful interpersonal communication cycle with particular reference to maritime operations

ILO2. Explain the principles and factors that influence optimum interpersonal communication in a maritime professional career

ILO3. Demonstrate the use of good interpersonal communications for productive maritime operational outcomes

| *Day* | *Topics* | *TLAs* | *Learning Modality* | *Assessment* | *Resources and Equipment* |
|---|---|---|---|---|---|
| 1 (60 mins) | Briefing and Orientation | - Ice-breaking activities<br>- Briefly introduce the course topic and content | Synchronous | | Zoom |
| 2 | - Email Etiquette<br>- Importance of effective communication on board - Components of a successful interpersonal communication cycle<br>- Interpersonal communication principles<br>- Barriers to effective communication | (individual)<br>- Practice sending emails<br>- Reading materials and discussing through Learning Management System (LMS) | Asynchronous | Output emails sent | Materials in LMS |
| 3 | BREAK | | | | |
| 4 | - Technique to develop effective communication skills<br>- Closed loop communications<br>- Concept of challenge and response | (by group)<br>- Reading provided materials, critique videos and sending the critique through LMS | Asynchronous | Written Video Critique | Materials in LMS |
| 5 (60 mins) | - Concept and visualization of challenge and response, closed loop communications<br>- Barriers to effective communication | - Lecture<br>- Debate on communicating activities in common maritime incidents | Synchronous | Debate discussion | Zoom |
| (30 mins) | Evaluation | Focus group interview | Synchronous | | Zoom |

The participants were grouped, considering the equal representation of the participating universities. It was intentional to see how students from different universities and with different nationalities communicate and work together to accomplish the tasks of the course. A break on day 3 was also considered, to give time off to the participants.

To be able to work together virtually, the student participants created a group chat without the instructors to freely communicate amongst the group. However, a general group chat was also created with the instructors for streamlined communication, specifically with concerns regarding instructions among others.

For activities done in asynchronous modality, a Learning Management System was developed where students could access the course materials and also contribute to the forums with their ideas. On the other hand, video conferencing with the use of Zoom was employed in synchronous teaching. More specifically, students were sent into breakout rooms to continue with group discussions, where the instructors observed how the students communicated.

Forms of assessments were also required, including sending emails and observing proper email etiquette, where the students communicated with a shipping company representative, and were sent to the instructor, where feedback was discussed in the last day. Students also critique videos about communication, where they needed to send a written critique, which was also discussed in the last day. Debate was also employed, where the students were able to exchange ideas about the use of English language onboard the ship. Overall, the students experienced working individually and in groups to attain the learning outcomes set by the course. More importantly, they were able to communicate with other people both in written and oral forms.

*4.2.2 Challenges*

One of the challenges encountered during the delivery of the course include issues with connectivity. Additionally, there were minor concerns with time difference, where, during the synchronous delivery, it was morning in Batumi, Georgia and afternoon in Ho Chi Minh, Vietnam and Mariveles, Bataan, Philippines, not to mention the constraints in the schedule of some students, who were preparing for the final examination. Nevertheless, the rest of the students continued with the course and completed it until day 5.

*4.3 Phase 3: Evaluate the outcomes of the course*

In this phase, researchers evaluate the outcomes of the course through the lens of participating students. They reflected their opinions about the course in a semi-structured interview and gave their feedback in the form that was given after the last synchronous session. The key themes stemming from the evaluation are:

*4.3.1 Enhancing life-long learning skills*

In addition to attaining intended learning outcomes, many students highlighted that they have developed so-called life-long learning skills such as critical thinking, adaptability, social skills, and problem solving skills. One student indicated that through debate activities, he learned how to look at a problem from different angles and understand the opinions of others by critically examining them. Another appreciated the chance to find solutions to group working problems and improvise to achieve the outcome of the group activities.

Many students also specified that they have enhanced their social skills, making new friends from different nationalities. During their time working together, they acknowledged differences in culture, accent, and time and overcame barriers to communicate with each other to accomplish both individual and group exercises. Some students shared that they increased their confidence in communication, particularly with foreign classmates and they have learned to be more assertive.

*4.3.2 Multinational learning environment is valuable*

Numerous students appreciated the opportunity to collaborate with classmates from different countries. This training provides the chance for individuals to practice interacting with others from diverse cultural backgrounds, preparing them for their future international working environment onboard ships. Some students highlighted that this is the difference between the course and the curriculum in their institutions. Furthermore, they also indicated that the learning activities helped them step out of their comfort zone, communicating with people from various cultures and accents.

*4.3.3 Lack of communication activities in universities' curriculum*

Through the course, some students realized that they lacked communication training at their universities. For example, one student pointed out that he had never learned similar skills at his university. Another indicated that the activities in the course were different from the English subjects in his university's curriculum. In line with this, one student commented that the course enabled him to practice, unlike the English subjects at the university, where he merely memorized the knowledge. Another group of students reported that they appreciate email etiquette activities as they lack these practical skills during training at their institutions.

*4.3.4 Variety of learning content increase attention span*

One interesting insight solicited from students is the impact of diversifying the learning activities. On each day of the course, students were required to do different tasks individually or as a group, ranging from reading comprehension, email practice, video critique, and debate. Students stated that they engaged in these activities, and different learning activities keep them focused and helped maintain their attention.

**5. Discussion and conclusion**

The outcome of the action research cycle informs researchers about the need for communication training in maritime educational institutions. At these universities, participants, particularly lecturers, who has seafaring experience, recognized the significance of communication skills for conducting technical work effectively and fostering social relationship onboard, thereby reducing work-related stress. These findings align with Ahmmed

(2018), indicating that good communication skills affect both professional and personal lives. The education needs for communication in the maritime domain are also evident in the study conducted by Bolmsten et al. (2021).

The study determined learning outcomes for interpersonal communication based on the inputs from the first phase and the achievement level of communication training in BoK. From the students' perspective, the course complemented communication subjects at participating institutions. Communication skills should be prioritized as essential life-long skills for future mariners to succeed in their careers, in addition to technical skills.

The collaborative e-learning course in the study is an interesting intervention, bringing students from different institutions together to create a multinational learning environment. The e-learning approach helps METIs minimize the travel expenses and time investment for the collaboration, facilitating the connection between them. By implementing such a collaborative course, the institutions can learn from each other and share good practices. The approach is also advocated by Vuong (2021).

In summation, researchers posit the joint e-learning course as an innovative educational intervention, aiming to enhance the collaboration between maritime universities to improve communication skills for students. This prototype should be a first step, paving the way for maritime educational institutions to maintain such collaborative courses as one approach to complementing necessary skills that will help future seafarers become global maritime professionals.

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# Students' Mental Wellness: Basis for Designing a Wellness Intervention Program for Maritime Students

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**Abstract:** Mental health issues remain a matter of concern worldwide and in our society. Seafaring is one industry where these issues are not commonly addressed due to a dearth of studies, especially on Filipino seafarers. This study aimed to determine the level of mental wellness among maritime students and to design an intervention program to develop their mental wellness. The study employed a descriptive-correlational design in a sample of 320 students drawn from a population of 1897 maritime students of a maritime university. Mental wellness was determined through a standardized test adapted from Warwick-Edinburgh's (2007) Mental Well-being Scale. The result of the maritime students' level of mental wellness was measured as moderate regardless of their ages, academic year levels, and college programs. There was also no significant difference nor influence from these variables on their mental wellness. The results show that the moderate level of mental wellness among these maritime students does not constitute an absence of mental illnesses or vice versa. Furthermore, the moderate level could still gain much and improve resilience and quality of life by taking evidence-based activities.

*Keywords*: mental health; mental wellness; wellness; well-being; intervention program

## 1. Introduction

### *1.1 Background of the Study*

Mental health has remained to be a matter of global concern. According to the World Health Organization (2022), 280 million people worldwide are affected by depression as a serious form of mental illness. During Mental Health Awareness Week in the U.K. in 2020, a higher number of seafarers appeared to suffer from depression than other working groups. Factors of mental health disorders among seafarers included environmental work factors, job satisfaction, and self-rated health (ISWAN, 2020). This state of mind can be catastrophic and fatal if not given proper attention (Abila & Acejo, 2021; Iversen, 2012; Lucas et al., 2021).

In the 63 studies reviewed by Brooks and Greenberg (2022), various risk factors, such as being younger, being single, and having poor physical health, were associated with poor mental health among seafarers. Additional factors included being around noise and vibration, feeling unsafe, having a demanding job, working long hours, working nights or irregular shifts, getting little sleep, having a bad team cohesiveness, having a low opinion of the management, having little social support, having little autonomy, having unpredictable schedules, spending a lot of time at sea, and being overly committed. A recent assessment of studies on the mental health of seafarers revealed that during the previous ten years, the prevalence of psychological disorders and mental health problems ranged from 28 to 65%, depressive symptoms from 14 to 49%, and burnout at 10.8% (Jonglertmontree et al., 2022). In the Philippines, a recent study by Abila and Acejo (2021) stated that there is a scarcity of academically published research that tackles seafarers' mental health in the Philippines. The few primary data sources on Filipino seafarers lack focus on mental health needs, making it difficult to grasp the extent of the problem. There are inconsistent reports of seafarers' disclosure of mental health and disclosure from ship operators and companies. The lack of a mandatory centralized database also offers little help in understanding other effects of poor mental health. This suggests that further studies and data are vital in determining what more could be done to promote better mental health among Filipino seafarers (Abila & Acejo, 2021).

Maritime Institutions play a crucial role in ensuring that future seafarers are mentally prepared to face the realities of seafaring. In the context of the academe, it is deemed essential to develop policies and programs for the promotion of mental health (Abila & Acejo, 2021) and integrate stress management and diversity training in the higher education of future seafarers on board to ensure mental readiness (Jensen & Oldenburg, 2020). Ideally, maritime students and seafarers must be educated on the basics of mental health to train them mentally and holistically (Abila & Acejo, 2021). In general, the state of mental wellness of maritime students could serve as a basis for building structured programs to prepare them for the realities they will face as professionals. Instead of waiting for a mental ailment to strike when they are already onboard, developing proactive mental wellness programs and activities tailored for maritime students could improve their preparedness to deal with challenging situations.

*1.2 Objectives*

The purpose of this study was to gather baseline data that could be used as a basis for designing a mental wellness intervention program that maritime schools can use to prepare their students for the realities of life on board. It sought to (1) determine the maritime students' mental wellness level when taken as a whole and grouped according to age, academic year level, and college program, (2) determine if there was a significant difference in the maritime students' mental wellness when grouped according to the variables mentioned above, and (3) determine which among the three variables significantly influences the maritime students' mental wellness.

*1.2 Conceptual Framework*

Figure 1 illustrates the concept of this study in the IPO framework. The input presents the profile of maritime students in terms of age, academic year level, and college program. The process of the research involves measuring the level of mental wellness of the said students. Lastly, the output points to the development of a mental wellness intervention program based on the results of the study.

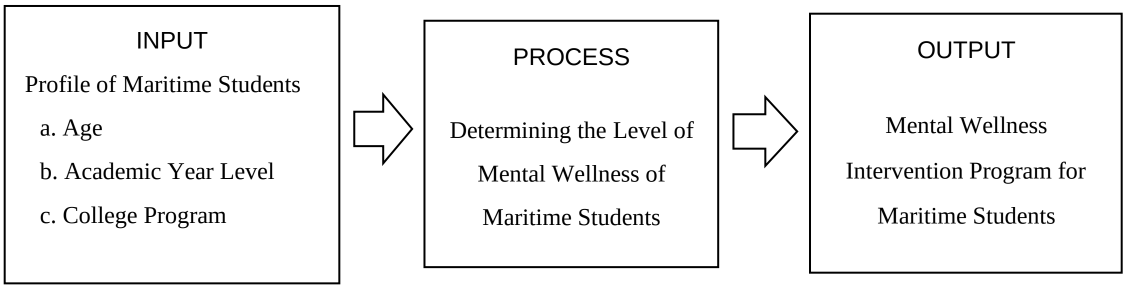


Figure 1. Schematic Diagram of the Concept of the Study

## 2. Methods

The study employed a descriptive-correlational research design using the survey method. Stratified random sampling was used to select a sample of 320 from a population of 1897 maritime students enrolled during the second semester of the school year 2022-2023.

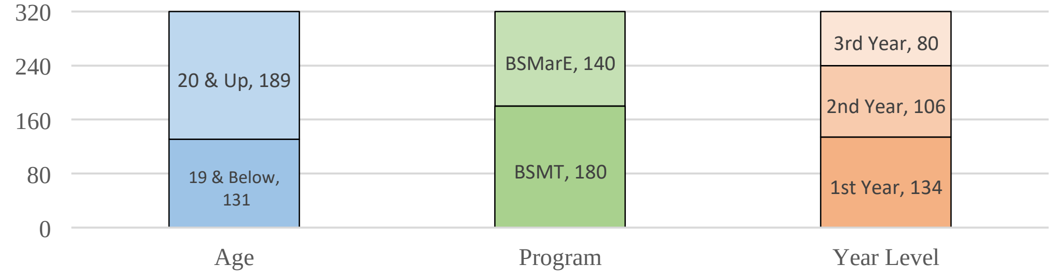


Figure 2. Profile of the Respondents

The research instrument was adapted from Warwick-Edinburgh's (2007) Mental Well-being Scale (WEMWBS), which underwent construct validity in the United Kingdom. Its reliability was tested using Cronbach's alpha, resulting in a coefficient value of 0.89 (n=348), interpreted as high. The scale was first registered before being used at the University of Warwick, England, through online registration for noncommercial use.

Mean and Standard Deviation were used to measure the maritime students' mental wellness level. The adapted instrument's analysis tool categorizes the respondents as having low well-being, where the total score is less than 43, moderate for 43-60, and high for greater than 60.

To find out if there is a significant difference in the mental wellness of the students when grouped according to age and college program, a t-test was carried out. Analysis of Variance was used when the students were grouped according to their academic year level. Regression analysis was used to determine which variables significantly influence/s their mental wellness.

## 3. Results and Discussion

The findings showed that the level of mental wellness among the sample size was moderate as a whole and when grouped according to age, academic year level, and college program. No significant differences were noted between the groups.

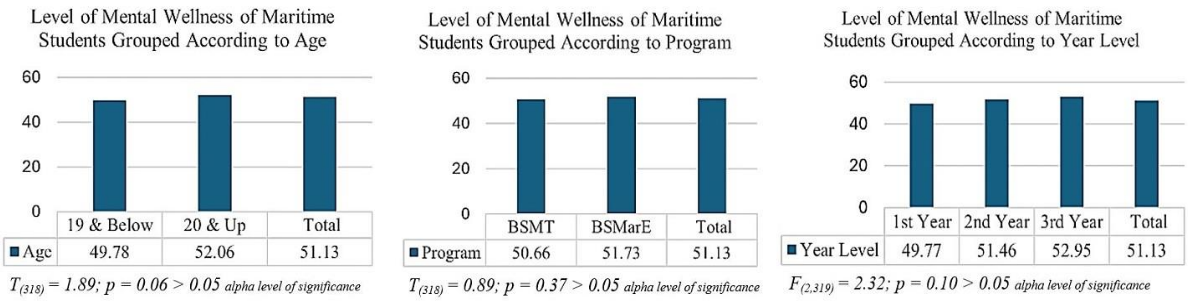


Figure 3. Level of Mental Wellness of Maritime Students

The Regression Analysis test resulted in (F=1.84, p=0.14), interpreted as not significant at 0.05 alpha level. Data from the questionnaires revealed that age, programs, and year level did not significantly influence maritime students' mental wellness.

Table 1. Regression Analysis Results

| Variables | r | $r^2$ | F | p |
|---|---|---|---|---|
| Age<br>College Program<br>Academic Year Level | 0.131 | 0.017 | 1.84 | 0.14 |

*p < 0.05, significant alpha level of significance

The study of Oldenburg et al. (2013) found that emotional exhaustion was not significantly associated with age. Likewise**,** Jo and Koh (2021) found well-being and age to have no association. On the other hand, Lipson and Eisenberg (2017) emphasized that the well-being of students in higher education is under attention. Students' ages in full-time higher education generally range between 17–24 years, which is also the critical age for the onset of psychological problems. According to McGroarty (2021), mental health can both lessen and prevent mental illness. Raising our degree of mental wellbeing can both prevent mental disease from occurring and lessen its symptoms. The same source also demonstrated that, independent of a mental disease diagnosis, people who are "flourishing" outperform those who are "languishing" or in middling mental wellbeing. Compared to individuals who continued to thrive, those whose degree of mental wellbeing fell from thriving to moderate had a nearly 3.5-fold increased risk of mental disease. On the other hand, mental illness was 86% more likely to strike those whose mental wellbeing sank from moderate to languishing. According to Keyes (2002), raising one's level of mental wellbeing from low to moderate cuts the likelihood of developing mental disease in the future in half. It does not imply that mental health issues can be resolved or treated; however, it is becoming more widely acknowledged that the behaviors that enhance and support our mental wellness—such as getting enough sleep, eating a healthy diet, exercising, forming meaningful relationships, managing stress, and practicing meditation—protect our mental health and lessen the severity and symptoms of mental illness. The review of Brooks and Greenberg (2022) on ethnicity as a predictive factor of mental health presented mixed results. Oldenburg and Jensen (2019) found that subjective stress is not associated with ethnicity. However, one study showed that those with Hispanic/Latino ethnicity have a higher risk of depression (Arcury-Quandt et al., 2019). Europe and the Philippines have more claims of mental illnesses compared to other parts of Asia (Lefkowitz et al., 2019).

## 4. Conclusions and Recommendations

The study provides a comprehensive overview of research on maritime students' mental wellness and well-being. The results generally reveal interesting drift in the field's evolution over the years and provide a better understanding of maritime students' mental health and well-being.

The study concluded that though the students' level of mental wellness was moderate – meaning they are doing well – the score could still gain much in terms of resilience and quality of life by taking evidence-based activities to improve their mental well-being.

Scientific findings on the mental wellness of maritime students support the notion that mental wellness is not a static state of being but is more about prevention. It is a lifelong process and a proactive strategy to strengthen maritime students' mental, emotional, social, and psychological aspects. Moreover, mental wellness is about prevention, coping with life's adversity, and resilience when facing stress, worry, loneliness, anger, and sadness. This is fundamental in seafaring since problems aboard the ship are varied.

Interestingly, Keyes' (2002) Dual Continuum Model shows that mental illness does not necessarily imply an absence of mental wellness and vice versa. Mental wellness can co-exist with mental illness. Improving one's mental wellness is recognized to be a protective factor for mental health and aids in reducing the severity of mental illness symptoms (Abila & Acejo, 2021).

Based on the findings gathered, the researchers of this study have proposed a Mental Wellness Program and other institutional initiatives to promote mental wellness among maritime students.

Table 2. Proposed Mental Wellness Program

| Program | Strategic Objectives | Plans and Activities | Timeline | Persons/ Departments Responsible |
|---|---|---|---|---|
| HEALTH SCREENING | Conduct regular health screening and assessments for assessing and managing students' health. | a. Pre-Screening of Enrollees through a series of Psychological Tests | Before Enrolling in the First year | Student Affairs Services |
| | | b. Determine Psychological Condition during SHS years | Before Enrolling in the First year | Student Affairs Services, Basic Education Department |
| | | c. Career Assessment of incoming Freshmen (Aptitude Test) | Before Enrolling in the First year | Student Affairs Services, Basic Education Department |
| REGULAR CHECK-INS | Assess and enhance students' wellbeing ensuring continuous feedback to identify potential issues | a. Do a longitudinal study to monitor the mental wellbeing of Maritime Students | 1st year to 3rd year | Research Department, College of Maritime Education |
| | | b. Create a series of activities as mental exercises | 1st year to 3rd year | Student Affairs Services, College of Maritime Education |
| | | c. Hands-on career exposure of maritime students for building mental rigidity | 1st year to 3rd year | Student Affairs Services, College of Maritime Education |
| | | d. Provide accessible mental health care and therapies | 1st year to 3rd year | Student Affairs Services |
| MENTAL HEALTH SUPPORT | Provide access to mental health resources, counseling, and stress management workshops to support student's emotional wellbeing. | a. Conduct psychological tests prior onboard training | Post Graduation | Student Affairs Services, School Psychologist, Guidance Counselor |
| | | b. Create a Mental Health Hotline for Onboard Trainees and Alumni | Post Graduation | Onboard Training Office Student Affairs Services |

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# Achieving gender equality through simulator training

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**Abstract:** Simulators in maritime education and training (MET) have been advancing with the rise of modern technologies and industry needs. While technical benefits of using simulators for training are often emphasized, its social benefits are hardly discussed. This paper argues how simulator training is potentially beneficial to promote equal access to MET as well as achieving gender equality. A mixed method was used to conduct (1) conceptual analysis of simulator training at philosophical level; and (2) quantitative analysis of gender-segregated data on simulator instructors around the world at pragmatic level. First, the characteristics of onboard and simulator training were critically analyzed by using gender theories and philosophical inquiries, including ontology and epistemology. Second, our data sampled from six MET institutions show that simulator instructors on average were mostly men (91.7%), and women were even zero in some MET institutions. More gender-balanced teaching staff, including simulator instructors, will increase an overall awareness of gender equality and incorporate various perspectives and pedagogical inputs to teaching. The paper concludes that simulator training has social benefits of providing fair and quality education for all, including women, as well as career opportunities to work as simulator instructors who can contribute to the gender equal future of MET.

*Keywords*: simulator training and onboard training; social benefits; gender equality; fair and quality MET

## 1. Introduction

Simulator training has been recognized as an effective and alternative training method to onboard training and gaining high attention in recent years (Demirel and Albayrak 2022). Currently, some aspects of maritime training mandate the use of simulators. For instance, radar operation training has been mandatory for simulator use since the 1995 amendments of STCW; and Electronic Chart Display and Information Systems (ECDIS) became mandated for using simulators since the 2010 Manila amendment under Regulation I/12 and Section A-I/12 of STCW Code. Furthermore, the Maritime and Coastguard Agency (MCA) approved a course which permitted the approved maritime colleges to credit the use of a bridge watchkeeping skills simulator towards the seagoing service requirements (UK Ship Register 2020). As simulator technology advances, a big potential of simulators has been recognized that they contribute to quality MET at technical level, such as resembling technical aspects of onboard training. While such technical benefits of simulator training are often highlighted, its social benefits are hardly discussed.

It is known in the maritime industry that limited number of cadets are given access to berths and not everyone can complete the mandatory 12-month onboard training in order to obtain a Certificate of Competency (CoC) (Chkhikbadze and Kitada 2022, Frimpong 2023, Rosario et al. 2020). Insufficient onboard training opportunities have been reported by cadets for years (Demirel 2020). This situation is even more severe for women cadets who tend to be less favored by shipowners in employment (Kitada and Langåker 2017; GMF 2023). An assumption can be made that gender-based discrimination against cadets is less likely to happen in simulator training compared to onboard training, thus simulator training could improve equal access to quality MET as well as contributing to a sustainable maritime workforce (Kim et al. 2021).

Our focus is on how fair MET is achievable rather than MET should be fair. This paper argues how simulator training is potentially beneficial to promote equal access to MET as well as achieving gender equality. Despite a slow but small increase of women cadets in MET institutions in recent years (BIMCO and ICS 2021), there is little research addressing the gender balance of MET instructors. The study also suggests where and how the current practices in simulator training can be improved to maximize its potential to achieve these goals. The following sections are structured as follows: Methods of this study are presented in Section 2 and maritime simulator and its implication to gender is presented in Section 3. This is followed by Section 4 on the empirical data analysis on simulator instructors and their gender, and the conclusion is presented in Section 5.

## 2. Methods

The study employs a mixed method of: (1) conceptual analysis of simulator training at philosophical level; and (2) quantitative analysis of gender-segregated data on simulator instructors around the world at pragmatic level. First, the study explored the implications of gender in simulator training as well as onboard training, using conceptual analysis of which Hanna (1998) explains direct definitional analysis of conceptual contents. The essence and characteristics of simulators were critically analyzed in terms of their purposes and abilities by reflecting social and gender theories and identified knowledge gaps.

Second, the study also benefited from the collection of gender-disaggregated data about simulator instructors from six MET institutions located in different countries (i.e., Germany, India, Japan, the Philippines, Sweden, and the UK). Simulator instructors were defined as those who use simulators for training. An opportunistic sampling method was used by directly contacting MET institutions. Descriptive analysis of quantitative data was presented to show the gender balance of simulator instructors in those selected MET institutions and to discuss the implication of gender in simulator training for fair and quality MET.

## 3. Maritime simulator and its implication to gender

### *3.1 History of simulators*

Simulators have been utilized in medicine for thousands of years, such as materials to mimic human bodies and clay livers (Bienstock and Heuer 2022). For simulator training, Hippocrates advised the necessity of using simulators for practical training in 460-367 BC while Aristotle emphasized the importance of feedback and repetition to develop specialized skills and knowledge (Owen 2016).

In the maritime field, simulator technology was developed in the late 1950s for training on how to use a radar. However, it was used on a limited basis, such as research and design of ship and port (Muirhead 2003). Several countries, including Sweden, the Netherlands, the US, and Japan, introduced the first ship-handling simulators in the late 1960s (Nautilus International 2021). The first meeting of the International Marine Simulation Forum (IMSF) was held in 1978 to discuss the use of simulators in MET and exchange ideas for the development of simulation-related standards and regulations (IMSF 2024). Compared to the world history of simulators and their application in training, the use of simulators in MET is a relatively new field.

### *3.2 Simulator training vs. Onboard training from gender perspectives*

Onboard training takes place at open sea where risks and hazards are surrounded whereas simulator training is offered in a closed and protected space out of real risks. It is indicative that the conditions of an onboard training environment typically attribute to masculine norms and a simulator training environment arguably implies feminine norms. A similar notion of gender division is presented by Scharff (1992) who explains that the first design of cars did not have a roof which was considered to remind of a home where women stayed inside the fences. Apparently, it is an outdated understanding of gender division, but gender roles such as breadwinner men and homemaker women still exist in many societies. In this regard, moving from onboard training to simulator training can be seen as feminization of training.

On the other hand, simulator training has a masculine element since it can *control* the environment of navigation, such as weather, sea conditions, and geographical and traffic conditions. Conquering the environment has been seen in the development of human culture, namely a series of industrialization, through extracting natural resources for manufacturing. This attitude is embraced as industrial masculinities (Hultman and Pulé 2018) which is associated with the progress of civilization to force nature "to obey human will, under the guidance of science" (Freud 2010). An American anthropologist, Alezander Goldenweiser asserts that 'humans change the natural environment' and 'make their own environment instead of being determined by it' (Moran EF and Brondízio 2012). Simulators have an ability of both *control* (masculinist) and *choice* (feminist); however, onboard training cannot do so, because it totally depends on the natural environment. From this natureindependence/dependence discourse, it is possible to state that simulator training permits human's agency to *control* and *choose* the natural environment as we wish, hence more progressive and flexible than onboard training.

Additionally, it is important to note that there is no standardized onboard training, because onboard training can look quite different depending on ship type, cargo, ship age, Captain and the crew, voyage route and weather conditions, among others. Acknowledging the diversity of onboard training questions the homogeneity of onboard training as one fixed type of training or a standardized artifact. In fact, the diversity of onboard training is evident compared to scenario-based simulator training. In this regard, onboard training is dynamic and unexpected compared to simulator training.

*3.3 Replica of reality*

On many occasions, marine simulators replicate the reality of the marine environment and bridge/engine room on board. “Replica” is originally an Italian word for copy, repetition, and reply, meaning reproduced artwork, derived from a Latin word of “replicate” (Hoad 2003). The exact reproduction of the object, including marine environment and navigation equipment, is aimed, if not achieved, by marine simulators. What has been replicated so far by simulators poses an ontological question of what else can be replicated. To get closer to the reality, simulators have been evolved to faithfully replicate various technical aspects of ship operation, taking into account vibrations and ship motions like swaying, rolling and pitching. What has not been considered for the replication by simulators are social aspects. Ironically, the male-dominated work environment as a social aspect exists in simulator training without intending the replica of male-dominance at sea. What if we are more conscious about achieving gender equality through simulator training? If gender equality starts in MET, how can we accommodate the philosophy of fair and quality MET towards the sustainable future of maritime industry, including gender equality? An epistemological approach to replicate what it should be in future instead of what it is now is to strengthen the merit and rationale of using simulator training which is capable of replicating gender equal values at a faster pace than onboard training. With such potentials of simulators, MET can consider multi-level simulation on both the biosphere and social sphere to reflect the future vision of sustainable shipping.

**4. Simulator instructors: Gender analysis**

The role of simulator instructors is specified in the IMO model course 6.10, as a facilitator, dedicated teacher, manager, flexible and adaptable, learning strategist/organizer, guide, motivator, evaluator, and native psychologist. They are expected to have operational experience/familiarization, technical/subject-related knowledge, and pedagogical skills (IMO 2012). In the section of technical/subject-related knowledge, at least the same qualifications (CoC) as the students are recommended. As argued in the earlier section, women tend to face more challenges to obtain CoC than men due to their access to training berths, which means that fewer women can apply for a simulator instructor job. Nevertheless, the described roles of simulator instructors with required knowledge and experience do not have any gender implications. In contrast, onboard training instructors as active seafarers are expected to possess a certain level of fitness associated to masculine norms and values. It is therefore possible to assume that the position of simulator instructors carries no gender bias, meaning that there is no evidence to hinder women to become simulator instructors. Simulator instructor jobs are technically equivalent to seafarers despite being shore-based, providing a better work-life career opportunity.

Based on the gender-segregated data collected from six MET institutions in six different countries (i.e., Germany, India, Japan, the Philippines, Sweden, and the UK), it revealed that simulator instructors in all sampled MET institutions (n=109) are mostly men (n=100; 91.7% on average), and women (n=9; 8.3% on average) are even zero in some MET institutions (Table 1 and Figure 1), which replicates a male-dominated workplace on board ships. It is ironic that the current simulator training “simulates” not only technical aspects (e.g., bridge, workstation) but also social aspects (e.g., gender imbalance). The status-quo of socio-technical systems in simulator training can be modernized in MET institutions which can act as an active agent for gender equality.

Today, many MET institutions are aware of the importance of gender equality in MET and speak about increasing the number of women students to enroll in nautical and engineering courses. However, it is equally important to consider the gender balance of teaching staff, including simulator instructors. The merits of genderbalanced teaching staff are expected to increase an overall awareness of gender equality and incorporate various perspectives and pedagogical inputs to teaching (Barahona-Fuentes et al. 2023). Feminization of training by increasing the use of simulators will have a potential to reshape maritime science and its institution to accommodate women in MET.

Table 1. Gender disaggregated data of simulator instructors in selected MET institutions (Data collected in January 2024; * Nautical department only.)

| METIs | Country | Male | Female | % of female instructors |
|---|---|---|---|---|
| A | Philippines | 56 | 4 | 6.7% |
| B | India | 18 | 0 | 0.0% |
| C | Sweden | 11 | 1 | 8.3% |
| D | UK | 8 | 0 | 0.0% |
| E* | Germany | 6 | 3 | 33.3% |
| F | Japan | 1 | 1 | 50.0% |
| **Total** | | **100** | **9** | **8.3%** |

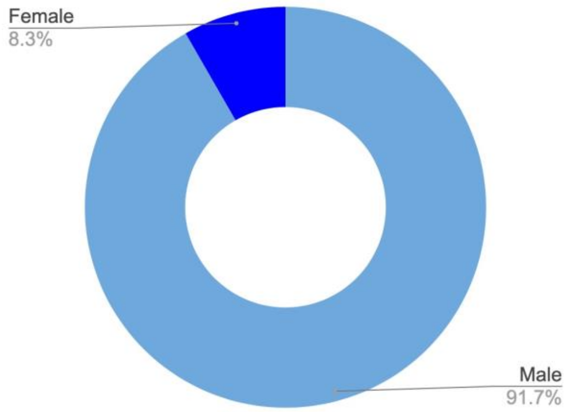


Figure 1. The average percentages of female and male simulator instructors in selected MET institutions (n=6) (Data collected in January 2024; One of MET institutions submitted the data from the nautical department only.)

## 5. Conclusion

The dependence on onboard training has been limiting the opportunities of fair and quality MET and creating a disadvantage for young cadets, including women. Based on the analysis, the paper concludes that simulator training has social benefits of providing fair and quality education for all, including women, as well as career opportunities to work as simulator instructors who can contribute to incorporating different perspectives and pedagogies to MET.

These unspoken social benefits will support the ongoing discussions of considering simulator training as an alternative to onboard training required for CoC under the STCW Convention. However, such discussions involve a number of questions, for example, to what extent simulator training can resemble required onboard training and replicate the work environment. So far, simulators replicate technical aspects on board but what is not well considered are social aspects. Ironically in our study, the gender-disaggregated data of simulator instructors around the world reflect the reality of gender inequality at sea. Ontological understanding of simulator training (what it is now) also helps develop epistemological understanding of how simulator training can advance fair and quality MET (what it should be in future). In other words, understanding the ability of simulators to replicate the world view is an important step to reshape maritime science and its institution to accommodate women in MET.

Finally, the study is methodologically limited to make use of relatively small sample size and the future research can run a larger survey among the IAMU member universities, including additional information, such as any gender-based discrimination experienced by students during simulator training.

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# Integration of LNG Simulators and Dual-Fuel Technologies in Decarbonization Training – A Case Study of the Italian Shipping Academy

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**Abstract:** This paper explores the contribution of the Italian Shipping Academy Foundation in maritime decarbonization training, with a particular focus on the use of simulators for Liquefied Natural Gas (LNG) in dual-fuel engine operations. As the shipping industry shifts towards more environmentally friendly practices, dual-fuel engines operating on LNG are increasingly recognized for reducing Greenhouse Gas(GHG) emissions.

The study investigates the application of advanced simulators that provide realistic training scenarios on LNG system operations, an essential aspect of dual-fuel engine management. Integrating such cutting-edge technology into maritime education aligns with the shipping industry's commitment to sustainability. Additionally, the paper addresses the development and implementation of training curricula that incorporate LNG system simulators, underscoring the importance of practical, hands-on training methodologies in preparing maritime professionals and seafarers for the future.

However, integrating such simulator-based education also has challenges and obstacles. This article examines these aspects through a SWOT analysis, offering insights into the strengths, weaknesses, opportunities, and threats associated with deploying simulator technology in maritime education for decarbonization.

*Keywords*: maritime decarbonization, dual-fueled engines, LNG systems, training simulator, SWOT analysis

## 1. Introduction to the IGF Code of the International Maritime Organization (IMO)

International shipping is essential to global trade but significantly contributes to air pollution and greenhouse gas (GHG) emissions, impacting climate change and air quality (Fridell, 2019; Karimpour et al., 2022). Liquefied natural gas (LNG) is a promising solution, reducing emissions of sulfur oxides, nitrogen oxides, particulate matter, and carbon dioxide by up to 25% compared to traditional fuels (Al-Enazi et al., 2021).

The International Maritime Organization (IMO) adopted the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) to ensure the safe operation of ships using low-flashpoint fuels like LNG. The IGF Code addresses design, construction, and operational standards to minimize risks to ships, crews, and the environment (IMO, 2015). The IMO's 2023 GHG Strategy emphasizes the use of dual-fuel engines, which can operate on both conventional fuels and greener alternatives like LNG. These engines help reduce sulfur oxides, nitrogen oxides, and particulate matter emissions, aligning with IMO regulations (AakkoSaksa et al., 2023). Despite the benefits, dual-fuel technology faces challenges, including infrastructure development, lifecycle emissions, methane slip, and the need for crew training (Wang et al., 2023). Advanced simulators can address training challenges, making dual-fuel technology a key component in achieving the IMO's emissions reduction targets.

## 2. IGF Courses in Maritime Education

In the evolving landscape of maritime education, IGF courses play a pivotal role as the shipping industry embraces more sustainable practices by adopting LNG and other low-flashpoint fuels. As required by the STCW Convention and following the guidelines of the IMO Model courses 7.13 and 7.14, maritime academies, universities, and institutes worldwide have responded by developing structured training programs tailored to equip seafarers and maritime engineers with the necessary skills to handle, operate, and ensure the safety of gas-fueled ships(IMO, 2024). These programs are distinctly categorized into basic and advanced courses. The Basic IGF Training focuses on fundamental safety responsibilities, emergency responses, and the operational management of gas fuels. Meanwhile, the Advanced IGF Training is designed for those in more senior roles, emphasizing the technical, managerial, and emergency management aspects of operating gas-fueled ships. Both levels of training incorporate hands-on learning experiences, primarily facilitated through advanced simulators that replicate the real-life challenges of managing dual-fuel engine operations, thereby aligning maritime training with the industry's shift towards decarbonization (Wang & Notteboom, 2014).

At maritime universities and training centres, much of the IGF training is conducted using advanced simulators that mimic the operating environment of gas-fueled ships. These simulators provide a risk-free platform for hands-on learning, allowing trainees to experience and respond to various scenarios, including emergencies, without real-world consequences. Using simulators enhances understanding and competence in handling sophisticated systems and technologies associated with low-flashpoint fuels. Simulation-based training is crucial in ensuring that maritime professionals are well-prepared to operate within the confines of new regulations and changing technologies in the shipping industry. It equips them with the necessary skills and confidence to manage and operate LNG-powered ships safely and efficiently, which is crucial for the modern maritime workforce adapting to greener shipping practices.

## 3. IGF Course Offerings at the Italian Shipping Academy Foundation FAIMM

The Italian Shipping Academy Foundation FAIMM has been actively engaged in delivering STCW training courses using the specific "IGF Code ship models" of the following engine/IGF simulation systems: Wartsila LCHS 5000 TechSim, and also GTT G-Sim LGHS (Liquid Gas Handling Simulator). The below data provides an overview of the offerings and participation in these courses from 2021 to 2024, specifically for the IGF Base and IGF Advanced courses.

*Table 1 IGF Course Offerings at the Italian Shipping Academy Foundation FAIMM since 2021*

| Year | Course Type | Courses Conducted | Participants | Total Hours |
|---|---|---|---|---|
| 2021 | IGF Base | 3 | 27 | 54 |
| 2021 | IGF Advanced | 2 | 18 | 80 |
| 2022 | IGF Base | 18 | 163 | 324 |
| 2022 | IGF Advanced | 7 | 61 | 280 |
| 2023 | IGF Base | 10 | 81 | 180 |
| 2023 | IGF Advanced | 8 | 62 | 320 |
| 2024 | IGF Base | 3 | 22 | 54 |
| 2024 | IGF Advanced | 2 | 15 | 80 |
| **Total** | **IGF Base** | **34** | **293** | **612** |
| **Total** | **IGF Advanced** | **19** | **156** | **760** |
| **Overall Total** | **-** | **53** | **449** | **1372** |

### *3.1 IGF Base Courses*

The IGF Base course, essential for beginners, has seen a total of 34 sessions over the reported period. In 2021, there were 3 courses with 27 participants. This number significantly increased in 2022, with 18 courses conducted and 163 participants, indicating a growing interest and need for basic IGF training. In 2023, the academy organized 10 courses for 81 participants. However, there was a noticeable reduction in both courses and participation in 2024, with only 3 courses and 22 participants. Over the years, the total duration of these courses amounted to 612 hours.

*3.2 IGF Advanced Courses*

The IGF Advanced course, designed for more experienced individuals, consisted of 19 sessions during the same period. The academy held 2 advanced courses with 18 participants in 2021, which increased to 7 courses for 61 participants in 2022. The participation remained relatively high in 2023, with 8 courses and 62 participants. In 2024, similar to the basic course, there was a reduction, with just 2 courses and 15 participants, as this research collected the information till the middle of 2024. The cumulative duration for the advanced courses reached 760 hours.

*3.3 Overall Impact and Progression*

From 2021 to 2024, the Italian Shipping Academy Foundation FAIMM provided a total of 53 training courses, amounting to 1,372 hours of instruction. During this period, 449 individuals participated, with 293 attending the IGF Base and 156 in the IGF Advanced courses. This data illustrates the dynamic nature of maritime training, influenced by industry demand, technological advancements, and regulatory changes. Notably, a peak in participation in 2022 suggested shifts in priorities, resource allocation, or external economic factors impacting the industry. The comprehensive data on course offerings and participation not only demonstrates the academy's dedication to maritime safety and education but also highlights the specialized nature of the training essential for operational excellence in the shipping sector. This analysis provides stakeholders with crucial insights for strategic planning and policymaking to advance maritime education and safety standards. The feedback form depicted was utilized to gather insights from participants of the IGF Course, focusing specifically on evaluations, as illustrated below, submitted since the beginning of 2023. This targeted analysis helps to reflect the most current experiences and opinions related to the training. See below.

1. To what extent did this training session meet your expectations? [Exectations] Rating: 1 to 5
2. How beneficial was it to your daily responsibilities? [Relevance] Rating: 1 to 5
3. Did you find the contents of the training clear and effective? [Clarity] Rating: 1 to 5
4. Was the training location suitable? [Location] Rating: 1 to 5
5. Were the training materials and equipment pertinent and useful? [Materials] Rating: 1 to 5
6. Was the duration sufficient for the topic? [Duration] Rating: 1 to 5
7. Were the trainers qualified and well-prepared? [Trainers] Rating: 1 to 5
8. Were participation and interaction encouraged? [Interaction] Rating: 1 to 5
9. Were your doubts and questions clarified? [Clarification] Rating: 1 to 5
10. What would you add or remove to improve this training? [No rating applicable]

The course feedback encompasses a wide array of seafarers, including both officers and crew. Notably, a significant proportion of the attendees belong to the cruise industry. This strategic approach underscores the cruise industry's role in advancing the shipping industry toward a more sustainable and adaptable future.

As illustrated in Figure 1, the feedback for the IGF Basic Course at the Italian Shipping Academy FAIMM shows a highly positive response across multiple facets. The course exceptionally met participants' expectations with a perfect score. It also scored very well on relevance and clarity, indicating that the content was wellaligned with the needs of the attendees and communicated effectively. The materials and duration of the course were also well-received, although these aspects scored slightly lower, suggesting some room for improvement. The location and trainers received good ratings, reflecting general satisfaction with the logistical and instructional aspects of the course. The lowest scores, though still above average, were in interaction and clarification, indicating potential areas for enhancing participant engagement and understanding in future sessions. A few responses to the last open-ended question highlighted the advanced nature of the academy and the preparedness of the trainers, indicating strong foundational support for the course. Other comments suggested improvements in location and recommended more practical experiences, such as ship visits to enhance understanding. A recurrent suggestion was more hands-on sessions and multimedia aids to deepen skills and knowledge.

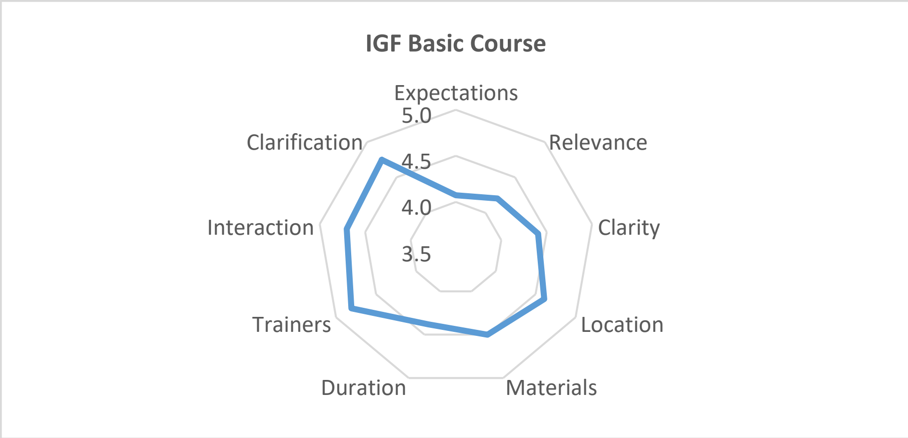


*Figure 1 The feedback for the IGF Basic Course at the Italian Shipping Academy FAIMM between Jan2023-Jun2024*


*Figure 2 The feedback for the IGF Advanced Course at the Italian Shipping Academy FAIMM between Jan2023-Jun2024*

Regarding the IGF Advanced Course, as shown in Figure 2, the participants' feedback indicated a generally positive experience but highlighted more areas for improvement than the basic course. The course nearly met participants' high expectations and maintained relevance to their advanced learning needs. Clarity of content received a good rating, though not as high as in the basic course, suggesting that the more complex material could be communicated more effectively. The trainers were well-regarded, while the materials and duration received moderately positive feedback, pointing to a need for refining the resources and timing. The ratings for location, interaction, and clarification were the lowest, underscoring the necessity to improve the learning environment and foster better engagement and understanding among the participants. Feedback from the IGF Advanced Course participants was also limited, but it pointed to a well-organized course structure and clarity in delivery. Some attendees felt the need for more practical examples and greater interaction during the course. The suggestion for adding ship tours was noted by several participants, indicating a desire for practical, realworld applications of the course material to better understand the equipment and operations on LNG-fueled ships.

The integration of LNG simulators and dual-fuel technologies at the Italian Shipping Academy exemplifies a forward-thinking approach to maritime training, essential for advancing environmental sustainability in the shipping industry. These cutting-edge simulators are crucial for training maritime professionals in managing the complexities of modern dual-fuel systems, aligning with global goals to reduce greenhouse gas emissions. The effective application of such technologies not only ensures compliance with international standards but also boosts operational efficiency. Based on this strategic integration, a SWOT analysis was conducted to further explore the strengths, weaknesses, opportunities, and threats associated with the use of IGF simulators at the academy. This analysis is detailed in Table 2, offering insights into the potential impacts and areas for improvement in their training programs, supported by other related academic publications.

*Table 2 SWOT analysis of using IGF simulator at FAIMM academy*

| Strengths | Weaknesses |
|---|---|
| - Realistic training scenarios: Enhances learning with hands-on, real-world challenges crucial for operating LNG-fueled ships (Baldauf et al., 2018; Rong et al., 2016). (e.g., 95% of trainees reported improved practical skills in post-course evaluations). | - High costs: Significant financial resources are required to set up and maintain advanced simulators (Barnett et al., 2013). |
| - Compliance with global standards: The training adheres to the latest International Maritime Organization (IMO) standards, ensuring that maritime professionals are up-to-date with current and emerging global regulations (IMO, n.d). (e.g., 100% compliance rate with IMO training standards). | - Demand for expertise: The need for ongoing technical expertise to manage these complex simulator systems introduces additional operational complexity and costs (Hanzu-Pazara et al., 2008). (e.g., only a few instructors are currently qualified to teach IGF courses at the academy FAIMM). |
| **Opportunities** | **Threats** |
| - Expansion of training programs: Potential to expand training to other regions and advanced courses as demand for green shipping practices grows (Di Lieto, 2017). (e.g., projected 20% increase in trainee enrollment over the next five years). | - Technological evolution: The fast pace of technological advancements necessitates frequent updates to simulator systems, which can be both costly and resource-intensive (Lutzhoft et al., 2011). |
| - Collaborations and partnerships: Opportunities for partnerships with technology providers, other academies, and shipping companies to enhance training and reduce costs (Jeevan et al., 2020). (e.g., there has been an agreement between the Italian Shipping Academy and MSC Shipping Lines for IGF courses training). | - Competitive pressure: Increasing competition from other maritime academies adopting similar or more advanced technologies (Schröder-Hinrichs et al., 2013). (e.g., other Italian institutes such as Italian Maritime Academy Technologies (IMAT) and RINA have similar capabilities in offering maritime IGF courses). |

## 4. Discussion

The Italian Shipping Academy Foundation (FAIMM) has advanced maritime education by incorporating LNG simulators and dual-fuel technologies, aligning with global sustainability goals and industry needs. This provides realistic training essential for managing dual-fuel systems. Feedback from participants of IGF Courses since early 2023 highlights training effectiveness. Participants rated the training on expectations, relevance, clarity, location suitability, material usefulness, duration, trainer qualifications, participation encouragement, and doubt resolution. Key outcomes show high satisfaction with training relevance, clarity, and practical applications, particularly in the IGF Basic (4.20/5 relevance, 4.40/5 clarity, 4.80/5 practical) and Advanced Courses (4.28/5 relevance, 4.62/5 clarity, 4.71/5 practical). These structured courses cover critical areas like safety, operational management, emergency responses, and meeting industry needs.

A SWOT analysis was conducted to further explore the strengths, weaknesses, opportunities, and threats associated with the use of IGF simulators at the academy. The SWOT analysis revealed that despite high implementation costs, the benefits of realistic training scenarios and compliance with international standards are substantial. Strengths include realistic training scenarios and global compliance with IMO guidelines, while weaknesses involve high costs and the need for continuous technical expertise. Opportunities for expanding programs and forming partnerships were identified by 2025. However, threats such as rapid technological evolution and competitive pressure from other academies necessitate frequent updates and adaptation.

Based on the above discussion, to further improve, it is recommended to increase practical training through more hands-on sessions and ship visits, expand course offerings by developing advanced and specialized training modules, and foster industry partnerships by collaborating with technology providers and shipping companies to share resources and enhance training quality. The academy's approach models global maritime education, enhancing skills and supporting sustainable practices. This initiative aligns with the International Maritime Organization's strategy to reduce greenhouse gas emissions, positioning the academy as a leader in maritime sustainability education. By addressing feedback and incorporating improvements, the Italian Shipping Academy FAIMM is poised to lead in maritime education and support the industry's transition towards greener practices.

## 5. Conclusion

The Italian Shipping Academy Foundation FAIMM has significantly advanced maritime education by integrating LNG simulators and dual-fuel technologies. These simulators have improved trainee competency and preparedness, with high satisfaction ratings reflecting the training's relevance and practical applications. The IGF Basic and Advanced courses address industry needs by providing comprehensive training in safety, operational management, and emergency response for LNG-fueled ships. A SWOT analysis identified strengths such as realistic training scenarios and compliance with international standards, along with challenges like high implementation costs and the need for continuous technical expertise. Feedback suggests increasing hands-on training, expanding course offerings, and fostering industry partnerships.

These efforts align with the International Maritime Organization's strategy to reduce greenhouse gas emissions, positioning the academy as a leading institute in maritime sustainability education. By addressing feedback and incorporating improvements, the academy supports the industry's transition to greener practices and meets evolving maritime demands.

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# Enhancing Professional Development through Foreign Language Communicative Competence in Navigation and Ship Handling Specialists

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**Abstract:** The paper discusses the system for developing foreign language communicative competence among specialists in navigation and ship handling at sea within the framework of lifelong education. The proposed system is designed as a structured educational framework that not only provides knowledge but also develops critical professional skills. It includes a comprehensive integration of theoretical, structural, technological and diagnostic components, each of which is essential to provide a comprehensive education that meets international maritime standards. At its core, the system includes a concept and objectives component that defines the strategic direction and goals of the educational process and ensures compliance with legal and regulatory standards. The content and structure component addresses the curriculum and teaching resources required to develop the foreign language skills critical for professional interactions in the international maritime context. In addition, the technology component enhances the learning experience through modern educational technologies and methods and contributes to the development of practical communication skills required by the maritime industry. Finally, the diagnostic and corrective component focuses on the continuous evaluation and improvement of the educational process to meet the changing needs of the maritime sector and its professionals. Overall, this system seeks not only to meet the immediate educational needs of maritime professionals, but also to ensure their continuing professional development and adaptation to global industry standards and practices. This approach emphasises the importance of a holistic educational strategy to develop the necessary skills and competencies in a dynamically changing global context.

*Keywords*: foreign language communicative competence; navigation and ship handling; professional development of specialists in navigation, developing language proficiency.

## 1. Introduction

A modern specialist in navigation and ship handling is today a universally recognized leader in implementing state programs aimed at the purposeful development of foreign language communicative competence, which facilitates the successful execution of professional duties at an international level. Professional education provides the initial acquisition of substantial knowledge, the development of creative abilities and cognitive interests, and the ability to apply them in real professional processes. The challenge of integrating the system of forming foreign language communicative competence for specialists in navigation and ship handling within the context of lifelong education into a competitive educational environment is directly related to the development of a design concept that ensures high-quality education and guaranteed developmental outcomes.

A comprehensive analysis of research and priority measures directed at implementing state policy to improve the educational process of foreign language education for forming foreign language communicative competence among specialists in navigation and ship handling in the context of lifelong education reveals the following contradictions: the increasing demands of international and national quality standards for foreign language communicative competence among specialists in navigation and ship handling, juxtaposed with the insufficient level of their professional training; the necessity of forming professional foreign language communicative competence among specialists in navigation and ship handling in conditions of lifelong education, contrasted with the lack of scientifically grounded organizational and pedagogical conditions to ensure this process; modern requirements for improving the system of forming professional foreign language communicative competence among specialists in navigation and ship handling versus the current state of its scientific and pedagogical support; the need for effective methods of forming professional foreign language communicative competence among specialists in navigation and ship handling and the insufficient scientificmethodological development of the application of modern teaching technologies. To meet the stringent requirements outlined by the STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) [1], it is essential to develop a robust system for cultivating foreign language communicative competence among specialists in navigation and ship handling within the framework of lifelong education.

The social significance and objective need of the maritime sector for specialists in navigation and ship handling with a high level of foreign language communicative competence, coupled with the insufficient theoretical and methodological development of this issue in the theory and practice of professional education, and the need to address the identified contradictions, have necessitated the creation of a system for developing foreign language communicative competence among specialists in navigation and ship handling within the framework of lifelong education. *The aim of the research* is to provide a scientific and theoretical justification for the system of developing foreign language communicative competence among specialists in navigation and ship handling within the context of lifelong education.

## 2. Training maritime professionals with a systematic approach

Given the increasing international demands for maritime safety, effective communication between crew members and port infrastructure, and the need to meet international training standards, proficiency in foreign languages has become a critically important factor in professional competence. In this context, creating and implementing a system aimed at the continuous improvement of foreign language skills and the development of communicative competencies is an urgent task requiring a comprehensive approach and consideration of the specifics of the maritime industry. This will not only enhance the professional level of specialists in navigation and ship handling but also contribute to the safety and effectiveness of international shipping as a whole. As a fundamental theoretical concept, we use the definition of a "system," which involves describing a complex of interrelated elements forming a structured unity with a common goal. Key characteristics of a system include the multiplicity of components, integration, interrelation of elements, purposeful management, and hierarchy. The educational process in higher maritime educational institutions is thus viewed through the lens of a pedagogical system that encompasses not only the transfer of knowledge but also the formation of essential professional competencies and attributes.

In our research, we define the "System of Formation of Foreign Language Communicative Competence for Specialists in Navigation and Ship Handling in Lifelong Education" as a comprehensive educational structure integrating conceptual-target, content-structural, technological, and diagnostic-corrective components. This system is designed to develop foreign language communicative skills necessary for the effective performance of professional duties by navigation and ship handling specialists in the international maritime environment, in accordance with international regulatory documents. It ensures continuous professional development within the framework of lifelong education and emphasizes functionality, synergy, and hierarchy, involving all participants in the educational process from cadets and students to academic staff, ship captains, and crew management company executives. The implementation of this proposed system follows the hierarchy of educational levels from junior specialist to master's degree and continues with adult education, ensuring continuity. The designed system provides for the sequential development and enhancement of this competence, taking into account specific requirements at each educational-professional level.

## 3. Structuring Maritime Communication Competence in Continuing Education

The system for developing foreign language communicative competence among specialists in navigation and ship handling within the framework of lifelong education is structured around interconnected subsystems (blocks): conceptual-target, content-structural, technological, and diagnostic-outcome.

*3.1. Conceptual-target block: definition of strategies and objectives.*

The conceptual-target component of the system defines the strategic directions, establishing goals, fundamental methodological approaches, and principles that guide activities towards the defined end result, namely: the development of foreign language communicative competence among specialists in navigation and ship handling within the framework of lifelong education.

The content of the target component of the training program for specialists in the field of "River and Maritime Transport" [2] is determined by social demands and expectations regarding the qualifications of graduates, aimed at enhancing the foreign language communicative competence of specialists in navigation and ship handling. This requirement aligns with global trends in lifelong education and professional development within the maritime sector, emphasizing the importance of intercultural communication in the international maritime environment.

The conceptual-target component of the system for developing foreign language communicative competence among specialists in navigation and ship handling within the context of lifelong education involves selecting and integrating a regulatory and legal framework that provides legal and normative support to the system, ensuring its compliance with established requirements and standards. Important international documents from the International Maritime Organization (IMO) relevant to the development of foreign language communicative competence include: the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention) 1978 (as amended), the International Regulations for Preventing Collisions at Sea (COLREGS), the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), the International Safety Management (ISM) Code, IMO Model Courses for additional training and certification of seafarers, as well as national documents such as: "The Maritime Doctrine of Ukraine," "Strategic Plan for the Development of Maritime Transport up to 2020," "Strategy for the Development of Seaports of Ukraine up to 2038," and "Regulations on the State System for Maritime Safety Management."Thus, the conceptual-target component serves as the foundation upon which strategic planning and implementation of the educational process are built, ensuring its coherence, systematic approach, and effectiveness.

*3.2. Content and structural component: integration of disciplines and methods*

The content-structural component of the educational process for specialists in "River and Maritime Transport" encompasses a comprehensive approach to defining the curriculum, including the selection of subjects, development of training programs, and methodological resources aimed at enhancing foreign language communicative competence (FLCC) in specialists in navigation and ship handling. This component entails the systematic organization of educational material, ensuring logical coherence and integrity within the educational process.

The core content of the "Navigation and Ship Handling" program includes course syllabi for both professionally communicative (e.g., Foreign Language, English for Professional Purposes, Maritime English, Business English) and professionally practical subjects (e.g., Theory and Construction of Ships, Maneuvering and Ship Handling), ensuring comprehensive training in alignment with international and national standards.

The study details the content of key components of FLCC within the context of lifelong education, including axiological-motivational (enhancing motivation and value attitudes towards learning foreign languages), cognitive (developing knowledge, skills, and abilities in specialized foreign languages), and regulatory-activity components (applying practical skills for effective professional communication). This holistic approach to developing FLCC within lifelong education highlights the integrated learning process, addressing various aspects of professional competence for navigation and ship handling specialists, and enhancing their effective performance in the international professional environment. The interdisciplinary connection between foreign language study and specialized subjects enables learners to better understand professional terminology and its application, which is crucial for a deeper grasp of international maritime standards, regulations, and international maritime law.

The process of developing FLCC in the international context is multi-tiered and requires consideration of international standards, notably the requirements of the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW 78/95), as well as national educational standards. Defining specific tasks at each educational level involves differentiating learning objectives and methods to achieve optimal professional training considering the specifics of working in the international maritime environment. This approach provides flexibility and adaptability in the educational process to changing conditions and requirements of the international labor market in maritime transport.

Key components of FLCC, such as axiological-motivational, cognitive, and regulatory-activity aspects, support systematic and conscious application of linguistic and intercultural abilities. This structure aids specialists in perceiving and understanding other cultural positions and values, and facilitates effective professional interactions based on subject-subject cooperation and dialogue. This integrated system forms the foundation for successful execution of international professional duties and intercultural dialogue, and is crucial for developing professional skills in the context of lifelong education.

The content-structural block includes the development, testing, and implementation of innovative proprietary contributions to the educational process in the system for developing FLCC among navigation and ship handling specialists. These include: electronic courses on "Maritime English"; a repository of audio and video materials, test tasks developed using the "MOODLE" platform; a model curriculum for "General English Language Level B1-C1"; instructional and methodological materials for "Maritime English," including sections on "Bulk Cargo Carriers" and "Visual and Sound Signaling," and instructor's books for these modules.

Based on the research, specialized courses have been developed and implemented into the educational process: "Fundamentals of Foreign Language Communicative Competence for Navigation and Ship Handling Specialists" for junior bachelor and bachelor levels in "Navigation and Ship Handling"; "Business Foreign Language Communicative Competence: Advanced Course for Maritime Leaders" and practical training for master's level students in "Navigation and Ship Handling"; and "Leadership and Team Dynamics" and "Mastering Team Leadership and Communication" in collaborative online international learning (COIL). Training and methodological materials for the educational component "Maritime English" have been prepared and implemented, including: "While Ashore" (co-authored) and "Welcome Aboard" (co-authored), addressing the required competencies for navigation and ship handling specialists within the context of lifelong education. In conclusion, the content-structural component of the educational process in preparing specialists in "River and Maritime Transport" necessitates a comprehensive approach integrating theoretical knowledge, practical skills, and communicative competencies. The challenges of modern maritime transport demand not only high levels of professional preparation but also the ability to engage in effective intercultural communication and adapt to the global professional environment.

*3.3. Technological component: use of modern educational technologies*

The technological block in the educational process for training specialists in navigation and ship management encompasses the implementation of modern educational technologies and active learning methods, as well as tools and forms of the educational process that contribute not only to the acquisition of language skills but also to the development of practical professional communication abilities.

Forms of the Educational Process:Classroom Activities: e-learning, flipped learning, blended learning, practical sessions.

Extracurricular Activities: conversation clubs with native speakers, Writing Cafe and Speaking Cafe, interdisciplinary quests (e.g., "Amazing Quest," "Geographical Quests," and COLREG competition), workshops, masterclasses, guest lectures, and academic poster sessions, scientific SANDPITS for cadets and instructors, and scientific seminars.

Self-Directed Learning: reflective portfolios, case analysis and resolution, interactive webinars and video courses, online simulations and training tools.

Active Learning Methods: brainstorming, formal debate, simulation, delegate discussions, market groups (also known as 'world cafes'), question and answer, role-play, think-pair-share, snowballing, jigsaw, buzz groups, fishbowl, duo, gapped handout, worksheet, vote-with-your-feet (continuum or spectrum), one-minuteessay, write a summary, and others. The use of interactive methods creates conditions for integrating theoretical knowledge with practical skills and motivates students to actively engage in the educational process.

An important component of the technological block is the tools. These include:

Organizational and Methodological Tools: Working programs for educational components, syllabi, methodological recommendations.

Educational and Methodological Tools: Materials developed in LMS Moodle, a repository of audiovisual and video materials (a repository of maritime professional literature in a foreign language), training tasks (flashcards), test tasks "Self-Study" and "Stop and Check" on the Moodle platform in LMS.

Technical Tools: Multimedia projectors, simulators, VR equipment. Didactic Tools: Software and applications (Google cloud applications), LMS Moodle, Zoom, Canva, Learning Apps, and others.

Technologies for developing foreign language communicative competence in specialists in navigation and ship management within the framework of continuous education include: Immersive technologies: Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR); Gaming and simulation technologies: Interactive exercises and online platforms; Project-based technologies: International projects such as the "Hello Project" and "Leadership"; Collaborative Online International Learning (COIL); Content and Language Integrated Learning (CLIL); Immersive Language Exposure.

*3.4. Diagnostic and correction block: monitoring and evaluation of learning effectiveness*

The Diagnostic and Corrective Block focuses on evaluating the performance of the educational process and the achievement of established educational goals. This component incorporates a systematic procedure for monitoring and appreciating academic achievements, including knowledge, skills, and abilities. It analyzes the effectiveness of the educational process and initiates corrective measures based on the analysis of accumulated data. This approach supports the implementation of an integrated strategy for training specialists, aimed at their comprehensive development in the aspect of FLCC, which is crucial for professional success. The system emphasizes the necessity for continuous improvement of the educational process, based on the educational needs of learners and the requirements of the international professional community, and targets the development of a deep understanding of cultural and intercultural competence, which is key to effective international communication in maritime contexts.

The Diagnostic and Corrective Block is directed at assessing the level of formation of FLCC necessary for effective professional activity. The importance of regular monitoring of the quality of preparation for professional activity is determined by the need to provide current information about the state of the system, expressed through specific parameters and characteristics at present. This monitoring is conducted using defined criteria and indicators of professional readiness and its levels of formation. Due to potential discrepancies between expected and actual results of continuous professional training, corrective adjustments to the training process are based on a detailed analysis of preparedness, identification of factors affecting the quality of the educational process, and professional significance.

One of the key features of the continuous professional training system for future ship officers in higher maritime educational institutions is the structure of relationships between its components (subsystems). Based on our research, we affirm that the inherent universal and regular relationship of the designed system facilitates the coordination of interaction among all system elements. Considering the conceptual foundations of forming FLCC in specialists in navigation and ship management within the framework of continuous education, it can be asserted that this universal relationship integrates pedagogical and psychological principles, patterns, and principles of personal development of future specialists, which interact and are structured at various levels: methodological, theoretical, and technological.

Organizational and Pedagogical Conditions for developing FLCC in future specialists in navigation and ship management within the framework of continuous education are pervasive at all stages of formation and integrate theoretical research with practical experience. They are based on methodological principles that play a crucial role in the preparation of specialists within the framework of continuous professional education. These conditions include optimizing educational and methodological support based on an interdisciplinary approach; implementing innovative pedagogical methods and forms of the educational process to engage learners actively in the development of FLCC; involving learners in a professionally oriented educational-linguistic environment through active self-educational activities; and ensuring scientific and methodological support for the development of FLCC in navigation and ship management specialists. The enhancement of FLCC is the result of applying a set of these organizational and pedagogical conditions, enabling qualified specialists to adapt to various challenges and demands of the global labor market, effectively operate in a multicultural maritime environment, and implement innovative technologies in their professional activities.

## 4. Results and Discussions

One of the key features of the system of continuous professional education of future seafarers in higher maritime educational institutions is the structure of relations between its components (subsystems). On the basis of our research we state that the universal and natural connection inherent in the designed system contributes to the coordination of the interaction of all elements of the system. Taking into account the conceptual provisions on the formation of foreign language communicative competence of specialists in navigation and ship management in the context of continuous education, it can be argued that the mentioned universal connection is an integration of pedagogical and psychological bases, patterns and principles of personality development of future specialists, which interact and are structured at different levels: methodological, theoretical and technological.

The results of the study on the formation of foreign language communicative competence among specialists in navigation and ship handling within the context of lifelong education demonstrate the significance of employing integrated diagnostic methods. Scenario simulations, projects and case studies, analysis of openended responses, feedback and self-assessment, as well as Collaborative Online International Learning (COIL) [3], have proven effective in developing activity-based reflective criteria, which are crucial for the formation of foreign language communicative competence. The application of these methods not only allowed for a deep evaluation of the level of communicative skills acquisition but also helped identify key areas for further learning and self-improvement of the learners. Based on the analysis of structural characteristics related to the formation of foreign language communicative competence in the field of ship management, it can be concluded that the effectiveness of this formation is closely linked to several key systemic elements of professional education. These include the goals and objectives of the educational process aimed at developing professionally significant personal qualities and achieving specific professional outcomes, as well as fostering interests and needs that influence the formation of personal ideological convictions.

Additionally, the content of education, formats, methodologies, techniques, and procedures employed during the execution of professional tasks and functions are of particular importance. Therefore, the effectiveness of the process of forming foreign language communicative competence among navigation specialists requires a comprehensive approach that integrates these components into a cohesive system.

## 5. Conclusions: prospects and challenges in the field of vocational education and training

The **System of Formation of Foreign Language Communicative Competence (FLCC)** for specialists in navigation and ship handling represents a notable advancement in vocational education, offering both significant prospects and notable challenges. The system, structured around conceptual-target, contentstructural, technological, and diagnostic components, is designed to enhance the foreign language skills of maritime professionals, ensuring their effectiveness in global maritime contexts.

On the one hand, the integration of lifelong learning within this system facilitates continuous professional development, allowing specialists to remain current with evolving maritime regulations and technological advancements. This approach supports not only immediate educational needs but also long-term career growth. The holistic nature of the system, involving all educational stakeholders — from cadets and students to faculty and industry professionals — promotes a comprehensive and synergistic learning environment. Moreover, the incorporation of modern educational technologies, such as immersive simulations and interactive platforms, enhances practical communication skills and ensures the system's relevance in a rapidly changing industry. However, the implementation of this complex system is not without challenges. Coordinating the various educational components and stakeholders requires meticulous planning and resource management. The rapid pace of technological and regulatory changes necessitates ongoing updates to the system to maintain its effectiveness. Additionally, ensuring rigorous monitoring and evaluation to assess the system’s impact and address any gaps is crucial for maintaining high standards. The allocation of adequate resources, including financial support, technological infrastructure, and trained personnel, is essential for the successful operation of the system.

In conclusion, while the **System of Formation of Foreign Language Communicative Competence (FLCC)** holds substantial promise for enhancing vocational education and training in the maritime sector, addressing these challenges is vital for achieving its full potential. By overcoming these obstacles, the system can significantly contribute to the professional development of maritime specialists, equipping them with the necessary skills and adaptability for success in an increasingly globalized maritime industry.

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# Gender mainstreaming practices in METIs: Some case studies

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**Abstract:** The existing gender imbalance, discrimination and difficulties that female students face in Maritime Education and Training (MET) constitutes a widespread concern. To address this situation, Maritime Education and Training Institutions (METIs) have turned to gender mainstreaming looking for strategies and practices that may bring about possible solutions. This paper reviewed existing literature to identify specific case studies on in-depth gender mainstreaming actions undertaken in different METIs. Seven case studies were selected to illustrate specific interventions and practices to mainstream gender and their possible applicability and transferability across institutions. The results of the analysis show that the interventions presented combine different strategies and approaches, but no standard procedure to mainstream gender. However, most proposals describe some common or overlapping practices like the importance of networking and mentoring programmes, considering female students' expectations and motivations for enrolling in MET, rethinking recruitment and, most importantly, reviewing the maritime curriculum incorporating more gender-inclusive practices. Additionally, most of the interventions analysed reveal benefits for female students and, frequently, also for all students. Hence, most case studies agree to promote the development of gender strategic plans for METIs. In sum, such practices should be extended and transferred across METIs for fostering more inclusive MET environments.

*Keywords*: gender mainstreaming; Maritime Education and Training (MET); Education of Global Maritime Professionals (GMPs), Maritime Education and Training Institutions (METIs); case studies

## 1. Introduction

Gender mainstreaming among Science, Technology, Engineering and Mathematics (STEM) disciplines has lately received considerable attention owing to the prevalent gender gap in these scientific and technological fields. This situation becomes more critical in Maritime Education and Training (MET), where the number of enrolled female students plummets to even lower percentages (Barahona-Fuentes et al., 2020; Mahabir-Lee & Rambarath-Parasram, 2019; Novas et al., 2015). To address this situation, Maritime Education and Training Institutions (METIs) have turned towards gender mainstreaming looking for solutions. To shed some light on the causes of gender imbalance, different aspects are usually examined among which there is the design of the discipline, the contents of the study programs and the gender situation of the study environment. Following this analysis, priorities are established, new strategic directions are set and interventions are designed. Finally, being education and training the core activity of METIs, gender mainstreaming in teaching becomes a key component of interventions aimed at improving the pedagogical and teaching practice with a view to providing maritime students with the necessary gender knowledge and awareness. Such learning becomes crucial not only for students' present academic life but also to train Global Maritime Professionals (GMPs) with a more useful gender perspective for society.

This article reviews existing literature to identify in-depth case studies on gender mainstreaming interventions in different METIs. Although many efforts are being addressed to bridge the gender gap and to advance towards gender equality in MET, the review of the literature shows a limited number of institutional case studies on gender mainstreaming practices. In spite of the somewhat limited findings so far, these become fundamental to pave the way for future actions and strengthen and expand forthcoming research. Some recurrent strategies identified to mainstream gender in MET are discussed in the analysis of the different case studies. Thus, this article provides an account of different experiences to achieve a better gender equality in MET which also pays off for the shipping industry.

## 2. Methodology

The review of literature was conducted through two leading interdisciplinary databases (i.e. Web of Science and Scopus), and through a well-known search engine for academic and scientific literature (i.e. Google Scholar). The search was restricted to gender mainstreaming in maritime education and training. Although there is abundant literature on gender mainstreaming in the maritime, that for MET is not as extensive. Altogether, forty records were selected and assessed for eligibility. These forty records obtained were screened by browsing titles, abstracts and keywords. The papers that were not central to the intended review were rejected and those that were considered to provide meaningful contributions were reviewed in depth. The aim was to identify detailed case studies and assessment of gender mainstreaming practices in METIs with a view to generating a better understanding of this key issue in one of its natural contexts, educational settings. The final seven case studies selected are mostly peer-reviewed articles and conference proceedings, published by reliable editors and institutions. The studies refer to different world countries with no limitation to any particular region and describe specific interventions and practices to mainstream gender in some METIs. They have been chosen to illustrate the applicability and transferability of gender mainstreaming strategies across METIs.

## 3. METIs case studies on in-depth gender mainstreaming practices

This section provides a detailed account of the seven case studies identified that describe in-depth practices and interventions to improve gender equality in different METIs. The interventions and experiences presented combine different strategies to mainstream gender. Particular attention has been given to the implementation, outcomes and assessment of the interventions described with a view to later discussing those practices that have proved to be more successful and their possible transferability across institutions. Most of the studies relate the experience of individual METIs (Barahona-Fuentes et al., 2023; Brickman, 2008; Horck, 2010; Romero Lares, 2017; Walker et al., 2003; Zhao et al., 2017) while one describes the situation of eight METIs in four of the five top-ranked countries according to the Global Gender Gap Index in 2013 (Boström Cars & Österman, 2015). The different studies are presented below following a chronological order according to their publication date. Research papers referring to the same institution are discussed together in the same section (i.e., Horck, 2010 and Romero Lares, 2017).

### *3.1. A United Kingdom merchant navy training school (Walker et al., 2003)*

This study seeks to understand the difficulties and experiences women face when trying to survive in a male-dominated Merchant Navy Training School of the United Kingdom and, subsequently, in their careers at sea. As disclosed in the article, this female cadet struggle may constitute an obstacle when trying to construct an identity for women in maritime educational and work settings. Constructing such an identity becomes a complex and changing task which depends on different factors, sometimes unrelated between them. Factors like the presence of critical personnel and career, circumstantial or personal incidents may produce a demotivating effect on women and a polarisation between female and male students' experiences. The study demonstrates that discouraging incidents in school training and at sea have a significant effect on female students' disposition and frame of mind, who are constantly reassuring their attitudes. Hence, female voices, no matter how small and fragmented, should be listened to and incorporated to provide new insights and ways of doing. As claimed by the authors, this new understanding is necessary not only to see what encourages women to stay but also to re-educate and re-culture the maritime educational and professional sectors.

To help women overcome the barrier of an alienating environment, the authors put forward different proposals for METIs: (a) to rethink courses and make them more accessible to all students, as in some US university engineering programmes, which benefits not only female gender profiles but also the total recruitment figures; (b) to normalise the merchant marine as a career for female students; (c) to offer career orientation and socialising mentoring programmes; (d) to analyse the marine school working and studying processes to incorporate new ways of functioning; (e) to revise the practices of male tutors and their interactions with female students; and (f) to rethink the recruitment methods and the advice given to prospective female students to better capture their interest. Finally, it is equally important to monitor all the interventions and to generate strategies, continual assessment policies and dialogue with all the parties involved to increase women's access and participation. Walker et al. (2003) conclude that this close examination to female students' experiences and maritime institutions' working practices may serve to transform the present maritime environment for a better female inclusion.

*3.2. The United States Merchant Marine Academy (USMMA), Kings Point (Brickman, 2008)*

This study explores the changes brought about by the incorporation of female students in the US Merchant Marine Academy (USMMA). Initially, with the first enrolments of female cadets between the 1970s and the 1980s, the USMMA interpreted gender equality as sameness and their main focus was on the physical integration of women in the Academy by providing separate facilities and adequate spaces. During this initial stage, they expected female cadets to adjust to the status quo. This lack of encouragement on the part of the institution led to female attrition and psychological consequences for many of the female graduates of this first period. These unforeseen and somewhat disappointing outcomes caused administrators to reconsider the Academy's policies. Consequently, at the beginning of the 1980s, the USMMA redefined its notion of gender equality as recognition of the differences between male and female students in order to provide a more effective and equal education. This change of approach permitted a differentiated treatment between genders and initiated a series of programmes and services exclusively for women. These initiatives included the appointment of an advisor, who proposed programmes addressed to women's needs such as prevention of sexual harassment, eating disorders, assertiveness, and preparation for on-board periods. The advisor also promoted changes in the institution regulations and encouraged faculty and staff to adopt a more inclusive language and behaviour. In addition, different team-building, mentoring and leadership initiatives brought about very positive results among female cadets. However, these actions and special programmes were not exempted of criticism, especially by male students, as they were considered a form of privilege.

Gradually, some of the services and initiatives incorporated for women were universalised and extended to all students of the Academy due to the reported benefits. For example, the new pedagogical approaches initially incorporated to improve female students' retention also had a positive impact on men's education. Thus, the continuous efforts for integrating women resulted in an improved recruitment and retention, not only of female students but also of female academic staff, and in modifications to the educational programme for the benefit of all students. Nevertheless, female figures in maritime education remain low, so the author concludes that adaptations of curricula as well as differentiated gender treatment are still necessary to achieve an equal educational experience, at least until the gender gap in METIs is reduced. In closing, recent events prove that in spite of all the efforts to improve gender equality, there still exist potential gaps between reported literature and reality. For example, breaking news unfortunately disclosed that USMMA's female students that had been sexually harassed and assaulted became silent due to fear and lack of trust with the institution (Ellis & Hicken, 2022), thus revealing a mismatch between theory and practice.

*3.3. The World Maritime University (WMU) (Horck, 2010; Romero Lares, 2017)*

Horck's study aims to examine how METIs have met the incorporation of female students and how the shipping industry has reacted to gender equality. The paper makes an appeal to METIs to develop policies on gender perspective and diversity management to meet the growing demand of female and multicultural students. In line with this, as a way of fostering inclusion in the classroom, the author also suggests the promotion of tolerance and urges teachers to engage students in collaborative teamwork while ensuring a sense of equality. Horck states that this ability to work well with others across cultures and genders develops and enriches students' leadership skills, which they may transfer to their future professional careers as global managers. In addition, the author proposes the incorporation some additional compulsory courses on pedagogy and cultural awareness and the integration of the gender perspective in the curriculum to address the increasing numbers of women in the shipping industry. This enhanced training would benefit all students, not only women, and should be extended to teaching staff if more effective results want to be obtained. Finally, as practising equal opportunities is part of the WMU policy, he also considers the employment of more female teaching staff. Increasing the numbers of female faculty would encourage the recruitment of female students and widen the range of experiences while contributing to avoid an androcentric way of thinking in MET.

Seven years later, in her case study, Romero Lares describes the evolution of the WMU's policies on gender equality and their impact on students, teaching staff and curriculum. According to the WMU's strategic plans, the institution contributes to the elimination of discrimination against women and to gender equality and women's empowerment through education. Thus, one of the goals of WMU is the incorporation of the gender perspective throughout academic activities. In 2014, the WMU incorporated two new courses dealing with diversity, gender and cultural awareness and with policy issues on gender equality. To expand this academic offer, Romero Lares suggests the joint collaboration with IMO through its programme GENMET (IMO, 2016) to develop gender-sensitive training materials that could be used as a common course for all maritime students. The university also organises conferences and seminars focusing on gender issues such as the International Conference for Empowering Professional Women in the Maritime World (2008) or Maritime Women: Global Leadership (2014), the latter resulting in the publication of a book by the female faculty and the establishment of the WMU Women's Association. On the other hand, policies for increasing the enrolment of female students have been quite successful. However, the incorporation of female teaching staff has not followed the same pace with an increase from 2 to 7 positions, which represents a modest rise from 10.52% to 21.87% of the total teaching staff between 2010 and 2017. In spite of these low numbers, female faculty have become role models for both students and women in the sector and have greatly contributed with their female perspective to maritime education.

*3.4. MET in four top-ranked countries in the Global Gender Gap Index (Boström Cars & Österman, 2015)*

This study examines how gender equality is addressed in the curricula of maritime education in the five top-ranked countries according to the Global Gender Gap Index in 2013. The authors analysed the study plans for the equivalent of the Bachelor's degree in Nautical Science in eight METIs in Finland, Norway, Sweden, and the Philippines. In the fifth country, Iceland, no university providing maritime education was found, so this country was left out. The analysis performed was based on theories of gender-conscious pedagogy and included programme descriptions, learning objectives and course contents. Discouragingly, the findings reveal no mention of gender issues in any of the course plans examined, which indicates a clear lack of strategies on the matter. As the STCW convention determines the objectives and contents of maritime education, all study plans had many similarities. For example, some kind of cultural awareness was mentioned in many of them, but it was limited to the understanding of values from different countries and nationalities without encompassing other discrimination structures such as age, class, religion, gender or sexual orientation. According to Boström Cars & Österman (2015), study plans are expected to reflect the national legislation on gender equality, particularly in four top-ranked countries in the Global Gender Gap Index. However, there seems to be a mismatch between regulations on gender mainstreaming and their practical application.

The results of this research disclose a general gender-blindness in MET probably as a result of a traditional male-dominated maritime sector. Some students' perceptions may deem gender discourse unnecessary and some academic staff may be of the opinion that gender issues are completely irrelevant for certain subjects.

According to the authors, gender awareness may help to overcome all these stereotypical perceptions, so there's a need for operationalising gender equality policies in METIs. However, Boström Cars & Österman claim that this should go further than the urgently needed inclusion of the gender perspective in the curricula and the definition of gender-conscious pedagogical and didactic approaches. If gender-inclusive polices are to become structurally embedded in education, clear guidelines, incentives and audits are also required. In addition, support from institutional leaders, faculty and gender experts is also key for a successful implementation as increasing the numbers of female students alone will not serve to address the bias in the shipping industry. Hence, the authors conclude that it is necessary to rethink the contents and organisation of maritime study programmes with the support of governance and administration to include gender-inclusive policies and practices.

*3.5. Shanghai Maritime University (SMU) (Zhao et al., 2017)*

This paper forms part of the research outcomes of the Gender, Empowerment and Multi-cultural Crew (GEM) Project (Pike et al., 2016) aimed at studying seafarers' welfare, with a special attention on gender issues in multi-cultural crew environments. The present study focuses on the experiences of women seafarers and cadets in China to discuss state policies on gender equality in university recruitment. In China, Shanghai Maritime University (SMU) is the only MET institution that accepts women among its students since 2000, against the general mainstream, which bans women from joining maritime universities. Nonetheless, female students can only enrol in the BSc in Navigation as, even in this university, the BSc in Marine Engineering is only open to men. In addition, a vast majority of female cadets will not have the opportunity to develop their careers at sea due to social bias, traditional values, expectations and the prejudices and discrimination of shipping companies against women's participation in the sector. In this context, the SMU developed the Women Cadets Programme in an attempt to give some advantage to female cadets in their future maritime jobs.

The Women Cadets Programme offers female cadets additional compulsory courses in International Shipping Management to open the doors for them in the maritime industry. Since this expanded syllabus almost doubles the study units female cadets need to complete, the university has created a special Female Curriculum eliminating some of the most technical courses. On the other hand, the increment of study units also increases their tuition fees, which double the amount paid by male students. On top of this, male cadets receive subsidies from the government when they go to the sea after training whereas female cadets do not as they are not expected or required to go to sea after university. The double burden of extra courses and increased university fees have negative impacts on female cadets, who also complain about the lack of certain skills due to the expanded curriculum and the absence of some technical courses. Consequently, the Women Cadets Programme did not have the expected results, so the authors conclude that METIs should clarify the objectives of any gender programme from the beginning and be realistic. A lack of clarity is misleading, creates confusion and even discrimination among female students. Finally, the authors propose the development of strategic plans for METIs and shipping companies including gender-specific policies on women recruitment and employment. The joint collaboration of governmental administrations and agencies, key stakeholders, METIs and women's associations is key to promote gender equality and foster women's participation in the shipping industry.

### *3.6. Barcelona School of Nautical Studies (FNB-UPC) (Barahona-Fuentes et al., 2023)*

In this case study, the authors describe the implementation of a project for mainstreaming gender in maritime studies at Barcelona School of Nautical Studies (FNB-UPC). This project served to promote the university's commitment to equality, non-discrimination and respect for diversity and to comply with an administrative regulation of AQU Catalunya, a university quality assurance agency, which enacted legislation for the incorporation of the gender perspective in all university education in Catalonia. The project involved three main actions aimed at providing MET practitioners with tools to effectively incorporate the gender perspective in their everyday teaching practices. These actions included: (1) the development of a web platform with resources for mainstreaming gender in teaching, (2) teacher training on feminist pedagogies and (3) the transformation of the three courses participating in this initiative. The web platform (available at (https://igualtat.fnb.upc.edu/en) contained resources to mainstream gender in MET and also served as a repository of materials generated by those subjects being transformed. The teacher training course provided teachers with the necessary gender work for developing strategies to transform their teaching practices in a more gender-sensitive manner. Finally, out of all the participants in this teacher training module, three courses were selected to incorporate a new cross-disciplinary gender perspective competence.

The methodology consisted in transforming the study plans of the three participating courses with respect to competences, objectives, contents, teaching methodology and assessment by incorporating the gender dimension. Based on these changes, classroom activities, teaching practices and methodology were modified accordingly. To analyse the impact of this implementation pre- and post-surveys were used to gather information on perceptions, awareness, attitudes, and behaviours on the actions conducted. As data was disaggregated by sex, the surveys also served to determine any significant difference between men and women so as to obtain a better understanding of female students' needs and expectations. The results of the study show an overall positive assessment of this initiative both from teaching staff and students. Such a transformation helped to raise students' awareness concerning gender issues and to question certain accepted values, which some students positively value for their future professional career. Interestingly, the actions conducted were not only favourable for women but for all students, which resulted in an improved engagement and motivation with the course contents. Thus, in spite of some male students' resistances in an attempt to defend their institutionalised privilege, the outcomes are overwhelmingly positive. As a final point, the authors appeal to METIs to make the necessary changes to incorporate the gender dimension in the curricula and to provide teaching staff with tools to transform their teaching practices for a much-needed change in the MET domain.

## 4. Conclusions

The results of this literature review show that there are still few case studies describing in-depth practices or interventions carried out to implement gender mainstreaming in METIs and that most of them have taken place in recent years. This already suggests that this is an emerging field of research with promising opportunities for advancement and that additional research is needed to explore all these themes further. In addition, METIs are at different stages of the process of gender mainstreaming and they do not follow any common practice or standard procedure. However, although the implementation of gender mainstreaming adopts different approaches in the case studies described, most proposals show some common or overlapping practices. Hence, most studies agree on some important strategies to mainstream gender in MET. First, most studies emphasise the importance of networking and mentoring programmes to promote team building and socialisation among female students and to normalise their participation in these studies. Next, studies call for considering female students' expectations and motivations for enrolling in MET and for clear goals in the development of any gender programme. This can help reduce the discrimination women suffer and improve their attraction and retention in MET. In line with this, rethinking recruitment in MET is another necessary action described to help women fight cultural stereotypes and provide them with tools to promote their access to training. Another key intervention deals with the maritime study programmes themselves. Many studies propose a review of the teaching practices and contents taught with a view to incorporating the gender perspective in the maritime curriculum. They suggest this can be done in a number of ways, from including new courses dealing with diversity, gender awareness, gender equality policies, and social and cultural issues to adopting more gender-conscious pedagogical and didactic approaches in MET. In addition, some claim the training of women in leadership skills that cater for different styles and the revision of the male staff teaching practices. Most of all these practices proposed have resulted in favourable effects for women as well as for men. Thus, gender mainstreaming facilitates equal opportunities and advantages for all students. For this reason, such practices should be extended and transferred across METIs for fostering more inclusive MET environments for the benefit of all maritime students. Finally, studies show a general agreement to promote the development of gender strategic plans for METIs, which would also benefit women's recruitment and employment in the shipping industry to move towards the attainment of equal opportunities in the maritime sector with these added benefits for all.

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# A pathway to competency by optimizing sea time and lecture time: A comparative analysis and the case of MET in Japan

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Abstract: The ratio of sea time to lecture time in Maritime Education and Training (MET) may vary by country in accordance with the framework set by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978 as amended. Few studies have addressed such differences in MET, emphasizing the necessity for research in achieving competency-based education by optimizing sea time and lecture time. A comparative analysis was conducted using primary data from Japan and secondary data from the UK and Australia. The research revealed that Japan emphasizes longer lecture time and shorter sea time compared to the UK and Australia due to differences in onboard training systems, such as whether they are primarily managed by an MET public agency or private sector-led systems. Furthermore, Japanese lecture credits comprise general subjects (48%) and maritime specialized subjects (52%), with 17% of the total credits for a Certificate of Competency (CoC). The study employed a case study method to present the analysis of Japanese MET, focusing on its advantages and disadvantages. These findings highlighted the importance of further research that includes the perspective of key stakeholders to explore effective pedagogical approaches for implementing competency-based education in MET across countries.

Keywords: Maritime Education and Training (MET) curricula, competency-based education, comparative analysis, Certificate of Competency (CoC)

## 1. Introduction

Seafarers are recognized for playing a significant role in contributing to sustainable global maritime transportation (Mejia 2010). Approximately 1.9 million crew members work on board to support the international shipping industry, accounting for about 90% of global trade (BIMCO and ICS 2021). The International Maritime Organization (IMO) places the highest importance on human elements and Maritime Education and Training (MET) based on the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978 as amended for the safe operation of ships (IMO 2015). Generally, MET curricula consist of a blend of onboard training and lectures, with simulator training being utilized to a limited extent. Candidates should meet the competence standards specified in Section A-II/1 for the deck department and Section A-III/1 for the engine department of the STCW Code. Additionally, it is necessary for them to complete an approved seagoing service of no less than 12 months as part of an approved training program under the STCW Convention.

The methods and systems for onboard training vary between countries. For example, onboard training in Japan is primarily managed and operated by a public MET institution that owns training ships, whereas candidates undergo onboard training as cadets on cargo ships operated by private shipping companies in the UK and Australia. Alternatively, lectures at maritime academies of higher education are typically divided into general subjects, such as mathematics and science, which are not required for obtaining a Certificate of Competency (CoC), while maritime specialized subjects, such as maritime traffic laws and regulations and navigation English, are essential for obtaining a CoC. According to Manrique et al. (2018), the general subjects play a significant role in providing fundamental knowledge necessary for certification. Specifically, mathematics is essential for the navigational watch, including measuring distances and speeds and calculating engine machinery parameters. Science aids in understanding the principles, such as tides, currents, and weather forecasts for the deck department, and the system of diesel engines and marine boilers for the engine department.

MET is designed as a competency-based education, with the primary objective of providing seafarers with the essential Knowledge, Understanding, and Proficiencies (KUPs) required by the STCW Code (Gundić et al. 2020). The States are responsible for compliance in alignment of standards in their MET systems. However, few studies have addressed the relationship between onboard training and lectures, as well as the balance between sea time and lecture time. Therefore, it is important to examine different approaches adopted by different MET systems, considering the optimization of resource allocation in sea time and lecture time. The aim of this paper is to clarify how different approaches to MET can effectively balance these resources in order to achieve the effective implementation of competency-based education in MET.

## 2. Competency-based education in MET

Competency-based education, derived from the behaviorism learning theory, proves highly beneficial for acquiring particular knowledge and skills aligned with rules and regulations, thus widely employed across various occupations whereas the application of competency-based education for more intricate performance fields remains ambiguous (Morcke et al. 2013). Focusing on the MET domain, the STCW 1995 amendments led to a shift from knowledge-based education to competency-based education, which involves less theoretical instruction in the classroom and emphasizes practical training in workshops such as onboard training and simulator exercises. The integration of onboard training with educational systems for obtaining a CoC introduces additional complexity to the implementation of maritime educational activities (Cross 2007). Additionally, every candidate is required to demonstrate competence for each department and level, including KUPs, meeting the required minimum standard based on the STCW Code. (Gundić et al. 2020). For instance, one of the competencies required for seafarers of the deck department at the operational level is the ability to plan and conduct a passage and determine position. With this competence, the candidates should demonstrate proficiency in using celestial bodies to determine the ship’s position.

## 3. Research Questions and Methodology

### 3.1 Research Questions

The study has undertaken a comparative analysis of selected MET curricula, aiming to identify the different approaches to combining sea time with lecture time. It also adopts a case study of Japanese MET to analyze a balance between general subjects and maritime specialized subjects, focusing on its advantages and disadvantages. Furthermore, it explores the pedagogical challenges inherent in this endeavor within the context of Japanese MET. In order to achieve the aims, the research established the following two research questions:

1) What are the ratios of onboard training to lectures practiced in different countries?
2) What is the balance between general subjects and maritime specialized subjects in Japanese MET?

### 3.2 Methodology

Data and information for this research were obtained from the literature and documents, including MET curricula, and secondary data analysis was conducted. Taking inspiration from the research conducted by Karlis et al. (2016), who explored the training periods required to obtain a CoC in different countries, the same methodology was employed to examine the case of Japan. Detailed MET curricula in Japan were analyzed as primary data and a comparative analysis was conducted with secondary data from two other countries, i.e. the UK and Australia. Additionally, this paper utilized data regarding the lecture credits from a Japanese maritime university (i.e., Tokyo University of Marine Science And Technology (TUMSAT)) to illustrate the proportion of general subjects and maritime specialized subjects. It examines the advantages and disadvantages, with a focus on general subjects in the MET field within the context of competency-based education, supported by literature review.

## 4. Findings

### 4.1 The ratio of onboard training to lectures

The study reveals that the Bachelor of Science (BSc) MET curriculum in Japan comprises 56 weeks of onboard training and 130 weeks of lectures (TUMAST 2024), resulting in a ratio of sea time to lecture time of approximately 1:2. In contrast, the ratios of sea time to lecture time in the UK and Australia are nearly 1:1

(Figure 1). This indicates that Japanese BSc MET programs allocate significantly more lecture time and less sea time compared to their counterparts in the UK and Australia. The Japanese curriculum features longer lecture periods and shorter durations for sea time, highlighting distinct differences in educational approaches across these countries. It implies that there are variations in optimizing between specific national needs in MET and global standardization under STCW.

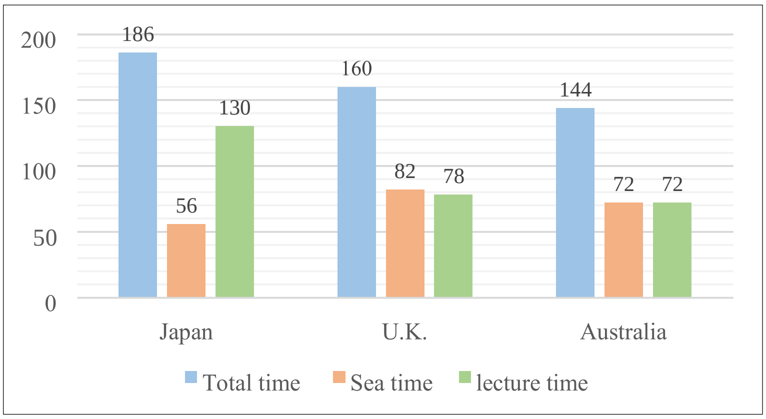


Figure 1. Comparison of MET duration in weeks to CoC (Source: Authors; Karlis et al. 2016)

The majority of the 56 weeks of sea time in Japan is regulated by a public MET agency, which is integrated as part of the MET curriculum in higher education. This public-led MET system utilizing training vessels differs from the private-led onboard training system employed with cargo ships as cadets in the UK and Australia. Generally, many Japanese candidates obtain a CoC through a 12-month seagoing service on public training vessels. Frimpong's (2023) study noted it is essential to have many resources, including personnel and financial costs, particularly in fuel and ship maintenance, to ensure high educational quality with training vessels and safe ship operation. Consequently, the sea time in Japan (56 weeks) can be expected to closely align with the minimum requirements by the STCW Convention (approximately 52 weeks), considering limitations in such resources.

4.2 Case study of competency-based education in Japanese MET

By employing a case study method, this section presents the analyses of competency-based education in Japanese MET in terms of its advantages and disadvantages.

4.2.1 The ratio of general subjects to maritime specialized subjects

The lecture credits in the navigation system course at TUMSAT comprise 48% of general subjects (e.g., calculus, linear algebra, physics, basic information processing, statistics, and computer science) and 52% of maritime specialized subjects. Of the total credits, 35% are not required for CoC (e.g., navigation system, electrical engineering, ship dynamics, ship and crew management, and atmospheric science) while 17% are essential for CoC (e.g., navigation English, maritime traffic laws and regulations, maritime radio regulations, nautical medicine, and maritime systems engineering laboratory and exercise) in the maritime specialized subjects (Figure 2).

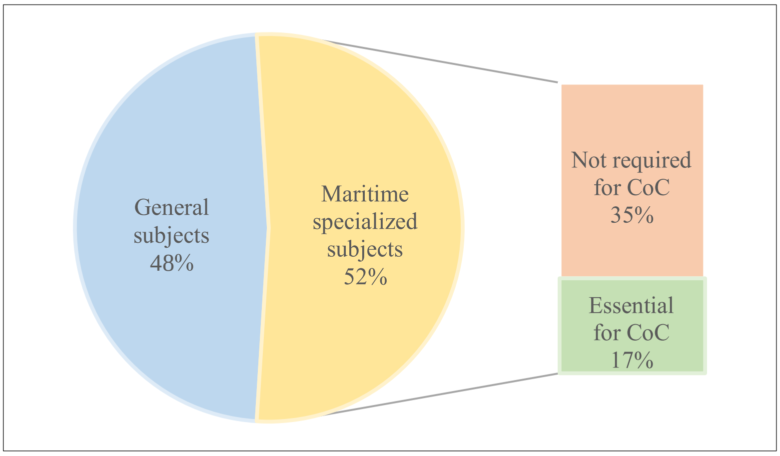


Figure 2. Comparison of general and specialized subjects based on lecture credits (Source: TUMSAT)

The MET places emphasis on both general subjects and maritime specialized subjects as it focuses not only on competency-based education for becoming a seafarer according to STCW standards but also on enhancing scientific and technical knowledge and critical thinking to advance ship operational systems. (Amemiya 2001; Shoji 2019). In fact, from 2018 to 2021, approximately 75% of graduates from the deck department and approximately 80% of graduates from the engine department who obtained a CoC secured employment at shipping companies. Others found employment at maritime organizations such as ship inspectors, shipbuilding companies, and maritime research institutions (TUMAST 2022). This trend may not only be confined to Japan but could also be observed in the broader domain of seafarers worldwide. A survey conducted from 2019 to 2021 with more than 6,000 seafarers revealed that 68% of them are interested in a shore-based career (Danica 2023). It turned out that many seafarers, including Japanese, pursue employment ashore by utilizing their experience in working onboard and certifications.

The skills and knowledge required of seafarers have changed or may evolve further beyond STCW standards in response to technological advancement and labor market demands. According to Naito (2021), significant shifts in the maritime sector over the past fifty years, with larger vessels and more diverse crews becoming common. Japanese seafarers now need expertise in ship and crew management, as well as in maritime projects such as decarbonization and digitalization. Similarly, the gap between the STCW minimum requirements and technological innovations has been increasing, especially in the long term (2031-2040) (WMU 2023).

4.2.2 Advantages and Disadvantages of Japanese MET

The analysis of detailed MET curricula from TUMSAT as a case study provided several implications in terms of both the advantages and disadvantages of emphasizing both general subjects and maritime specialized subjects.

4.2.2.1 Advantages of focusing on general subjects in MET

- Adaptability and diverse skills acquisition:

One of the biggest advantages of including general subjects in the MET curriculum is the enhancement of adaptability, which enables students to acquire diverse skills and knowledge beyond the STCW-related competencies. The scope of the KUPs of seafarers has been expanding, including not only ship navigation and maintenance but also areas related to the marine environment such as decarbonization (e.g., alternative fuel systems) and the development of new technologies (e.g., autonomous ships). This adaptability presumably equips students with the skills needed for diverse roles within the maritime industry and enhances their career flexibility.

- Strengthening critical thinking and research skills:

Enhanced general subjects contributes to the development of logical and critical thinking skills, which are crucial for conducting in-depth research-based analysis. Uncertainties in maritime careers put an emphasis on lifelong learning to address the rapid evolution of the shipping industry (WMU 2023). For instance, at Japanese universities that emphasize general education, graduates are more likely to pursue graduate school or enter a professional career. In such cases, during undergraduate education, students may be able to expect further success in the future by developing basic academic skills rather than focusing solely on specialized subjects (Akasaka 2021).

- Increased career opportunities:

Graduates from the MET curriculum with general subjects would have a chance to explore more career opportunities (Manuel 2017). These opportunities are particularly relevant as many candidates and seafarers express a desire to work ashore, utilizing their maritime knowledge, experience, and qualifications after graduation from maritime universities or later in their sea careers (Danica 2023).

4.2.2.2 Disadvantages of focusing on general subjects in MET

- Resource allocation challenges:

Emphasizing general subjects in the MET curriculum requires high resource allocation and additional investments in human resources, materials, and finances (Bower 1972). To what extent MET institutions should distribute their curricula between general subjects and maritime specialization subjects is not an easy task. While general subjects are important, maritime specialization subjects are essential for obtaining a CoC. However, these specialization subjects have a fixed volume of content that must be covered within specific lecture requirements (Shoji 2019).

- The complexity of curriculum design:

Multiple stakeholders are involved in MET curriculum design, delivery, and assessment, and each process can permit diverse opinions on what constitutes optimal seafarer education (Manuel 2017). Consequently, curriculum design can become complex. This complexity raises a concern about the influence of stakeholders, such as shipping companies and maritime administrations, who are seeking a new skill set from seafarers.

- Potential impact on seafaring motivation:

From a student perspective, particularly for those who enroll in maritime universities with the sole aim of becoming seafarers or acquiring qualifications, questions arise about how a diverse range of learning plans, including general courses, will impact their motivation for seafaring professions.

4.2.3 Implications to Competency-Based Education

An unbalanced curriculum that focuses too heavily on either general subjects or maritime specialized subjects can have implications for competency-based education. For example, a curriculum that focuses too much on specialized subjects may potentially overlook broader educational needs and limit seafarers' adaptability and critical thinking. Conversely, a curriculum that focuses too much on general subjects may fail to provide the specific technical expertise required for safe navigation required by the STCW. Either approach in the MET curriculum can impact the competencies of seafarers to perform their duties safely and effectively.

## 5. Conclusion

With technological advancement, especially in simulator technologies, the optimization of sea time with simulator training has gained an interest in debates. However, this paper highlights the importance of optimizing sea time and lecture time as a holistic approach to MET. The optimized relationship between sea time and lecture time remains relatively unexplored. MET curricula typically mix onboard training and lectures, yet the methods for onboard training and lectures vary across countries. Compared to Australia and the UK, Japan has a shorter sea time and longer lecture time. Furthermore, in the case of an MET higher institution in Japan, the credits for general subjects and maritime specialized subjects are almost equally distributed. This equal balance contributes to enhancing critical thinking skills and adaptability to the future, which are essential as the skills and knowledge required of future seafarers to work in addition to the STCW standards.

Competency-based education is most prevalent at MET, aiming to equip seafarers with the essential KUPs required by the STCW Code. However, enhancing competency-based education requires careful consideration of various factors, including the allocation of resources such as sea time and lecture time as well as balancing between general subjects and maritime specialized subjects. It is necessary to explore what specific knowledge and skills are sought by seafarers in alignment with the needs of stakeholders. The findings of this study highlight the need for further exploration of methodologies adopted by different MET systems worldwide to effectively balance the MET curriculum.

It should be, however, noted that this study used limited available data and information as secondary sources from the literature and documents. Future research can consider conducting comparative analyses of MET curricula with a larger sample of countries to identify optimal approaches for integrating sea time and lecture time, as well as balancing general subjects and maritime specialized subjects. Additionally, it is significant to incorporate the perspectives of key stakeholders, such as crewing companies, seafarers, and MET institutions, to explore effective pedagogical approaches for implementing competency-based education in alignment with the needs of the maritime industry. This can be a good research project for the International Association of Maritime Universities (IAMU) community to work together through measurable and meaningful collaboration to support the Global Maritime Professional (GMP) activities (IAMU 2019). IAMU is recognized as a key platform for these discussions and is actively considering benchmark curricula across borders (Manuel 2017). The GMP initiative enables us to seize the opportunity to clarify the competencies required in the future maritime environment and to develop the MET curriculum in collaboration with the members of IAMU.

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# Charting New Courses: Reimagining Information Literacy in Maritime Education and Training

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**Abstract:** This paper reviews selected Standards of Training, Certification and Watchkeeping for Seafarers (STCW) performance standards for implicit information practices. The perceived divide in maritime education between academic learning and hands-on, skills-based instruction can affect the operations and curricula of maritime institutions of higher education, creating a sense among students and instructors that academic disciplines are disconnected from the core maritime curriculum. Information literacy has traditionally been perceived as an academic discipline, involving library and/or web-based research, and the evaluation and use of information from text-based resources. Recent scholarship, however, recognizes that human cognition encompasses physical, situational, and social aspects instead of being a purely individual activity. In the maritime context, successful vessel navigation relies on cognition that is cultural and distributed, not purely individual. Maritime emergency situations can require multiple types of information literacy: selecting and understanding text-based rules, procedures, manuals and/or regulations; using physical information, gathered through the senses; awareness of the limits and opportunities of the specific environment; physical action; and social interaction and communication. Examining the STCW performance standards for their implicit information practices reveals that these practices are embodied, situated, social, and cognitively complex, with implications for information literacy and maritime education.

*Keywords*: Maritime education and training; STCW; information literacy; situational learning

## 1. Introduction

Maritime education in universities acknowledges a divide between academic learning and hands-on, skillsbased instruction in compliance with the IMO International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (Regional Maritime University 2013; International Maritime Organization 2017; Manuel 2017). This perceived divide can affect the operations and curricula of maritime institutions of higher education, creating a sense among students and instructors that academic disciplines are disconnected from the core maritime curriculum. Information literacy has traditionally been perceived as an academic discipline, involving library and/or web-based research, and the evaluation and use of information from text-based resources. Recent scholarship, however, recognizes that human cognition encompasses physical, situational, and social aspects instead of being a purely individual activity (Paul 2022). The Association of College & Research Libraries Framework for Information Literacy, adopted in 2016, is in line with these developments, and has moved to a broader view of information literacy, acknowledging the social and societal aspects of information retrieval and use (Association of College and Research Libraries 2016).

In the maritime context, successful vessel navigation relies on cognition that is cultural and distributed, such as the practice of Bridge Resource Management (Hutchins 1995). Maritime emergency situations can require multiple types of information literacy: selecting and understanding text-based rules, procedures, manuals and/or regulations; using physical information, gathered through the senses; awareness of the limits and opportunities of the specific environment; physical action; and social interaction and communication. Discussions of information literacy usually assume that information is text-based and often digital; in the maritime context, studies and programs of information literacy do not acknowledge the role of non-text-based information (Constantinou and Fazal 2007; Chlomoudis et al. 2022). Maritime uses of information beyond textbased sources are not usually acknowledged to be examples of information literacy in action, creating a false appearance of division between STCW knowledge and competencies, and information literacy as a discipline. Better integration between academic and traditional hands-on marine education provides a scaffold for future maritime educators to respond to emerging problems and technological developments, thus enhancing mariner competence, safety, and dependability.

The current STCW focuses on hands-on, task-based competencies, having evolved from a cognitive education paradigm in the initial 1978 Convention due to concerns about the need for effective training to produce competent mariners (Manuel 2017). The 1998 and 2010 Manila Amendments provide assessments which measure students' competence according to granular criteria focused on specific practical skills (Manuel 2017). STCW competencies vary in the degree of their connection to academic disciplines; the functions of navigation, controlling the ship's operations, and marine engineering are more likely to be taught by instructors with advanced academic degrees (Regional Maritime University 2013). Discussions of the perceived divide between academic education and STCW accept the assumption that the STCW competencies do not themselves contain high-level cognition, adopting what Andy Clark identifies as a "brainbound" concept of human thinking, limiting cognition to the physical brain and neglecting the vital role of embodied, situational and social interactions like those found in maritime education (2011).

Lloyd and Olsson make the distinction between information behavior, "constructed as a problem-focused, individual, purposive and cognitive process," and information practices, which are embodied, situated, and social (2016). Lloyd's research includes hands-on information practitioners: nurses, firefighters, refugees. She concludes that embodied information practices are always situated, expressed corporeally, and are key to people understanding the full complexity of the information landscape. Moreover, embodied information practices are places for know-how knowledge which cannot be easily expressed in written form alone (Lloyd and Olsson 2016). Talja and Lloyd also state that "Sociocultural learning theories assume that all human practices, including information practices, are fundamentally social and bound to a specific context and activity setting" (2010). In the maritime context, examples of such practices could include Bridge Resource Management or working as part of a mooring team (Lloyd and Olsson 2016). Extending the discussion of information literacy in the maritime context to consider information practices offers the possibility of reconciling hands-on, practical approaches with academic approaches to education.

## 2. Methodology

The cognitive complexity of maritime labor is implicit; this project seeks to explore and identify the embodied, situated and social aspects of the tasks and skills in the STCW competencies. Our research consisted of exploratory text analysis to learn about the contexts and boundaries of information literacy in maritime education. The research is also qualitative in nature, which enables us to examine and understand the lived experiences of people as they engage with information literacy as part of their everyday use of the STCW (Lloyd 2021). We used three assessment guidelines in our investigation: Able Seafarer-Deck (ASD), Officer in Charge of a Navigational Watch on vessels of 500 GT or more (OICNW), and Ratings Forming Part of a Navigational Watch (RFPNW). We chose these guidelines because together they represent a substantial percentage of deckrelated competencies. Each assessment guideline is further broken down into individual tasks that clarify the STCW competency, resulting in specific performance standards that are ultimately assessed. A single STCW task number may have several performance standards associated with it. These performance standards are used to assess the performance and competence of candidates for STCW certifications. Together, ASD, OICNW and RFPNW account for 720 individual performance standards which are evaluated for this research.

The role of information literacy in curricular competencies has been examined in other practice-based professions where students receive training in university settings, such as health professions (Waltz et al. 2020). Waltz et al.'s review noted that information literacy outcomes are often implicit or de-emphasized in the vocational curriculum, and that review and analysis is required to identify information literacy outcomes in students' training. While the specific approach in Waltz et al.'s study wasn't applicable to STCW, the overall approach of using inductive qualitative coding to identify hidden information practices in professional education was useful and formed the basis for our examination of STCW.

We entered every performance standard into a spreadsheet with all necessary information needed to clarify expectations and requirements for the performance standards, such as performance condition or behavior. Each performance standard was coded based on information literacy in each of the following categories developed and informed by a review of information literacy landscapes which represent ways of knowing about all forms of knowledge. Most often, modalities of information can be social, epistemic or corporeal (Lloyd 2021). These modalities are often entwined, and understanding information fluency requires agreeing upon the shared meanings about the activity at hand (Lloyd 2021). We started with the three modalities listed above, and further refined them to include the following more fine-grained six categories of information practices, which we feel better describe the full array of information practices implicit in STCW:

- Social: consists of explicit communication with others in oral or written form.
- Physical (gross): consists of body movements using large muscle groups and most often involved ondeck activities, e.g. mooring the ship and cargo operations.
- Physical (fine): consists of physical interactions involving manual dexterity and fine motor skills, e.g. navigation or operating the radar.
- Text-based: consists of investigation and use of texts e.g. using the nautical almanac, plotting a position, or applying regulations or other laws.
- Instrumental: consists of interactions with instruments and equipment e.g. the radar or sextant.
- Sensory: consists of using senses not otherwise covered to take in information, such as visually or aurally. For example, sensory practices may involve listening for sound signals, visually identifying objects or observing the weather.

The researchers coded each performance standard according to these categories. For example, performance standard 1.6.A.1, in which the candidate compares the locations of geographic and magnetic poles, was coded for both text-based and physical (fine) practices as the candidate must calculate and compare the two poles. Performance standard 5.6.B.2, in which the candidate demonstrates lifting methods to prevent back injury, proper methods to set down the load, was coded as both physical (gross) and social because someone must observe and verify the appropriate lifting methods.

Each performance standard was coded by one researcher, then reviewed by the team and individually for a third time to verify the coding. All told, 720 individual performance standards were evaluated for information fluency. Next, we conducted simple statistical analyses of the coding to better understand the implicit information practices in STCW. One limitation to our study is that our categories are social constructs, and therefore, applying these categories to performance standards may yield slightly different interpretations from different researchers.

## 3. Results

Overall, the six categories we used in coding were used a total of 1204 times (Table 1). Half of the standards, 360, had one implicit category; while 360 (surprisingly, the same number), had more than one implicit category. The single highest populated category was the social category with 447 performance standards. ASD had the most standards coded as social with 290, followed by OICNW (88) and RFPNW (69). The physical (fine) category had 324 performance standards. Of these, OICNW and ASD both had significant numbers (172 and 117 respectively) while RFPNW had only 35 physical (fine) performance standards. Physical (gross) was in third place with a total number of performance standards at 157. Of these, 123 were in ASD assessments due to the large numbers of deck-based competencies including mooring and cargo handling. The instrumental category characterized 127 performance standards with most coming from OICNW (78), followed by RFPNW (49). ASD had no instrumental performance standards. The text-based category had 105 performance standards, most of which were from OICNW (84). ASD and RFPNW both had fewer than 20 in this category (16 and 5 respectively). Finally, the sensory category only characterized 44 performance standards with 31 of those representing RFPNW and only 2 representing OICNW. See Table 1 and Figure 1.

Table 1. STCW Implicit Practices Coding Results.

| | Social | Physical (gross) | Physical (fine) | Textbased | Instrumental | Sensory | Single | Multiple |
|---|---|---|---|---|---|---|---|---|
| ASD | 290 | 123 | 117 | 16 | 0 | 11 | 186 | 153 |
| OICNW | 88 | 2 | 172 | 84 | 78 | 2 | 150 | 128 |
| RFPNW | 69 | 32 | 35 | 5 | 49 | 31 | 24 | 79 |
| Total | 447 | 157 | 324 | 105 | 127 | 44 | 360 | 360 |

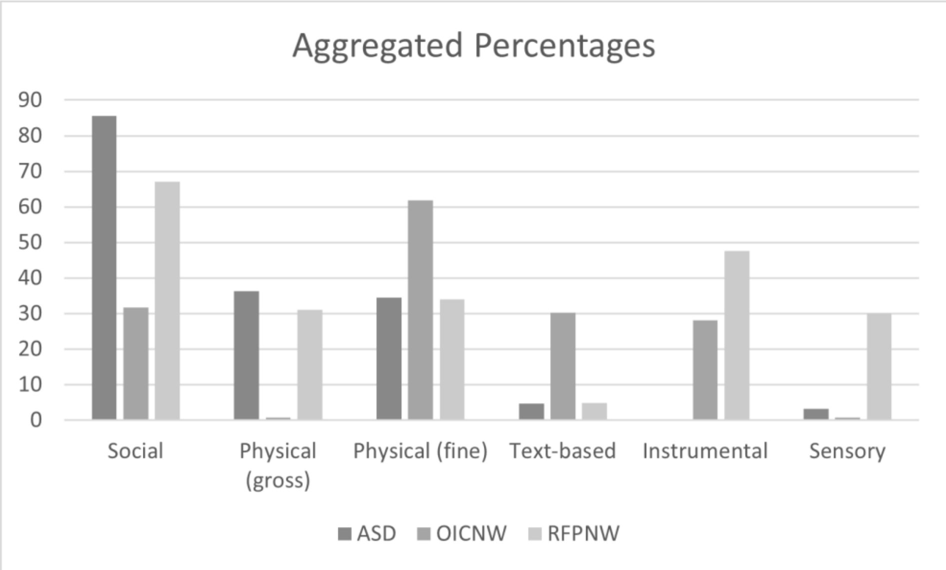


Figure 1: Aggregated Percentages, ASD, OICNW and RFPNW

*3.1. Review of Findings by Assessment: Able Seafarer-Deck*

The social category characterized the most performance standards found in the ASD assessment with 290. The social category is particularly high for ASD due to the emphasis on mastering the helm and responding to helm commands, demonstrating mooring skills, describing lines, and so on. ‘Describe’ was the verb used most often in ASD performance standards, followed by ‘demonstrate’ resulting in the high number of social performance standards. The physical (gross) category had 123 performance standards, far outnumbering OICNW and RFPNW. The high number in the physical (gross) category had to do with the large number of deck-based competencies, specifically, mooring, anchoring, cargo handling, and ship maintenance. The physical (fine) category was close with 117 performance standards. These also related to many of the same categories as physical (gross) but represented the more dexterous elements of these performance standards. The text-based category only had 16 performance standards, mostly related to International Maritime Dangerous Goods references, flags, and regulatory compliance standards. The sensory category only had 11 performance standards related to preparing surfaces for paint, assessing weather and motion of the vessel. The instrumental category had no performance standards associated with it.

*3.2. Review of Findings by Assessment: Officer in Charge of a Navigational Watch*

OICNW had 88 performance standards that were characterized by the social category. Many of these consisted of principles of bridge-team management, VHF communications, managing the crew, and describing responses to various shipboard emergencies. The physical (gross) category had only 2 performance standards relating to checking equipment and PPE. The physical (fine) category had the most performance standards of any assessment with 172. These included performance standards related to electronic and terrestrial navigation, collision avoidance, celestial navigation and VHF communications. OICNW also had the most text-based performance standards with 84. Again, these performance standards were related largely to elements of celestial and terrestrial navigation and compliance with regulatory policies, COLREGS and MARPOL. The instrumental category also had more performance standards than the other assessments with 78. The candidates’ use of radar/ARPA, ECDIS, and other bridge equipment were responsible for most of the performance standards categorized in this way. Finally, the OICNW assessment only had two performance standards listed in the sensory category, relating to avoiding risk of collision and identifying aids to navigation.

*3.3. Review of Findings by Assessment: Ratings Forming Part of a Navigational Watch*

The social category accounted for 69 performance standards, primarily related to operating the helm, watch exchange, performing lookout duties and vessel identification. The physical (gross) category accounted for 32 performance standards while the physical (fine) category accounted for 35 performance standards. These were related mostly to operating the helm. The text-based category accounted for only 5 performance standards. The instrument category accounted for 49 performance standards, the most of any assessment, mostly from operating the helm (steering, switching modes, etc.). The sensory category accounted for 31 performance standards, also the most of any assessment. These performance standards involved visual cues to determine the aspect of vessels for collision avoidance.

## 4. Discussion

The high value of 'social' interactions, with 62% of all performance standards having a social component, does not come as a surprise given the number of performance standards that require a candidate to describe what they are doing or seeing, repeat an order, or demonstrate what they are about to do. ASD shows an even higher percentage, with 89% of the coded categories containing a social aspect, because of the interpersonal nature of many of the performance assessments in this assessment guideline. The importance of the social category also underscores the importance of human interaction and teamwork in the maritime field generally, and in assessing STCW competencies specifically. The physical (fine) category accounted for 45% of performance standards, mostly in the OICNW assessment, while physical (gross) only accounted for 22%, almost all of which were in ASD. While ASD is focused mostly on deck competencies ("Able bodied seafarer"), OICNW assesses candidates as they interact with bridge equipment including sextants and VHF radios. As technology continues to advance, we will likely see even more assessments for OICNW in the physical (fine) and instrumental categories, for example, with artificial intelligence. The text-based category (15%) is also largest for OICNW; in the future, we will also likely see more performance standards focused on regulatory compliance including environmental protection and decarbonization resulting in even more text-based performance standards. Overall, the text-based category was much more likely to be coded along with one or more other categories (67%) than to stand alone (33%), indicating that text-based practices are intertwined with other aspects of maritime work. The instrumental category (18%) is used mostly for OICNW and RFPNW performance standards, and only one ASD assessment, reflecting the less technological emphasis of ASD assessments and greater emphasis on physical (gross) performance standards. Finally, the sensory category only accounted for 6% of all performance standards across all assessments. This is not surprising given the rise of technologies used to augment or replace the need for sensory experiences, for example, the use of radar to 'see' through fog to 'observe' other vessels. While it could be argued that almost all the performance standards described in STCW require sensory interaction, we coded this category based on explicit sensory experiences. These include listening for and hearing sound signals, observing other ships including their lights and day shapes, and observing and experiencing weather phenomena. Almost all the sensory experiences fall under RFPNW with observing weather conditions when conducting cargo operations or other weather sensitive deck operations. OICNW is barely represented by sensory experiences, namely by the visual observation of risk of collision.

## 5. Conclusion

Coding STCW performance standards by the six categories outlined above transformed implicit characterizations of performance standards into explicit characterizations, with lessons for the fields of information literacy and maritime education. Specifically, results suggest the importance of soft skills and social interactions such as interpersonal communication and active listening, skills which may or may not be taught explicitly in maritime education. Results also have pedagogical implications by recognizing the need to address everything from text-based learning to physical actions. Identifying the embodied, situated and complex information practices implicit in such competencies can help improve information literacy instruction and deepen its connection with disciplines with practical, task-based competencies such as marine transportation. For example, explaining the information use that is implicit in the vocational training and professional practice in a discipline could deepen students' understanding and learning, and bridge the perceived divide between academic and vocational education. Additionally, centering text-based instruction on the cognitive complexity of maritime information practices can deepen its actual and perceived relevance to the curriculum. These insights facilitate the development of information literacy curricula directly applicable to STCW competencies, such as connecting text-based knowledge of regulations and best practices with physical action. Incorporating the specific, embodied and situational nature of information practice in the maritime context (and similar contexts) could lead to the creation of more relevant and effective instruction.

Using the categorical descriptions as we did also has specific pedagogical implications for educators in marine transportation. By understanding the information literacy characterizations of specific performance standards, we may be able to identify where some students could have difficulty with passing assessments and provide contextual, scaffolded and more effective support for the students. For example, some students are more adept at physical (gross) skills than text-based skills, or vice versa. Educators, armed with a better understanding of information practices, can tailor their training more effectively. Findings from this study also impact the relationship between information use and learning, and how information use and learning interact (Kari and Savolainen in Talja and Lloyd 2010). Improved understanding of the categorical descriptions will enable instructors to better shape students' understanding of their own cognition and learning which will have implications in their preparation for licensing exams. Or, as Gherardi states, "to know is to be capable of participating with the requisite competence in the complex web of relationships among people, material artefacts and activities... it follows that knowing practice is always a practical accomplishment" (2008 p 517). Illuminating the academic complexity of situational, social and embodied work also supports equity by acknowledging the value of diverse learning approaches. Finally, educators can benefit from understanding the information literacy categories of the performance standards by tailoring their teaching efforts to better match expectations for specific learning outcomes, recognizing that a maritime education can be both holistic and context-specific.

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# Long COVID: How Norwegian Cruise Line Struggled to Ride a Post-Pandemic Wave - An Inductive Analysis

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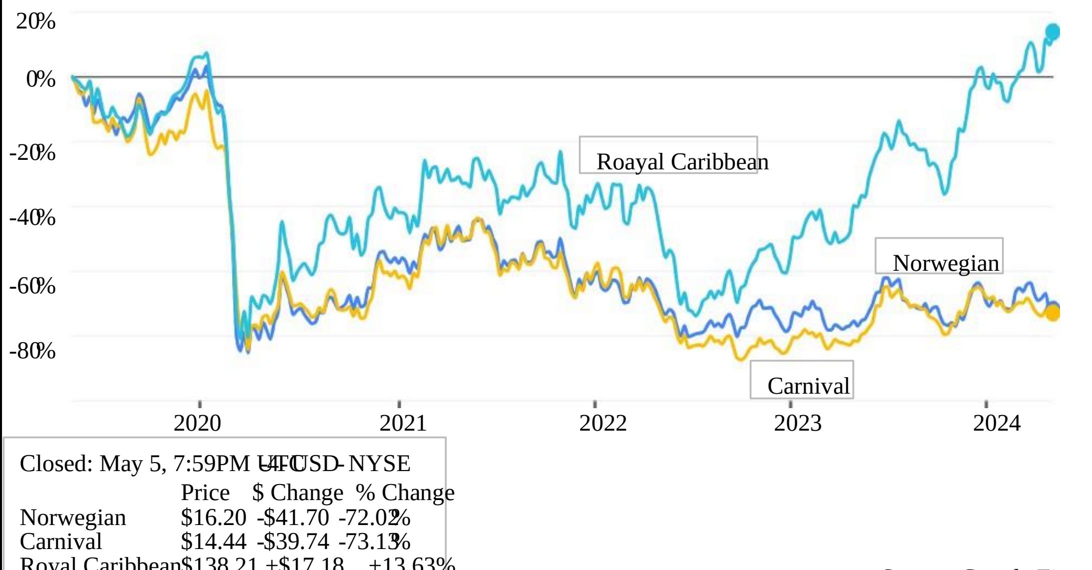
**Abstract:** This paper, focusing on managerial decision-making at Norwegian Cruise Line Holdings (NCLH) during the COVID-19 crisis, is an inductive analysis exploring a specific case to identify relationships that may be assessed further in future research. Evidence presented suggests that the decision of executives to seek, and of the board of directors to award, exceptionally high executive pay during the COVID crisis may have contributed to lagging performance at NCLH by undermining employee satisfaction. The results of this analysis suggest that future researchers may benefit from exploring whether executive compensation packages may restrict managers' capacity to engage in authentic communication or servant leadership, two fields that have received much contemporary research focus. The results further suggest that potential connections between executive compensation, leadership style, employee satisfaction, and firm value may strengthen during a crisis.

*Keywords*: servant leadership; authentic communication; crisis management; executive compensation

## 1. Introduction

In May of 2020, at the height of the COVID-19 (COVID) pandemic, Norwegian Cruise Line Holdings (NCLH) sat on the verge of ruin. Managers issued a public statement indicating that there was "substantial doubt" about whether the company could continue as a "going concern" and said that they may need to seek bankruptcy protection (Feuer 2022). Stock prices of all three dominant firms in the industry plunged (see Figure 1). Annual global passenger throughput dropped from almost thirty million in 2019 to around five million in

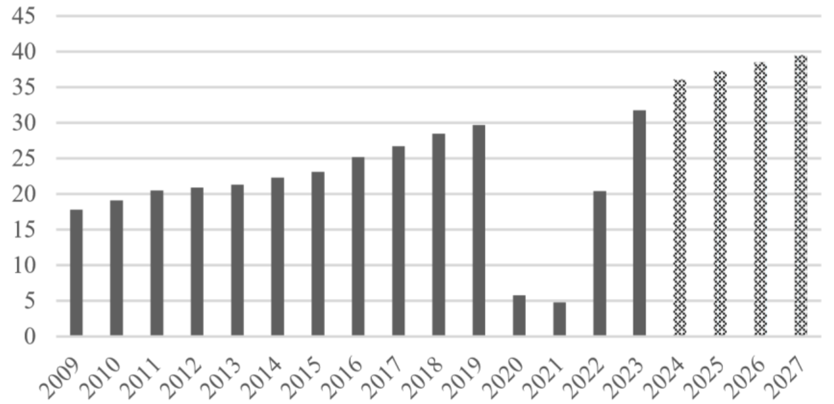
Figure 1. Five Year Historical Stock Performance




Source: Google Finance

2020 and 2021 (See Figure 2). By 2023 the picture had changed dramatically. Yet as COVID-era restrictions lifted, NCLH lagged behind the share price performance of its rival, Royal Caribbean. Rapid industry-wide growth in consumer demand (see Figure 2) also suggested that better performance was possible. By the middle of 2024, NCLH's share price was about the same as it was four years earlier (see Figure 1) when significant uncertainty existed about whether cruise ships would ever sail again.

Figure 2. Annual Global Cruise Line Passengers (in millions)




Source: Statista 2023a, Ocean cruise passengers worldwide

Unique among firms in the cruise industry, during the COVID emergency, the board of directors at NCLH approved a dramatic increase in executive compensation. The results of this analysis suggest that the board's decision may have contributed to a culture at NCLH that undermined the employee satisfaction and related motivation needed to overcome the COVID crisis. This analysis begins by documenting key managerial decisions made at NCLH during the COVID emergency. Next, some potential relationships among variables including executive compensation, crisis management, employee satisfaction, and firm value are discussed. Lastly, some promising insights relevant to management scholars and practitioners are presented and other potential causes of NCLH's depressed performance are discussed.

## 2. Management of NCLH during the COVID-19 emergency

### *2.1 Austerity for workers*

In April 2020, The Miami Herald reported that due to the COVD emergency, NCLH managers would furlough 20% of their shoreside staff (Dolven 2020). In December 2022, the Miami Herald picked up the story again, reporting that NCLH managers intended to lay off 9% of their shoreside workforce (Jean Kaiser 2022). The layoff totals do not fully capture the difficulty that workers at NCLH experienced because employees aboard ship generally are not laid off, rather their contracts are simply not renewed.

NCLH workers who were not laid off or did not see their contracts expire during the pandemic faced their own economic hardships. In 2020 NCLH switched to a four-day workweek, cutting the salaries of all employees by 20% (Kalosh 2020; Melin 2021) and eliminating matching 401k contributions (Peterson 2020). NCLH executives, including Del Rio, also took a 20% cut in salary (Melin, 2021). A company spokesperson explained:

> "Part of adapting is making sacrifices and difficult decisions…. We want to do this as much as possible to make it through together as a team, and we are thus implementing the following changes to our compensation policy." (Peterson 2020)

### *2.2 Prosperity for executives*

NCLH employees imagining that managers and workers would suffer austerity together as a team would be disappointed. Executive salaries at NCLH were cut by 20%, but on average salary only comprises about 10% of corporate executive compensation (Francis & Broughton, 2021). At the peak of the pandemic, the NCLH Board of Directors began issuing retention inducements, or pay-to-stay bonuses to executives (Melin 2021). Pay packages were further buoyed by the implementation of less demanding pay-for-performance metrics (Melin, 2021). As the pandemic caused profitability and share prices to tank, corporate boards of the three major cruise lines shifted executive pay metrics (Mullaney 2022). Revised performance benchmarks emphasized return to service speed, environmental achievements, and management of cash resources (Mullaney 2022). As a result of these changes, the total compensation of every NCLH executive reported to the Securities and Exchange

Commission (SEC) increased by at least 40% from 2019 to 2020 (As You Sow 2021). The salary of NCLH's CEO Del Rio ballooned from $17.8 million in 2019, to $36.4 million in 2020 (Jean Kaiser 2022; Kalosh 2023).

The Miami Herald, which is widely circulated in the Miami area where many NCLH employees are based, was highly critical of Del Rio's pay package, noting that the $36.4 million sum was approved while NCLH was simultaneously laying off thousands of workers (Jean Kaiser 2022). The Herald was critical of other leadership changes at NCLH, specifically the promotion of Del Rio's son, Frank Del Rio Jr., to President of Oceania Cruises, a NCLH subsidiary, noting that this move included the outgoing president being awarded a "special advisor" position (Jean Kaiser 2022). The outgoing President of Regent Seven Seas, another NCLH subsidiary, was also awarded a "special advisor" position after Andrea DeMarco who had previously served as NCLH's chief sales and marketing officer was named President of Regent (Jean Kaiser 2022).

When Del Rio Jr. was promoted, employees may have noticed a potential conflict with NCLH's Code of Ethical Business Conduct, section 2d of which states: "A member of your immediate family is not permitted to work in your same department or in any other position outside that department in which NCLH believes an inherent conflict of interest may exist (Code of ethical business conduct, n.d.)." To make way for Del Rio Jr. and DeMarco, the departing presidents of Oceania and Regent each received compensation totaling $6.6 million, including $2 million bonuses as part of their release agreements (Kalosh, 2023). These payments were in addition to compensation received by virtue of their newly created special advisory roles (Jean Kaiser 2022).

At the end of 2020, when Del Rio claimed $36.4 million in total compensation, the share price of NCLH was at least 50% lower than it was at the start of 2020 (see Figure 1), the company had just posted a $5 billion loss for the year, revenue was down 80% (Francis & Broughton, 2021), and thousands of NCLH workers were unemployed. That same year, the CEOs at Royal Caribbean and Carnival made just $11 million (Cruise Industry News 2021) and $13.3 million (Kilgore 2022) respectively. Del Rio collected over $10 million more than both rival CEOs combined, even though Royal Caribbean ($36.4 billion market cap) and Carnival ($18.5 billion market cap) are both much larger than NCLH ($6.7 billion market cap) (Global Ranking, n.d.). Royal Caribbean at least (see Figure 1), and possibly Carnival (Mullaney 2022), also significantly outperformed NCLH in 2020. Del Rio's $36.4 million 2020 pay package was approved over the nonbinding objections of 83% of votes cast by shareholders (Kerber 2022), the weakest support for an executive pay package ever reported by a company on the S&P 500 (Mullaney 2022). Following approval of the pay package, NCLH managers committed that in the future they would "carefully consider" shareholder concerns about executive pay (Kerber 2022). NCLH also claimed that $10 million of Del Rio's pay was owed per the terms of his previous employment contract (As You Sow 2021). However, $8.8 million was discretionary and largely attributable to a retention inducement awarded solely for continuing employment (Melin 2021).

The new executive performance metrics adopted by NCLH during the COVID emergency were complex. NCLH dedicated 38 pages of its annual SEC proxy filing to explaining them (Mullaney 2022). In comparison, just four pages of text were used to explain the election of new directors to the board (Mullaney 2022). Despite the exhaustive explanation, shareholders struggled to understand how CEO Del Rio earned so much when in 2021 among the three major cruise lines NCLH had the lowest proportion of its fleet in operation; a reported 57% of ships, compared to 85% at Royal Caribbean (Mullaney 2022). Del Rio's COVID-era pay was harshly criticized in the New York Times (*e.g.,* Geles, 2021), the Wall Street Journal (*e.g.,* Francis & Broughton 2021), The Seattle Times (*e.g.,* Melin 2021), The Miami Herald (*e.g.,* Jean Kaiser 2022), and Reuters (*e.g.,* Kerber 2022). On July 1, 2023, Del Rio resigned as CEO and became a "special consultant" to NCLH (Kalosh 2023). Experienced NCLH insider, Harry Sommer, took over as CEO (Kalosh 2023).

## 4. Discussion

### *4.1 Executive compensation and leadership style*

In the management literature, a leadership quality frequently cited as being likely to cause followers to become satisfied and/or motivated is visible managerial self-sacrifice, or what is commonly referred to as servant leadership (*e.g.,* Choi & Mai-Dalton 1999; De Cremer & van Knippenberg 2004; Greenleaf 2002). Another field of leadership scholarship that has been popularized in contemporary research is the concept of authentic leadership, or what is sometimes referred to more broadly as authentic communication. Authenticity in leadership or communication involves, among other characteristics, truth telling, admitting mistakes, and taking actions that are consistent with expressed beliefs or values (Kernis & Goldman, 2006). In an extensive study involving 30 leaders interacting with 252 followers, Leroy *et al.*, 2015 found that authentic leadership was positively related to employee satisfaction which, in turn, was positively related to employee performance.

NCLH executives, in effect, used the austerity they imposed on employees to subsidize their own rapidly growing pay. Such a large increase in management costs also increased the looming risk of insolvency that executives themselves were urgently warning of (*e.g.*, Feuer 2022). These actions were the opposite of the servant leadership that research suggests produces employee satisfaction and motivation. These managerial decisions also created an incentive for managers to engage in inauthentic communication. Inauthentic communication at NCLH was most clearly represented by executives' misleading claims to be sharing in the pay austerity imposed on employees and their insistence that they would carefully consider shareholder concerns about executive pay *in the future*, among other statements.

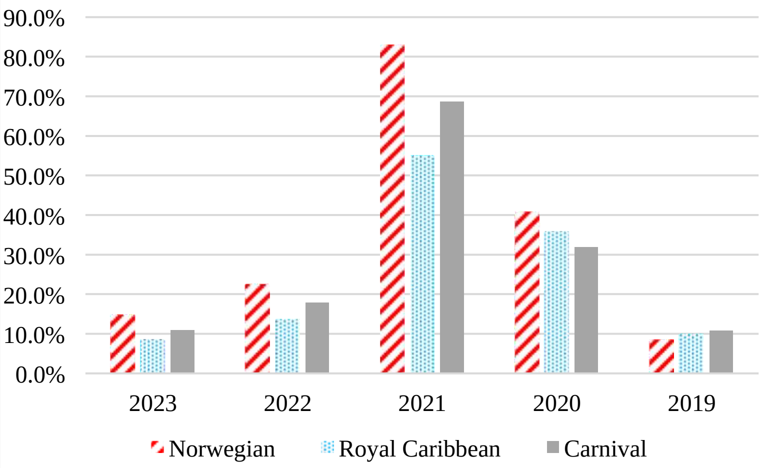
*4.2 Leadership style and employee satisfaction*

In the case of NCLH, the decision to drastically increase executive compensation during a crisis reduced the potential for authentic communication. Managers could not convincingly explain why austerity was being imposed on employees while executives were uniformly being awarded major pay increases. This juxtaposition was inconsistent with managerial warnings about impending financial ruin. This inconsistency also made it difficult for NCLH executives to be perceived as servant leaders. The leadership style that emerged at Norwegian is what Greenleaf (2002) termed "leader first" leadership. This type of leadership, which emphasizes the needs and preferences of leaders, while de-emphasizing those of followers, is likely to lead to a reduction in employee satisfaction and performance (De Cremer & van Knippenberg 2004; Greenleaf 2002).

*4.3 Employee satisfaction and firm value*

Assessing the connection between employee satisfaction and firm value is difficult because causality could run in either direction (Edmans, et al. 2023). By analyzing the relationship between companies that employees identified as the most desirable to work for and stock market performance, Edmans (2011) found that employee satisfaction was positively related to shareholder returns and that this advantage materialized partly in the form of reduced labor costs.

Figure 3. Cost of Labor (operations payroll as a % of revenue)




Direct labor (operating payroll) came from three Statista reports (Statista 2024b; Statista 2024c & Statista 2024d).

Direct labor is estimated using the measure payroll & related. Payroll and related is defined on SEC Form 10K submitted by Carnival Corporation November 30, 2023 as "costs of officers and crew in bridge and hotel operations." The payroll and related figure omits shoreside staff salaries. Source of yearly revenue is the Wall Street Journal - Markets Section (https://www.wsj.com/finance).

The cost of labor (direct labor costs divided by total revenue) at NCLH during and following the COVID emergency were exceptionally high when compared with rival firms (see Figure 3). This was new for NCLH. In 2019, NCLH had the most efficient cost of labor when compared with competitors (see Figure 3). This change from having low labor costs to having exceptionally high labor costs does not resolve whether executive compensation was a significant causal factor but suggests at least that some change unique to NCLH and beginning during the COVID emergency was the proximate cause. In 2023, NCLH spent 14.8% of revenues on labor while Royal Caribbean spent just 8.6% and Carnival spent 11% (see Figure 3). Despite NCLH's high labor costs, the company was the slowest of the major cruise lines to return to full operational capacity following the COVID emergency (Mullaney 2022). During the COVID pandemic, NCLH spent the most on labor when compared with other firms in the industry and received the lowest operational return on that investment, causing concern among stock analysts who as recently as August 2023 argued that NCLH is "bogged down" by high labor costs (*e.g.,* Vanaik 2023).

**5. Conclusion**

Crises are, by nature, novel, unforeseen, and out of the ordinary. Managing and recovering from a crisis is therefore a departure from the expected or normal employee/employer relationship. Critical employee actions needed for a firm to recover may not be required per employment contracts or pre-established norms. In the absence of detailed instruction or guidance, often impossible for managers to provide in a crisis, employees of successful organizations must independently recognize the needs of their employer. On their own initiative, employees must identify and complete tasks that support those needs. In some crises, including COVID, this may require accepting personal risk. Employee satisfaction and related motivational elements are critical.

In addition to the effect on employee morale, high executive pay may have affected corporate performance at NCLH in other ways. The argument that inadequate focus on strategy formation existed is supported by the fact that 38 pages of NCLH's annual SEC proxy filing were dedicated to explaining new COVID-era executive performance metrics, while just four pages of text were used to explain the election of a new board of directors (Mullaney 2022). It is also reasonable to question whether NCLH executives were able to give corporate strategy their full attention when national media outlets, including The New York Times (*e.g.,* Geles 2021), The Wall Street Journal (*e.g.,* Francis & Broughton 2021), The Seattle Times (*e.g.,* Melin 2021), The Miami Herald (*e.g.,* Jean Kaiser 2022), and Reuters (*e.g.,* Kerber 2022) were loudly criticizing their CEO's pay package.

The manipulation of executive pay was common during the pandemic (Francis & Broughton, 2021). The Wall Street Journal conducted a study of executive pay by analyzing the pay packages of a sample of over 300 CEOs at the biggest U.S. public companies (Francis & Broughton 2021). In 2020, pay rose for 206 of the 322 CEOs in the study, with the median raise equal to 15% (Francis & Broughton, 2021). While the conditions surrounding these raises were not assessed in the study, the ubiquity and scale of COVID-era executive pay increases suggest that management challenges like those experienced at NCLH may be widespread.

Hence, exploring the relationships between executive pay, leadership style, employee satisfaction, and firm value may be promising avenues for future research. Scholarship better defining the conditions under which exceptionally high executive compensation may contribute most significantly to decreased corporate performance would be instrumental for both practitioners and scholars. The results of this analysis suggest that corporate boards should give more consideration to the signaling and potential corporate cultural effects of executive pay. Additionally, corporate boards, and all corporate stakeholders, should note the leadership signals sent by the compensation package demanded by executives and consider those signals when assessing executive managers' leadership potential.

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# Are extras just extra? Extra-curricular activities and the attainment of GMP BoK Learning Outcomes

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**Abstract:** The International Association of Maritime Universities (IAMU) launched the Global Maritime Professional (GMP) Initiative and introduced the inaugural edition of the Body of Knowledge (BoK) in 2019. This marked a significant effort to support Maritime Education and Training (MET) institutions in equipping their students for an evolving future (IAMU, 2019). This study aimed to determine the potential impact of extra-curricular activities in the attainment of the learning outcomes in BoK. Specifically, the research explored the motivation and participation in clubs of students to achieve the learning outcomes of Tier A in the affective domain of the following focus areas: Leadership, teamwork and discipline; Effective (interpersonal) communication; Decision-making and proactivity; and Professionalism and ethical responsibility. Five hundred nineteen (519) students of the Maritime Academy of Asia and the Pacific (MAAP) were surveyed, including 44 Midshipmen-in-Charge (MIC), who were also interviewed, to gain the students' perception as well as their motivation in joining clubs. The results showed that MAAP students joined clubs to pursue their interest and passion, to develop their skills and to grow personally. Moreover, the MIC agreed that joining clubs and the exposure and experience in clubs' activities led the student members to achieve the learning outcomes set by this study. The findings imply that the activities of the different clubs of MAAP were deemed contributory to developing global maritime professionals; hence, said activities and similar endeavors are suggested to be facilitated and enhanced to meet the changing landscape of the maritime profession. Moreover, it is recommended to explore other focus areas in BoK where student clubs may have a potential impact on attaining their learning outcomes.

*Keywords*: Global Maritime Professional; Student clubs; Body of Knowledge; Extra-curricular

## 1. Introduction

Shipping plays a pivotal role in global trade, facilitating the movement of 80% of goods (UNCTAD, 2023). However, the maritime sector is confronted with a myriad of challenges in the field of technology, environmental, social, regulatory and the evolving nature of global trade patterns. As the industry adapts to these changes, it is imperative to ensure that maritime professionals are equipped with the necessary knowledge, skills and competencies to navigate the complexities of their roles effectively. Recognizing this need, the International Association of Maritime Universities (IAMU) launched the Global Maritime Professional (GMP) Initiative in 2019. It includes the Body of Knowledge (BoK) that contains the learning outcomes deemed necessary to becoming a GMP (IAMU, 2019).

This study aims to delve into the potential impact of extracurricular activities with MET institutions to contribute to the attainment of the learning outcomes in BoK. Specifically, it intends to investigate into application of the learning outcomes in the affective domain of Tier A, thus, the use of the experience of the bachelor's degree students of the Maritime Academy of Asia and the Pacific (MAAP). Moreover, it aims to determine the student's motivations in joining clubs and organizations.

This study answered the following questions: (1) What are the motivations of MAAP cadets in joining clubs?; (2) How do the activities of the clubs address the affective learning outcomes of the following focus areas in the BoK: leadership, teamwork and discipline, effective communication, decision-making and proactivity, and professionalism and ethical responsibility?; and (3) How may the effects of joining MAAP clubs and organizations be described as experienced by MAAP cadets?

## 2. Global Maritime Professional

The GMP BoK is rooted in the efforts of individuals striving to standardize maritime education and training (MET). Recognizing the inherent multinational, interdependent, and fragmented nature of the industry, there is a belief that a globally unified MET system is not only advantageous but also enhances efficiency and innovation. Before the GMP BoK's release, substantial work had already been done on the universalization of MET. However, since 2019, more scholarly attention has been directed towards applying and analyzing this framework. Maritime educators have started implementing the GMP BoK framework in various aspects of MET. Ghalwash et al. (2022) in their case study, proposed a protocol for GMP-BoK implementation. On the other hand, Szwed and Benton (2022) reviewed GMP BoK framework using case analysis. Some researchers applied the framework in curriculum development and design (see Bayotas, 2023; Benton, 2021). In the area of curriculum delivery, Bolmsten et. al (2021) focused on the application using collaborative e-learning approach while Loginovsky (2021) specifically applied it in teaching risk assessment course. Baylon and Rowihil (2021) also related GMP as a concept to sustainable development.

This study focused on the potential of extra-curricular activities specifically student clubs and organizations in the attainment of the learning outcomes in BoK, specifically in the affective domain of Tier A of specific areas, detailed in Table 1, including their learning outcomes.

Table 1. Focus areas and their learning outcomes in the affective domain of Tier A.

| **Focus Area** | **Level of achievement** | | |
|---|---|---|---|
| | Receiving (awareness) | Responding (reacting) | Valuing (understanding and acting) |
| Leadership, teamwork and discipline | Follow concepts of leadership, teamwork, and discipline and acknowledge their importance in a maritime context | Practice leadership and teamwork skills in a disciplined manner to achieve the organization goals | Differentiate the importance of teamwork and commitment to leadership as indispensable for maritime professional practice |
| Effective (interpersonal) communication | Identify various interpersonal communication principles | Discuss advanced communication techniques and practice them in a professional manner | Demonstrate belief in multi-directional communication and the importance of listening and assist in eliminating interference and barriers in communication |
| Decision-makin g and proactivity | Acknowledge the importance of prompt well-informed decision-making and proactivity within the maritime workspace | | |

| | | | |
|---|---|---|---|
| Professionalism and ethical responsibility | Acknowledge the need for professionalism and the importance of ethics in the maritime industry | Comply with existing codes of ethics and professionalism | Demonstrate responsibility and professional and ethical behaviour even in the absence of explicitly written codes of professional and ethical conduct |

**3. Attainment of learning outcomes in the affective domain**

Assessing the affective domain in education is a complex process involving many aspects, as noted by Ventura et al. (2010). Andrusyszyn (1989) emphasized the importance of considering the inherent strengths and limitations of various evaluation mechanisms, and the need for clear and constructive objectives. The IAMU has acknowledged this importance, thus, the explicit learning outcomes stated in BoK, and in this research, as presented in Table 1. Syaiful et al. (2019) reviewed different methods for assessing the affective domain and found the value of using fuzzy logic, but it was only limited to the *receiving* and *responding* levels. Doherty (2014) used reflective activities in a form of a journal which formed part of the affective domain assessment, giving importance to the role of facilitators or instructors who should initiate engagement and motivation to learners. Grootenboer (2010) also discussed teaching approaches that facilitate affective development which include modelling, the ”rub-off” effect, storytelling, case studies, role playing, and first-person writing. These researches underscore the necessity for a well-considered and detailed methods when assessing the affective domain in educational settings.

**4. Extra-curricular activities**

Sumague (2023) found different effects of joining clubs and organizations in school. These include development of their leadership and communication skills, and improvement of their academic performance. Meanwhile, Cabrejas and Mendoza (2023) elicited from their respondents the following impacts of clubs and organizations: self-development, socialization and communication, recreation and stress alleviation, mental health, and collaboration and leadership.

In terms of motivation, Wiedarjati and Sudrajat (2021) determined through literature review that the motivation of students in joining school organizations was internal and external. The researchers further noted that the higher the internal motivation of the students to join a certain organization, the higher their chance of achieving their objectives. These objectives can be equated with the reasons of students for joining clubs and organizations. These reasons were as follows: academic gains (Smith, 2022); sense of belongingness and development of leadership (Johnson, 2020; Haines, 2019; Diaz, 2019); influence of friends (Diaz, 2019); and influence of persons they respect, socialization factor, objective/s of the activities or meetings, productivity of attending the organization’s event, establishing connections for future career, and personal appreciation of the organization’s activities (Coppedge, 2019).

*3.1. Student clubs in MAAP*

Currently, MAAP has 44 student clubs in total, each has designated Midshipman-in-Charge. Student clubs in MAAP are classified into five: academic, sports, religious organizations, special organizations, and those that are linked to external organizations, as presented in Table 2. All the extra-curricular activities are carried out after academic period and during the weekends as the students in MAAP are all staying in the dormitory inside the campus. All the student clubs are also assigned a Faculty-in-Charge that serves as an adviser.

Table 2. Classification and Number of Student Clubs in MAAP.

| Classification of Student Club | Number |
|---|---|
| Academic | 7 |
| Sports | 15 |
| Religious | 3 |
| Special Organizations | 13 |

| | |
|---|---|
| Linked to external organizations | 6 |
| Total | 44 |

## 4. Methods

Utilizing a survey questionnaire to gather data, this quantitative descriptive research targeted the whole student fleet of MAAP as its respondents. With a total of 1465 students this present academic year, 519 students from different classes responded to the survey questions that were distributed as Google forms. This survey return value exceeded the required sample size of 305. Taken per year level, there were 53 responses from the fourth year students, 107 from the third year students, 132 and 227 from the second and first year students respectively. The survey is composed of four parts: demographics; motivations in joining student clubs – which was answered by all the students. The third part, which are the learning outcomes, as stated above, and the perception of students as to how their club goals through their activities address the learning outcomes, was answered by Midshipmen-in-Charge (MIC). In addition, focused group interview was conducted to the MIC, which was attended by 12 students representing 24 clubs, to gather in depth information as to how their clubs address the mentioned learning outcomes. The last part about the effects of joining clubs and organizations was also answered by all the respondents. The data of the survey were analyzed using descriptive statistics while thematic analysis was used for the focus group interview data.

## 5. Results and discussion

Results showed that the top motivations of MAAP cadets in joining student clubs are *interest and passion, skills development,* and *personal growth*. These reasons of MAAP cadets may be said to be internal (Wiedarjati & Sudrajat, 2021) or intrinsic, meaning that they joined clubs and organizations in the Academy because they wanted to and they enjoyed participating in the club's activities. Similarly, Haines (2019) also mentioned that students joined organizations because they developed skills like leadership.

From the interview, it was also revealed that aside from volunteerism, students join clubs to have the opportunity to compete against students from other universities. In an environment where students stay in the dormitory inside the campus with no regular schedules to go out, some students are driven to join clubs to be able to go out of the campus, on top of enjoying the clubs' activities.

Club's activities are overlapping in terms of addressing the learning outcomes of the targeted focus areas. In terms of addressing the learning outcomes in the affective domain of BoK in the specified focus areas, the MIC strongly agreed that their clubs addressed the learning outcomes on *Leadership, teamwork and discipline*. Student clubs have different experiences in terms of the attainment of the learning outcomes. Specifically, the religious clubs intentionally plan their activities to demonstrate leadership, teamwork and discipline, while other clubs in the academics, sports, special organizations and those that are linked to external organizations mentioned that they carry out mainly their activities first, and then realize that they have demonstrated leadership, teamwork and discipline. Both approaches, though different, led to the same perceived results. It is also noteworthy that the MICs set examples, designate tasks to their members and check the accomplishment of these tasks, form small groups, plan in advance and manage their time effectively so they can accomplish their goals. All these practices demonstrate leadership, teamwork and discipline. While they perform the tasks, they also communicate with one another so interpersonal communication skills, decision-making and proactivity, professionalism and ethical responsibility are also developed between and among themselves.

In terms of communication, MICs concur that they exercise open communication, and that their members can voice out their suggestions and opinions in club meetings - all for the team development and camaraderie. Communication barriers include time and location constraints in conducting regular meetings and meeting new members.

Teamwork is also exercised in decision making, as most of the MICs collaborate with their members first before making decisions. The importance of teamwork was noted by Askari et al. (2020) who found that teamwork positively affected the performance of an organization. An organization is not a one-man team; it is composed of personnel with different roles. In order for the organization to succeed, the different roles have to cohere and work collectively.

Although there is an absence of a written code of ethics and professionalism in all the clubs, students operate based on the rules and regulations of the institution, contextualizing it in their own student clubs. In particular, they follow protocols or go through the communication chain to make sure that they do not bypass anybody. In their other interactions, some MICs shared that they learned to be sensitive to others to avoid conflicts or to avoid offending the other party.

The respondents also agreed that joining student clubs boosts their time management skills as well as it helped them achieve a good study-life balance. Moreover, the respondents disagreed that joining student clubs increases their stress levels. This supports their motivation in joining clubs and organizations. They joined not because they are forced or they had to but because they wanted to and enjoyed the activities facilitated in the club. On the other hand, they neither agreed nor disagreed if joining student clubs strengthens their academic performance. This result seemingly contradicts the findings of Sumague (2023) and Smith (2022) who reported that joining clubs and organizations helped the students academically.

The research findings indicate that extracurricular activities play a significant role in developing students' affective dimensions. Given this, it may be beneficial to reassess the academic course packages at MAAP and other maritime institutions to explicitly incorporate learning outcomes focused on the affective domain. While it can be argued that affective skills are addressed through discussions and classroom activities, intentionally integrating these outcomes into the curriculum will better ensure students' holistic development. After all, a competent and world-class maritime professional is not only equipped with cognitive and psychomotor skills but also demonstrates essential soft skills in their work. Adopting and implementing the GMP Book of Knowledge across all Maritime Education and Training Institutions (METIs) could address this need effectively. Extracurricular activities or student organizations are not participated in by all the students so their positive outcomes are appreciated by the members only. If affective learning outcomes are included in the course packages, it increases the chance for all students to be positively affected.

## 6. Conclusion and Recommendation

Surveys and interviews were conducted to inquire about the motivations of MAAP cadets in joining the different clubs and organizations in the Academy, their perceptions on the development of specific skills through their clubs' activities, and their experiences while participating in the club's activities. Results showed that cadets are intrinsically motivated to join the organizations or clubs in the Academy. While these clubs and organizations do not have express objectives, their activities lead to the development of certain GMP BoK focus areas, including those specified in this study. Moreover, the respondents agreed that MAAP clubs and organizations affected them positively as they had fun in the activities and developed new skills at the same time. The researchers recommend to take further the study to explore the possibility of directly addressing the attainment of learning outcomes in BoK through extracurricular activities, by collaborating with student clubs to be able to offer practical solutions, by using action research as another method. In addition, the researchers gathered data in one METI only so it is recommended that similar study be conducted in other institutions in general and maritime higher education in particular. This may widen the scope of the research and deepen the analysis of the data, thus arriving at a stronger conclusion. With the findings on the positive effects of extracurricular activities on developing the affective domain of the students, it is also suggested that learning outcomes under the said domain be included in the course packages so that they can be explicitly addressed and assessed.

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# Verifying Alignment of IMO (Simulation) Model Courses

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**Abstract:** International Maritime Organization (IMO) model courses provide member states and other stakeholders a useful resource for developing training programs in support of seafarer qualification and certification required by the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW). This is important because it provides a benchmark for the quality of seafarer training programs. Even though the IMO has a process for validating model courses (to ensure they fulfill the requirements of the corresponding instruments, as appropriate), they do not have a process to verify model courses (to ensure they actually achieve the desired outcomes). This paper proposes a process of verification which examines the constructive alignment among the learning outcomes, learning activities, and assessment of learners' achievement of the outcomes (i.e. learning assessment). This study reviews three high-priority model courses (each of which is focused on simulator training in different contexts). The action verb taxonomy of the IMO Maritime Safety Committee (MSC) Subcommittee on Human Element, Training, and Watchkeeping (HTW) was used to classify the learning domains of the overarching course objectives and the specific learning objectives (i.e., knowledge, understanding, and proficiency (KUPs)) in the detailed teaching syllabus. Additionally, when present, the approximate time allocations (for each instructional mode) for each subject area in the course outline were then compared to the learning domains identified using the KUPs in those subject areas. There is evidence to indicate the "learning objectives" do not align with the "course objectives." Further, there is also evidence that the instructional modes (as indicated by approximate times) do not align with the learning objectives. It was not possible to fully evaluate the alignment of learning assessment to the learning activities or the learning outcomes because there is insufficient information in the model courses. This paper proposes a process of verification to ensure constructive alignment of model courses. It also makes a series of recommendations on how the IMO can modify their guidelines to incorporate verification into the model course review process and focus more on "learning outcomes" as opposed to learning objectives.

*Keywords*: STCW, IMO model course, validation, verification, constructive alignment

## 1. Introduction

The International Maritime Organization (the UN specialized agency responsible for maritime safety, security, and environmental protection) has developed a series of model courses available to course providers to train seafarers to the standards set forth by the IMO and the STCW Convention in particular. These model courses are widely used (Vujičić et al., 2022). A set of guidelines (IMO, 2022) establishes a process for developing, reviewing, and validating model courses. While this set of guidelines is necessary, it may not be sufficient to ensure seafarers who are trained using these model courses are actually achieving the competencies set forth in the STCW and relevant IMO instruments.

Borrowing from the "Verification and Validation" (or V&V) literature of modeling (e.g., Thacker, et al., 2004), the roles of verification and validation are quite separate. Simply stated, validation asks whether the "right" course was designed and verification asks if the course was designed "right." Within the concept of the IMO model course, the validation function is well-established. It specifies that review of model courses should validate that they are "consistent with the requirements of IMO instruments." In other words, the validation process determines if the model course has adequately covered the requirements and standards of the relevant IMO instrument(s). In the case of the STCW Convention, this is accomplished through careful mapping of the functions, competencies, knowledge, understanding, and proficiencies (KUPs). This helps to ensure the "right" course has been developed. What remains to be seen is whether students completing these model courses will actually achieve the required functions, competencies, and KUPs (the intended learning outcomes, in other words) – or whether the course has been designed "right." This is partially due to the fact that many model courses are developed in a general way to allow for customization in specific contexts.

One way to achieve the verification function is to apply the concepts of constructive alignment (Biggs, 1996) – to ensure coherence among learning outcomes, learning activities, and learning assessment (see figure 1).

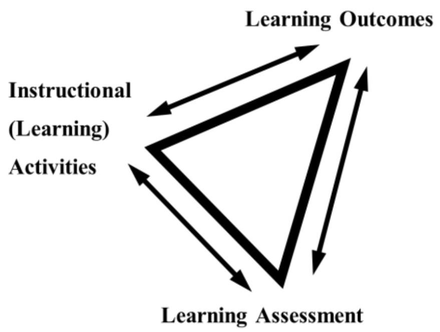



Figure 1: Illustration of Coherence in Constructive Alignment

Typically, learning outcomes are established first by identifying the critical outcomes students should achieve as a result of learning experience such as may be provided in a course or program. Then learning activities are then identified which should result in those outcomes, and finally a scheme for assessing the learning is established to confirm that the outcomes have in fact been achieved by students.

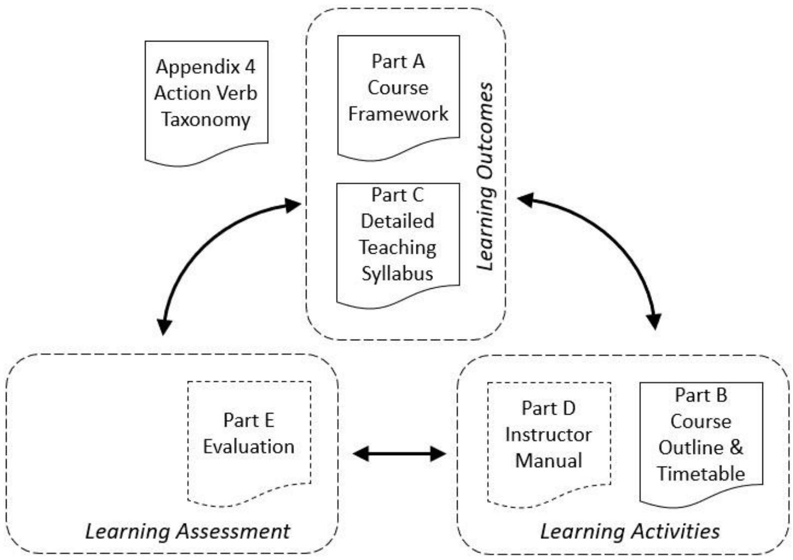



Figure 2: Constructive Alignment for Model Courses

In the context of the IMO model course framework, the Course Framework (Part A) specifies the course aim, , objectives, entry standards, and other introductory matters. The Detailed Teaching Syllabus (Part C) specifies the particular competencies in the form of KUPs. Together these two (Parts A and C) define the learning outcomes. Together, these two parts establish the learning objectives. The Instructor Manual (Part D) identifies how instruction or teaching will take place. In practice, only general guidelines are provided rather than specific instruction strategies for each outcome or set of outcomes. The Course Outline and Timetable (Part B) also provides time allocation for each subject (topic) area and may also indicate how that time allocation will be devoted (e.g., toward lecture versus practical activities or simulation). Together, these two may be considered to define the learning activities. Finally, the Evaluation section (Part E) provides guidelines on how to assess learning. In practice, there is no alignment to or coherence among specific learning outcomes and recommended methods of learning assessment. Figure 2 provides a notional constructive alignment for model courses.

This study will investigate the constructive alignment of a small sample of model courses to determine how well aligned the learning outcomes are to the learning activities and the learning assessment.

## 2. Methods

In 2023, the HTW identified two high-priority model courses for review and validation (IMO, 2023):

- Chemical Tanker Cargo and Ballast Handling Simulator model course 1.37
- Oil Tanker Cargo and Ballast Handling Simulator model course 2.06

In conjunction with that work, this study investigated constructive alignment of those two courses as well as a related third course:

- Engine Room Simulator model course 2.07

The following sections describe the methods used to verify the constructive alignment within those three courses.

### *2.1 Assessing Learning Objectives Domain Coverage*

In some prior studies of model courses (Szwed & Manuel, 2022; Szwed, Hanzu-Pazara, & Manuel, 2021), a process for evaluating professional courses developed by Cambridge Assessment (Suto, Greatorex, & Vitello, 2020) was found suitable for assessing learning domain coverage in IMO model courses. However, this process required manually coding each outcome statement (as many as 147 knowledge, understanding, and proficiency statements per course) based upon which type of learning was required – informational task, mental procedure, psychomotor procedure, or interpersonal procedure (which correspond to three learning domain taxonomies). This process was repeated across multiple raters and reliability was calculated.

Since then, HTW has developed an action verb taxonomy for the cognitive, psychomotor, and affective learning domains. The action verb taxonomy has been included as Appendix 4 to the IMO Guidelines for the Development, Review, and Validation of Model Courses (IMO, 2022). For this study, this action verb taxonomy was used to automatically code the KUPs and the learning outcome statements based on learning domain coverage (i.e., cognitive, affective, and psychomotor). This was performed for all three model courses. Additionally, the results for the cognitive learning domain were split into two parts (declarative knowledge for levels 1 and 2, and procedural knowledge for levels 3 through 6 of Bloom’s taxonomy).

Using this, an evaluation was undertaken to determine whether the KUP outcome domains (found in Part C) align with the stated course objectives (found in Part A).

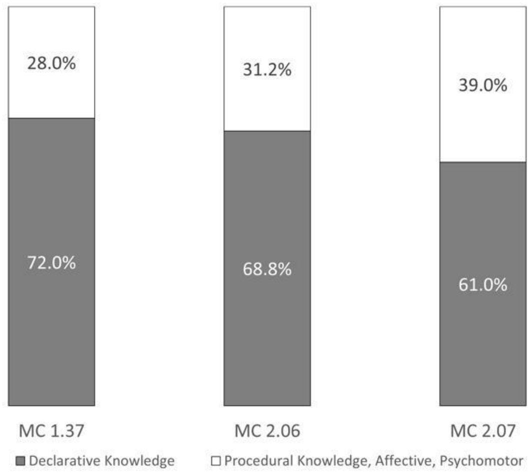
### *2.2 Assessing Alignment of Learning Activities to Learning Outcomes*

Part D (Instructor Manual) of model courses is general in nature and is intended to provide guidance rather than specific lesson plans for the instructor. Therefore, it is not possible to precisely assess the alignment of learning activities to the learning outcomes since the activities have not been specified. However, in Part B (Course Outline and Timetable), the time allocations may be useful in inferring how much time is devoted to each learning domain and in determining if these correspond to the learning domains identified in the previous analysis.

Finally, Part E (Evaluation) has even less specificity than Part D (Instructor Manual) and, therefore, evaluating the alignment of actual learning to learning objectives is not possible.

**3. Results**

For each model course, KUPs were mapped to learning domains (e.g., cognitive, affective, and psychomotor) using the HTW action verb taxonomy (Appendix 4 as a code). Additionally, the cognitive outcomes can be further divided into declarative knowledge (categories 1 and 2 of Bloom's revised taxonomy) and procedural knowledge (from the remaining four "higher-order" categories in Bloom's revised taxonomy). By grouping the procedural knowledge outcomes with the affective and psychomotor outcomes, you can




observe "higher order" learning domain outcomes expected of more advanced training and instruction (e.g., practical work). As shown in figure 3, model courses 1.37, 2.06, and 2.07 have 72.0%, 68.8%, and 61.0% declarative knowledge, respectively. Thus, it is evident that each of these three courses has a preponderance of "lower order" declarative knowledge that would be well-suited to lecture and discussion.

Figure 3. Breakdown of learning domains within each of three model courses

This preponderance of focus on "lower order" declarative knowledge can also be seen by which action verbs were used in the KUPs (see figure 4). For example, the first three listed verbs, which are used in twothirds of all KUP statements, are associated with the lowest level of Bloom's taxonomy – *Remember*, in which learners retain information (see Appendix 4 of IMO, 2022 for further description).

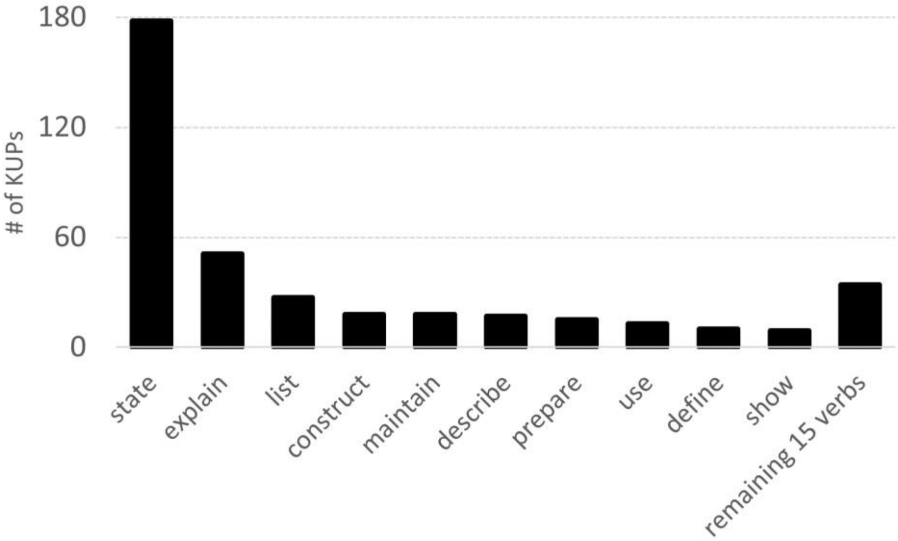



Figure 4. Frequency of action verbs for three IMO model courses.

Clearly, these three model courses are apparently focused on declarative information, or lowest level cognitive outcomes, based upon an analysis of the domain coverage of the KUP statements and verbs. However, the course objectives (found in Part A) underscore a different focus. For the three model courses, the following are the five high-level objectives:

1. Familiarization with equipment, instrumentation, and controls
2. Awareness of need for proper pre-planning, use of checklists, and timescales involved 3. Awareness to apply proper and safe procedures
4. Experience in identifying operational problems and troubleshooting
5. Ability to make decisions and promote safety and protect environment

It is clear that each of these course objectives has cognitive aspects. It appears, however, that all but the first objective will have affective components – 2 and 3 in particular as they require awareness, and 5 as well because values assessments are required. Additionally, it seems that at least 1, 3, and 4 would require some psychomotor manipulation of equipment or application of procedure, and result in an experience. So, without formally establishing the exact coverage within each domain, it can be deduced that 100% of the course objectives are cognitive in nature and that between 75% and 80% have affective elements and also that between 50% and 60% have psychomotor elements (see figure 5). The reason for such differences is that model course 2.07 has only four stated course objectives, whereas model courses 1.37 and 2.06 have five course objectives.

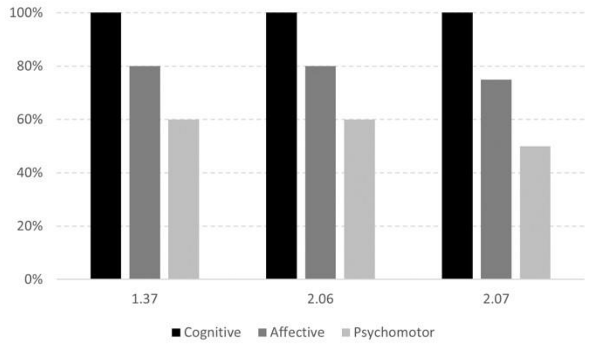



Figure 5: Approximate domain coverage of course objectives.

Many model courses provide approximate times to be devoted to each of the relevant subject areas, but do not distinguish which type of instruction should occur (often placing times under the heading of lecture, discussion, and practical work). However, MC 1.37 has allocated approximate time based upon instructional method (i.e., whether lecture and discussion *or* practical work) in the Course Outline and Timetable (Part B). This allowed a direct comparison between the learning domain of the outcomes (as determined by the action verbs in the KUPs) and the instructional methods. In MC 1.37, 94.6% of the action verbs for the KUPs were cognitive, and 2.7% were affective, and 2.7% were from the psychomotor domain. The cognitive outcomes can be further divided into declarative knowledge (categories 1 and 2 of Bloom's revised taxonomy) and procedural knowledge (from the remaining four "higher-order" categories in Bloom's revised taxonomy). In MC 1.37, 78% of the outcomes were focused on declarative knowledge and the remaining 22% were focused on procedural knowledge, and affective and psychomotor outcomes. Also, in MC 1,.37, the course outline indicates 22 hours of practical work (or 73%) and 8 hours of lecture and discussion (27%).

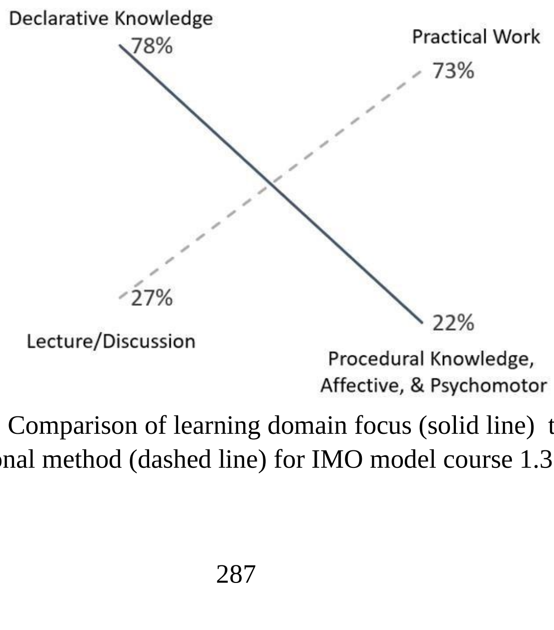



Figure 6. Comparison of learning domain focus (solid line) to instructional method (dashed line) for IMO model course 1.37.

No analysis was possible of learning activities since the Instructor Manual (Part D) did not provide specific lesson plans or specify particular instructional strategies.

## 4. Discussion

As noted in the introduction, the IMO model course framework does an efficient and effective job of validating courses – to ensure the "right" course was designed to meet the relevant IMO instruments. However, there is no verification process to ensure the course was designed "right" – to ensure learners obtained the desired learning outcomes.

Based upon an analysis of these three simulator courses, it is evident that constructive alignment does not exist between learning outcomes and learning activities. The KUP learning outcomes are predominantly declarative in nature, while the course objectives contain a substantial emphasis on high-order cognitive, affective, and psychomotor outcomes. Similarly, an analysis of the KUP statements shows a disproportionate focus on declarative knowledge, the lowest-order of the cognitive domain. Therefore, there is an "imbalance" between the objectives of an action-oriented experiential simulation course and the overly-simplified KUP outcome statements within the course itself. Further, by comparing the time allocation between the actions and experiences of a practical-based simulator course and the domains represented by the KUP outcome statements, there is an inversion or "imbalance" as well.

## 5. Conclusions and Recommendations

In conclusion, these three IMO model courses devoted to simulation training do not exhibit constructive alignment (i.e., the KUP outcomes are not coherent with the course objectives, and the KUP outcomes are not coherent with the time allocations between lecture and practice). It would be expected that for model courses devoted to simulation, there would be a preponderance of procedural knowledge, psycho-motor procedures, and affective learning.

In order to ensure effective constructive alignment in these three model courses, the KUP statements should be rewritten to reflect higher order cognitive procedures, psychomotor procedures, and affective learning. These KUP statements can be determined using the evidence-based guidance contained in Annex 4 of the guidelines (i.e., the HTW action verb taxonomy).

To create a process of verification for model courses, the following specific recommendations would be offered:

- In Appendix 1 of the guidelines, rename block (2) Model course review and verification, and add language that allows the committee to consider the draft and either: a) verify the model course, or b) return the model course to the course developer.
- In Appendix 2 of the guidelines, after 1), include a statement that "This model course will be (reviewed and) verified by…" (similar in nature to the existing statement about validation.
- In Appendix 3 of the guidelines, add a paragraph after section 2.1.2 to emphasize the importance of constructive alignment and its basis in an outcome-based educational paradigm. The following is a sample paragraph: "Constructive alignment (derived from an outcome-based educational paradigm) in model courses ensures learners achieve stated learning outcomes by systematically aligning course objectives, instructional methods, and assessment strategies. By ensuring coherence between these elements, learners are guided through activities specifically designed to facilitate the attainment of desired competencies. This approach enhances transparency, accountability, and effectiveness in maritime education and training, fostering a clearer pathway for learners to meet IMO and STCW regulatory standards. Through iterative refinement and alignment of course components, constructive alignment supports continuous improvement, empowering learners."
- In Appendix 3 of the guidelines, in 3.1.3, provide a statement guiding course developers to use the action verb taxonomy (Appendix 4) in developing KUPs and provide guidance to motivate constructive alignment between domain coverage of KUP outcome statements and domain coverage of course objectives.
- As part of the review, verification, and validation process, course developers should submit much more detailed instructions and recommendations on learning activities (in Part D – Instructor Manual) and learning assessment (in Part E – Evaluation and Assessment). There should be

repeated mention of the importance of constructive alignment to ensure the course has been designed "right."

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# Absenteeism in Maritime Education: Insights, Challenges, and Innovative Solutions

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**Abstract:** Students' attendance at classes is a measure that reflects students' enthusiasm for the course and their status in the university. University-level absenteeism is influenced by various factors, ranging from academic self-perception and attitudes towards lecturers to academic performance. Work-related absenteeism is also linked to stress, group size, commitment, and job satisfaction. It is essential to discern the specific importance of these factors.

The STCW-IMO convention provides the international minimum standards for maritime education and training and the minimum requirements for the competences of seafarers and also adapted standard models of competence-based training to this convention. Even though all this knowledge and skills are well specified, attendance is only required for some specific maritime courses. Due to the importance of classroom attendance, this paper presents the results of the teaching innovation project titled "Active methodologies for face-to-face and participatory learning (ASAP-UPC)" and seeks to quantify current levels of absenteeism, identify its main causes and propose initiatives to improve classroom attendance at the Barcelona School of Nautical Studies (FNB-UPC). These findings hold significance for FNB-UPC lecturers and decision-making bodies, as they highlight areas that can be improved to offer a more useful experience to our students. Moreover, the outcomes of this research can potentially be applied to other Maritime Education and Training Institutions (METIs).

*Keywords*: Absenteeism; Maritime Education and Training; polytechnic studies; teaching innovation

## 1. Introduction

Students' attendance at classes is a measure that reflects students' enthusiasm for the course and their status in the university (Westerman, Perez-Batres, Coffey and Pouder, 2011). A multitude of studies have explored the reasons of absenteeism at higher education institutions and have investigated the correlation between class attendance and academic achievement at the university level (Pappu, Vandrangi and VizayaKumar, 2006; Rendleman, 2017; Moores, Birdi and Higson, 2019; Keyser, 2019; Nja, Cornelius-Ukpepi and Chinyere Ihejiamaizu, 2019; Shaaban and Reda, 2021; Summers, Higson and Moores, 2021; Deng, Jianjun, Jing and Zitong, 2021). University-level absenteeism is influenced by various factors, ranging from academic self-perception and attitudes towards lecturers to academic performance. Work-related absenteeism is also linked to stress, group size, commitment, and job satisfaction. It is essential to discern the specific importance of these factors. A comprehensive global analysis of absenteeism worldwide is lacking, with only specific studybased absenteeism percentages currently available. According to results in López-Bonilla & López-Bonilla (2015), students regard the lecturer's teaching method and competence as the most influential factor of their absenteeism. Nevertheless, while low-quality lectures may foster absenteeism, higher-quality lectures do not necessarily guarantee increased attendance.

In the context of Maritime Education and Training (MET), higher education institutions have specific requirements whereby students must adhere to the particular characteristics of internationalization and specialization as outlined by the International Maritime Organization (IMO). The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW code) provides the international minimum standards for maritime education and training and the minimum requirements for the competences of seafarers (IMO, 2010) and adapted standard models of competence-based training to this convention. By requiring these courses in Maritime Education and Training Institutions (METIs), aspiring seafarers can acquire the necessary qualifications to pursue career opportunities in the maritime industry. Additionally, ongoing training and certification help experienced seafarers stay updated on new regulations, technologies, and best practices, enhancing their employability and career prospects. The international nature of these standards ensures universal acknowledgment of minimum requirements, maintaining a consistent level of competency among seafarers regardless of their nationality or the vessel's flag they serve on. The requirement for STCW courses in METIs aids countries in adhering to these global standards. Despite the detailed specifications of knowledge and skills, attendance is mandatory only for certain maritime courses.

Due to the importance of classroom attendance, this paper presents the results of the teaching innovation project titled "Active methodologies for face-to-face and participatory learning (ASAP-UPC)" and seeks to quantify current levels of absenteeism, identify its main causes and propose initiatives to improve classroom attendance at the Barcelona School of Nautical Studies of Universitat Politècnica de Catalunya (UPC). UPC is a Spanish public institution of research and higher education specializing in engineering, architecture, sciences and technology. UPC encompasses nine campuses and 17 schools. In particular, Barcelona School of Nautical Studies (FNB) accommodates 697 bachelor students and 117 master students (academic year 2023-24). The school offers three bachelor's degree programs: Bachelor's degree in marine technologies (GTM), Bachelor's degree in nautical science and maritime transport (GNTM) and Bachelor's degree in naval systems and technology engineering (GESTN). Additionally, the FNB offers three master's degree programs: Master's degree nautical science and maritime transport management (MUNGTM), Master's degree in the management and operation of the marine energy facilities (MUGOIEM) and Master's degree in naval architecture and ocean engineering (MUENO). The GTM, GNTM, MUNGTM and MUGOIEM degrees are designed to prepare seafarers to obtain the required competences and obtain STCW certificates. All bachelor's degree programs are on-site offering mass enrollment, and master's degree programs, which offer fewer submissions, can be categorized into on-site (MUENO) or blended degrees (MUNGTM and MUGOIEM). In spite of the nature of STCW courses in METIs to promote safety, professionalism, and competence among seafarers, the general academic regulations of the UPC do not consider attendance and therefore do not establish rules in this regard (Vicerectorat de Política Acadèmica UPC, 2023). Additionally, according to the STCW Convention, maritime cadets must fulfill a 12-month onboard training to be eligible for a Certificate of Competency (CoC). This situation also does not contribute to an increase in-person attendance in class, especially in the STCW master's degree programs (MUNGTM and MUGOIEM). This is the main reason why these master's degree programs are blended.

Absenteeism rate at FNB have been steadily increasing, causing concern among lecturers. The first attempt to understand the current situation and take action to implement measures occurred in 2020-2021 through a general absenteeism survey distributed to all UPC students. In all surveyed centers, absenteeism was observed, as the average was 39.76% (Vicerectorat Política Universitària, Gabinet de Planificació, Avaluació i Qualitat UPC, 2022). The underlying reasons for the high absenteeism rate indicated the need for further investigation.

This study aims to assess current absenteeism situation and propose mitigation strategies by addressing the following research questions (RQ):

RQ1. What is the extent of absenteeism at FNB, and which degree programs are the most affected?

RQ2. What are the underlying causes of absenteeism at FNB?

RQ3. Is there a correlation between attendance and attainment at FNB?

RQ4. Which teaching strategies do FNB lecturers deem most effective in improving attendance?

## 2. Methodology

The methodology applied not only analyzes and quantifies the current level of absenteeism but also identifies its main causes within the nautical field, aiming to determine its impact on both students and lecturers. The methodology consisted of two stages: gathering and analyzing students and lecturers data and redesigning teaching methodologies to mitigate absenteeism (see Figure 1).

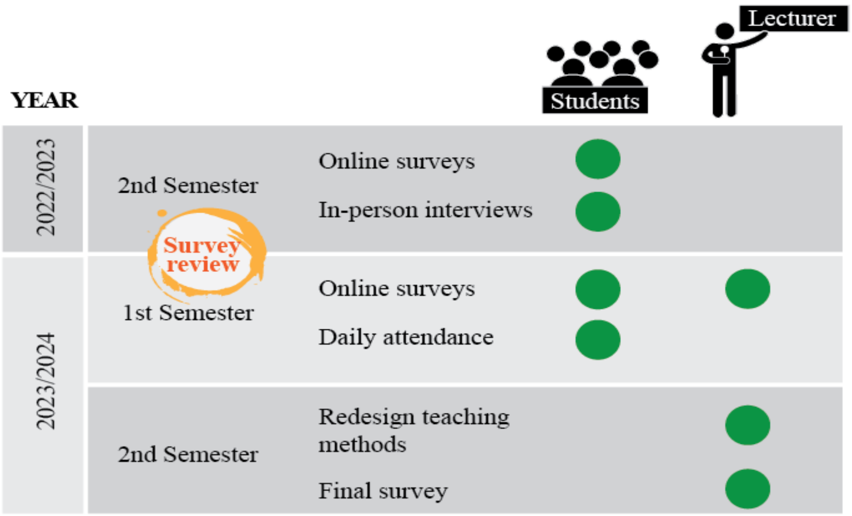


Figure 1. Research methodology

Initially, to picture the absenteeism within the area of MET, the methodology employed involved conducting surveys and interviews. These methods were utilized to gather insights concerning lecturers' and students' perceptions. Secondly, daily attendance records were tracked and analyzed alongside students' grades. Finally, after analyzing student and lecturers' data and daily attendance records, redesigned teaching methodologies were proposed to mitigate absenteeism through a final survey.

### *2.1. Surveys & Interviews*

A survey, which targeted students enrolled in the second semester of the 2022-23 academic year in Bachelor's degree programs (BSc), was created to identify the factors behind students' absenteeism, to explore strategies that could improve attendance, and to determine the skills they consider most crucial for their profession. During the same semester, some in-person interviews were conducted with students who attended less than 25% of the classes, inquiring about the specific reasons for their non-attendance. Based on the results, in the first semester of the 2023-24 academic year, an improved iteration of the survey was administered to students of Bachelor's and Master's degree programs offered at FNB, following a comprehensive analysis of the initial findings. Table 1 shows the number of targeted students involved throughout this entire period. The rate of response was 30.3% for the first survey and 47.8% for the second one.

Table 1. Online surveys and in-person interviews targeting MET students, disaggregated by sex

| **Academic Year** | **Bachelor (BSc)/Master's Degree (MSc)** | **Enrolled students** | **Woman** | **Man** |
|---|---|---|---|---|
| 2nd semester 2022-23 | Online Surveys. BSc | 151 | 22% | 78% |
| | In-person interviews. BSc | 14 | 15% | 85% |
| 1st semester 2023-24 | Online Surveys. BSc | 127 | 18% | 82% |
| | Online Surveys. Blended MSc | 34 | 7.5% | 92.5% |
| | Online Surveys. On-site MSc | 21 | 29% | 71% |

On the other hand, an online survey to FNB lecturers was also conducted during the first semester of the academic year 2023-24 to collect their perceptions. This survey included basic questions regarding subject type, whether attendance was compulsory and on the evolution of absenteeism over the years, including more specific questions concerning potential actions to improve attendance. The participation rate was 31.4%.

*2.2. Daily Attendance record*

Daily attendance was tracked for subjects taught by ASAP-UPC lecturers and analyzed alongside students' grades at the end of the first semester of academic year 2023-24. Tracking class attendance is necessary to evaluate absenteeism for several reasons. Firstly, it allows lecturers to identify trends and patterns in student attendance, which can reveal potential issues such as disengagement, disinterest, or personal challenges that may be hindering students from attending class regularly. By understanding these patterns, lecturers can intervene early and provide necessary support to help students to stay on track academically. It can also be discerned that interest and attendance in the classroom contribute to achieving higher scores.

*3.3. Redesign teaching methods*

Finally, based on the results obtained in the previous sections, a second survey was conducted to collect information regarding ongoing modifications of their subjects aimed at boosting attendance. A list of potential actions to implement were presented, including new methodologies and assessment methods, which were selected based on team debates held during the whole project.

## 3. Results

### *3.1. Surveys & Interviews*

The main objective of these surveys and interviews is to conduct a causal analysis of absenteeism to propose possible practical solutions to address it. In the first online survey addressed to bachelor’s students, they were asked about the reasons for not attending class. A high percentage (41.7%) responded with "others," without specifying what these other reasons were in the open-ended question that followed. Consequently, it was decided to conduct personal interviews with students who had attended less than 25% of the classes, aiming to gain deeper insights into the cause for their lack of attendance. According to the responses, the primary reason for not attending classes was work obligations (43%), despite acknowledging the importance of attending class. Students stated that the problem does not stem from the quality of teaching, but rather from other factors. To get more insight in this “other” response, in the 1st semester of the academic year 2023-24, the student survey was redesigned, providing more mandatory closed-ended responses to this question in order to analyze it more effectively. Thirty-five percent of students cannot attend classes due to the time scheduling (they are retaking the subject and have another class scheduled at the same time) and twenty-one percent of students miss lessons due to medical reasons. It was observed that the percentage of "other" responses had decreased to 6%. In Figure 2, it is shown that although the main causes of absenteeism are the same in bachelor's (Bs) and master's (MSc) degrees, in the case of bachelor's degrees, there are more reasons for non-attendance, while in master's degrees, it is concentrated in less responses, the main one being that the schedule doesn't fit (probably because they are on-board).

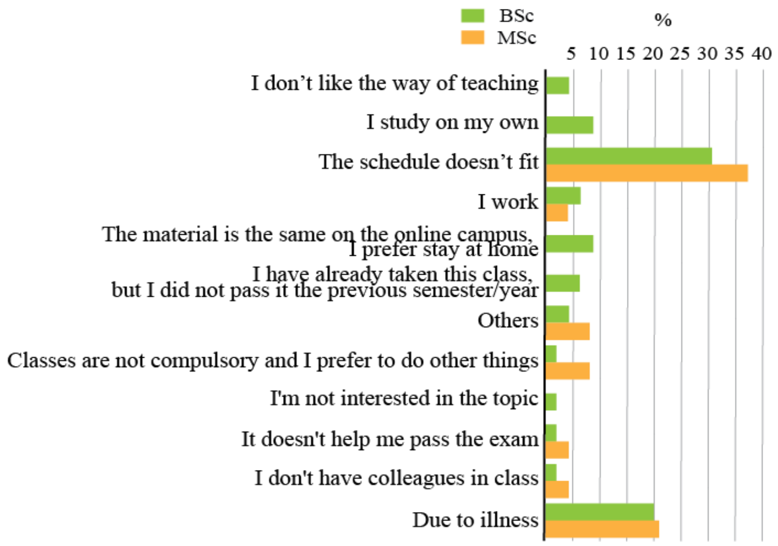


Figure 2. Participants' main reasons for not attending classes

Over half of the surveyed students indicated that they would be more interested in attending class if they perceived that the classes held greater value for their learning and were useful in passing their subjects. In the last question, students were asked about the skills that they considered most relevant to their professional life, with the answers being "gaining knowledge" (35.2%) followed by "resolution capacity" (30%). These results aligned with the responses that students had provided regarding the actions necessary to increase class attendance.

Finally, the lecturer's survey examined the lecturer's involvement in implementing new methodologies to improve their teaching practices and thus increase classroom attendance. Fifty-seven percent of lecturers have taken action to improve their teaching based on the feedback and comments of the general UPC student satisfaction survey conducted at the end of each semester. However, among those who had taken any action, 66.7% report that they had not noticed any improvement in class attendance after implementing them.

### *3.2. Daily Attendance record*

Results for attendance rate for each degree are presented in Figure 3 (left). In general terms, absenteeism tend to be higher in the case of bachelor's degree programs (the final increase in the GNTM is due to mandatory simulator practices), while in master's programs, attendance increases over time, and they exhibit high levels of attendance, attributed to their status as specialized master's programs, fostering high student motivation.

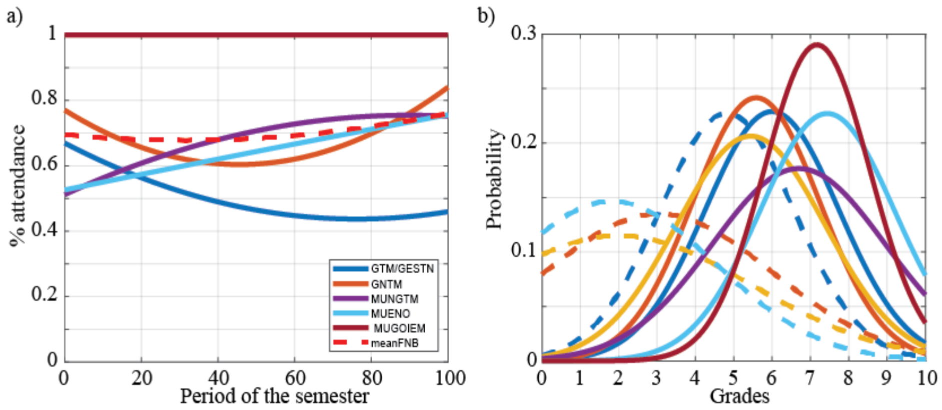


Figure 3. (left) Attendance rate evolution during first semester of 2023-24 academic year; (right) Gaussian curves of the students grades base on their attendance (continuous line attendance higher 50%; dashed line attendance less than 50%; orange: GNTM, dark blue: GTM/GESTN, purple: MUNGTM, light blue: MUENO and dark red MUGOIEM)

On the other hand, Figure 3 (right) shows Guassian curves representing the probability of achieving a particular grade based on attendance. A typical Gaussian shape is obtained of those students attending at least 50% of the classes (continuous line) indicating that most regularly attending students achieve grades in the range of 5.5 and 6.5 in the bachelor's degree programs and higher grades in the master's degree programs. However, students attending less than 50% of the lessons (dashed line), the mean grade is lower than 5. This illustrates how class attendance may correlate with attainment, showing that students with higher attendance tend to achieve higher grades compared to those with lower attendance.

### *3.3. Redesign teaching methods*

Based on the students' and lecturers' responses, a new survey was conducted among members of the ASAP-UPC project. Specific methodologies for teaching improvements were discussed. Each coordinating lecturer, with the collaboration of the teaching team, designed an improvement action based on identified best practices. Best practices to improve classroom attendance were categorized into three groups: (1) Specific follow-up activities, which include tasks such as quizzes, exercises, tutorials, group assignments and follow-up questionnaires; (2) Teaching innovation activities, which involve incorporating innovative teaching methods such as collaborative activities, the flipped classroom approach, and an increase in laboratory or simulation practices to offer a more active learning framework and (3) Modification of the syllabus, a proposal for reducing some theoretical contents and introducing more hands-on activities. The most common improvement measure implemented was the introduction of additional exercises during lessons. Specifically, 71% of the ASAP-UPC members now integrate student-solved exercises into their classes. Moreover, exercise resolution is included in the assessment system of 91% of subjects, and many lecturers intend to strengthen this aspect. Active learning laboratory and simulator practices are incorporated into 65% of subjects, and 77% of lecturers plan to increase their frequency. Another finding is that 35% of subjects are adjusting exam format to avoid standardized exams that can be answered without a deep understanding of the topic.

## 4. Conclusions

The main goal of this study is to provide a more comprehensive understanding of the causes of absenteeism in maritime studies. To achieve this goal, different surveys and interviews were conducted to explore the insights of lecturers and students on absenteeism in a higher MET education. The findings indicate that the extension of absenteeism at FNB varies significantly across the programs, with heightened absenteeism in large groups of students at the Bachelor's degree level. Many students express dissatisfaction with face-to-face classes, citing a perceived lack of balance between theory, experimental practice, and problem-solving components. Additionally, they perceive that attendance is unhelpful to pass exams. However, research has shown that there is a correlation between attendance and attainment, suggesting that increased attendance enhances the probability of obtaining higher grades in the FNB context. The literature indicates that aligning teaching and assessment methodologies may increase the perceived value of classes. Hence, adopting a more contextualized teaching approach, emphasizing problem-solving activities, and adapting exams to a nonstandardized format seem to be feasible teaching solutions. On the other hand, all master's programs have higher attendance, and therefore higher grades, even as the semester progresses. This could be due to courses having fewer students, as well as that two master's programs are blended and the in-person classes are particularly important (for practices, simulations, exams, and visits).

Building on these findings, guided by group reflections, the next phase involves formulating and integrating identified good practices into a database. The proposed good practices are expected to be a turning point, not only in student motivation, but to foster in cultivating more significant learning experiences that can be shared among Maritime Education and Training Institutions (METIs). However, a period of implementation is needed to find out if these measures are effective.

## Acknowledgements

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# Policy / Political Aspect

# Autonomous Vessels and Fairways – The Nordic Law approaches

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**Abstract:**
The MASS Code will be implemented in SOLAS first as voluntary instrument in 2026, but it will enter into force as mandatory instrument 1.1.2028. This means that it will be automatically enforced by all nations which are parties to SOLAS Convention. At the same time all these nations must prepare national legislation also in relation to use of autonomous vessels in their coastal fairways as the autonomous shipping has to be made possible for international traffic. This means that legislators need to follow closely the work of the IMO when preparing the laws for use of their fairways. However, there is no guidance for making this legislation by the IMO as IMO is still working under the general rules for the use of autonomous vessels. The issues which need to be considered nationally are for example requirements concerning the use of fairways, surveillance by the authorities on the safety issues, granting permissions for use of autonomous vessels on fairways, arranging pilotage, environmental risk assessment, salvage response etc.

The technical requirements must be in line with the other requirements, especially relating to navigational aids and interoperability of systems and software when assessing the traffic on fairways. According to IMO resolution the electric charts need to be in line with S100 standards by 2029 and the autonomous vessels must be able to exchange information with traditional vessels and between MASS vessels already by 1.1.2028 at latest. The national legislation on mandatory pilotage on fairways must legislate how the pilotage of autonomous vessels is to be arranged. The ship owners must be able to demonstrate on paper in their applications that the autonomous vessel is at least as safe as a conventional vessel before it is entitled to get a permission to enter the national fairways. The permission requirements for how this can be guaranteed is currently under development and will be analyzed in the paper.

The basic legal framework for these issues has already been established in Norway, but the laws in other Nordic countries are still being prepared in different stages. Nordic Maritime Codes are close to identical, but the legal framework for the use of fairways is different in all Nordic countries. Norway, which has first established legislation on use of autonomous vessels on its fairways, can be used as guidance but not as direct model for creating laws and regulations in other Nordic countries. Research on these issues will be presented on how the changes which are demanded by 1.1.2028 can be reached by legislative efforts in these Nordic jurisdictions. One of the results of the research project when comparing the legislation in different Nordic jurisdictions was that the organizational differences in maritime administrations and differences in making the rules and regulation make the co-operative efforts demanding and time consuming. All Nordic countries follow their own tradition when it comes to legislating use of fairways. Reasons for this development were analyzed. When comparison in this field was made to the practically identical maritime codes in these countries, the difference was remarkable.

*Keywords*: MASS Code; autonomous vessel; fairways; safety issues; pilotage

## 1. Introduction

The International Maritime Organization (IMO) is currently preparing the MASS Code which is to become part of SOLAS Convention. Maritime Safety Committee (MSC) has established an international Working Group (IWG) which is working between the Committee sessions and Legal Committee has established its own IWG to work on issues related to autonomous MASS vessels on the Conventions under its auspices. Also, Facilitation Committee (FAL) is starting its work on autonomous issues. The Joint IWG for all these Committees has also been established in order to monitor the common issues concerning MASS vessels in order to create coherence and common concepts for the work of these Committees and IWG´s. The author of this article works as a Finnish representative in these Committees and participates also in national work concerning the legal demands that will face the use of national coastal fairways in relation to use of autonomous surface ships (MASS).

The MASS Code will be implemented in SOLAS first as voluntary instrument in 2026, but it will enter into force as mandatory instrument 1.1.2028. This means that it will be automatically enforced by all nations which are parties to SOLAS Convention. At the same time all these nations must prepare national legislation also in relation to use of autonomous vessels in their coastal fairways as the autonomous shipping has to be made possible for international traffic. This means that legislators need to follow closely the work of the IMO when preparing the laws for use of their fairways. However, there is no guidance for making this legislation by the IMO as IMO is still working under the general rules for the use of autonomous vessels. The issues which need to be considered nationally are for example requirements concerning the use of fairways, surveillance by the authorities on the safety issues, granting permissions for use of autonomous vessels on fairways, arranging pilotage, environmental risk assessment, salvage response etc.

## 2. Nordic maritime law tradition and co-operation in maritime legislation

For a long time, shipping has been regulated very uniformly in the Nordic countries. There is a long tradition of legislation behind this. In the Nordic countries, Maritime Codes are very similar in content and are based on long-standing legislative cooperation, which dates back to the late 1800s. For Sweden-Finland, this tradition dates back to the 1600s. During the period of autonomy, Finland followed the Swedish-Finnish Maritime Code from 1667, until after independence, the Maritime Code, which was the result of cooperation between the other Nordic countries, was adopted when the Finnish Maritime Code was amended in 1939. The Nordic tradition of legislative drafting has continued later in connection with amendments to the Maritime Code, when the amendments have mainly been related to the implementation of international conventions in the Nordic countries, either uniformly and simultaneously or, if simultaneous transposition has not been possible, uniformly. In the 1990s, the Nordic countries adopted a uniform approach to reforming Chapters 13 and 14 of the Maritime Code by taking as their starting point the further establishment of carrier liability in the HagueVisby Convention and, as a joint Nordic solution, writing parts of the Act based on the liability regulation of the Hamburg Convention in order to modernise and harmonise the liability provisions applicable to carriers in the carriage of general cargo. The solution adopted was aimed at uniform regulation also in the event that the Nordic countries later joined the so-called Hamburg Convention liability regulation. The Act drafted in connection with the amendment is called the Maritime Code of 1994.

Most of the chapters of the current 1994 Maritime Code are based on the adoption and enforcement of various conventions in the Nordic countries, but the regulation also contains specifications jointly defined in the Nordic countries, insofar as they do not conflict with the conventions. In some respects, however, the maritime laws of the Nordic countries are not uniform. However, uniformity of regulation is the main rule even with regard to figures and section numbering, even though the chapters and section numbering in Finland and Sweden (numbering in each chapter from the beginning of the field) differ from the section numbering running through Denmark and Norway. Nordic legal unity has also had an impact on the regulation of liability issues in relation to the use of fairways and acting as a transport infrastructure authority. Cooperation in the preparation of the Tort Liability Act and the authorities' liability for damages has also been significant in regulating and defining the liability of waterway authorities.

The relatively convergent maritime laws of the Nordic countries provide a good basis for a joint Nordic interpretation of the law, which is supplemented by the Collection of Court Cases maintained in the Nordic languages since the beginning of 1900. This joint Nordic collection and uniform Maritime law have also been used in joint Nordic maritime law education, which for some 50 years was based on the activities of the Scandinavian Institute of Maritime Law at the University of Oslo. Funded by the Nordic Council of Ministers, this institute brought together Nordic maritime law students and researchers for almost 50 years. Although the Institute's status as a joint Nordic institute has now ended, it still organizes Nordic seminars every two years, alternately in different Nordic countries. Since then, Nordic co-operation has intensified, for example, in the field of marine insurance, where Nordic regulation on ship insurance has been brought within the scope of uniform Nordic marine insurance terms and conditions from 2013(Nordic Marine Insurance Plan 2013). Since 2018, the Nordic Maritime Law Associations have also developed joint arbitration and mediation rules by the Nordic Offshore and Maritime Arbitration Association (NOMA) in order to maintain legal unity in the Nordic countries in the future, also with regard to the increasing jurisprudence on arbitration, and to bring the practice together as uniformly as possible since the beginning of 1900 Nordic Court Reports.

## 3. The regulation of waterways

In the Nordic countries, on the other hand, the regulation of waterways is not uniformly regulated. Regulation was reviewed and comparisons were made between different Nordic countries in a research project by the writer in autumn 2023 and some of the results of the legal comparative work are summarized in this paper. The study revealed that roads in Finland and Norway have gone in different directions in terms of regulating waterways. Norway was selected as the main reference country for the study because its legislation had just been reformed, and it provided a benchmark for many of the issues for which the survey was based and for which a solution was sought in the formulation of the questions on which the study was based.

### *3.1 Norway as an example to other Nordic Countries*

In Norway, the "Havne- og farvannsloven" (Harbor- and Waterways Act), which entered into force at the beginning of 2020, combines regulation of water areas, fairways and ports under a single act, to which for the first time the previously separate Pilotage Act (Losloven) was also attached. The stated aim of the legislative proposal has been to simplify and clarify the regulation of the water areas of ports and fairways. Such a law can be called a kind of "framework law" (in Norwegian *rammelov*), as the Norwegians call it. Based on the law, more detailed regulations can be drawn up for each of its areas. In Norway, combining pilotage regulation with the same act was considered appropriate in the preparation of the act that entered into force on 1.1.2020, because at the same time the act regulated the conditions for operating coastal autonomous maritime transport.

### *3.2 Finland has a different legal approach to legislating fairways*

In Norway, however, official tasks concerning waterways have not been decentralized in the same way as in Finland. In Finland, regulation has traditionally been divided into separate regulations and different acts, the latest of which are the Water Transport Act and the Pilotage Act. From a legal point of view, the solutions in these countries therefore differ considerably, because Finland has not considered it necessary to compile regulations concerning ports and water areas and the use of fairways into a similar "framework act". However, this does not automatically mean that the regulation of waterways in Finland is not as advanced, because at the same time the regulation in Finland has been reformed through the enactment of separate legislation. However, separate laws mean that there may be internal conflicts or different definitions of the laws and they may easily cause practical interpretation problems. Norway's "Havne- og farvannslov" contains uniform definitions for all the chapters it contains, which will contribute to a uniform interpretation of the regulation also in the future when legislation is developed. On the other hand, the development of regulation divided into separate acts may also be more agile in times of change and enable different and more creative solutions. From the legislator's point of view, however, the solution is more laborious, as it usually requires amendments to several laws and the preparation of amendments. Finland will soon see a need for creative solutions, as the legislative model centralized in Norway's "framework law" has already dealt with the licensing process for autonomous maritime traffic and the exemptions required by pilotage. While one of the objectives of the Act in addition to maritime safety is to enable the flexible use of fairways for the needs of various business life, Finland is still dealing with the permit process for autonomous maritime traffic concerning the use of fairways.

## 3. Autonomous ships – Questions on pilotage & permitting process in Norway

The amendment described above, which transferred the regulation of pilotage from a separate act to the Norwegian "Havne- og farvannslov" law, was based on the harmonisation of regulations concerning autonomous transport on waterways. In order to enable autonomous navigation on the fairways in Norway and to regulate the permit process required for it, its relationship with the obligation to use pilotage had to be arranged at the same time.

### *3.1. Obligation to use pilotage*

In Norway shipowners may, upon application, obtain an authorisation from the Ministry for autonomous coastal shipping. A permit for autonomous coastal traffic gives the right to sail in designated mandatory lanes or areas, with designated vessels without a pilot. The application shall not be admissible if the vessel is unable to navigate or navigate the area safely or if there is a risk of loss of life, environmental damage or loss of value. The shipowner shall take all necessary measures to prevent and prevent loss of life, environmental damage or value caused by the voyage. The Ministry may issue regulations on permits for independent coastal traffic. The regulations may contain provisions on application requirements, functions that must be safeguarded in order for the ship to navigate and navigate safely, and restrictions on autonomous coastal navigation.

### *3.2. Authorisation to operate autonomous coastal shipping services*

In the drafting of legislation, "autonomous coastal traffic" refers to "journeys in mandatory pilotage waters where the master on the bridge of the vessel does not take care of the navigation and manoeuvring of the vessel. The navigation and manoeuvring of the ship may be entrusted to systems which automatically steer the ship or to the master located away from the navigating bridge (remote control)"

Autonomous vessels can include varying degrees of automation and autonomy, from advanced decision support for navigators, to increased automation and even to fully autonomous vessels that navigate and move autonomously without human supervision or monitoring.

The most important condition for obtaining a permit is that the safety of the vessel in question and other waterborne traffic can be guaranteed. The third paragraph of "Havne- og farvannslov" Article 25 specifies that an application for a licence may not be granted if the vessel is unable to navigate safely in the area or if there is a risk of loss of life, environmental damage or material damage. This means that an overall assessment must be made as to whether the ship's autonomous navigation systems have sufficient information about the waters concerned to enable it to operate safely. The ability of the vessel to navigate safely in that area shall be assessed. However, this assessment shall be considered as part of the assessment of the general equipment and operation of the ship in accordance with other provisions. The assessment under section 25(3) must, for example, assess the navigation system with which the ship is equipped and what capabilities the system has to navigate in the waters concerned. It may also be appropriate to consider the presence in the ground control centre of personnel with navigation expertise in the area concerned and the possibility for such personnel to influence, direct or intervene in decision-making processes concerning the navigation and manoeuvring of the ship.

According to the same preparatory work, other factors in the assessment may relate to traffic in the area, the specific sailing route, the nature of the waters, the ship's ICT security systems to prevent unauthorised seizure of the voyage and other factors that may affect safety. Furthermore, authorization may not be granted if there is a risk of loss of life, environmental damage or loss of value. It follows from the preparatory work that the basic condition for granting a permit under the provision must be that the safety of the vessel in question and other waterborne traffic is at least as high as in the case of normal traffic. This means that a license under section 25 cannot be granted if there is a greater risk to human life, the environment or loss of property than the risk associated with normal sailing.

### *3.3. Documentation obligation for obtaining the license.*

In Norway the applicant shall document and demonstrate that the safety of the waterways, the use of which is the subject of the authorization, is at least as high as that of normal compulsory pilotage journeys. This means that the application must document and demonstrate that the ship is able to navigate the area safely, and the applicant must ensure that the authority handling the application has access to sufficient documentation to assess whether, and to what extent the risks posed by autonomous coastal shipping pose a risk of loss of life, environmental damage and loss of value.

*3.4. An example for other Nordic countries*

In Finland and also in the other Nordic countries like Denmark and Sweden, measures should be taken to find out what requirements the IMO SOLAS amendments (MASS code) that are expected to enter into force on 1.1.2028, will set for the use and supervision of the use of fairways when they enter into force as mandatory instrument. The solutions adopted in the Norwegian "Havne- og farvannslov" Act can serve as a model for regulation, at least to some extent. In Norway, the law entered into force already in January 2020.

In Finland, it would have been possible to include similar provisions on pilotage in the Pilotage Act in connection with its reform 2023. As far as supervision is concerned, it would be possible at this stage to envisage uniform regulation and application of the supervisory function of the Pilotage Act and the task of supervising autonomous traffic, since, as described above for Norway, the use of autonomous vessels is closely linked to pilotage and exemption from pilotage. When reforming the Pilotage Act, the Government proposal was based on the premise that the implementation of the Act requires closer cooperation between the supervisor and the supervised party. This is necessary in order to fulfil the purpose of the Act with regard to enhancing training and specifying the operating manual defined in the Pilotage Act, also with regard to supervision.

Similarly, it is clear from the above regulation on the conditions for the use of autonomous vessels and the authorization procedure laid down in the Norwegian Havne- og Farvannslov Act that the granting and monitoring of compliance with permits is essential for the safety of fairways for all fairway users.

## 4. Autonomous shipping, nautical charting and development of the S100 product family

The technical requirements must be in line with the other requirements, especially relating to navigational aids and interoperability of systems and software when assessing the traffic on fairways. According to IMO resolution the electric charts need to be in line with S100 standards by 2029 and the autonomous vessels must be able to exchange information with traditional vessels and between MASS vessels already by 1.1.2028 at latest. The ongoing development of marine mapping is based on strategic goals and decisions set by the IMO and IHO. E-Navigation is a concept of the International Maritime Organization (IMO) that aims to make more extensive use of digital information possible in shipping.

The International Hydrographic Organization (IHO) standardizes the content of nautical charts and nautical publications intended for international use. In terms of nautical charts and maritime publications, the e-navigation concept is implemented by creating new digital products based on the IHO S-100 framework. In addition to the current (S-57) ECDIS charting devices (ECDIS = Electronic Chart Display and Information System), the use of equipment utilizing S-100 products on board vessels will be permitted by IMO decision from 2026 onwards. From 2029, new ECDIS devices must support S-100 products in accordance with IMO resolution.

A prerequisite for autonomous transport on the routes is machine readability of data, which is enabled by the products of the S100 product family. IALA has a number of S100 products that can be classified as AIDS to Navigation in the future.

International cooperation is extensive, and the Nordic countries are involved in numerous projects, for example in the Baltic Sea region. ECDIS systems will be developed so that they can use navigation products produced in accordance with IHO S-100 standards (e.g. S-101 Electronic Navigational Chart (ENC) and S-102 Bathymetric Surface), enabling the use of other parts of the S100 product family in the system and machine readability for other products in the family as well. In the future, this will also enable the use of IMO-classified MASS level 3 and 4 vessels on fairways. As can be inferred from the IMO's timetable for the introduction of the S100 standards and the mandatory implementation of autonomous shipping, there is little room for delay if the Nordic countries want to maintain their position as pioneers in autonomous shipping.

## 5. Conclusions

The national legislation on mandatory pilotage on fairways must legislate how the pilotage of autonomous vessels is to be arranged. The ship owners must be able to demonstrate on paper in their applications that the autonomous vessel is at least as safe as a conventional vessel before it is entitled to get permission to enter the national fairways. The permission requirements for how this can be guaranteed are currently under development.

The basic legal framework for these issues has already been established in Norway, but the laws in other Nordic countries are still being prepared in different stages. Nordic Maritime Codes are close to identical, but the legal framework for the use of fairways is different in all Nordic countries. Norway, which has first established legislation on use of autonomous vessels on its fairways, can be used as guidance but not as direct model for creating laws and regulations in other Nordic countries as organizational structures in maritime administrations differ from country to another. Also, legal systems are surprisingly differently structured in all Nordic countries in relation to fairways and their use. This was one of the key findings in the research. The Norwegian model with framework law is an excellent solution, but it is no longer possible to achieve such in other Nordic countries as the national legislation has taken another route. The time pressure is hard for both the legislators and maritime administrations as the IMO and IHO decisions on both MASS and ECDIS are waiting around the corner in only after couple of more years.

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# Integrating public policies to increase digital skills among the MET faculty: The case of Ukraine

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**Abstract:** Increasing demands in digital skills are worldwide and various countries developed their public policies to emphasize the development of digital skills as a need for sustainable development. From the perspective of public policy, digital skills are considered critical enablers in geopolitical, societal, economic, and environmental sustainability. The maritime industry also faces the same challenges in seafarer skill gaps, including digital skills, anticipated by new transitions in digitalization and automation in shipping. This emphasizes the important role of maritime education and training (MET) to ensure that maritime professionals are equipped with digital skills. To do this, digital skills among the MET faculty need to be strengthened as well. However, to what extent public policies on digital skills are integrated in MET remains unclear. This paper explores how MET can benefit from a public policy framework to increase digital skills among the MET faculty using a case study with a survey on teachers' digital skills from two Ukrainian universities.

*Keywords*: digital skills; public policy; policy coherence for sustainable development; maritime education and training (MET); case study of Ukraine

## 1. Introduction

Increasing demands on digital skills and the shortage of skilled labor are common challenges worldwide due to the rapid advancement of technology. It is frequently reported that a gap exists between the digital skills demanded by employers and those possessed by job seekers, which may lead to unemployment and underemployment (EC 2017). Ongoing technological innovation necessitates continuous upskilling and reskilling to keep pace with evolving digital tools and platforms (EC 2016). In Europe, only 54% of workers have the digital skills needed and more than one-third (35%) of the European population lacks basic digital skills (EC 2022). To respond to this challenge, the Digital Education Action Plan (DEAP) was launched in 2018, followed by the initiative of the Digital Decade in 2021 (EC 2023a).

It is worth noting that a digital skill gap would become wider in marginalized communities of certain demographic groups, such as older adults, low-income individuals, and those living in rural areas, who face barriers to accessing digital skills training and education (EC 2020, UNCTAD 2019). Ukraine is an example of such marginalized communities as the country regularly faces life-threatening events due to the full-scale invasion.[1] In Ukraine, digital skills relating to information and communication are recognized as one of the key competencies that every modern individual needs for a successful life and activities. In 2019, the Ministry of Digital Transformation of Ukraine set a strategic goal for the engagement of 6 million citizens in digital literacy programs (Ministry of Digital Transformation of Ukraine 2024).

[1] IMO Resolution A.1183(33) adopted on 4 December 2023.

At the national and regional levels, the importance of skills and employment is often translated into public policy. However, it is rarely discussed how public policy of strengthening digital skills supports the digital skill gap in the maritime industry where new transitions towards digitalization and automation would increase seafarer skill gaps in the future. Indeed, digital skills are listed as a major skill gap among seafarers (WMU 2023). There is a research gap that the extent to which the maritime sector is consciously active under the public policy of digital skills is unknown. Therefore, it is the focus of this paper to discuss how maritime education and training (MET) can benefit from a public policy framework to increase digital skills among the MET faculty using a case study using a survey on teachers' digital skills from two Ukrainian universities.

**2. Policy initiatives in developing digital skills**

Fostering digital literacy and proficiency has been observable at various levels. International organizations such as the Organization for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) have emphasized the importance of digital skills development as a key component of national education and workforce policies (OECD 2019); the UNESCOled Broadband Commission for Sustainable Development has highlighted the critical role of digital skills in achieving the Sustainable Development Goals (SDGs) and narrowing the digital divide between countries (UNESCO 2023).

At the regional level, the European Commission (EC) calls for collective efforts through policy measures to improve digital skills. From the perspective of public policy, digital skills are considered as critical enablers in geopolitical, societal, economic, and environmental sustainability (EC 2023a). Digital Skills and Jobs Coalition was established in 2013, aiming to bring together stakeholders from the public and private sectors to promote digital skills development and training initiatives, with a particular focus on reducing digital skills disparities and fostering workforce competitiveness (EC 2017); New Skills Agenda for Europe was introduced in 2016, seeking to equip Europeans with the skills needed for the digital age by promoting upskilling, reskilling, and recognition of non-formal and informal learning (EC 2016). In addition, the European Union (EU) is investing in digital skills initiatives through funding programs such as the European Structural and Investment Funds (ESIF) and the Digital Europe Programme, which aim to support digital skills training, digital infrastructure development, and innovation in digital technologies (EC 2020). Recently, the EU launched the Digital Education Action Plan (DEAP) in 2018 as well as the initiative of the Digital Decade in 2021 to address digital skills gaps, foster digital inclusion, and promote lifelong learning opportunities across the member states (EC 2023a). The COVID-19 pandemic has underscored the importance of digital skills for remote work, distance learning, and digital citizenship, prompting accelerated efforts to address digital divides and enhance digital literacy across the EU (EC 2023a). The success of the Digital Decade is considered pivotal for the EU's economic future, potentially unlocking substantial economic value of over EUR 2.8 trillion which is equivalent to 21% of the EU's current economy (EC 2023b). These initiatives collectively aim to address digital skills gaps to foster inclusivity and drive socio-economic development in the digital age which can be defined as an era characterized by the pervasive influence of digital technologies on many aspects of people's lives (Salfin et al., 2024).

At the national level, each government set up a public policy to address digital skills. Examples from nonEU countries include Digital Economy Strategy (Australia); E-Digital strategy (Brazil); Innovation and Skills Plan (Canada); Internet Plus Strategy (China); Digital India (India); Smart Japan ICT Strategy (Japan); National e-Commerce Strategic Roadmap/National Policy on Industry 4.0 (Malaysia); E-Commerce Roadmap (Philippines); Creative Economy (Republic of Korea); SkillsFuture Singapore/Digital Economy Framework for Action (Singapore); National Digital and Future Skills Strategy (South Africa); Digital Economy and Society Development Plan (Thailand); and National Digital Participation Plan (United Arab Emirates) (WMU 2023, p.77). In the case of Ukraine, the Ministry of Digital Transformation of Ukraine set a strategic goal in 2019 for the engagement of 6 million citizens in digital literacy programs. The expected result was the improvement of Ukrainians' digital skills and the increased use of online tools both for work and personal development. It was the first time in Ukraine's history, digital literacy became a state priority. Subsequently, the Concept for the Development of Digital Literacy at the national and regional levels was approved and European frameworks DigiComp 2.1 and 2.2 were adopted (Ministry of Digital Transformation of Ukraine 2021).

**3. Policy coherence for sustainable development**

Public policies at international, regional and national levels are ideally coherent so that every effort at different policy levels can be efficient and effective in its implementation. The concept of policy coherence for sustainable development (PCSD) was coined by the OECD in 2016. PCSD is critical for balancing economic, social, and environmental areas in sustainability while mitigating negative effects on the well-being of people here and now, elsewhere and later (OECD 2023). The case of digital skills development demonstrates PCSD through the coordinated alignment of public policies across international, regional, and national levels. However, there is little evidence on how PCSD is consciously achieved through cross-sectoral collaboration, such as between public and private sectors in the maritime domain. Public-private partnerships are increasingly common in digital skills initiatives, leveraging the resources and expertise of both public and private sectors to reach broader audiences and address specific workforce needs (World Economic Forum 2020). In this regard, PCSD should inspire the maritime industry to align its digital skill strategy with public policy. This paper is particularly interested in how MET can be supported by public policies when promoting digital skills.

The relationship between education and public policy on digital skills is well documented in the European Framework for the Digital Competence of Educators which details 22 competencies within six areas of educators' professional skills, including digital skills (Redecker & Punie 2017). This demonstrates how digital skills are important for improving education to an innovative level where educators' pedagogical skills and competencies elevate teaching and learning with digital resources and assessment, leading to increased learners' digital skills. Many governments around the world are integrating digital skills into educational curricula from primary school to higher education levels, emphasizing computational thinking, coding, and digital literacy. Lifelong learning programs and adult education initiatives are gaining traction, offering opportunities for individuals to acquire new digital skills and adapt to changing job market requirements (EC 2020). Companies are collaborating with educational institutions and governments to develop tailored training programs and certifications (EC 2023b). However, integrating digital technologies into educational curricula and teaching practices poses challenges related to infrastructure, teacher training, and pedagogical approaches (FernandezSanchez et al. 2022). Public policy on digital skills is not necessarily tailored for education sectors and it is important to develop a case study on how education sectors can be supported by digital skill development in alignment with public policy. This research uses a case study in Ukrainian MET to understand the issue of integrating public policy to increase digital skills among MET faculty who can develop MET curriculum for the 21st-century youth, including future seafarers, and maritime industry professionals.

**4. Methods**

The study employs document analysis and a case study as methods. Ukraine was chosen as a case study because understanding the level of digital skills of teachers is necessary since the country continues to provide online education after the COVID-19 pandemic due to the geopolitical situation. A case study was supported by a survey on teachers' digital skills from two Ukrainian universities (Odessa National Maritime University and Ukrainian State University of Science and Technology). A survey was administered in November 2023 and a total of 126 responses were collected for descriptive statistical analysis. Document analysis was conducted based on the review of public policy documents on digital skills in Ukraine and the EU to identify policy gaps.

**5. Findings: The Case of Ukraine**

Similar to many other countries, Ukraine experienced the challenges of building digital skills among its citizens. However, according to the Ministry of Digital Transformation sociological study, nearly 60% of Ukrainians now possess basic and advanced digital skills—a 12.6% increase since 2019—now aligning with EU countries' indicators (53.84% of the EU population as of 2021). This was due to the government's effort to policy coherence between their Digital Decade and the EU's digital development vision until 2030 (Ministry of Digital Transformation of Ukraine 2021). From 2019 to 2023, the proportion of Ukrainian Internet users within the population rose by 8% to reach 94%. The frequency of Internet usage correlates directly with respondents' age: 71% of the oldest age category (60–70 years old) and 96% of the youngest adults (18–29 years old) who use the Internet daily. The majority of Ukrainian adults (91%) consider Internet access a fundamental modern necessity (Ministry of Digital Transformation of Ukraine 2023). Generally, the Ukrainian population's digital skills exhibit a trend of steady growth as adults lacking digital skills are decreasing while those possessing basic skills or higher are increasing. In 2023, 93% of Ukraine's adult population aged 18–70 possessed digital skills—an 8% rise from 2019. The Ministry of Digital Transformation study categorizes the population's digital skills into several groups: information and communication skills, problem-solving skills using digital technologies, and digital content creation skills. Among adults, the largest share possesses information (91%) or communication (91%) skills, while digital content creation skills are less prevalent (60%) (Ministry of Digital Transformation of Ukraine 2024). The project on "Framework of Digital Competence for Scientific and Teaching Staff in Ukraine" proposes five spheres of digital competence for such personnel: c1-digital literacy, c2-professional engagement, c3-digital educational resources, c4-educational activities, and c5-fostering the formation and development of information and digital competence among students. This last sphere c5 considers whether teachers can effectively impart digital competencies to students, such as fostering information and media literacy, encouraging digital content creation skills, teaching effective communication in digital environments, promoting digital culture and cybersecurity, and enhancing problem-solving skills in digital environments among students (Ministry of Digital Transformation of Ukraine 2024).

With this success in increasing digital skills in Ukrainian citizens as well as teaching staff, the question remains to what extent MET benefited from the Ukrainian government's initiative to enhance digital skills among their teaching staff. A survey study was conducted in two Ukrainian universities regarding the digital proficiency of teaching staff, including 72 women and 54 men aged between 20 and 75 years old. They were grouped into four age groups (25-35, 36-45, 46-59 years, and over 60 years). To assess their competencies, respondents were asked to respond on a Likert scale (from very competent (5) to not competent at all (1)).

Nearly half of respondents (47%) were aged over 46. All respondents acknowledged their awareness of Learning Management Systems (LMS), with more than 90% (117) utilizing them to deliver learning activities online due to the full-scale invasion in Ukraine. Similarly, 90% of teachers (114) use platforms or applications facilitating student engagement and interaction, including discussion forums, chatbots, and real-time feedback systems (Fig.1).

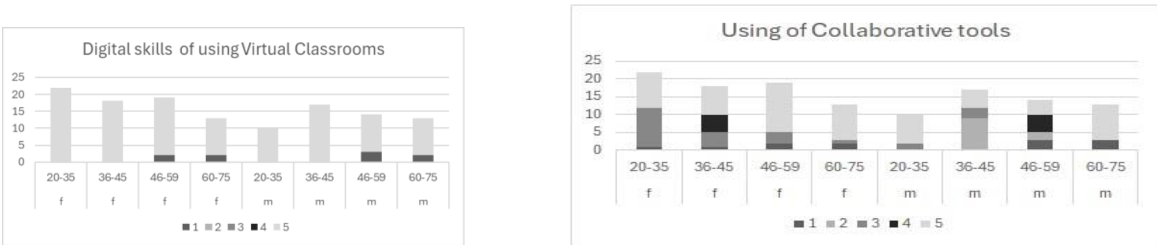


Figure 1. Ukrainian teacher's self-assessment by age and gender

Periodic restrictions on access to workplaces and the need to stay in shelters during the working day led to the full development of mobile learning by Ukrainian teachers. Such mobile learning refers to the use of mobile devices for work, such as smartphones and tablets, to access educational content and engage in learning activities, since the geopolitical impacts on the educational process in Ukraine continue. Students, being in safe places either domestically or internationally (under the temporary protection of other countries), can continue to participate in educational activities. The results show that Ukrainian teaching staff in the sample had the same level of digital skills compared to the general public in Ukraine. The government's public policy made positive effects on enhancing digital skills among the Ukrainian teaching staff.

However, the survey also reveals that only 7% (10) of participants utilize adaptive learning and personalized learning systems. Adaptive learning and personalized learning systems will tailor students' learning experiences in order to meet the individual needs of each student. Such modern digital pedagogy is highly valuable in addition to the development of mobile learning and LMS which has already been in place. The survey also shows that approximately 10% (12) of participants employ tools for immersive digital simulations of real-world scenarios (Fig.2).

Further, 4% (5) of the respondents use game elements and mechanics to engage students and make learning more fun and interactive. Attention should be paid to the fact that these advanced digital technologies indicated above are being used by both male and female teachers aged between 36 and 45 years and a small number of teaching staff aged between 46 and 59 years and over 60 years.


Figure 2. Digital skills using different educational tools by age and gender

It is worth noting from the survey analysis that: 1) the average age of the surveyed university teachers in Ukraine was 46 years and they had completed their education when digitization was at the early stage of its development; 2) digital technologies were poorly implemented in higher education processes due to the oldfashioned education approaches and teaching methods; and 3) there is no evidence that Ukrainian MET institutions developed a policy on digital skills which are aligned to the national and EU public policies. Since the collaboration between Ukraine and the EU is increasing, it is natural to expect that EU's digital development could somewhat influence Ukraine's MET policy making on digital skills.

## 6. Conclusions

The significance of developing digital skills and competencies among university personnel lies in their role as educators of the 21st-century youth, who must adapt to the digital economy and society as well as actively contribute to designing the future. Insufficient digital competence among teachers hampers the formation of high-level digital competence among students across all educational levels. To facilitate digital skills among Ukrainian teachers in MET, it is important to consider that their MET institutions develop a policy on digital skills that is aligned with the national and EU public policies. The results exhibit opportunities for Ukrainian MET to learn from other countries where their regional and national policies on digital skills are integrated into MET. As the pace of digital technology development accelerates and innovative solutions permeate all aspects of social life, there is a pressing need to enhance training quality for workers, including MET teachers, to enable the modernization of the country's economy on contemporary demands.

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# Technology Aspect

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# Designing a Remote Operation Centre from an operators perspective

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**Abstract:** Strides are being made in designing and building autonomous navigation systems. However, it is unclear if ships will ever sail without the ability for a human operator to monitor and control the ships. The first intermediate step is having an operator sailing the ship from a remote operation centre (ROC). Currently companies and research focus on being able to display all information that is available on the bridge. This research approaches the design of the ROC from the perspective of the operator. In a series of experiments, the required information in different operation conditions; open sea, busy waters and manoeuvring in port, is determined. This leads to an overview of which information an operator would want available immediately and which information should be available but does not need to be displayed on a screen at all times.

*Keywords*: Remote operating center, design for operator, remote control, autonomous ship

## 1. Introduction

One of the largest remaining tasks for ships to sail unmanned or autonomous is designing, programming and building a reliable navigation systems. While strides have been made in term of collision avoidance and route following, the current systems are far from being able to fully replace a competent human navigator (Felski & Zwolak, 2020). Additionally, there is an inherent distrust towards fully automated ships, and any form of transportation. Therefore, much of the research that is currently being done assumes that a ship that is sailing unmanned or autonomous will be under the control or at least under the supervision of a human operator (Kretschmann et al., 2015).

There are also other reasons why it would be beneficial for a ship to be operated from a remote operation centre (ROC). In 2021 there was a shortage of over 26.000 STCW trained officers and it is expected that this number will only increase as the years go by (Srinivasan, 2021). In addition, the consensus is that there are more and more seafarers making the choice to work on shore instead of on a ship (Caesar et al., 2015). An ROC could help combat these challenges. People that cannot or will not work on a ship for some reason could perhaps be retained for the maritime profession as it would allow them to work on shore. Additionally, it has been suggested that one operator in a ROC could monitor several ships at the same time, thus lowering the number of trained officers required to monitor ships.

### *1.1 ROC in practice and research*

There are currently several companies and research institutes that are working on remote control for ships. At this point the Belgium company Seafar seems to be the front runner. They operate several inland ship remotely in Flanders and since this year also sail ships between the Netherlands and Germany (*Home - Seafar*, n.d.). Currently, their remote operations re in addition to a qualified navigator on the ship, but their success shows that a ROC is a possibility. Other companies such as the Norwegian company Massterly are also working on operating ships remotely (Massterly, 2024).

One of the first mentions of an ROC is in the MUNIN project. The analysis made in this project still forms the basis for much of the other research that is currently performed (MUNIN project, n.d.). A large project that is currently looking into many details of the ROC is the AUTOSHIP project. This project looks into many aspects of the ROC and the connection between autonomous and unmanned ships and human operators.

Research tasks within this project focus on, among other elements; situational awareness in the ROC, the possibility of operating multiple ships and how to quickly get situational awareness in this case (Porathe, 2021).

Additionally, the ROMAS project focusses on an ROC of the engine room (DNV, 2019). The remote monitoring of the engine room can also address the shortage of seafarers. However, in this article, the focus only lies on moving the bridge tasks to an ROC.

*1.2 Aim of the article*

The examples of remote control of ships in practice and in research shows that the idea has merit. However, there is one thing that is not currently researched well; what equipment should be available for the operator and what equipment is not especially needed. The current design for an ROC consists of a large number of screens presenting lots of different information to the operator. However, it is unclear if this information is truly needed to operate the ship or if this information could be contributing to an information overload.

In this article, this question is addressed by looking at the design of the ROC from the needs of the controller. The aim is to identify what information an OOW uses in different situations, thereby determining what information need to be available front and centre and what information could be placed on a second screen or could even be left out completely.

This is done by performing experiments in several situations that a ship might encounter. Experienced officers are observed in how the handle the situation and what equipment they use. These findings are combined with the regulations stated in Bureau Veritas' *Guidelines for Autonomous shipping* (Bureau Veritas, 2019) to make a suggestion regarding the design of the ROC from an operators perspective.

**2. Bureau Veritas Guidelines for Autonomous shipping**

In 2019 Bureau Veritas presented their *Guidelines for Autonomous shipping.* In these guidelines the rules and regulations regarding ROC's are defined in section 3 chapter 7 (Bureau Veritas, 2019). The starting point of the regulations is that the ROC is an extension of the ship and that it is designed to facilitate the decision making process and remote control for the operators. The station should provide accurate situational awareness and should be set up in such a way that it is clear that all control and monitoring systems are operational.

The rules are general and open to interpretation, giving some freedom in the design of the shore control station. The regulations only state the following information must be available in the ROC: *In addition to have a clear visibility around the ship as requested by SOLAS Ch V reg 22 (Navigation bridge visibility), the dashboard should also include sea chart, radar screen and weather chart* (Bureau Veritas, 2019). All other types of information that are supplied are not specified.

In terms of the information supplied, it is important that the risk of an overload due to the high amount of information supplied is avoided. This means that fusing data gained from the sensors might be required. However, there is one element that must not be forgotten in the design of an ROC. Section 4 paragraph 3.3.4 states that: *All information required by the user to perform an operation should be available on the current display* (Bureau Veritas, 2019). That means that it should be possible to display enough information to perform the most complicated procedures. However, this does not necessarily mean that this information should be available at all times.

**3. Experiments**

To identify which equipment is used on the bridge during different stages of the ship sailing, several experiments were performed. In these experiments experienced seafarers where asked to perform three predefined scenario's on the bridge simulator. During these experiments, their use of the equipment was observed. Afterwards they were asked questions about their experience and which information they would want available while performing this scenario and if this information should be available at all times or if it could be available in the background, where it could be accessed if needed.

*2.1 Details of ship and simulator used*

The experiments were performed on one of the ships available on the simulator, the "Maasgracht". This ship is a conventional multipurpose ship that is propelled by one main engine, a Becker Flap rudder, CPP and bow thruster.

The bridge build in the simulator is a complete bridge, that means that all standard navigation equipment is available on the bridge.

*2.2 Scenarios*

The first scenario is the scenario of sailing in open waters with some other traffic nearby, see Figure 1. The scenario involves the crossing of a ship, which has right of way. The closest point of approach (CPA) is 0 meters and the time to CPA is 12 minutes. The goal for the OOW is avoid the crossing ship. The scenario ends once the ship passed well clear. This scenario is meant as a representation of a ocean crossing, where there is limited traffic and other dangers.

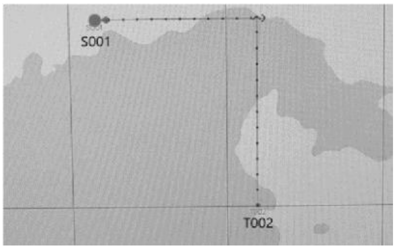


Figure 1. Scenario 1, sailing in light traffic on the North Sea

The second scenario is aimed at sailing in busy waters, in this case the Dover straight. The OOW is tasked with crossing the traffic separation scheme (TSS) to sail towards the port of Dover, see Figure 2. The TSS and the added challenges of shallow water and buoyage means that this scenario involves more than scenario 1. The scenario ends once the whole TSS is crossed.

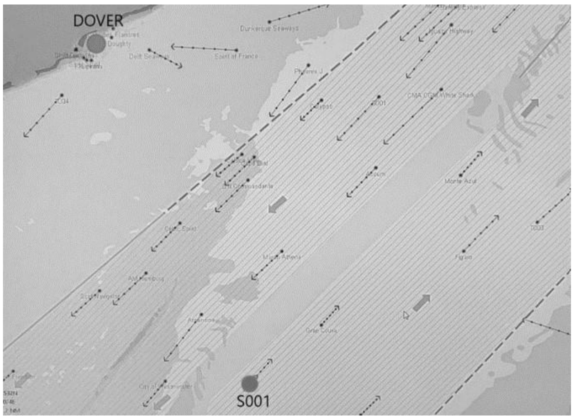


Figure 2. Scenario 2, sailing is busy traffic in the Dover Straight

The final scenario involves mooring the ship in the port of Rotterdam, see Figure 3. The OOW is tasked with making two turns to finally end up at the line marked “Aanlegplaats”. During this manoeuvre, there is additional traffic simulated as well. The scenario ends once the ship is moored at the stated location.

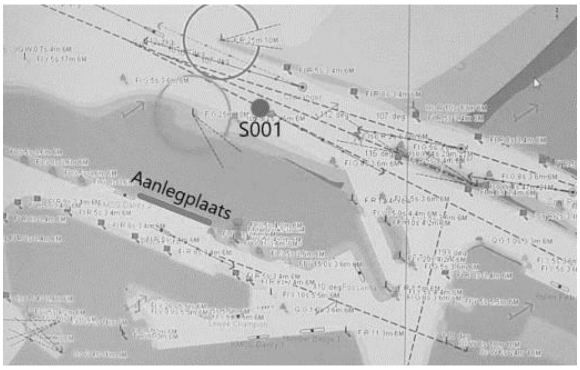


Figure 3. Scenario 3, mooring in the port of Rotterdam

For each of the experiments the OOW's are asked to set up their own route. This better represents a real world scenario and also increases their situational awareness. As these are the first experiments that are performed, the weather is currently set to be favourable, meaning good visibility.

**4. Results**

In this section, the results and findings will be discussed per scenario. The aim of the different scenarios was to find the minimum required information and to find which information is not needed front and centre. As expected, there was no consensus among the participants of the experiments, as every OOW has their own preference for the settings of the bridge and the equipment they use. For example, one participant stated that the conning display is required, while the next participant stated that the conning display is not needed on the foreground of the ROC. Therefore, the results will discuss both the consensus and the disagreements between participants.

The use of the equipment per scenario was observed. After the completion of the experiment participants were asked to state what equipment they would want available on the foreground and on the background during the execution of the scenario. Foreground means that the information would immediately be available, whereas information on the background could be accessed by adding it to an additional screen or switching to another view on a screen. The results are presented in Table 1, Table 2 and Table 3.

Table 1. Summary of results for scenario 1

| | Foreground | Background |
|---|---|---|
| Consensus | Radar<br>Autopilot<br>Speed over ground (SOG)<br>Speed through water (STW)<br>Heading<br>Rate of turn<br>Rudder indicator | Outside view (180-270 degrees)<br>VHF<br>Instrument to register sound signals |
| Dissensus | Telegraph<br>Windmeter<br>Manual rudder control<br>ECDIS | Telegraph<br>Windmeter<br>Manual rudder control<br>ECDIS |
| Additional information | Under Keel Clearance (UKC) | |

Table 2. Summary of results for scenario 2

| | Foreground | Background |
|---|---|---|
| Consensus | Radar<br>ECDIS<br>Autopilot<br>Telegraph<br>SOG and STW<br>Heading<br>Rate of turn<br>Rudder indicator | ECDIS<br>VHF<br>Instrument to register sound signals |
| Dissensus | Manual rudder control Outside view (180 – 270 degrees) | Manual rudder control<br>Outside view (180 – 270 degrees) |

| | | |
|---|---|---|
| Additional information | UKC<br>Windmeter | Blindspot cameras |

Table 3. Summary of results of scenario 3

| | Foreground | Background |
|---|---|---|
| Consensus | Outside view (180-270 degrees)<br>Blind spot cameras<br>ECDIS<br>Manual rudder control<br>Telegraph<br>SOG and STW<br>Bow thruster control<br>Heading<br>Rate of turn<br>Rudder indicator<br>Windmeter<br>UKC<br>Radar (in bad visibility) | ECDIS<br>VHF<br>Instrument to register sound signals<br>Radar (in good visibility)<br>Blind spot cameras |
| Dissensus | | VHF |
| Additional information | VHF<br>Rudder setpoint | Autopilot |

As is to be expected, the amount of information that the participants would want available increases with increasing complexity of the scenario. For much of the information needed to complete each scenario there was a consensus between the participants. However, in some cases there is some dissensus in terms of what is needed. Additionally participants state that there is a large difference between the information that is strictly needed for safe completion of the scenarios and the information that would be nice to have. For example, for scenario 1, the participants agreed that the outside view should be supplied on the background but stated the would probably look at it during the scenario.

The results also show that different participants have different wishes for each scenario. One participant stated that they would not complete scenario 2 without outside vision, citing the close proximity of other ships as a reason. Another stated that they would be able to complete the scenario but that having an outside view would make it easier.

The outside view is an interesting case by itself. Although not needed for the first scenario, it would be beneficial to have it, for example to see if the ship that is near has limited manoeuvrability. While this information should be available within the AIS, this information is not always reliable. Additionally, looking out of the window provides valuable information regarding the current situation outside such as about the weather and visibility. A difference in weather does not only influence how you as the OOW should react but also how other ships will react to situations.

A lot of the information is shared between the different pieces of equipment or can be combined into one view, for example combining a lot of ship information in the conning display or combining the ECDIS and the radar into a chartradar. The combination of the information could be valuable, as more information is available in the same place.

## 5. Conclusions

An increasingly complex scenario with more elements to consider leads to a wish for more information from the operator. The first scenario could be completed safely with a radar and a display which shows information about SOG, STW, a heading, rate of turn and a rudder indicator. This could for example be the conning display. This information would be enough to monitor and control the ship while it is in open water with limited traffic. In this case, it would be possible to have a set up with only two screens. However, the outside view should always be accessible for the operator for additional safety.

The difference in information required between the different scenarios means that it might be beneficial to set up different modes within the ROC. Allowing an operator to switch between a sea mode, a busy traffic mode and a mooring mode would potentially cut down on the possibility of information overload, therefor complying with the BV rules. However, the experiments also show that different operators would have different preferences in terms of what information is used an is available. This means that the set-up would require some flexibility to allow switching between operators. The basis of an ROC station should be the same for every operator, to allow for an easy handover of the controls if necessary, however, it should also be possible to add additional information if preferred by the operator.

### *5.1 Future research*

The experiments performed in this article provide a starting point for designing an ROC from an operators perspective. The three scenarios that were used in the experiments make a distinction between three different operating modes on board, however, the traffic and location of the ship are not the only things that can affect which equipment is used. The weather, visibility and also the sea state could also affect which equipment an operator would like to have available. Further experiments should be conducted where these elements are taken into account.

A further step would be to perform experiments where the operator only has the selected information available. This way, the results can be verified. These experiments can also be used to make a start on the actual design, looking at what information is placed where and in which manner.

Finally, it would be interesting to perform experiments in an actual ROC. The use of the simulator inherently decreases the consequences if something goes wrong, which might influence the confidence of the participants in the experiments.

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# Unmanned ships: Are they appropriate solution or cause for further concern?

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**Abstract:** The shipping industry has always been considered the lifeline of the global economy, and ships and crew members are an indispensable part of it. However, inadequate human actions have been recognised as a weakness in the system. Despite all efforts to mitigate this problem, statistics show that the human factor is still the main cause of all accidents at sea. The impetus for improvement came from the industry in the form of the concept of unmanned ships. The idea was positively received and supported by the International Maritime Organisation (IMO) in 2018. Numerous studies with specific objectives have been carried out and the benefits of the concept have been presented. However, the concept also has a negative side that is still largely unknown. Among the fundamental issues to be considered are the requirements for the installation of basic navigation, machinery and cargo equipment, its reliability and related costs. In view of this, it is clear that the concept also involves numerous risks, and the feedback from insurance companies is still unknown. Finally, the brunt of the costs will obviously be passed on to the end users, which in turn may have an impact on the global economy.

*Keywords*: MASS concept; operational reliability; concept viability; industry impact

## 1. Introduction

The shipping industry has traditionally been regarded as the lifeline of the global economy (Stopford, 2009). As part of the transport chain, ships are an indispensable component. Numerous international conventions and laws aim to ensure their safety, the protection of the environment and the lives of seafarers.
However, human error has proven to be a weak point in this system (Schröder-Hinrichs et al,.2012; Mišković et al. 2018). The industry has recognised the problem and numerous legislative changes have been introduced, including greater automation and digitalisation of ship systems (Turan et al. 2016). Nevertheless, the available statistical data shows that no suitable solution has been found to mitigate the problem (EMSA 2022). The impetus for improvement came from the industry and the International Maritime Organisation (IMO 2018) in the form of the Maritime Autonomous Surface Ships (MASS) guidelines; first for remotely controlled and then for fully autonomous ships. Both concepts have the exclusion of seafarers from the ships and the advantages in common. Unmanned ships offer the potential for greater operational efficiency and productivity. By eliminating crew accommodation on board, unmanned vessels can provide more space for cargo storage, maximising revenue-generating capacity. In addition, autonomous systems can optimise navigation routes and operating parameters, thereby optimising fuel efficiency and reducing operating costs (e.g. Burmeister 2014; Kim et al. 2020). Furthermore, Ventikos et al. (2020) state that the main technological and financial are to be resolved soon.

Although the concept of unmanned ships promises the advantages mentioned above, the associated disadvantages must also be emphasised, which could give cause for concern. Felski and Zwolak (2020) pointed out the hazards arising from issues of system reliability and resilience in relation to the safety of equipment and cargo and recommended further testing. Jovanović et al. (2022) investigated the viability of unmanned container ships and concluded that the concept offers no advantages other than fuel savings. From a different perspective, Wróbel et al. (2017) stated that autonomous ships will certainly improve the situation in terms of navigationrelated accidents. However, should an accident occur, damage assessment and control would be difficult without human presence. Kim et al. (2022) state that key safety, legal and economic issues should be addressed further. They also emphasise that there will eventually be a mixed navigation environment where conventional and unmanned ships are combined, bringing additional risks to the industry. Hoem at al. (2019) state that unmanned ships will become more technically complex and the possibility of technical failure will increase. Furthermore,

Ziajka-Poznańska and Montewka (2021) analysed the costs and benefits of unmanned ship operations and concluded that the financial models are skewed and should be further researched.

In light of the above, the aim of this paper is to outline the basic operational requirements for future unmanned ships and the associated risks, operational and financial viability, affordability and potential economic impact on shipping and related industries. Fundamental issues include the requirements relating to the installation of basic navigation, machinery and cargo equipment. As there is no crew on board, remotely operated and fully autonomous ships are considered to be equivalent. Given the complexity of the systems required in the future, it is of utmost importance to address the issue of their reliability. In addition, it should be noted that any installed equipment raises the issue of maintenance, which must be carried out in the absence of the ship's crew by the shore service and/or while the ship is in dry dock. Therefore, the maintenance requirements are also shown (Figure 1). In both cases, this means an increase in costs for the owner. To summarise, it can be said that the concept is associated with a large number of risks. It is therefore legitimate to ask which insurance company is prepared to offer the required service and at what price.

## 2. Basic requirements, related risks and associated costs for unmanned ships

For unmanned ships, there are some important considerations regarding the necessary navigation, machinery and auxiliary equipment, their reliability and the maintenance required. An overview of each of these aspects can be found in Figure 1. It should also be noted that related security, cyber security and ship control issues (from shore or through artificial intelligence) are not considered in this paper.

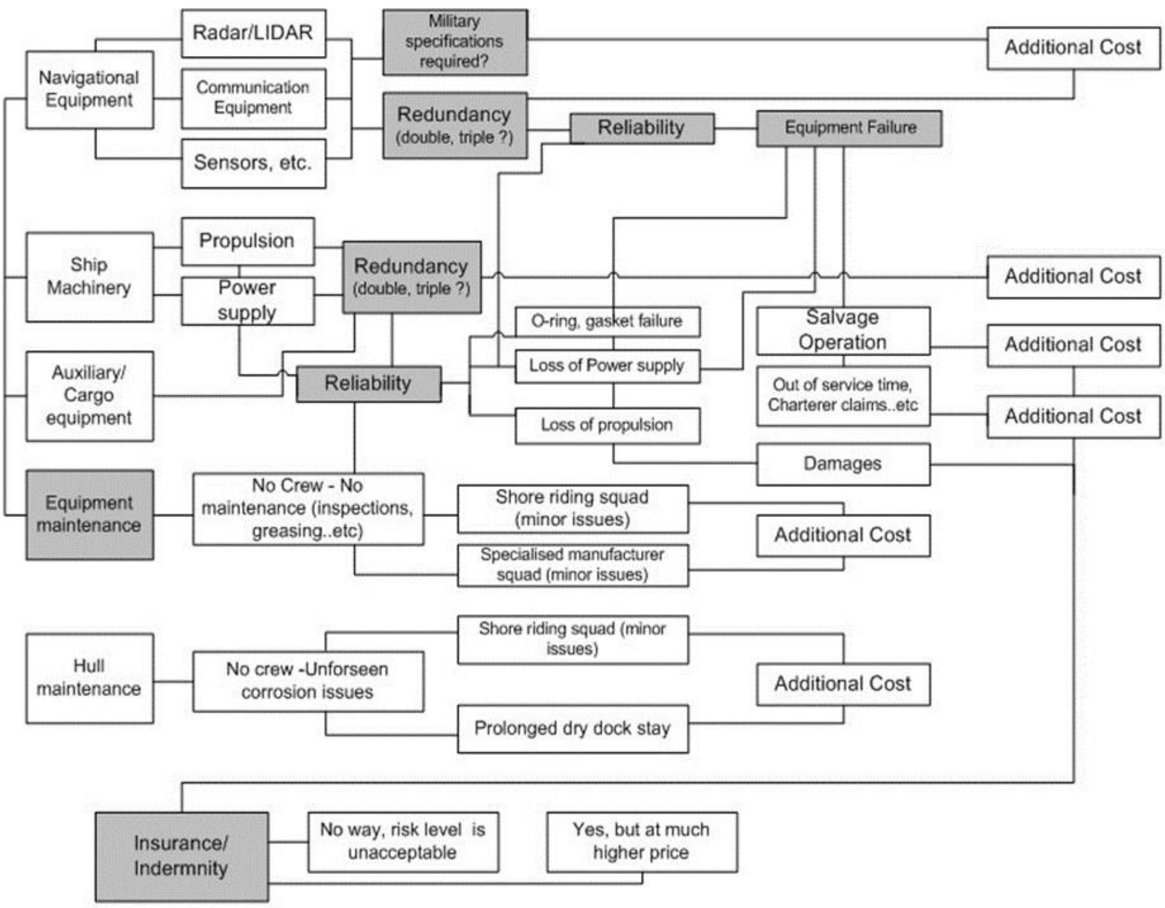


Figure 1. Fundamental requirements for unmanned ships, related risks and associated costs.

### *2.1. Navigational Equipment*

In the absence of humans, future unmanned ships will be either remotely controlled or controlled by artificial intelligence (AI) and machine learning algorithms supported by advanced sensors to navigate through complex maritime environments. However, basic navigation equipment such as radar, global positioning system (GPS), light detection and ranging (LiDAR), sonar system, automatic identification system (AIS) and cameras are essential for autonomous operation (traži literature). In addition, both concepts require robust communication systems for interaction with other ships, data transmission to shore-based operations centres and/or support from the manufacturer. Radar systems, the backbone of collision avoidance, provide reliable detection and tracking of nearby vessels and obstacles. They provide critical situational awareness, especially in poor visibility conditions. Despite their reliability, radar systems can occasionally fail due to environmental factors or electronic problems. Therefore, they should be supported by LIDAR sensors that can provide detailed 3D maps of the environment to improve situational awareness and obstacle detection.

In addition, the question arises whether the civilian devices are sufficient or whether future requirements foresee the use of military navigation devices that fulfil certain operational requirements, i.e. higher performance and security standards such as encrypted communication, anti-jamming capabilities, increased resistance to electronic warfare and integration with military command and control systems in the event of an emergency.

### *2.2. Machinery Equipment*

The machinery equipment on board unmanned ships should include a propulsion system, power generation units and monitoring/control systems. These components are essential for ship propulsion, power supply and general operational performance. Propulsion systems can range from traditional diesel engines, diesel-electric engines to innovative electric, hybrid or even fully electric propulsion systems. Each propulsion system has its own advantages and challenges, with factors such as reliability, efficiency and environmental impact being paramount. Although generally reliable, propulsion systems can fail due to mechanical wear or problems with the fuel system. The electrical power supply is also an essential part of any ship. Traditionally, the power supply is generated by the shaft generator or diesel generators. Technological progress could provide new solutions such as fuel cells or batteries for power generation (USDE 2015). However, any system must be robust and reliable to ensure an uninterrupted power supply for the propulsion and systems on board.

Monitoring and control systems play a central role in overseeing machinery performance, detecting anomalies and optimising operational efficiency. Ensuring the reliability and resilience of machinery is critical to maintaining the autonomy and safety of unmanned ships during extended periods at sea. Despite their crucial role, reliability problems can arise due to sensor failures or software errors, among other things.

### *2.3. Auxiliary /Cargo Equipment*

Similar to conventional ships, unmanned ships should also have associated auxiliary equipment to support the propulsion systems, manoeuvring and associated cargo operations. In general, auxiliary equipment in the engine room such as coolers/heaters, steering machinery, numerous pumps, related pipelines and associated valves support the work of the propulsion system and are indispensable components of the engine room. The deck machinery is an essential part of every ship to ensure that daily operations run smoothly. The basic equipment on deck includes mooring winches (forward and aft) for mooring the ship, windlass and anchors for anchoring operations. Depending on the type of ship, the associated cargo equipment should also be present, i.e. hatch covers for bulk carriers, cargo pumps and pipelines supported by numerous sensors for tankers, etc. Again, all deck equipment is powered by electrical/hydraulic systems via numerous pipelines and associated valves. Once the ship is securely moored, there should of course also be a boarding system, i.e. a gangway for harbour workers to board the ship. Although the unmanned vessels have no crew, they should be equipped with a heating, ventilation and air conditioning (HVAC) system to fulfil the environmental requirements for the associated navigation and electronic equipment.

## 3. Maintenance

Conventional ships have a small crew on board who are responsible for monitoring the systems, responding to alarms and solving problems. Their duties involve basic maintenance activities, such as visual inspections, checking equipment, lubricating and carrying out almost all types of repairs. In addition, one of the routine maintenance tasks of the deck crew is related to “chip-and-paint” actions on the ships hull, which reduces the ship's dry dock time.

In the scenario where a ship is categorised as unmanned, maintenance tasks would need to be performed by the ship's autonomous systems or by shore-based maintenance personnel. Although current AI and robotics technology is advancing rapidly, there are limitations to what AI can accomplish in terms of physical maintenance tasks, especially in the dynamic and often unpredictable environment of the open sea. Therefore, it is reasonable to expect that most of the work will be done by maintenance personnel while the ship is at anchor and/or while in port.

## 4. Equipment Reliability

Reliability is a cornerstone of ship operation and includes both navigation and machinery equipment. Robustness, redundancy and fault tolerance are essential attributes that must be integrated into the design and implementation of future systems. Navigation equipment must be able to operate autonomously and reliably under various environmental conditions, including adverse weather, sea states, and electromagnetic interference. Similarly, machinery equipment must be highly reliable to withstand the rigours of maritime operations and minimise the risk of downtime or failures. Continuous monitoring, proactive maintenance and adherence to strict quality standards are key strategies to increase reliability and ensure the safe and efficient operation of MASS.

In addition, several factors influence the reliability of navigation and machinery equipment. Maintenance practises, including regular inspections, calibrations and software updates, are crucial to maintaining reliability. Environmental conditions such as saltwater corrosion or extreme temperatures can affect equipment performance. Technological advances, including improved materials and manufacturing processes, contribute to increased reliability over time. Conventional regulations specify redundancy requirements for critical ship systems to mitigate the effects of equipment failures. Therefore, unmanned ships should have redundant systems for critical components such as propulsion, power supply, navigation and communications.

## 5. Discussion

This paper analyses the concept of unmanned ships in terms of navigation, machinery and auxiliary/cargo equipment and maintenance requirements to ensure the required level of reliability. Certainly, the navigation, propulsion and power generation systems are the essential parts of any ship, including an unmanned one, and their continuous operation is necessary to fulfil the required tasks.

The easiest way to ensure reliability is therefore to ensure the redundancy of the individual ship systems. Although this is the simplest/most practical method, it incurs additional costs and presents an initial weakness expecially in the case of duplication of the main engine and associated equipment. Therefore, future testing should confirm which systems should be duplicated/triplicated to ensure the desired level of reliability. These issues should be mutually agreed by the classification societies.From this, it can be seen that several unknowns associated with the ship's equipment can affect the acquisition cost of the vessel. The issues of financial viability and affordability are therefore subject to detailed analysis.

Secondly, there are issues related to maintenance. Since there are no humans, conventional maintenance strategies cannot be applied. However, there are several ways in which AI and autonomous systems could contribute to maintenance tasks on unmanned ships: some maintenance tasks can be automated by on-board systems equipped with predictive maintenance capabilities, automated diagnostic systems should be able to detect equipment faults or anomalies and initiate corrective actions autonomously or with minimal human intervention (remotely controlled), autonomous maintenance robots or drones equipped with sensors and tools can be used to perform certain maintenance tasks, and predictive maintenance techniques can use data from onboard sensors and monitoring systems to anticipate equipment failures and schedule maintenance activities accordingly.

Although these measures sound sensible, they pose additional risks and vulnerabilities. It is obvious that all maintenance work should be carried out by shore-based personnel while in port. This also raises the question of the associated maintenance costs, which can vary considerably. If it is a simple maintenance job, the local shore-based maintenance team can solve the problem relatively quickly and relatively cheaply. However, if the problem requires specialised skills and knowledge to resolve, the manufacturer's specialised team will need to step in, which will incur additional costs. In the author's opinion, these costs can be more than substantial, considering that the shore-based staff are normally located in their home country. So there are travelling, accommodation and other costs involved in getting them on site. In some cases, the maintenance work required may even extend this period and incur additional costs. Given the number of machinery and equipment currently on board, not to mention the complexity of future systems, it is clear that the maintenance costs required are unpredictable to say the least. In addition, a major equipment failure while the ship is underway could lead to collisions, property damage and/or pollution. It is also very likely that in the event of a failure, the ship will remain adrift in the middle of the sea awaiting salvage operation. In such cases, marine liability insurance serves as protection for the owner. It will therefore be interesting to see whether insurance companies are prepared to take on this type of risk and, if so, what the price for such a service will be.

## 6. Conclusions

This study provides a comprehensive overview of the operational requirements for future unmanned ships and the associated risks. At the same time, the current research gaps are highlighted and it can be concluded that the successful development of unmanned ships depends solely on the maturity of the technology, the acquisition costs and the associated costs for the equipment, its maintenance and insurance.

The rapid advancement of technology should solve the main problems related to navigation, machinery, auxiliaries and cargo equipment on board, thus reducing the likelihood of equipment failure. It is clear that the required level of redundancy increases the complexity of unmanned ships, resulting in additional acquisition costs for the owner, and that the issue of maintenance of such systems and associated costs is of critical importance to owners and will play a central role in concept development. However, the lack of such data is the limitation of the study.

The fundamental question is which shipping company can afford such an endeavour. There are certainly not very many. This leads to the conclusion that the implementation will be lengthy and that there will be a period of coexistence between conventional and unmanned ships. During the transition period, the industry will enter uncharted territory, i.e. the interaction between humans on board and shore-based operators and/or artificial intelligence will pose an additional risk. Therefore, the stated benefits of unmanned ships in terms of reducing human error, as the main cause of all accidents at sea, are certainly questionable and far-reaching.

Future research should therefore closely examine not only the operational aspects but also the financial viability of the concept. However, this concept will not be possible without the insurance companies, and they will have the final say. If the concept proves successful, it can be assumed that the main burden of the associated costs will be passed on to the end consumer, which in turn could have an impact not only on the shipping and related industries, but also on the global economy.

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# Wind-assisted propulsion system operating mode optimization

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**Abstract:** Like every other sector, the shipping industry needs to decarbonize in line with the Paris Agreement, but its emissions continue to grow. The IMO MEPC 80 session adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships, with enhanced targets to tackle harmful emissions. The revised IMO GHG Strategy includes an enhanced common ambition to reach net-zero GHG emissions from international shipping close to 2050, a commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030, as well as indicative checkpoints for 2030 and 2040. There are several types of wind-assisted propulsion systems (WAPS) that have been developed for the maritime industry; still others remain in development. These systems differ not only in terms of maturity, costs involved and fuel savings potential, but also in terms of their suitability for specific ship types. Optimizing ship's speed is one of the most effective ways to increase the economic efficiency of a fleet and reduce energy costs without requiring additional capital investments. Therefore, the task of choosing the most advantageous speed is of paramount importance in the design and operation of ships. The problem of optimizing speed for transport ship's with WAPS is no less acute. For such ships', its solution requires a specific approach, however, the proposed methods and the conclusions obtained are applicable to all types of sea going ships'. The problem can be rightfully considered at three stages: designing the ship, planning the voyage and its actual execution. This paper presents research results related to the optimization of ship's speed in operational conditions, that is, to the second and third of these stages. The presence of two types of propulsors: propellers and wind propulsors (WP), - on the ship determines the possibility of regulating the power of the main engine (ME) depending on the thrust of WP. The thrust provided by the WP can be used both to reduce fuel consumption and to increase the ship's speed.
*Keywords*: wind-assisted propulsion system, optimal control, main engine, fuel consumption.

## 1. Introduction

The use of auxiliary WP (rigid wing sails, soft sails, Flettner rotors, etc.) for ships is an important scientific and technical problem (Yunlong Wang et al. 2022, Reche-Vilanova et al. 2023) and prompts the solution of new problems of optimal control of the ship propulsion system. The general statement of the dynamic problem of optimal control of a ship with a WAPS includes: mathematical model of the propulsion system of the ship (Miyusov M. V. 1996, Kryvyi O. F. and Miyusov M. V. 2016, 2019), which determines feedback with the ship's control devices; control criteria (Petrov Yu. P. 1977), which determine the control goal; restrictions on phase coordinates and control parameters. If we limit ourselves to determining the optimal ship's speed for a voyage, then to the control criteria it is enough to add a given integral indicator, for example, the average speed per voyage or a given voyage time (the so-called isoperimetric problem). This work is devoted to the solution of such a problem, considering of WP. It should be noted that the presence of WP introduces significant differences and difficulties in determining the optimal ship's speed, since there is a need to constantly consider the speed and direction of the wind.

## 2. Determination of optimal modes of joint operation of main engines and wind propulsors

The main task of optimizing the modes of operation of energy systems is the task of minimizing energy consumption for the technological process, when it is necessary to fulfill the conditions determined by the tasks of a higher level of a complex hierarchical system (Miyusov M. V. 1996). For the "ship'" hierarchical level, such a condition is the achievement of the specified average speed of the ship per voyage $v_{sr}$, or the time of arrival at the destination port. The specified average ship's speed is determined using the objective function of the specific costs per voyage and can be achieved by using different modes of joint operation of the ME and WP, but the total fuel consumption per voyage will be different. Therefore, as a criterion for choosing the optimal modes of joint operation of the ME and WP, it is advisable to take the minimum total energy consumption per voyage at a given average ship's speed per voyage, which in this case is integral in nature. So, we have the following isoperimetric problem of the calculus of variations on a conditional extremum: find the extremals of the functional

$$E_{\Sigma} = \int_{0}^{T_{\Sigma}} (B + B_{dg} + B_{vk})dt \rightarrow \min ; \quad (1)$$

with an additional condition

$$\frac{1}{T_{\Sigma}} \int_{0}^{T_{\Sigma}} v(t)dt = v_{sr} , \quad (2)$$

where $E_{\Sigma}$ – the total energy consumption per voyage in kg of conditional fuel equivalent; $B$, $B_{dg}$, $B_{vk}$ – current fuel consumption for the operation of the ME, auxiliary engines (diesel generators) and auxiliary boilers, respectively; $T_{\Sigma}$ – voyage time; $v(t)$ - the current ship's speed. Note that the recommended average ship's speed per voyage can be determined using the method (Miyusov M. V. 1996), or, if the voyage time is fixed, then the indicated speed can be determined as follows $v_{sr} = L_{\Sigma} T_{\Sigma}^{-1}$.

Considering that the fuel consumption for auxiliary engines and boilers practically does not depend on the mode of operation of the ME, we will consider only the component of the total energy consumption related to the fuel consumption of the ME. Factors determining fuel consumption can be conditionally divided into two groups: external conditions and adjustable parameters, that can be controlled during operation. The external conditions include wind, sea waves, environmental parameters (atmospheric pressure, air and seawater temperature), ship loading, condition of the underwater part of the hull and propeller of the ship, fuel parameters, technical condition of the ME. The adjustable parameters that determine the fuel consumption of the ME on a ship with an WP include: the setting of the ME shaft speed (the fuel handle position or the engine speed governor setting); WP status (working or non-working); working area and angle of WP (for Flettner rotors – angular speed of rotation of the rotor); adjustable parameters of the thermal state of the ME; trim of the ship; angle of the blades of the controllable pitch propeller (CPP) (if available), etc.

All external conditions, regardless of their nature, can be represented as a function of time $t$ and (or) path coordinates $s$. For example, wind and sea waves can be considered a function of time, and the ship's load, which varies at ports of call, can be considered a function of the route. The condition of the propeller, the underwater part of the hull, the technical condition of the engine and the characteristics of the fuel can be considered unchanged during one passage of the ship between two ports. Regulated parameters (excluding ME shaft rotation speed) must be changed according to the relevant laws based on local criteria. For example, the state of the WP is determined by the speed and direction of the wind, and the WP angle is determined from the condition of obtaining the maximum driving force of the WP. The CPP blades angle must ensure the minimum specific fuel consumption (for example, according to the programmed dependence of the propeller pitch on the speed of rotation of the ME shaft) at the appropriate ship's speed. The ship's speed (other things being equal) will be uniquely determined by the given value of the engine shaft rotation speed.

In general, the current fuel consumption per unit time of the ship's ME under wind load conditions can be considered a function of three variables: time, speed, and derivative of the ship's speed: $B = B(t, v, v')$. To determine the latter, you can use a statistical, quasi-stationary approach and methods of regression analysis (Kryvyi O., Miyusov M. and Kryvyi M. 2023). At the same time, the sailing time can be divided into $n$ conditional time intervals, in each of which the wind and wave parameters are considered constant. At moments of time $t = t_k$, where $t_k \in (0; T_\Sigma)$, $k = \overline{1, n}$, there is an instantaneous change in wind and wave conditions. The quasi-stationary approach makes it possible to ignore the dynamics of transient processes at moments of time $t = t_k$ and to present the fuel consumption in the form of a piecewise smooth function with discontinuities of the first kind in points $t = t_k$:

$$B(t, v, v') = (v')^{\kappa} \sum_{m=0}^{p} b_m(t) v^m, \quad b_m(t) = b_{mk}, \text{ при } t \in (t_k, t_{k+1}), k = \overline{1, n}, m = \overline{1, p}. \quad (3)$$

Coefficients $b_{mk}$ are determined by regression analysis methods. The desired function in the optimal control problem (1), (2) is the ship's speed $v(t)$, which must satisfy the restrictions determined by the operating conditions of the ship. The restrictions on a control function $v(t)$ are variable and, given the problem formulation, are also piecewise smooth functions of time. Thus, to determine the optimal modes of joint operation of the ME and WP, the following optimal control problem can be formulated. Determine the ship's speed $v(t)$, that provides the minimum total fuel consumption of the ME per voyage $Q_\Sigma$, that is, delivers the minimum of a functional:

$$Q_\Sigma = \int_0^{T_\Sigma} B(t, v, v') dt \to \min, \quad (4)$$

with the additional integral condition (2), in the presence of control restrictions in the form of a double inequality

$$v_{\min}(t) \le v(t) \le v_{\max}(t), \quad (5)$$

where $v_{\min}(t)$, $v_{\max}(t)$ – given piecewise smooth functions with discontinuity points $t = t_k$, $k = \overline{1, n}$.

The formulated optimal control problem (4), (2), (5) is a variational problem for a conditional extremum. Its difference and complexity lies in the fact that restrictions (5) are imposed on the control, and they must be sought in the class of piecewise smooth functions. The authors developed a method that generalizes the methods of classical calculus of variations for the specified case (Miyusov M.V. 1996, Miyusov M.V. and Krivoy O.F. 2003). The essence of this method is given by the following theorem.

Theorem. Let the function $B(t, v, v')$ have discontinuities of the first kind at the points $t_k \in (a, b)$, $k = \overline{1, n}$, and satisfy the condition

$$\lim_{v'\to\infty}\frac{B(t,v,v')}{v'}=0\,, \tag{6}$$

then, in the presence of restrictions (5) and the fulfillment of condition (2), the functional (4) can reach an extremum in the class of piecewise-smooth functions, which jump from one value to another at the points $t_k$, $k=\overline{1,n}$ , on the curves consisting of parts of the boundary of the feasible region and pieces of extremals, that satisfy the Euler equation when $t \neq t_k$

$$\frac{\partial B}{\partial v}-\frac{d}{dt}\left(\frac{\partial B}{\partial v'}\right)=0\,,\ (t\neq t_k). \tag{7}$$

Taking into account the above theorem, the Lagrange function for the formulated problem of optimal control will be presented as follows

$$G=B(t,v)+\lambda_0 v\,, \tag{8}$$

where $\lambda_0 -$ the Lagrange multiplier. For function (8), condition (6) is fulfilled. Therefore, the extremum of the functional (4) in the presence of restrictions (5) and condition (2) is reached in the class of piecewise smooth functions consisting of parts of the boundary of the feasible region (4) and extremals determined from the Euler equation for the Lagrange function (8):

$$\frac{\partial G}{\partial v}-\frac{d}{dt}\left(\frac{\partial G}{\partial v'}\right)=0\,,\ t\in\bigcup_{k=1}^{n}\left(t_k,t_{k+1}\right). \tag{9}$$

At the same time, at the points $t_k$, $k=\overline{1,n}$ , the control jumps from one value to another. For our task we can assume that fuel consumption does not depend on the acceleration of the ship, then in representation (3) $\kappa=0$, and equation (9) will take the form

$$B'_v=C\,,\ t\in\bigcup_{k=1}^{n}\left(t_k,t_{k+1}\right), \tag{10}$$

where $C=-\lambda_0$. By substituting (3) into (10), we get the equation for determining the extremals

$$\sum_{m=0}^{p} m b_m(t)v^{m-1}=C\,,\ \ t\in\bigcup_{k=1}^{n}\left(t_k,t_{k+1}\right). \tag{11}$$

Studies show that to achieve sufficient correlation accuracy in the mathematical model (3), it is possible to limit oneself to the third degree $p=3$. This makes it possible to present the extremal of functional (4) in the presence of additional condition (2) and constraints (5) in the form:

$$v_{\text{opt}}=-b_2(t)\cdot b(t)+\sqrt{b_2^2(t)b^2(t)-b_1(t)b(t)+C\cdot b(t)}\,,\ \ b(t)=(3b_3(t))^{-1}\,,\ t\in\bigcup_{k=1}^{n}\left(t_k,t_{k+1}\right). \tag{12}$$

Therefore, for each time interval $\left(t_k,t_{k+1}\right)$, $k=\overline{0,n}$, characterized by unchanged external conditions, the ship's speed, which ensures the minimum total fuel consumption, is determined by expression (12). At moments of time $t_k$, when the external conditions change, the ship's speed must be changed to a new value according to formula (12). It is established that the extremals (12) satisfy the Legendre condition:

$$G''_{v^2}=2b_2(t)+6b_3(t)v>0\,,\ \ t\in\bigcup_{k=1}^{n}\left(t_k,t_{k+1}\right),$$

and, therefore, provide functional (4) with a minimum value. Note that the constant *C*, which is present in expression (12), depends on the average ship's speed per voyage and is determined from condition (2).

**3. Results of numerical studies**

Based on the proposed approach, a package of application programs has been developed, which considers the wind and wave characteristics of the routes and allows obtaining a number of important results regarding the joint work of ME and WP. Figure 1 shows how the change in the direction of the true wind $\gamma_t$ at a wind speed of 15 m/s affects the optimal ship's speed $v_{\text{opt}}(t)$ and the corresponding current hourly fuel consumption *B*. The calculations were carried out for a 5,000 tons' deadweight tanker, equipped with a wing-sails of 440 m2, at an average ship's speed of 10 knots. Figure 2 shows how the average hourly fuel consumption changes, depending on the average ship's speed without sails – curve 1, and with auxiliary sails of 880 m2 – curve 2. Calculations were made for a 5,000 tons deadweight tanker with cargo on the line Ventspils – Houston – Ventspils (season – winter). For the same tanker, on the same line, Figure 3 shows the total fuel consumption for a round trip, i.e. curve 1 corresponds to a ship without a WP, curve 2 – to a ship with an WP with an area of 440 m2, curve 3 – to a ship with a WP with an area of 880 m2, curve 4 – to a ship with an WP with an area of 880 m2 and an improved sail fold mechanism (the sail does not create movement resistance when folded).

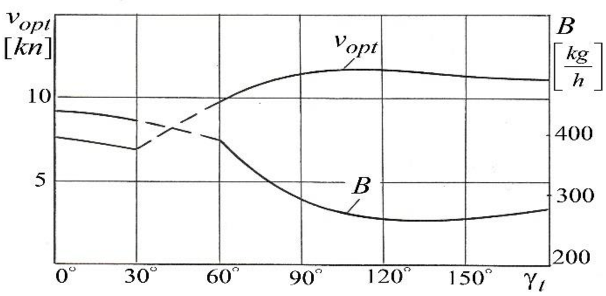


Figure 1. Dependence of $v_{\text{opt}}$ and *B* on the direction of the true wind $\gamma_t$.

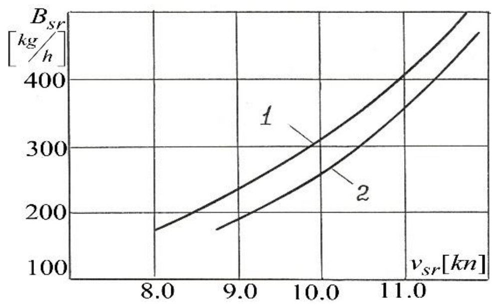


Figure 2. Dependence of the average hourly fuel consumption per voyage for a ship without a WP and with a WP.

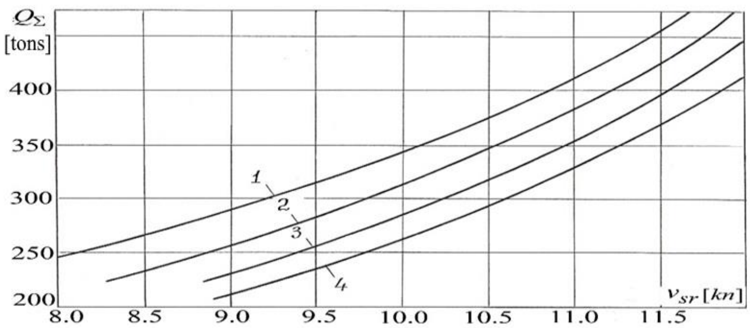


Figure 3. Total fuel consumption per voyage $Q_\Sigma$ for different sail area when opened and folded.

**4. Conclusions.**

A methodology has been developed for determining the optimal ship's speed and other important indicators of the operation of the combined propulsion system, considering WP (wing sails, etc.), in particular, average hourly and total fuel consumption per voyage. The results obtained are illustrated with specific examples confirming that the use of WP significantly increases the economic efficiency of ship operation and leads to a reducing harmful greenhouse gas emissions from ships.

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# Navigating tomorrow: Designing a Simulator Scenario for Generation of AI Training Data

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**Abstract:** This paper presents a model for creating a simulator scenario aimed at generating training data for an artificial intelligence (AI) to learn good seamanship, as referred to by the International Maritime Organization's Collision Regulations (COLREGs). The model is used to design a scenario for collecting high quality data intended for the training of the AI in the AI-Navigator project, which aims to develop an Advanced Navigation Assistance System (ADNAV) that is compliant with COLREGs, including the principles of good seamanship. ADNAV is intended to guide ship navigators by providing them with relevant options in demanding situations where cognitive overload is a risk. The model suggested in this paper ensures a simulation that challenges human navigators to demonstrate *proactive decision-making*, *situational awareness*, and *contextual compliance*, which are all identified as key components of good seamanship. The three key phases of the model are: objective identification, scenario design, and testing, each critical for ensuring the efficiency of a scenario and the realism of the situations. This study contributes to ongoing efforts in maritime safety research, exploring the synergy between human expertise and AI support in navigating increasingly congested and complex waterways.

*Keywords*: Navigation; AI, Seamanship; Simulator; Training

## 1. Introduction

The European Maritime Safety Agency (EMSA) reports that in the 10-year period between 2011 and 2021, its member states reported 8,800 occurrences of grounding, collision, and contacts. These accidents resulted in 173 fatalities and 719 injured persons (EMSA 2022). A possible explanation for some of these accidents is that the bridge of a modern ship, with extensive instrumentation, often lacks integration. The bombardment of information may lead to cognitive overload for the bridge team (Man et al. 2023). When overloaded, it hampers situational awareness and can lead to misinterpretations during navigation and collision avoidance. The navigation officer needs a way to comprehend all this information (Lee and Sanquist 2000). To create a better overview of all the available information, it seems a valid option to create a system to present the relevant information. Some even argue that such a system should take a step further and suggest different solutions to navigational challenges. The current decision support systems are strained when dealing with complex situations, especially where good seamanship is required (Aylward et al. 2022). Good seamanship can be defined as any precaution which may be required by the ordinary practice of seamen (Farwell 1937) and is an integrated part of the International Regulations for Preventing Collisions at Sea COLREGs (International Maritime Organization 1972). Good seamanship poses challenges for computers and algorithms because it involves paradoxes where one rule demands the breaking of another rule, without explicit criteria to when this is applicable. An advanced navigation assistance system (ADNAV) that complies with good seamanship is needed. A promising technology to realize such a system is artificial intelligence (AI).

The AI navigator project aims to develop, implement, and test a TRL5 system that provides guidance to the navigational officer in compliance with IMO COLREGs and the best practice of good seamanship. The project consists of five work packages (WP). WP1 ensures effective project management. WP2, WP3, and WP4 focus on technology development and validation (Figure 1), and WP5 manages result sharing and strategy for technology use. The content of this paper is part of the WP4 training and validation programs.

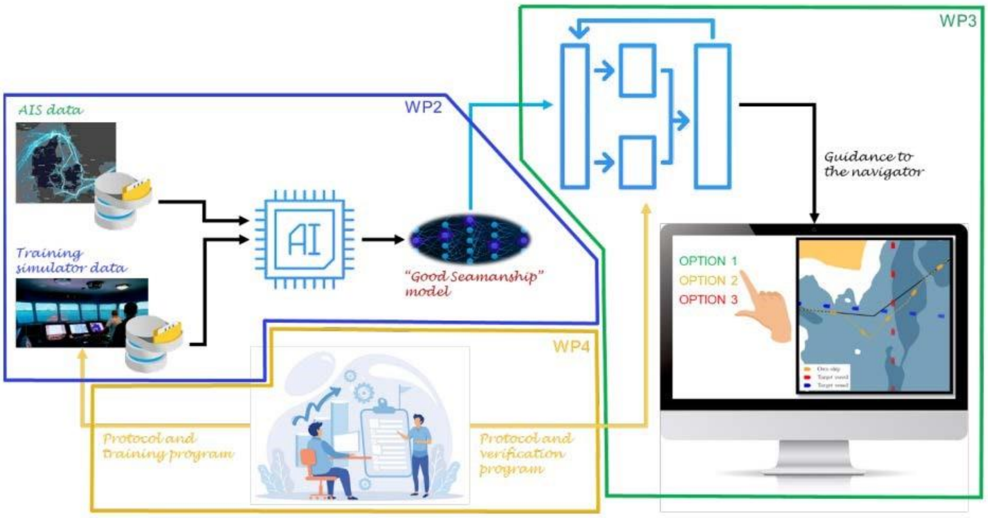


Figure 1. Interconnections of Work Packages 2, 3, and 4 in the AI Navigator Project

### *1.1. Detailed Description of WP4*

This paper focuses on the design of a simulation scenario for training the AI of the AI-Navigator ADNAV. This involves crafting a scenario and a simulator setup that introduces a range of navigational challenges. These challenges will compel human navigators to act according to good seamanship. The simulations are the foundation that enables the collection of high-quality data, which will be combined with a larger dataset collected from Automatic Identification System (AIS) surveillance in Scandinavia. Data collected from the simulation also includes a performance assessment of each situation. This assessment score will be an added input for the AI to better recognize good seamanship. This leads to the following research question:

***How can a simulation scenario be designed to challenge navigators and cause them to demonstrate their ability to practice good seamanship?***

## 2. Scenario Creation

Creation of the scenario is based on a scenario creation model (Figure 2), which consists of three phases: objective identification, scenario design, and testing. The testing and scenario design phases can be repeated in an iterative cycle. The model is inspired by other models used to create simulator scenarios for training shipremote-operations-operators (Hwang and Youn 2022a, b). The model also reflects the practices used by instructors when creating scenarios for maritime education and training (MET) at Svendborg International Maritime Academy (SIMAC). The three phases of the scenario creation model will be explained in the following section.

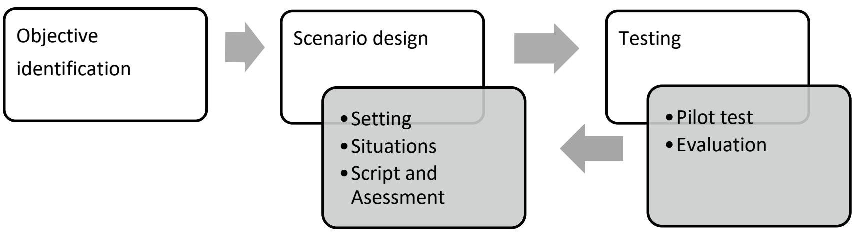


Figure 2. Scenario Creation Model

### *2.1 Phases of the Scenario Creation Model*

Objective identification is the process of clearly defining the skills the simulator training is intended to develop. In the case of this study, the person engaged in the simulation is not the one supposed to develop skills. The perspective is a step further away because the objective of the scenario is for an AI to learn. This learning comes from "observing" a person acting within a simulation. However, with this complication in mind, the scenario constructed for AI training is assumed to be very similar to scenarios for training a person.

Scenario design involves carefully planned situations, ensuring that the training is both targeting the right objective and reflects real-world conditions. The setting of the scenario, such as location, weather, visibility, and sea conditions. Situations should be created to prompt tasks that align with the objectives identified in the objective identification phase. Problems should emerge if situations are inadequately addressed, and these should be more challenging than the situations themselves. Problems should still target the skills associated with the objectives. All these elements must then be scripted and programmed into a simulator. Additionally, a set of instructions for the instructor running the simulation and guidelines for assessing performance must be formulated.

Testing is done simultaneously with the process of creating situations in the scenario design phase, to ensure that each situation works as intended. When all elements have been created, one or more pilot tests are carried out to ensure that the scenario as a whole works as intended and that the instructions provide the relevant information for the instructor. Each pilot test is evaluated, and it is determined whether any changes should be made to the scenario.

### *2.2 Technical Limitations of the Data Collection*

Although not a part of the model, it must also be considered which data can be collected and which data the AI accepts as input. In the case of the AI-Navigator ADNAV AI, visual data is not a part of the model. Data will have to come from AIS, radar plots and conning display data.

## 3. Objective identification

The objective of this scenario is to provide a dataset from which an AI can develop the ability to act according to good seamanship. To do this, the concept of good seamanship must be defined.

Good seamanship is a complex and multifaceted concept and consists of several components: *proactive decision-making, situational awareness, clear communication, contextual compliance,* and *technical proficiency*. *Proactive decision-making* involves anticipating potential hazards and making decisions early to prevent close-quarters situations with other vessels, rather than just reacting to them. *Situational awareness* is a constant awareness of the surrounding environment, including, but not limited to, weather conditions, traffic density, and the capabilities of the vessel. This helps in making informed decisions that comply with both the spirit and the letter of the COLREGs. *Clear communication* is effectively using signals and communication to convey intentions to other vessels as a key part of preventing misunderstandings and collisions. *Contextual compliance* covers that the rules set out in the COLREGs are fundamental, but good seamanship also involves interpreting these rules in a way that prioritizes safety under changing circumstances. Sometimes, strict adherence to the rules may not be sufficient to ensure safety. Good seamanship may require going beyond the regulations to ensure the safety of all vessels involved, especially in complex or emergency situations. *Technical Proficiency* is the skilled handling of the vessel, understanding its performance characteristics, and being competent with the navigational tools.

In essence, while COLREGs provide the necessary regulatory framework, good seamanship provides the wisdom and practical skills to apply these rules effectively and safely in every situation.

In this paper, only the components *proactive decision-making, situational awareness, and contextual compliance* are in focus. The objective of the scenario is to let participants display these three components and thus the scenario design must promote a behavior that allows that.

## 4. Scenario Design

The scenario is intended to generate data for the AI to learn from. The learning outcome for the participants is not a priority. For a human to learn, the difficulty of a task should be in the zone of proximal development (ZPD) (Vygotsky 1978). An AI will learn by observing participants acting, even in situations outside of their ZPD. The AI will simply see the outcome of actions in a context and use this to predict the outcome of other similar actions in similar contexts. As a result, scenarios may be designed without considering the participants' skill level. However, if all participants fail to solve the situations or if the situations are trivial, the value of the data will suffer. The value can be increased if the data is enhanced with an instructor's assessment of the performance. This way the AI do not have to interpret what outcome is most desirable.

The scenario design is done with the objective in mind and according to the steps of the creation model.

In the following section each step is described. For this scenario, a Kongsberg Polaris bridge simulator was used, but descriptions are made to allow the use of any simulation system. The scenario also includes a route plan for the participants to follow.

### *4.1. Setting*

The location of the scenario is the approach to Gothenburg where Göta Älv meets Kattegat. This area provides many opportunities to create situations where it can be difficult to adhere to COLREGs rule 11-18 (conduct of vessels in sight of one another) and where good seamanship in relation to both rule 2 (responsibility) and rule 8(a) (action to avoid collision) can be demonstrated. The weather, visibility, and sea conditions including current, are set to optimal conditions for navigating. This is done to limit the independent variables the AI must consider when trained with the data. As the AI is not intended to deal with rule 19 (conduct of vessels in restricted visibility) situations, the visibility must be perfect.

### *4.2. Situations and Problems*

In the following “own ship” refers to the ship controlled by the participant, other ships are controlled by the simulation and the instructor. The scenario is planned to have a duration of approximately 90 minutes, and seven situations are planned to happen. Due to the nature of simulating marine traffic and the unpredictability of human participants, more situations may arise. These may lead to variations in how the participants perceive the difficulty of the scenario and the work that the instructor must do to ensure that the planned situations happen as intended. The difficulty of the navigation and collision avoidance will often depend on prior decisions; thus, the longer the scenario runs, the more possible outcomes for the own ship's position and other ships' relative positions are possible. To ensure a realistic simulation, the instructor must at any given time be ready to take control of other ships for these to react on the presence of own ship and its actions.

In the following sections, a brief explanation of each situation and its intention is given. Each situation is targeted at a specific component of good seamanship. However, this does not mean that other components can be neglected. Situations and their associated quandaries are inspired by the work of Cockcroft and Lamijer (2011) as well as Jensen and Nielsen (2011).

#### *4.2.1. Start*

The first situation is the departure from the quay into traffic. Own ship is alongside and ready to depart. Aft of own ship an outbound vessel is approaching. In front of own ship, head on, is a vessel inbound. The situation requires the navigational officer to detect all relevant vessels, evaluate the area and depart without causing collision or a dangerous situation. This situation targets *situational awareness.*

#### *4.2.2. Small sailing yacht crossing*

A small sailing yacht is crossing the narrow channel in front of own ship. The yacht is coming from port side (Figure 3). This creates a situation where own ship is obligated to give way due to rule 18 (responsibilities between vessels); however, rule 9 (narrow channels) states that the yacht should not maneuver in a way that impedes own ships route. In this situation it happens anyway and then both rule 17 (action by stand-on vessel)

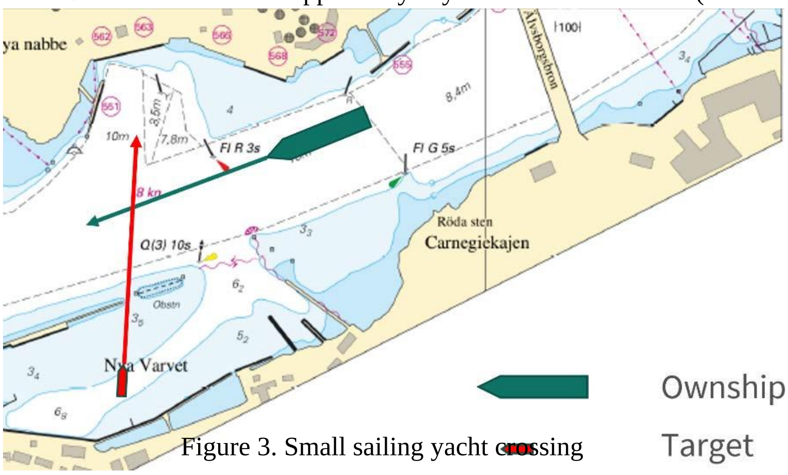


Figure 3. Small sailing yacht crossing

and rule 2 (responsibility) may come into play. What to do and when to do it becomes a question of good seamanship. There is the added problem that, if the crossing vessel is not correctly categorized as a sailing vessel the situation might be interpreted as a rule 15 crossing situation. However, the same use of rules 17 (action by stand-on vessel) and 2 (responsibility) applies if the small vessel does not give way. This situation targets *contextual compliance.*

#### *4.2.3. Unexpected turn from ship head on*

A large vessel is met head-on but slightly to port, which makes it a rule 14 head-on situation. However, the vessel will make a sudden port turn to go in front of own vessel with a very low closest point of approach (CPA). This turn could be explained by rudder malfunction or other technical problems and will force own vessel to react. The situation is designed to make own ship turn port thus trying to see a rule 17(c) (action by stand-on vessel) situation where it is not possible to turn starboard due to the narrow channel. This situation targets *contextual compliance.*

#### *4.2.4. Head on meeting with vessel in narrow channel.*

A large vessel is met head-on in a narrow channel during a turn. It is a rule 9 (narrow channels) and 14 head on situation, and the question here is how well the meeting is timed since there are different widths of the channel and differences in sharpness of the turns. There is no direct rule that governs this, and it is a question of ship sizes, and good seamanship. This situation targets *proactive decision-making.*

#### *4.2.5. Entering moving traffic*

Much like the first problem at the start, own ship must merge into traffic. This is a matter of adjusting the speed according to rule 6 (safe speed) and deciding on a comfortable distance to the other vessels. Mostly a question of good seamanship, and not any specific rule. However, all rules must be complied with in the specific setting. This situation targets *situational awareness.*

#### *4.2.6. Overtaking vessel in dense traffic*

Overtaking a vessel is covered in rule 13 (overtaking), but in the confined waters of this scenario it can be difficult to adhere to this alone, when ships are changing heading due to their waypoints and the course of the fairway. This situation targets *proactive decision-making.*

#### *4.2.7. More than three ships in close encounter*

In this situation, four other ships with the same CPA and time to closest point of approach (TCPA). The situation can be very effectively avoided by being proactive, but if it can be arranged to happen, it should provide interesting data. This situation targets *contextual compliance.*

### *4.3 Script and Assessment*

The planned situations are all listed in the instructor's guide to the scenario. This includes the expected timestamp for each situation, a brief description of the situation, the problematic aspects involved, the expected reaction from the participant, and a reminder for the instructor of what to consider next. The guide also includes information on how participants should be briefed before the simulation begins.

The assessment of the performance in each situation is important in this scenario because it will provide valuable information to the AI about which set of actions are considered the most appropriate. The scoring system used to evaluate the performance of the human navigator is the standard nine system (STANINE), which is also what is normally used at SIMAC when assessing students in the simulator. STANINE is a nine-point scale from 1-9 which follow the normal distribution with 5 as the median score (Anastasi and Urbina 1997). This scale is chosen because the instructors are familiar with it and the AI will be able to interpret it.

## **5. Testing**

The testing phase is conducted to make sure the scenario work in the specific simulator system it is implemented in and if all situations happen as intended.

The pilot tests were done by letting two experienced simulator instructors complete the scenario. Two trials were conducted, leading to several adjustments. For the sake of brevity, only a few of these changes shall be mentioned here. The current was changed since it was difficult to steer own ship at low speeds. AIS signals were added and modified to reflect ship names and types. Other ships in the simulation had their speeds adjusted to better align with the timing of own ship's location at the time of the planned situations.

## 6. Discussion and Conclusion

This study provides a model for creating a simulated environment for harnessing human expertise in navigating. The model systematically ensures that the scenario challenges navigators to demonstrate good seamanship. The scenario replicates complex navigational situations targeted at specific components of good seamanship, thereby providing rich data sets for training the AI-Navigator ADNAV AI system.

However, several challenges emerged in designing a simulation that both accurately reflects real maritime environments and is suitable to train AI systems. One such challenge was the unpredictability of human responses, which may cause difficulties ensuring that planned situations will happen. Furthermore, the complexity of maritime environments and the dynamic nature of maritime traffic necessitate ongoing adjustments to the scenario while running to ensure the scenario unfolds as scripted. These challenges highlight the need for a skilled instructor to run the scenario and assess the performance of participants dealing with the situations.

The data collected through this simulation will be a small piece of the data that the AI-Navigator ADNAV AI will be trained on. Additionally, the AI will train on a large dataset of complex situations identified by an algorithm from historic AIS data from Scandinavian waters. When the large general dataset is enhanced with the smaller specific dataset from simulators, it is expected to help the ADNAV in becoming a valuable tool for navigation officers when assessing complex situations, and provide real-time COLREGs compliant options applicable in a real-world setting, that are consistent with good seamanship.

## Acknowledgements

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# Spatial database creation applicable for global path planning in integrated navigational system

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Global and local path (GPP, LPP) planning is very actively researched for different vessels and manning levels. To employ planning algorithms or workflows, an environment model must be created, which is not commonly based on Electronic Navigational Chart (ENC), although it is the official and standardized representation of maritime environment. ENCs are used in Electronic Chart Display and Information System (ECDIS), a component of an Integrated Navigation System (INS), the software platform fusing ECDIS, radar, sensor data and functions including route planning for which GPP can be considered as a part thereof. ENCs were created primarily for human interpretation, however with intended usage not solely for navigation. Closed and proprietary navigational and research software, ENC format limitations, scarce availability of free ENC file formats and complex usage outside of regulated frameworks contribute to limited number of ENC based GPP research approaches, usually based on single or few ENC objects. Therefore, the purpose of this study was to create an open-source methodology based on spatially extended object-relational database, programming languages and libraries with geographic information system to manage ENC objects used for static environment modelling and GPP applicable in INS or broader context. We created the navigable area and environment model using ENC objects and hexagonal hierarchical grids from Uber's H3 Hexagonal Hierarchical Geospatial Indexing System library. For evaluation, we used ENC objects from different usage bands and scales for area between the ports of Savannah and Charleston in the USA with results confirming the open-source methodology applicability, along with possibilities for further research and development.

*Keywords: spatial database; global path planning; electronic navigational chart; open source; voyage planning,*

## 1. Introduction and background

In maritime navigation, path determination is part of route planning and broader, voyage planning carried out by certified on-board navigators using mainly the Electronic Chart Display and Information System (ECDIS). ECDIS and radar are the major components of the Integrated Navigation Systems (INS)—a data fusion, display, and alerting software platform combining sensors with various navigation functions, including route planning (Svilicic et al. 2019). Recent general and maritime specific technological advances have created considerable interest in the creation of human-oriented decision support systems (DSS) or autonomous solutions for path, route, and voyage planning (Öztürk et al. 2022). Global Path Planning (GPP), considered in the research, is used in a complete and known static environment. On the other hand, Local Path Planning (LPP) deals with the avoidance of static or dynamic obstacles while the vessel or any other moving object is underway (Šakan et al. 2022). Path planning approaches include classic—used often for GPP, advanced—used often for 5LPP), and hybrid used both for GPP and LPP (Vagale et al. 2021).

Global path planning algorithms usually require a static environment representation, often discrete in form of regular and irregular meshes, polygons, or graphs (Mąka and Magaj 2012) created from images or navigational charts. Being mandatory for maritime navigation, the Electronic Navigational Chart (ENC) should be the prime source for environmental representation. However, ENC-based path planning research is limited compared to general path and trajectory planning approaches in the maritime domain. Furthermore, it rarely deals with multiple ENCs and objects (Liang et al. 2021). Several factors might hinder wider adaptation for path planning. Firstly, there are encoding limitations of IHO S-57 standard, primarily developed, and almost exclusively used in ECDIS, although intended for other purposes. Secondly, available tools, notably free and open source, applicable to a variety of users interested in using ENCs outside the regulated ECDIS or simulator context are lacking. As an improvement, the S-100 family of standards resolves the limitations of S-57 (IHO 2023) due to full alignment with International Organization for Standardization (ISO) 19100 geographical information standards. This opens new and varied maritime context application possibilities, including marine Geographic Information Systems (GIS) or high-density hydrography (Contarinis et al. 2020). Thirdly, usage of many ENC layers and objects is complex, both in terms of programming and computational complexity. Finally, only a few national bodies provide ENCs or ENC based transformed formats for free, notably the USA National Oceanic and Atmospheric Administration (NOAA). When applied, the majority of ENC based environment modelling approaches employed regular grids, triangulated irregular networks, trapezoidal meshes, and potential fields with GPP paths determined using A* and Dijkstra algorithms (Šakan et al. 2022). With presented general ENC notions it is important to consider the challenges using ENC data, i.e., objects.

Data and objects can be handled directly, accessing datafiles, or ingested in a database, or formally Database Management System (DBMS). Data separation from direct application access ensures consistency, multiuser usage, and redundancy reduction, notably with large or growing data sets. In general, DMBS can be based on a relational, object-oriented, or object-relational model (Ogunlere and Idowu 2015). In the context of INS and ECDIS, converted System ENCs (SENC) are stored in relational and object-relational databases (Park et al. 2013). Further, to handle ENC spatial data, spatial database extensions are required. These extensions allow spatial operations according to standards, such as the Simple Features Access standard (SFA) from the Open Geospatial Consortium (OGC) currently updating to ISO 19125-1:2004—with last review and confirmation in 2023—becoming common SFA implementation and architecture standard (ISO 2004). Therefore, the database commonalities between the general and ECDIS data components in INS combined with standardized and extensive spatial functions open the possibility for creation of ENC spatial database and environment model for GPP. This was the main motivation behind our research and the development of the proposed methodology.

The remainder of the paper is structured as follows: Section 2 presents the methodology for data collection, preparation, and creation of the spatial database with an example of global path planning. Section 3 contains the results and discussion, while the conclusions and future research are provided in Section 4.

## 2. Methods

One challenge for adopting ENC-based global path planning is using ENCs outside of ECDIS. Several applications, like Esri's ArcGIS maritime extension (Esri 2023) and Teledyne's CARIS Composer (Teledyne 2023), support S-57 data. These tools focus on creating and managing ENCs. For open-source projects, the Geospatial Data Abstraction Library (GDAL) IHO S-57 driver is popular format converter (Warmerdam et al. 2023). However, it only partially translates some features. Additionally, the IHO S-52 symbol library is unavailable, and symbols are added manually or via scripts. As an alternative, NOAA provides ENC direct service (Office of Coast Survey, 2024) converting S-57 data for use in various formats, suitable for GIS or Computer Aided Design (CAD) applications. We chose the vector shapefile format for its widespread use and support in many GIS applications. This format efficiently stores geospatial data. It keeps points, lines, and polygons along with their details in separate files (Obe and Hsu 2021). The next step was selecting a group of ENCs with diverse objects to ensure our approach's validity.

The selected ENCs cover the navigational area between the ports of Savannah and Charleston on the east coast of the USA. The ENC data is of different usage bands and has numerous ENC object classes, including navigational obstacles, buoys, wrecks, and port approach channels. Thus, the area is geographically diverse, with many object classes and layers available for environment modelling. Furthermore, it has been studied for route similarity of ships of a large container ship company fleet (Šakan et al. 2023a) and can be used for future analysis of route and GPP. The scales of selected ENCs start at 1:1200000 for the US2EC02M, covering the area from Cape Hatteras to the Straits of Florida down to 1:20000 for the US5SC25M for the Charleston Harbor, which is presented with the extent of other selected ENCs in Figure 1.

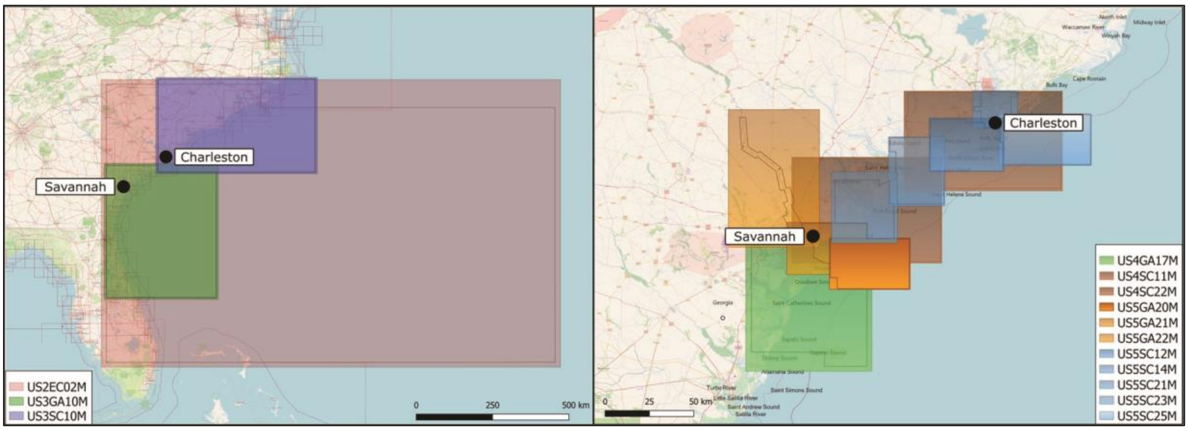


Figure 1. Selected ENCs and respective usage bands, general and coastal (left), approach and harbor (right).

For storage, we used the open-source PostgreSQL database, an Object Relational Database Management System (ORDMBS). This system handles complex queries, stores queries, and ensures transaction integrity using SQL and PL/Python (Obe and Hsu 2021). Various datatypes, function creation, operators, indexes, and geospatial PostGIS extension are available, which we used in the research (Silberschatz et al. 2020). PostGIS, an open-source geospatial extension, offers over 400 functions for managing different geospatial types. It adheres to the standards set by the Open Geospatial Consortium (OGC) and ISO. The OGC's Simple Feature Access (SFA) standard defines a model for geospatial data and geometries. This is implemented through geometric and geographic data types. Moreover, PostGIS complies with the SQL Multimedia Spatial (SQL/MM) standard (ISO/IEC 2016). This standard includes spatial functions found in other databases with spatial extensions (Obe and Hsu 2021). Examples include IBM DB2 Spatial Extender, SQL Server Spatial, and Oracle Spatial (Xie et al. 2022). Next, we aimed to build a consistent and efficient database using *entities* and *relations*. Entities are modeled objects, relations define their connections, and attributes describe them. This method is called Entity-Relationship Modelling (ERD). In our case, entities were S-57 objects with attributes defining their characteristics. The database structure and schema are presented in Figure 2, with the ingestion and database creation process explained as follows.

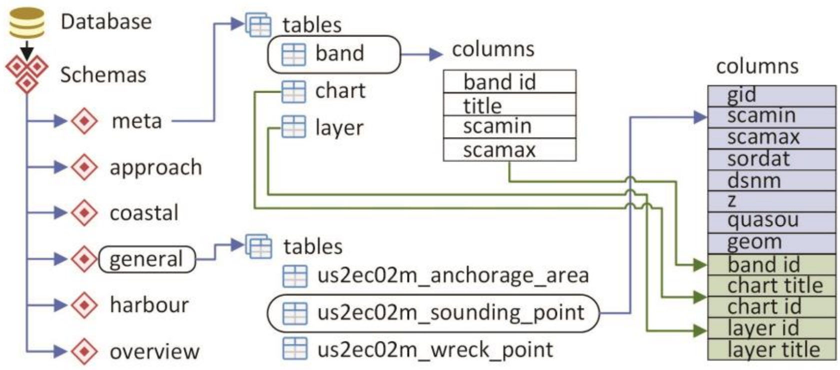


Figure 2. Basic database structure with separated ENC usage bands schemas and example structure of meta schema and general usage band schema with us2ec02m object sounding point table structure.

The entities, ENC shapefiles, were converted to *SQL* files with the *shp2pgsql* command line tool (The PostGIS Development Group 2023) and ingested to the database with the *psql* client (The PostgreSQL Global Development Group 2023). Since the individual objects from different ENCs had the same name, either for the S-57 (e.g., WRECKS) or shapefile format named equivalent (coastal_wreck_point), a prefix denoting the ENC number was added to differentiate them. Therefore, each object became a database table with prefix (e.g., us2ec02m_coastal_wreck_point or us4sc22m_ coastal_wreck_point) enabling multiple ENCs object entries in the schema. After ingestion, the database consisted of general usage band schema with 94 tables (or relations), coastal schema with 282, approach schema with 423, and harbor schema with 1421 tables. The next step was to create a single extent by combining objects from different usage bands and scales.

The ENC objects from individual usage band schemas were then transferred to a new schema. As a template, we used the structure of harbor usage band ENC US5GA20M. We then collected data about all database objects and names using a *materialized view*, a saved SQL query (Silberschatz et al. 2020). Also, we renamed US5GA20M integer indexes and exported all tables with data as **.csv* files. We reset table indexes and applied Generalized Search Tree index (GiST) on the geometric data attribute. Finally, we imported all ENC objects to the prepared schema and removed overlapped objects. The basic workflow can be observed in Figure 3.

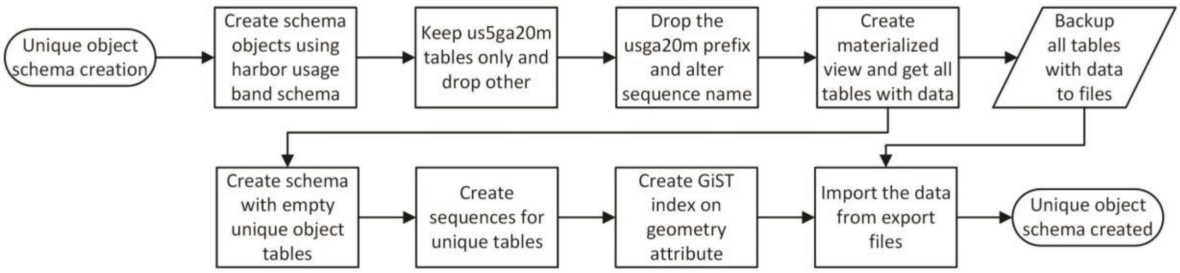


Figure 3. Unique object schema creation workflow.

We resolved overlapping using the M_NPUB (nautical_publication_information_area) ENC object which has the same spatial extent as the more basic M_COVR (coverage_area) object, which can be used as well. To separate and create unions of objects across all usage bands, PostGIS *ST_Union* and *ST_Difference* functions were used (The PostGIS Development Group 2023). The results can be observed in Figure 4.

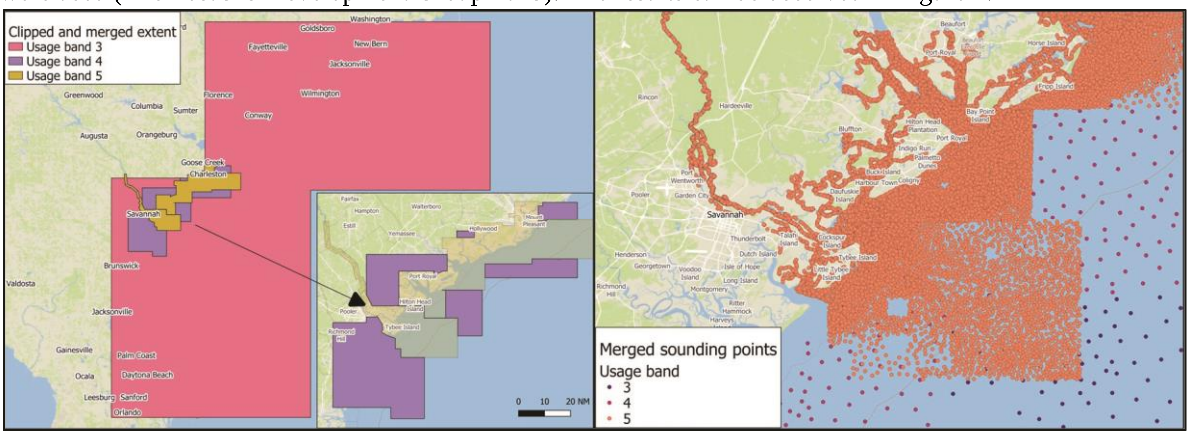


Figure 4. Usage bands union (left) and difference for approach and harbor usage band (right) portrayed in QGIS as representation of data display in INS.

As scale increases, the number of objects, lines, or points used in modeling transform to edges and vertices used in algorithm search. Therefore, it should be noted that methodology is adaptable and required objects can be called when querying, using, and displaying dedicated range, area, or usage band. An example can be observed with different coloring of sounding points in the right frame of Figure 4. Furthermore, future research must consider cartographic generalization and ENC object discontinuity. These include isobaths, coastlines and other objects bordering at different scales.

For environment modelling, we selected the area between the berth in port of Savannah (31° 56' 41.8" N, 80° 41' 20.0" W) and pilot station (32° 08' 14.3" N, 81° 08' 35.2" W). We created a bounding box from berth and pilot station coordinates and used it to search for or to create the extent of objects in the selected area. For this, we used PostGIS functions, *ST_Envelope* to create the bounding box, and *ST_Collect* to unite geometries (in this case points). To limit the navigable area, we set depth value of 12.8 m, reflecting an example of a ship's static draft for a container vessel of length over all (LOA) of 300 m and breadth (B) of 48 m departing Savannah berth. Finally, to retrieve objects of interest in dedicated bounded extent, we used *St_Intersects* function. The function checks and returns objects if they are inside the bounded geometry (The PostGIS Development Group 2023). The results can be observed in Figure 5.

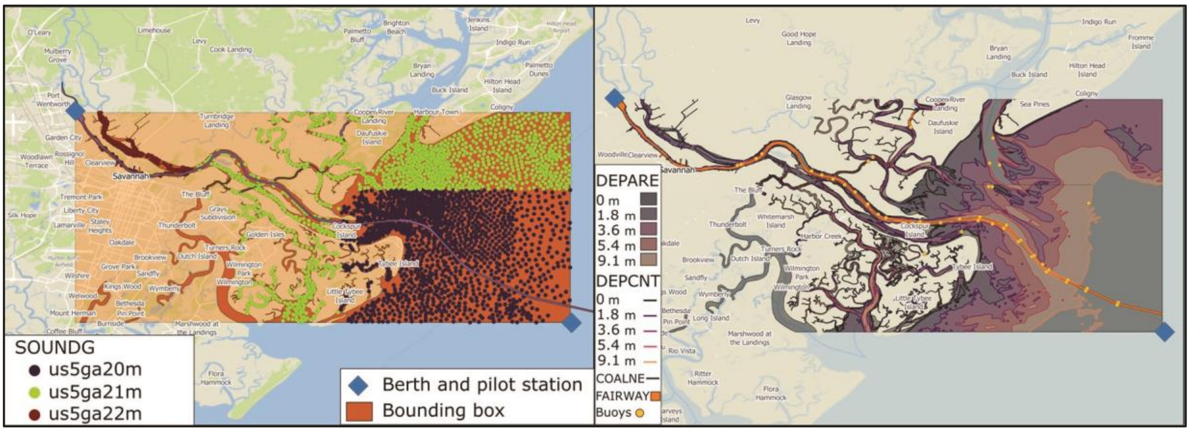


Figure 5. Bounding box and selected depth objects belonging to ENCs in the Savannah area between the Savannah pilot station and berth portrayed in QGIS as representation of data display in INS.

We repeated the process for other important objects for delineation between navigable and non-navigable area: coastline (COALNE), shoreline construction (SLCONS), sea area (SEAARE), wrecks (WRECKS) and depths (VALSOU)—less than static draught—buoys (BOYLAT, BOYSAW, BOYSPP), depth value area (DEPARE), bridge (BRIDGE) and fairway approach (FAIRWAY). Finally, for environmental modelling we used *h3* toolkit in free and open source QGIS (QGIS Development Team 2024) via Python bindings (h3-py Development Team 2024), based on Uber H3 Hexagonal Hierarchical Geospatial Indexing System (Bousquin 2021). Uber developed the H3 library to improve vehicle fare determination but also to analyze extremely large datasets at different geospatial resolutions. It is adapted for processing and merging of large datasets with machine learning models using multi-resolution hexagonal grids. Hexagonal grids have an advantage compared to triangular or square grids because hexagons have equal distances to their neighbors. Another advantage of the H3 system is hierarchical uniformity between 16 different resolutions. From available resolutions, we selected resolutions 10, 11 and 12—with their respective average edge lengths of 65.9, 24.9 and 9.4 m—(H3 Development Team 2024). They were most appropriate in terms of computational time and spatial resolution for the path planning testing. We created the hexagonal grid representing the navigable area as follows. We created H3 grid resolution 10 within the extent of Savannah berth and pilot station coordinates forming a bounding box. We then clipped H3 grid with merged sea area object (SEAARE) which defines the sea or other navigable waters, buffered land area (LNDARE), buffered coastline (COALNE) object (25 m), object lateral (BOYLAT) and special purpose buoys (BOYSPP) in the bounded area (10 m). Further, we added buffers (25 m) for the sounding points (SOUNDG) and wreck (WRECKS) area points and wreck area (25 m). Finally, we created the final grid as a difference between the resulting H3 grid and depth area object (DEPARE). The final grid can be observed in the left frame in Figure 6.

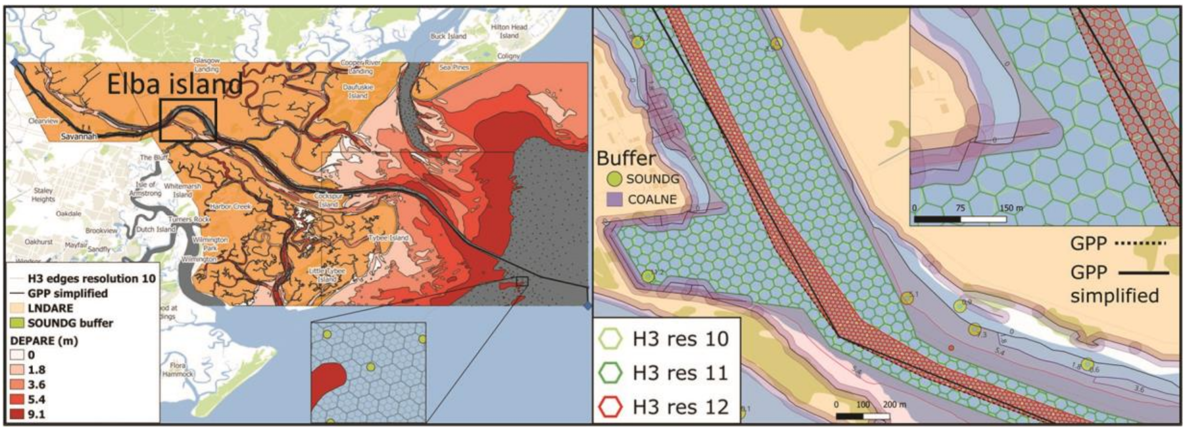


Figure 6. Hexagonal grid creation using various ENC objects (left) and final hexagonal grid with different H3 resolutions (right) portrayed in QGIS as representation of data display and path planning in INS.

Further, to improve GPP results, we increased the grid resolution to 11 in the navigable area, and to 12 in the fairway area object (FAIRWY). For safety, we applied a buffer larger than one ship breadth (equal to 55 m) from the fairway edge towards the fairway center. Therefore, the determined path was moved away from the possible dangers in the vicinity of the shallow depths and the coastal areas. The result can be observed in Figure 6. right frame, along with sounding and coast buffers and depths. For the path planning, we used Dijkstra's algorithm implementation from the default network analysis tool provided in QGIS. The path was simplified using Douglas Peucker algorithm with an initial tolerance of 0.001° or approximately 111 m, resulting in a calculated path length of 29.3 nautical miles (NM).

**3. Results and discussion**

To validate the final GPP path, we compared it with the paths of eight container ships and their twelve routes for voyages conducted in the first six months of 2019, which we investigated for route similarity in (Šakan et al. 2023a). Two vessels had LOA = 300 m and B = 48.2 m, with a reported maximum draught of 14.8 m, similar to our selected vessel sizes. The other vessels varied in length, ranging from 330 m to 360 m, with a B of up to 45.6 m and a draught of 15.5 m. The route and path data used are available in the Zenodo repository (Šakan et al. 2023b) with complete code and methodology. Upon observing the vessel paths, we found that the majority were within the fairway, with only a few instances going outside the fairway bounds (not depicted in the figures), a situation similar to the GPP path without simplification. However, in the absence of simplification, the number of GPP path vertices was very high. Applying the initial DP simplification value (0.001°) in certain areas resulted in the path straying outside the fairway, thereby approaching areas with potential dangers. Figure 7. provides an example, depicting the Savannah fairway bend near Elba Island. The left frame of the figure shows vessel paths that are color-coded according to their Maritime Mobile Service Identity (MMSI), revealing a grouping of paths towards the fairway center. In the figure's right frame, three GPP paths with various DP simplification values are visible. The coarsest path (0.001°, full line) passes approximately 40 m (on a 1:1500 chart scale) outside the fairway boundary. However, with finer simplification tolerance values (0.0009°, dash dot dotted line, and 0.0008°, dashed line), the paths are within the full fairway and buffered fairway bounds.

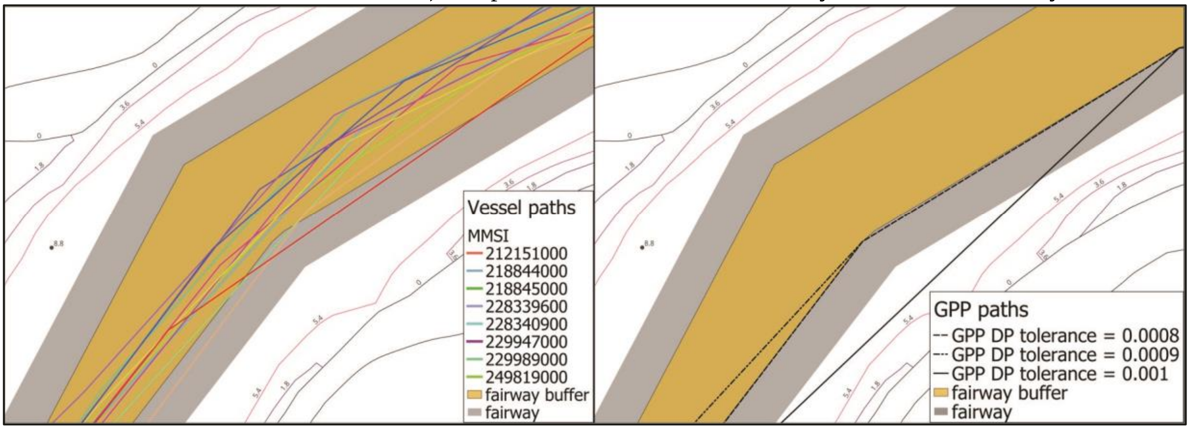


Figure 7. Comparison of vessel paths (left) in Savannah fairway near Elba Island and GPP paths (right) using different DP tolerance simplification values (in degrees)

Despite the influence of path simplification on the result, we refrained from further experimenting with simplification and smoothing algorithms. Our primary objective was to propose a baseline methodology for developing an ENC object-based spatial database for GPP that could be used in INS rather than implementing GPP in planning. In future research, we must address vessel and voyage details, including draft, squat, and vessel maneuvering capabilities, for a thorough evaluation of paths and trajectories. We must consider voyage planning in accordance with international regulations and recommendations, as well as common on-board company procedures, and align the proposed methodology with that of contemporary and future human navigators using ECDIS and INS systems, as well as the latter stages of future research in automated planning.

The presented spatial database creation methodology, in conjunction with the GPP application, provides opportunities for future development and potential implementation within the INS. Relational databases, such as Postgres in this case, are already used in some ECDIS systems in the INS, while the GPP result of the path planning can be checked using ECDIS route functions. Moreover, as previously stated, we can view INS as a software platform that incorporates route planning, where path determination is an integral part of the process. We can then view PostGIS spatial functions and algorithmic GPP approaches as an extension of the navigation planning possibilities offered by INS. Similar to S-100, the presented methodology's application of open-source, free, and standardized data, programming languages, and platforms aligns its spatial components with numerous international geospatial standards in the wider ISO geospatial suite. This creates new and expanded implementation opportunities that align with the objectives of S-100, supporting a range of usage data layers and formats. So, it's possible or even likely that path/route planning modules in INS systems and the use of geospatial tools will allow for even more alignment with a navigationally controlled environment for a number of INS systems. Compared to previous ENC-based approaches, the presented methodology and spatial database are based on a variety of ENC objects, including depth contours, sounding points, wrecks, buoys, coastlines, land, and sea areas, and can be further extended with other available ENC objects. The environmental representation is based on a hexagonal grid with equal neighbor distances. The H3 library has multiple standard size resolutions, facilitating coarseness implementation in modeling, depending on the scale used or route area covered. This is particularly important when considering implementation in terms of computational cost during environment modeling and GPP solution search. Lastly, the open and free-source nature of the methodology allows for its sharing and availability to other interested researchers and developers.

However, there are several challenges that arise from the research. The availability of ENC and ENC derived formats is limited to USA NOAA ENCs, therefore reducing the possible worldwide scope of application. Then comes the challenge of data ingestion and preparation. It is challenging to prepare seamless ENC object coverage of the research area across ENC usage bands, even with automated scripts. As a solution ENC producers could standardize or make them available instead. However, this necessitates the changes of chart creation and producing standards since they are based on human interpretation. To facilitate this task, we added additional usage band and chart attributes. Furthermore, for the presented baseline methodology, we used a limited number of ENC objects and charts. The approach will be much more challenging when planning transoceanic voyages using numerous ENC charts and objects, where computational cost and solution search speed become increasingly important. Additionally, the procedures and processes involved in maritime voyage planning and their impact on the creation of spatial databases and global path planning have not been addressed. Therefore, more research needs to be done and testing on bigger datasets, using numerous ENC objects, with detailed environment modelling and GPP processesing that could be used in real INS systems or their modules.

## 4. Conclusions

In the conducted research, we utilized an open-sourced PostgreSQL ORDMBS with a spatial PostGIS extension to store and manipulate ENC objects. This approach bridged the gap between the closed-sourced INS and the corresponding navigational modules, using a database to store and retrieve ENC objects. To create a near-smooth representation of the test area for GPP, we utilized ENC objects from various usage bands and scales. We added additional attributes to objects and their respective tables to make retrieval more flexible depending on chart, usage band, or object type. We also added the GiST index to improve the database search. Compared to other approaches, we used numerous ENC objects to create the environment model. We combined land, sea, and depth areas, buoys, contours, and other objects with hexagonal grids of multiple resolutions to determine the navigable area. We added buffer values for navigationally important objects, directing the planned path away from dangers. We applied Dijkstra's algorithm for GPP to evaluate the methodology in the area between the Savannah berth and the pilot station, and then simplified the resulting path using the DouglasPeucker algorithm. We also validated the GPP path against actual container vessel paths, confirming the applicability of the approach. In our future research, we plan to incorporate numerous ENC charts and objects, and make improvements in terms of computational cost and development within the spatial database. We will consider other platforms and possibilities for modeling and testing in INS systems, particularly the upcoming S-100 family of standards. The proposed methodology could serve as the foundation for future voyage planning modules, both in human-oriented support and automated approaches. However, to fully realize its potential, we must further evaluate it in accordance with international maritime voyage requirements and practices.

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# Design and functionalities of Decision Support System regarding the risk of Epidemic threats on a sea-going Vessel

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**Abstract:** In the global crisis of the COVID-19 pandemic, the maritime sector once again drew attention to the issue of epidemic threats on seagoing ships. As an isolated unit, the ship may be a potential source of an epidemic. In addition to COVID-19, there are several other threats, such as Legionnaires' disease, cholera, tuberculosis, infections related to the digestive system, dengue and many others. It should be noted that there is no specialized infectious disease ward or appropriate team of doctors on a seagoing ship (Wiliams et al 2018). There is a need to implement other tools - many of them are described, for example, by IMO and other organizations at global and local levels (Brown & Johnson 2019).. The consortium led by the Maritime University of Szczecin (Poland) set itself the goal of developing and implementing a decision support system in the event of an epidemic on a seagoing ship. The tool being developed is intended to assist captains, medical officers, etc., to assess the situation and take appropriate actions quickly. The system, tentatively named DESSEV (the acronym of the project implemented under the Erasmus+ program), operates based on a knowledge base prepared by medicine and maritime personnel specialists. It is a completely autonomous system, operating online and offline. Much attention was paid to its availability and describing functional and non-functional requirements so that its use was intuitive and did not require specialized training or documentation. The main functional requirements are: entering identified symptoms into the application, processing the received information based on the knowledge base, disease classification based on the probability of belonging to a given class. The Knowledge Base as the primary dataset was obtained from different available sources, including medical and nautical data repositories. Three algorithms were applied to solve the problem: random forest, decision tree and naïve Bayes. The best performance was in the case of random forest algorithm, what is presented in the paper. After developing the knowledge base and validating the algorithms of prediction, a web application was designed and is available online at www.dessevproject.eu/app, intended to serve as a user interface for the DESSEV decision support system. As a further step, a mobile application will be coded on the basis of the development of the web application, serving completely offline.

This article describes the DESSEV decision support system, defines the requirements, and summarizes conclusions based on a series of simulations using the system. DESSEV enhances the control on vessels by accurately recognizing diseases and providing mitigating actions throughout the risk management process. It offers independent and reliable support in maritime pandemic control. Nevertheless, it should be noted at the outset that further activities in this area, including interdisciplinary ones, are worth conducting. The DESSEV system is also intended to become the basis for further solutions of this type, especially given the emergence of further serious health crisis.

*Keywords:* outbreak, epidemic, seagoing vessel, COVID-19, decision support system

## 1. Introduction

Merchant ships have been and continue to be a fundamental uniting element on our planet. In addition to transporting people, today, more than 90% of our planet's raw and processed materials are transported by trucks.

Furthermore, maritime transport, key to globalisation, not only moves goods and people but also transports diseases that spread and, in many cases, can result in epidemics. Infectious diseases are transmitted by different routes and forms, and their incubation time varies. If detected on board, they cause a restriction on the entry and disembarkation of crew members or passengers, leaving them in quarantine until the risk of infection has passed. This can cause the disease to act with all its might, leading to a large number of deaths. Merchant ships have never had a medical service on board that could detect any contagious disease that affected a crew member. If a crew member was infected with such a disease, probably, by the time they realised it, the entire crew would be infected.

The COVID-19 pandemic that we have suffered in recent years not only affected maritime transport but all countries in the world. Without experts in contagious diseases, society could not provide a quick response and effective way to stop the pandemic. Only two measures were used: isolation of the entire population and, later, vaccination.

Covid-19 has shown that countries are unprepared to respond quickly to a pandemic. The ship's crew members are even less prepared if the countries with the best resources are not ready. It is important to remember that these are small vessels with limited crews and without adequate medical knowledge that travel to and from all world countries, making them potential disease carriers.

These reasons, as well as the aim of being able to identify in the shortest possible time the type of disease from which a crew member has fallen ill on board a ship and to prevent it from spreading, encouraged members of the Maritime University of Szczecin (MUS), the Polytechnic University of Cataluña (UPC), Satakunnan ammattikorkeakoulu (SAMK), The Maria Skłodowska-Curie Medical School (MU MSC), Spinaker, Idec and the Centre for Factories of the Future (C4ff) to carry out a 2-year project DESSEV – Decision Support System regarding the risk of Epidemic threats on a sea-going Vessel, Erasmus+ program co-funding.

The key objective of the project is to develop a Decision-Support System that enhances maritime safety by providing comprehensive risk assessments and mitigation strategies for the spread of infectious diseases on seagoing vessels. By leveraging a robust data repository and extensive knowledge base, this system aims to facilitate informed decision-making for maritime professionals, thereby reducing the risk of epidemic outbreaks aboard ships and ensuring the health and safety of crew members and passengers. The project identifies objectives:

- repository of data on epidemic situations;
- the knowledge base in the form of IF... THEN... rules;
- decision support system on the risk of epidemic threats on a maritime vessel,

which will be detailed in the following sections of the article.

## 2. The Repository of Infectious Diseases

A pivotal milestone was the development of the online repository, marked by creating a user-friendly interface. This phase was not just about aggregating information but also about enhancing its accessibility and usability for a wide range of users (Bodus-Olkowska et al, 2024). The repository was designed to be intuitive, ensuring that users could easily navigate the information available.

Until now, the repository contains 102 items of literature and includes:

- IMO (International Maritime Organization) and WHO (World Health Organization) and recommendations (IMO 2022; WHO 2006, WHO 2021);
- Centers for Disease Control and Prevention guidelines (CDC 2023, CDC 2024);
- specific case reports, and
- several scientific medical articles, primarily related to the most recent COVID-19 outbreak (Stamatakis et al. 2010; Wilson et al. 2021; Schlaich et al. 2009).

All types of papers collected in the repository are available online on the project website: www.dessevproject.eu. The gathered literature is divided into two categories: manuals for vessel crews and medical directives. The manuals for crew members gathered IMO and WHO recommendations or other institutions related to maritime transport; for example: "*Joint statement in support of keeping ships moving, ports open and cross-border trade flowing during the covid-19 pandemic*" published by IMO or "*Guide to the ship sanitation, 3rd edition*" published by WHO. It also contains several recommendations and duties governed by specific coasts or ports. The second category, the medical section, is related mainly to travel medicine.

Many articles in the repository refer to the Covid-19 pandemic as the latest case of globally prevailing disease. The outbreak of this coronavirus pandemic forced humanity to pay special attention to the principles of pre-infection prevention, education to avoid the spread of the disease and steps towards recovery. The individual documents have also been ranked very important, important and less important. The very important class includes all IMO manuals, WHO recommendations, and medically relevant scientific articles describing the most serious diseases. The important class includes port regulations and advice from port authorities when a communicable disease is detected on board. The remaining category includes popular science articles describing individual disease cases on board.

The repository, which includes abstracts and titles of individual publications, and the entire project website, which includes all results, will be translated into the languages of the project partners: Polish, Slovenian, Swedish, Finnish, Greek, and Spanish.

## 3. Knowledge Base and Prediction Algorithm Used in DESSEV Support System

The project's second aim was to develop a knowledge base and inference algorithms. The knowledge base is a NoSQL database containing a list of infectious diseases with the symptoms describing them, grouped into categories. Numerically, the knowledge base presents itself:

- 19 diseases;
- 8 symptom groups;
- 36 signs of a disease.

The prediction algorithm uses three AI models: random forest, decision tree and naive Bayes. These models are used to predict a disease directly based on the symptoms given.

### *3.1. Knowledge Base*

During the project's initial phase, our team's goal was to identify and prioritise for analysis the most prevalent infectious diseases that could potentially pose threats to maritime operations. To establish a robust diagnostic foundation, our team conducted an exhaustive review of scientific literature, statistics, and guidelines from leading health organisations such as the World Health Organization, Centers for Disease Control and Prevention, and European Centre for Disease Prevention and Control.

The selection was based on the diseases' substantial influence on worldwide health, their widespread occurrence, and patterns identified in recent data. This way, we identified 19 diseases for further analysis.

During the first step, diagnostic criteria for each infectious disease were identified based on peer-reviewed articles, editorials, books, and university press releases. The most prevalent symptoms for each disease were then selected and systematically categorised into a table by the frequency of occurrence (in %).

In-depth research was then repeated using Google Scholar, PubMed, Embase, Medline, ScienceDirect articles, and local government publications to complete the database. During this phase, acquiring accurate percentages for the occurrence of symptoms associated with different diseases proved challenging, indicating a potential gap in the detailed reporting of symptom frequencies within the existing literature.

Additionally, the research team engaged in targeted interviews with medical experts. These interviews aimed to elucidate the crucial elements in diagnosing infectious diseases and their interconnectedness with clinical decision-making parameters. The outcome was a comprehensive knowledge base intended for integration into a decision support system for maritime operations.

### *3.2. Prediction algorithm*

The prediction algorithm aims to give the possible infectious disease/s a patient may have based on her/his symptoms. The prediction algorithm has to be trained, and we trained it with the knowledge base of symptoms and infectious diseases.

The knowledge base of symptoms and infectious diseases was expressed in percentages, i.e. how many patients out of 100 would express a specific symptom when infected by a specific infectious disease. Based on these data, we randomly generated hundreds of artificial patients with specific symptoms so that we reached the exact percentages from the knowledge base for the whole group of artificial patients. We used this approach of randomly generating artificial patients to take into account that every human being is unique, so the symptoms appearing after infection are slightly different for each person.

We used these randomly generated data to train our prediction algorithm. In our prediction algorithm we were testing three AI models to be able to compare them and select the most accurate one: random forest, decision tree, and naive Bayes. These models are all used to predict a disease directly based on given symptoms.

The naive bayes model (Hand, 2001) is a classifier which assumes that the symptoms are conditionally independent, given the target disease. This assumption's strength (naivety) gives the classifier its name.

The decision tree model (Rokach, 2013) is a tree-like model of symptoms and possible diseases, including chance event outcomes, resource costs, and utility. Each branch represents the test's outcome (whether a symptom is present or not), and each leaf node represents a disease.

The random forest model (Breiman, 2001) is based on the decision tree model. Still, in the random forest model, a forest (a big number) of decision trees is generated considering only some symptoms for each decision tree. The output of the random forest is the disease selected by most decision trees.

The authors used Orange data mining software to build all three models. As it is a free, widely used software from which the generated models can be exported and then used outside the software just by using an Orange python library (Demsar J. et al. 2013). This allows to easily integrate the prediction algorithm into the website or phone app and make it publicly available

When tested on training data, the classification accuracy of all three models reaches nearly 100%, but the most important is the classification accuracy on test data. We collected a small number of real patients (1 per disease) and used their symptoms/disease combinations as the test data. It should be stressed that the test data was not used during the training process (while building these models). The classification accuracy of all three models, when tested on test data, was as follows:

- random forest: 100%
- decision tree: 57%
- naive Bayes: 86%

In the prediction algorithm, the random forest model outperforms other models in most similar medical applications (Sumwiza et al., 2023). These results confirm that the random forest model is the best model for disease prediction in medicine. Naturally, a limited amount of measurement data must be taken into account. A classification result of 100% is unrealistic in practical applications, but it indicates the correctness of the algorithm selection.

**4. Functional Concept of the DESSEV Decision Support System**

This part of the DESSEV project goal aims to delve into the importance of system design and the essential requirements of a system, emphasising the importance of user-friendliness, accuracy, simplicity, completeness, a concrete overview, and a quick conclusion for effective guidance.

A Decision Support System (DSS) is a computer-based information system that supports decision-making activities within an organisation or enterprise. It provides users with tools, data, and models to analyse complex problems and make informed decisions. Understanding and defining the requirements is crucial for the success of any system development process.

Several conditions exist for developing a user-friendly DSS, and the system design is decisive for how the DSS will be used. It involves conceptualising, planning, and detailing how components interact to efficiently achieve specific objectives.

The user interface serves as the primary point of interaction between users and the DSS. UI is crucial in apps and online platforms as a bridge between users and the system or application. It provides intuitive tools and visualisation techniques to ease use and facilitate analysis and decision-making. For this to be possible, the platform in question must be easy to use, navigate, and understand. The end user of this project's DSS will rarely be medically trained staff, which underlines the importance of easy understanding. Every cluster of symptoms that cannot be found in everyday language gets a more detailed explanation, this to avoid the user getting confused if the terminology is too medical especially when in a stressful situation.

A user interface that is easy to use and understand increases the chances of actual usage. This means that users can quickly learn to navigate the application or platform without having to go through extensive learning processes. This reduces user frustration and increases the likelihood that they will continue to use the product or service (Lunds University, 2012).

By using colour schemes, typography, and visual elements that are in line with the tone of the shipping industry, recognition and reassurance are provided. Continuous studies are done around interface and userfriendliness, and important information about fonts and colours has guided the development of this DSS.

A responsive user interface is essential to ensure the application or platform works smoothly on different devices and screen sizes, including smartphones, tablets and computers. Within the shipping industry, mobile devices will generally make up the largest use; therefore, the app must be adapted to mobile devices. In summary, the project's main goals for system design have been the following:

- *User-friendly* logical system: the user must quickly and easily understand how DSS works, even when using it for the first time.
- *Simplicity*: It is easy to navigate and understand within DSS.
- *Accuracy*: This is an important aspect since the situations in which DSS is used can be urgent or vulnerable.
- *Concrete overview*: all potential aspects must be covered.

This is the most challenging point as it is incredibly difficult to guard against all eventualities, DSS also does not claim to be able to cover all potential eventualities. Finally, DSS should provide quick conclusions and effective guidance for further steps.

## 5. On-line application

Considering all the above-mentioned aspects, developing an on-line application intended to serve as a user interface for the DESSEV decision support system was initiated. This web application operates on a clientserver communication model via the HTTP protocol. Here, the application sends a request along with specific parameters to the server, and the prediction system receives, analyses, and sends a response back to the user application. The primary aim was to smoothly guide the user through a simple web form, where they would provide personal data, travel-related information, and any symptoms observed or suspected to be indicative of infectious diseases. It is important to note that the DESSEV system is predictive and is not intended to assess the patient's health status or provide diagnoses fully. A disclaimer was included on the application page, clearly specifying the purpose of the system and the expected outcomes of its operation.

At the early stage of application development, it was decided that the application would primarily collect information from the user and, depending on the type of user (e.g., a seafarer, their superior, or another person acting on behalf of the symptomatic individual) and the purpose of its use, transmit the provided data and system results to a specified email address. Due to the sensitivity of the data (personal and health information), it was stipulated that the collected data should not be stored, shared, or processed by any third parties (including other databases or systems). Additionally, the decision was made to focus on the simplicity of application usability and minimise unnecessary content while still ensuring the provision of accessible options for users to access various information related to the DESSEV project, disease database, or detailed symptom descriptions from within the application interface. The final aspect considered during the preliminary design of the web application was the visual order and aesthetics, ensuring compliance with the previously agreed colour scheme and typographic design of the DESSEV project. An initial graphical design of the webpage was prepared using the Wix online software for website design and management.

After the initial analysis of the application project, significant changes were made. Considering that the application primarily serves for prediction based on observed symptoms and should not give the user a false impression of providing a complete medical diagnosis, the collection of personal information (demographics, travel history, or medical history) was abandoned. Moreover, users might feel discouraged or concerned by questions about sensitive data instead of quickly providing answers regarding predicting a potential infectious disease. Thus, the application's functionality was limited to collecting user input, which was strictly necessary for the prediction system.

The application form was divided into eight categories, each representing a group of symptoms, in the following order:

- General/systemic
- Respiratory
- Musculoskeletal
- Neurological
- Hematological
- Gastric
- Dermatological or associated
- Other

Users can select any number of observed symptoms from a given category (min. four) using checkboxes. For each symptom, there is an information field, which, upon clicking, provides expanded information about the respective symptom—a detailed description accessible in non-medical language. After going through all categories, the user submits the selected symptoms to the prediction system, which responds with the most probable disease for the given symptoms. Additionally, after obtaining information from the prediction system, the application allows the user to send information to a specified email address. If chosen, the user only provides basic personal data (name, age) and information about the person for whom the prediction was made, along with the prediction information and their comment, which can be sent to a doctor, supervisor, or ship captain. The data provided by the user in the application and the prediction information are not stored, retained, or utilised in any way. It disappears once the user finishes using the application.

The application is available in seven languages (English and the native languages of all parties involved in the DESSEV project). Additionally, at any time, the user can access the main page of the application, where its principles, information about its creators, the entire DESSEV project, contact information, and access to a repository containing useful resources such as articles, recommendations, and health procedures for maritime personnel during epidemic situations are available for reference.

## 6. Conclusions

This article presented the DESSEV online decision support system with a proven potential to add value in pandemic control onboard vessels engaged in international trade. The online tool has an onboard role in a chain of events that may impact the vessel. In an ideal situation, the mechanisms in the logistic chain surrounding the vessel prevent the pandemic from accessing the vessel altogether. We need to elaborate on the maritime logistic chain to understand better the possible routes for a pandemic to the vessel.

Crew transportation consists of multiple means of transportation in variable geographical regions. The opportunities for exposure to a pandemic are practically endless. Congested vehicles such as aeroplanes make it impossible to protect against airborne viruses, for example. When the travelling takes less than 24 hours, the symptoms rarely surface before joining the vessel.

Vessel supplies and maintenance activities during port calls cannot be avoided, and vessel crews are exposed to the local spread of viruses. However strict controls may be, the spread of viruses can only be partially avoided. Therefore, it is justified that high gravity in pandemic risk management should be placed on the onboard control actions.

The onboard environment is multicultural and highly congested. The crew members' language skills and social habits vary between nationalities and cultural backgrounds. The online tool is publicly available, and the use of it requires no medical expertise or clinical background. However, promising the initial results of using the online system are, it is merely a supporting mechanism for decision-making. DESSEV online decisionmaking support is not a substitute for a medical professional. With this in mind, regardless of the outcome of using online tools, shore-based medical professionals should be consulted, when possible, before making critical decisions. From a risk management perspective, the user needs to understand better the role of the online tool and the accumulation of decision-making support.

DESSEV online tool provides a holistic risk management tool for pandemic control on board ocean-going ships. In testing the tool, the system reached theoretically 100% accuracy in classifying a disease from a group of up to 21 options. However, this result should be viewed in light of the limited sample size and the controlled conditions of the test. In practical applications, symptom data is often incomplete and uncertain, making perfect classification unlikely. This accuracy is critical as the results are accumulating. If false supportive advice is given in the state of recognising the disease, the later support with the associated actions will likely not have the desired outcome. Therefore, as handling the patient proceeds further, the risk of a false supporting action becomes lower. The main strength of the DESSEV online decision support system lies in its ability to manage risks.

The initial step in risk management is generally known to be recognising hazards. A risk level associated with a hazard can be evaluated upon recognising a hazard. When the risk level is known, the mitigating actions help manage the risk and lower the risk to a tolerable level. The DESSEV online decision support system assists in recognising the hazard precisely and provides mitigating actions to manage the situation further.

DESSEV's online decision support system is strongly present in every step of the risk management process in a safety-critical environment. The online tool provides an independent and reliable option to fill a recognised gap in maritime pandemic control. The future of the DESSEV online decision support system is conditional on the successful implementation of the novel tool in a conventional safety management environment.

It should also be mentioned that DESSEV is a decision support system. A potential decision-maker should rely mainly on his or her experience. However, using tools of this type makes this work more effective.

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# Pareto Analysis of ISM Code Deficiencies

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**Abstract:** The International Safety Management (ISM) Code concerns safety at sea and marine environment protection; primarily regarding SOLAS class vessels. The main purpose of this paper is to highlight the importance of reviewing the outcome of ISM external audits and port inspections as well as analyzing accident reports with a view to improve safety at sea and marine environment protection. The paper focuses on the outcomes of some 50000 Administration and Recognized Organizations (RO) noted non-conformities and over 100000 deficiencies observed by Port State Control Officers (PSCO) during their inspections. Included is a sample selected from some 300 accident reports to establish the root causes of non-conformities, deficiencies and accidents at sea.

In reviewing the root causes and contributing factors to the accidents, audit non-conformities and inspection deficiencies, the paper makes an attempt to find those with highest frequency of occurrence by applying Pareto analysis.

This paper concludes with a taxonomy model identifying the key factors contributing to accidents, nonconformities noted by Administration or ROs, as well as deficiencies observed by PSCOs when inspecting ships.

**Keywords:** Maritime Safety, Accidents at sea, ISM Code Audits, PSC Inspection.

## 1. Background

The International Maritime Organization (IMO) works very closely with national administrations e.g., governments, the Flag States. These administrations interact with their shipping companies.

One of the reasons contributing to maritime accidents is considered by the IMO to be the lack of effective implementation of the Conventions by Contracting Parties, especially Flag States, which are not discharging their responsibilities and obligations. Due to these concerns, for international organizations such as the IMO, it is fundamental that each Member State properly implement and enforce the legislative framework to which they are party. Therefore, to strengthen maritime safety and protection of the marine environment and assist Member States in terms of the implementation of IMO instruments, the IMO Assembly adopted the IMO instruments implementation Code (III Code) in December 2013 through Resolution A.1070(28)3. This entered into force on 1st January 2016. The IMO Instruments Implementation Code (IIIC) is the key instrument behind the IMO Member State Audit Scheme. It provides a Code that all Member States are audited against to assess their capabilities and resources to satisfy international obligations in terms of Port State, Coastal State and Flag State.

Furthermore, MEPC 56/17/1 report noted that an increasing number of Port State Control (PSC) inspections are recording deficiencies under ISM Code-related codes. It is evident that these deficiencies do exits and may be a consequence of an ineffective implementation of the ISM Code ashore or aboard, or raise question about the effectiveness of the ISM Code itself. The identification of multiple deficiencies during a Port State Control inspection could indicate to a systematic failure of either the Safety Management System (SMS) or its implementation, or both, with the result that the ship is detained. Table 1 shows the non-conformities found in ISM audits during 2017-2023.

At the same MSC meeting MAIB identified that the audit should take into account factors including:

- recent changes in ship ownership, Flag State and classification society;
- maritime experience of the Company;
- knowledge of the Company in operating the particular ship type;
- company familiarity with the implementation of safety management systems.

A substantial number of shipping companies are family businesses and therefore the maritime experience of the companies and their knowledge of these companies in operating ship types varies. Furthermore, majority of these companies do not distinguish between management of the company and its governance. Yet, worldwide, each company has been allowed to establish their own safety policies, procedures and plans, often using another company's safety system without sufficient understanding of their responsibility for keeping the sea safe and the environment protected.

## 2. Introduction

The Centre for Factories of the Future (C4FF) has been actively involved in various marine safety and environmental protection projects. It recently carried out a major study on behalf of IMO on Effective Implementation of the ISM Code. As the Study is still confidential and IMO intends to present it to MSC 109, no direct references will be made to it in this paper. Information about C4FF marine and maritime projects can be found in the Centre's Education, Research and Innovation Platform, MariFuture (www.marifuture.org).

With the emergence of Maritime Autonomous Surface Ships (MASS) and the ongoing transformative changes in the shipping industry driven by advanced technologies and digitalization, the role of automation Ziarati et al. (2011) and Ziarati and Ziarati (2014) has become increasingly important. However, it is crucial to acknowledge that the human element continues to play a vital role both aboard and ashore and within the ISM Code as well as the STCW in the maritime sector.

To prevent accidents and incidents at sea and in ports, it is crucial to establish a safety system that focuses on prevention of contributing factors. This approach aims to ensure that safety measures are implemented correctly the first time (Right First Time) and focuses on eliminating the underlying causes through practices like Poka Yoke[1]. Establishing key performance indicators at international, national, and company levels can help reduce the risk of accidents by highlighting the main causes and enabling stakeholders to learn from past incidents. The existing databases maintained by the International Maritime Organization (IMO) can serve as a valuable resource for this purpose. It is essential to recognize that commercial considerations and pressures, such as adhering to schedules and key performance indicators, may sometimes work against the system, leading to under-reporting of incidents and non-conformities. The comparisons of PSC inspections deficiencies with ISM Code external audit non-conformities, as well as accident reviews clearly indicate that there is a great deal to learn about the implementation of the ISM Code and/or its effectiveness. However, one thing that is clear is that top management commitment is essential for effective implementation of the ISM Code. This in turn has a positive impact on companies' competitiveness (Pantouvakis and Karakasnaki, 2018).

It should be recognized that the companies, due to pressures from the clients, have introduced a host of ISO systems in addition to ISO 9000 such as ISO 14000, ISO 45000 and several have also opted for ISO 50000 and ISO 25000. Each of these systems demand top management commitment, involvement of all personnel in implementation of the ISM Code; and continuous development of quality assurance and control which includes development of the crew, ship and means to protect the marine environment. ISO systems are often the core of

[1] Poka Yoke is a mechanism for that is put in place to prevent human error. The purpose of a poka-yoke is to inhibit, correct or highlight an error as it occurs. Poka-yoke roughly means "avoid unexpected surprises" or "avoid blunders" in Japanese. In English, a poka-yoke is sometimes referred to as "mistake-proof" or "foolproof." See - Bayers, P. C. (1994), Using Poka Yoke (mistake proofing devices) to ensure quality, Proceedings of 1994 IEEE Applied Power Electronics Conference and Exposition - ASPEC'94

Total Quality Management. This promotes good management practices such as formation of a quality circle in an organization embracing personal and organization factors as well as employees' well-being. The quality

circle ensures all employees are involved in planning, monitoring and implementation of procedures as well as action plans. Therefore, employees/crews able freely to provide feedback and suggest ideas for improvements.

The Quality Specialists are aware that quality has grades, for instance, hotels start with 1-star to 7-star or in the Olympic games there are gold, silver and bronze medals. These represent given and well-defined standards of products, or services, or achievements. As companies are allowed to develop their safety management system, therefore, there are as many grades of quality as they are shipping companies. Quality means fitness-for-purpose and compliance with specification. The crews' and ships' fitness/seaworthiness are a measure of ISM effectiveness. Compliance with rules and regulations as well as the companies' own policies, procedures, processes/operations and plans are measures of effective implementation. Fitness/seaworthiness and compliance are the sides of the same quality coin.

It is recognised that a system is as strong as its weakest link. A review of corrective actions taken after audits or inspection as well as after accidents and incidents clearly suggests serious issues with ISM and its implementation.

Over 100,000 deficiencies including 5,000 ISM non-conformities were reported by PSC Paris MoU during 2019-2021 [2] and during 2018-2022 over 45,000 ISM non-conformities were reported by Recognised Organizations (IACS/LR) clearly suggesting that the shipping industry has to see the wood from the trees and address the ISM Code weaknesses.

A review of deficiencies by PSC Paris MoU shows that the ISM non-conformities have shown, by far, to be the highest category, responsible for some 25% of the deficiencies in the top 10 categories. This is also evidenced by a recent paper by Biocic et al. (2023).

It is a requirement of SMS to amend inadequate or inappropriate documented procedures and to identify where actual practices do not meet those that are documented and to propose corrective action(s).

It is important to distinguish between crew-related mistakes and company-related errors. Figure 1, adopted from Baines[3] analysis of investigation results, shows one way of doing this.

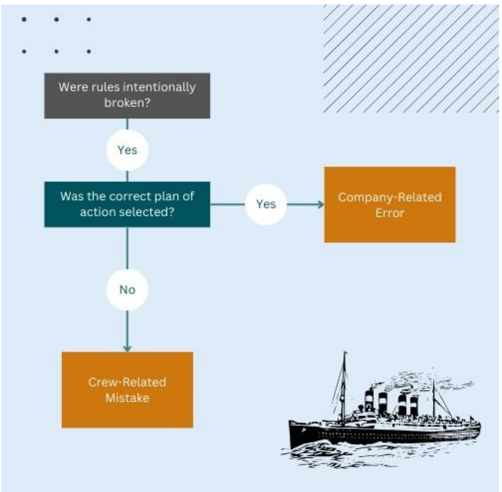


Figure 1. Adaptation from Baines- Company-related Error vs. Crew-related Mistake

[2] Paris MoU Annual Report 2022 - https://parismou.org/system/files/20236/Paris%20MOU%20Annual%20Report%202022.pdf

[3] https://www.raes-hfg.com/reports/21may09-Potential/21may09-baines.pdf

It would helpful if a system could be in place that distinguished between root cause of non-conformities either as human-element related (often referred by insurance companies as human negligence or crew-related Mistake) or ship quality assurance system/ISM (often referred to as Company-related Error). In this paper an analysis is carried out and a system has been developed to distinguish between deficiencies relating to quality assurance and those relating to the human element and the machinery system. It is important to realize that the quality assurance includes all the requirements of ISM Code which embraces the company's own policies, procedures, processes and plans.

**3. Data from Industry**

There are several sets of data presented in the paper viz., data from the IACS about the ISM Code nonconformities, PSC inspection deficiencies and accident reviews.

The data concerning non-conformities during 2017-2023 is presented in Table 1. To analysis this data and to ascertain the top non- conformities noted during Pareto analysis[4] was applied.

The application of the Pareto analysis, as shown in Tables 1a and 1b, has identified Ship Maintenance (Element 10), Shipboard Operation (Elements 7) and Resources and Personnel (Element 6) to be the top most frequent non-conformities.

Table 1a. ISM Non-Conformities Observed 2017-23 – Part 1 (Source: IACS)

| Non Conformities Observed/Noted | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Row Labels** | **1 Jan - 31 Dec 2018** | **2 Jan - 31 Dec 2019** | **3 Jan - 31 Dec 2020** | **4 Jan - 31 Dec 2021** | **5 Jan - 31 Dec 2022** | **Grand Total** | **Average** | |
| 1. General | 1401 | 1203 | 1207 | 1824 | 1765 | 7400 | 1480 | 1.2.2.1 - Safe Working Practices, 1.2.2.2 - Safeguards against identified risks, 1.2.2.3 - Safety Management skills & preparing for emergencies, 1.2.3.1 - Compliance with rules & regulations; 1.2.3.2 - Taking into account of codes, guidelines & standards; 1.4 - Functional Requirements |
| 2. SAFETY AND ENVIROMENTAL PROTECTION POLICY | 112 | 72 | 90 | 112 | 135 | 521 | 104.2 | 2.1 - Establishing a safety & environmental policy; 2.2 - Implementing the SMS Policy |
| 3. COMPANY RESPONSIBILITY AND AUTHORITY | 230 | 184 | 183 | 205 | 186 | 988 | 197.6 | 3.1 - Ship owner assigning ISM responsibility; 3.2 - Defining & documenting responsibilities and 3.3 - Adequate resources for the DPA |
| 4. DESIGNATED PERSON(S) | 95 | 76 | 83 | 79 | 107 | 440 | 88 | 4 - Role of the DPA |
| 5. MASTER'S RESPONSIBILITY AND AUTHORITY | 322 | 328 | 286 | 309 | 380 | 1625 | 325 | 5.1.1 - Master implementing the SMS Policy; 5.1.2 - Master motivating the crew; 5.1.4 - Master verifying SMS related activities; 5.1.5 - Master periodically reviewing the SMS and 5.2 - Use and knowledge of the overriding authority |
| 6. RESOURCES AND PERSONNEL | 1642 | 1625 | 1425 | 1732 | 1877 | 8301 | 1660.2 | 6.1.1 - Master properly qualified for command; 6.1.2 - Master fully conversant with SMS; 6.1.3 - Master given necessary support; 6.2.1 - Ship manned with qualified and medically fit personnel; 6.2.2 - Ship appropriately manned to safely cover all operations; 6.3 - Crews familiarisation on board; 6.4 - Adequate knowledge of rules and regulations; 6.5 - Identification of training needs; 6.6 - Working language used and 6.7 - Effective communication used. |

[4] Pareto analysis is a formal technique useful where many possible courses of action are competing for attention. In essence, the problem-solver estimates the benefit delivered by each action, then selects a number of the most effective actions that deliver a total benefit reasonably close to the maximal possible one. Alternatively, it can seek to find the contributing factors to a failure and identify the most frequent recuring cause or factor.

Table 1b. ISM Non-Conformities Observed 2017-23 – Part 2 (Source: IACS)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7. SHIPBOARD OPERATIONS | 2038 | 1897 | 1848 | 2027 | 2424 | 10234 | 2046.8 | 7 - Shipboard Operations |
| 8. EMERGENCY PREPARDNESS | 1201 | 1195 | 1033 | 1202 | 1470 | 6101 | 1220.2 | 8.1 - Identification of contingency plans; 8.2 - Drills & exercise planning for emergencies and 8.3 - Companys ability to respond to emergencies. |
| 9. REPORTS AND ANALYSIS OF NON-CONFORMITIES, ACCIDENTS NAD HAZARDOUS OCCURRENCES | 1127 | 1088 | 1028 | 967 | 1107 | 5317 | 1063.4 | 9.1 - Reporting, investigating, analysing accidents, NCs, etc. and 9.2 - Implementation of corrective actions. |
| 10. MAINTENANCE OF THE SHIP AND EQUIPMENT | 3968 | 3689 | 3296 | 3778 | 4419 | 19150 | 3830 | 10.1 - Establish procedures to maintain the ship; 10.2.1 - Inspections held at the proper interval; 10.2.2 - Deficiencies reported; 10.2.3 - Appropriate action on deficiencies taken; 10.2.4 - records of activities maintained; 10.3 - Identification & Measures for critical equipment and 10.4 - Inspection routines & follow up incorporated in the maintenance routines. |
| 11. DOCUMENTATION | 1152 | 965 | 912 | 968 | 1086 | 5083 | 1016.6 | 11.1 - Establishing document & data control; 11.2.1 - Valid documents available on relevant locations; 11.2.2 - Review & approval of (changes to) documentation; 11.2.3 - Obsolete documents promptly removed and 11.3 - Suitable & effective SMS maintained. |
| 12. COMPANY VERIFICATION, RECIEW AND EVALUATION | 692 | 713 | 679 | 719 | 728 | 3531 | 706.2 | 12.1 - Internal audits at 12 month intervals12.2 - Personnel undertaking tasks in conformity with Companys responsibilities; 12.3 - Management review; 12.4 - Audits and corrective actions in accordance with procedures; 12.5 - Independence of internal auditors; 12.6 - Reporting results of internal audits and reviews and 12.7 - Timely corrective action on findings noted. |
| Grand Total | 13980 | 13035 | 12070 | 13922 | 15684 | | | |

The data from IACS was complemented by the data obtained from LR, representing 15% of the IACS data. The difference between the data provided by the IACS and LR is significant. The IACS data only concerns the 12 elements of the ISM Code but the LR data goes deeper and provide non-conformities at sub-element levels. The reason why the LR data is significant is that whilst IACS data is able to identify for instance identify Ship Maintenance as the top most frequent non-conformity, the LR data shows that the top most frequent nonconformity to be Non-Compliance with rules & regulations (Sub-element 1.2.3.1). The following shows the top ten most frequent non-conformities from LR data:

- 1.2.3.1 Non-Compliance with rules & regulations.
- 10.2.1 - Inspections not held at the proper interval; 10.1 - Establish procedures not in place to maintain the ship; 10.3 - Identification & Measures not in place for critical equipment; 10.4 - Inspection routines & follow up not incorporated in the maintenance routines.
- 12.1 - Internal audits not held at 12-month intervals; 12.3 - Management review not conducted 12.4 - Audits and corrective actions not in accordance with procedures; 12.7 - Timely corrective action not taken on findings noted.
- 5.1.5 - Master not periodically reviewing the SMS.
- 7. Shipboard operations
- 1.2.2.2 Inadequate safeguards against identified risk
- 9.1 – Lack or inadequate reporting, investigating, analyzing accidents, NCs, etc.
- 8.2 – Inadequate drills & exercise planning for emergencies • 11.2.1 - Valid documents not available on relevant locations
- 9.2 – Non-implementation of corrective actions.

**Data from Port Inspections**

Table 2 displays the recorded number of ISM deficiencies across several PSC MoUs, with a notable portion being detainable. Typically, shipping companies must undertake corrective actions to ensure their vessels are fit for sailing. This emphasizes the importance of addressing these deficiencies promptly to maintain compliance and safety standards within the maritime industry. Table 4 shows the similar data for Paris MoU. Table 2. PSC MoU Observed deficiencies

| PSC MoU | US Coast Guard MoU | Mediterranean MoU | Black Sea MoU | Tokyo MoU | Riyadh MoU | Indian Ocean MoU Secretariat |
|---|---|---|---|---|---|---|
| PSC Inspections with ISM deficiencies | 929 | 944 | 1743 | 5630 | 891 | 1666 |
| ISM and ISM-related deficiencies | 1152 | 5657 | 11756 | 6187 | 994 | 1751 |
| Detainable ISM and ISM related deficiencies | 313 | 1213 | 1799 | 1230 | 42 | 332 |

It is important to point out that different MoU regions have their own categories of the ISM deficiencies. As an example, Table 3 shows the categories of considered by Black Sea MoU.

Table 3. PSC MoU observed deficiencies by Black Sea MoU

| Categories of the ISM Deficiencies Identified by Black Sea MoU |
|---|
| Safety and environment policy |
| Company responsibility and authority |
| Designated person(s) |
| Master's responsibility and authority |
| Resources and personnel |
| Shipboard operations |
| Emergency preparedness |
| Reports of non-conformities, accidents & hazardous occur |
| Maintenance of the ship and equipment |
| Documentation |
| Company verification, review and evaluation |

Table 4. PSC Paris MoU Observed deficiencies – Review of Inspections 2019 - 2021

| Year | 2019 | 2020 | 2021 |
|---|---|---|---|
| Number of inspections | 17,916 | 13,168 | 15,387 |
| Number of individual ships inspected | 15,447 | 12,092 | 13,797 |
| Number of deficiencies | 39,821 | 28,372 | 36,113 |
| Number of detainable deficiencies | 3,015 | 2,182 | 3,274 |
| Detentions in % of the total number of inspections | 2.98 | 2.92 | 3.43 |
| Number of refusals of access to ports | 25 | 8 | 11 |

The Figure 2 shows the ISM to be the highest category of deficiencies, responsible for some 25% of the deficiencies in the top 10 categories as observed by Paris MoU.

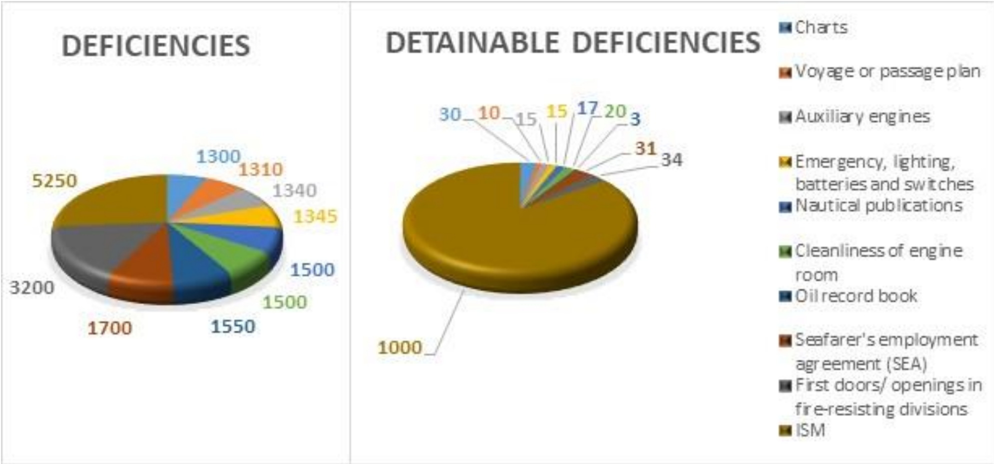


Figure 2. The ten most frequent deficiencies detected on ships during by Paris MoU 2019-2021 (Source: Paris MoU Annual Report 2022)[5]

**4. Learning from Audits, Inspections and Accidents**

C4FF through some 30 funded projects and having reviewed the results of external audits, port inspection and over 1000 accidents, has identified some 25 top root causes of accidents and non-conformities and deficiencies as shown in Table 5.

As it can be seen from Table 6 each group category has its top root-causes within each category group the key root causes/contributing factors are also identified. As can be seen the Leadership item, viz., "Inadequate risk assessment, inadequate team composition, inappropriate pressure to perform a task and a directed task with inadequate qualification, experience or equipment", was found to be the top cause of accidents.

Table 5a. The top 25 categories of the root cause of non-conformities, deficiencies and contributing factors to accidents and incidents at sea - Source: M'aider 2010, ACTs 2015 and ACTS Plus 2017 & OPTIMISM 2024[6]

[5] https://parismou.org/system/files/20236/Paris%20MOU%20Annual%20Report%202022.pdf

[6] Safety at Sea and Maritime Environment Protection with Special References to Human Factors, MT'24. 10th International Conference on Maritime Transport, Barcelona, June 5-7, 2024 - See also Stroeve, S., et al. (2023) Shield Human Factors Taxonomy and Database for Learning from Aviation and Maritime Safety Occurrences, Safety, MDPI 2023.

| | | | | | |
|---|---|---|---|---|---|
| A- Work Environment | 1 | Lack of visibility, excessive noise or vibration, hot/cold working environment, bad weather, sudden movements. | B- Personal | 5 | Inadequate personal fitness |
| | | | | 6 | Inadequate mental fitness |
| | | | | 7 | Inadequate Knowledge |
| | | | | 8 | Inadequate competence/skills |
| | | | | 9 | lack of motivation or complacency |
| | | | | 10 | Ineffective communication, language differences, non-standard (Non SMCP) or complex communication and the impact of differences in rank. |
| | 2 | Inappropriate work environment/ergonomics, poor human–machine interface, automation issues, maintenance and equipment misfunctions. | | 11 | Poor team operation, working towards different goals, no cross-checking, no means of reporting or speaking up, no quality circles. |
| | | | | 12 | Incorrect perception, motion illusion, visual pretention/illusion and the misperception of changing environments or instruments. |
| | 3 | Inadequate system design | | 13 | Lack of focus/incorrect awareness leading to misinterpretation of the operation by a crew member – lack of attention, confusion, distraction, discoordination, stress/poor mental perception. |
| | 4 | Issues with procurement/purchasing | | 14 | Forgetfulness, inaccurate recall or using outdated information. |

Table 5b. The top 25 categories of the root cause of non-conformities, deficiencies and contributing factors to accidents and incidents at sea – Source: M'aider 2010, ACTs 2015 and ACTS Plus 2017 and OPTIMISM 2024[7]

| | | | | | |
|---|---|---|---|---|---|
| C- Leadership | 15 | Inadequate leadership and personnel management, including no personnel measures against regular risky behavior, a lack of feedback on safety reporting, no role model and personality conflicts. | D - Organizational | 19 | Inappropriate policy manual |
| | | | | 20 | Inappropriate/inadquate procedure |
| | | | | 21 | Inadquate supervision |
| | | | | 22 | Problems with safety culture, lack of culture of reporting, learning or just culture, social and status barriers causing misunderstandings. |
| | 16 | Inadequate risk assessment, inadequate team composition, inappropriate pressure to perform a task and a directed task with inadequate qualification, experience or equipment. | | 23 | Unsuitable documented policy or procedures, limitations of proactive risk management, reactive safety assurance, lack of safety promotion and training |
| | 17 | Inadequate leadership of operational tasks, including a lack of correction of unsafe practices, no enforcement of existing rules, allowing unwritten policies to become standards and directed deviations from procedures | | 24 | Insufficient resources for safe operations, including personnel, budgets, equipment, training programs, operational information and lack of operational manual of ship installations. |
| | 18 | Inadequate manning (intentional or unintentional disregard for the guidelines). | | 25 | Commercial Pressures, business and competition affecting safety, including relations with contractors, trade pressure to keep the plans and costs. |

Table 6. Frequency occurrence of the top 25 root cause of non-conformities, deficiencies and contributing factors to accidents and incidence for some 50 accidents selected from over 300 accidents.

Legend: • = Applies

| NO | Vessel | Accident type | Working Environment | | | | Personal | | | | | | | | | | Leadership | | | | Organisation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1 | | Loss of Stability | | | | | | | | • | • | • | • | | • | | • | • | • | • | | • | • | • | • | | • |
| 2 | | Human Factor | | | • | • | | | | | | | | | • | | • | • | • | | | | • | | | • | |
| 3 | | Collision | | | • | | | | | | • | | | | | | • | • | • | | • | • | • | • | • | • | • |
| 4 | | Operational Accident | | • | • | | | | | • | | | • | | | | • | • | • | | • | • | • | | • | • | |
| 5 | | Operational Accident | | • | • | | | | | | | | | • | | | | • | • | | • | • | • | | | • | |
| 6 | | Collision | | • | | | • | | | | | | | | | | | • | | | • | • | • | | | | • |
| 7 | | Grounding | | • | | | | | | | | | • | | | | • | • | | | • | • | • | • | | • | • |
| 8 | | Collision | | • | | | | | | • | | | • | | • | | | • | | | • | • | • | | | • | |
| 9 | | Grounding | | | | | | | | • | | | • | • | | | | • | • | | • | • | | • | | | |
| 10 | | Capsize | | • | | | • | • | • | • | • | | • | • | • | | • | • | • | • | • | • | | • | | | • |
| 11 | | Capsize and Grounding | | | | | | | • | • | • | | | | | | • | • | • | | • | • | • | • | • | | |
| 12 | | Fall from 18m height | • | | • | | | | | • | | | • | • | | | • | • | | | | | | | | | |
| 13 | | Overflow and Pollution | | • | • | | | | | • | • | | | | • | | | • | • | • | | | • | | | | |
| 14 | | Collision | | • | • | | | | | • | | | • | | | | | • | • | | | | • | | | | |
| 15 | | Ent. Into enclosed space | | | | | | | • | • | • | | • | • | • | | • | • | • | | • | • | • | • | | | |
| 16 | | Ent. Into enclosed space | | | | | | | • | • | | | | • | | | • | • | • | | | • | • | | | | |
| 17 | | Operational Accident | | • | | | | | | • | | | • | | • | | • | • | • | | • | • | • | • | | | |
| 18 | | Operational Accident | | • | | | • | | | • | | | • | • | • | | • | • | • | • | • | • | • | • | • | • | |
| 19 | | Operational Accident | | • | | | | | | • | | | | • | | | | • | | | | | | • | | | |
| 20 | | Grounding | | | | | • | • | • | • | • | | | • | | | • | • | • | • | • | • | • | • | | | • |
| 21 | | Fire in Engine Room | | • | | | | | • | | | • | | | | | | • | | | • | • | • | • | | | |
| 22 | | Collision | | | • | | | | | | | • | • | | | | | | | | | | | | | | |
| 23 | | Sinking while Towage | • | • | • | | | | • | • | • | | | | | | | | | | • | • | • | | | | |
| 24 | | Container over board | • | • | | | | | | | | • | • | • | | | | | | | • | • | • | • | | | |
| 25 | | Collision | | • | | | | | | | | • | • | • | | | • | | | | | | | | | | |
| 26 | | Accident in Drills | | | | | | | • | • | | | | | | | | • | • | | | • | • | | | | |
| 27 | | Lifeboat Failed | | | • | | | | | | | | | | | | | | | | | | | | | | |
| 28 | | Lifeboat Failed | | | • | | | | | | | | | | | | | | | | | | | | | | |
| 29 | | Engine Room Accident | | | | | | • | • | | • | | | | | | | | | | | | | | | | |
| 30 | | Overboard Accident | • | • | | | | | • | • | | | | | | | • | • | | | • | • | • | • | • | • | |
| 31 | | Collision | | | | | | | | | | • | • | • | • | | | | | | | | | | | | |
| 32 | | Crew Member Died | • | | | | | | | | | • | • | | | | | | | | | • | | • | | | |
| 33 | | Man fell overboard | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34 | | Man fell from height | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35 | | Operational Accident | | • | | | | | • | | | | | | | | | • | • | | | | | | | | |
| 36 | | Operational Accident | • | | | | | | | • | | | • | | | | | • | | | | | | | • | | |
| 37 | | Operational Accident | • | • | | | | | • | • | | • | | | | | | | • | | | | | | | | |
| 38 | | Operational Accident | | • | | | | | • | • | | | • | | | | • | • | • | | | • | • | | | | |
| 39 | | Death of Passenger | | | • | | | | | | | | | | | | | | | | | | • | | | • | |
| 40 | | Operational Accident | | | | | | | • | | | | • | | • | | | • | • | | • | • | • | • | | | |
| TOTAL | | | 7 | 19 | 12 | 1 | 4 | 3 | 14 | 21 | 9 | 8 | 19 | 12 | 10 | 0 | 16 | 27 | 20 | 5 | 18 | 23 | 24 | 16 | 7 | 9 | 6 |

During a further review of accidents, as depicted in appendixes 1 and 2, it was found that the key contribution factors in accident are human vulnerability, poor decision making and/or person-to-person communication. In this further review an attempt was made to also identify whether the accident was Crew-related Mistake or Company-related Error.

## Conclusions

The Pareto Analysis of ISM Non-conformities, PSC Inspections and accidents clearly suggests that focusing on ship maintenance, shipboard operations and non-compliance with rules and regulations to be the top most frequent key factors in audit non-conformities, inspection deficiencies and accidents. The Pareto analysis of findings from accidents showed that the highest frequency occurrences are the ISM Code Elements 1, 7 and 10. this was true for the IACS/LR's data and PSC inspection. In Element 1 'Compliance with rules and regulations', 'Taking into account codes, guidelines and standards’, 'Safeguard against identified risks' and 'Safe working practices' were the main problem areas. Element 7 'Shipboard Operations' was the second most occurring problem area. In Element 10 'Establishing procedures to maintain the ship' was the next top occurring problem area. If these problem areas are targeted and resolved, they are expected to make the most impact on effectiveness and the effective implementation of the ISM Code. Review of accidents also showed that 'Ineffective communication/language issues'. 'Inadequate supervisions', Crew familiarization on board', 'Human Vulnerabilities' ands 'lack of knowledge' to be main root causes of, or a contributing factor to many accidents. The review of accidents tallied well with the outcome of the ISM audits by IACS/LR, on like for like basis.

It is equally important to identify other specific aspects of rules and regulations that have led to accident at sea such as COLREGs. In appendix 3, it is shown that Pareto analysis identified one of the key issues regarding accidents at sea to be collisions primarily due to complexities of the Rules, particularly Rule 19.

The results presented here clearly shows that the focus of improving the effectiveness and effective implementation of ISM Code should be on ISM audit non-conformities, PSC Inspections and accidents and a further analysis is required to ascertain what are the key issues with specific rules for instance with COLREGs or ship maintenance or shipboard operations. Safety improvements are only possible if ISM and STCW are review together since ISM and STCW are sides of the same coin. Furthermore, the studies that have led to this paper clearly suggest human vulnerability, decision-making and person-to-person communications to be key factors for consideration. Safety is not an absolute phenomenon and a system such as ISM is as strong as its weakest point. Risk assessment plays a major rule in ISM. To this end, whilst this paper promotes the idea of Pareto analysis to focus on areas that bear maximum impact, it should be noted that each non-conformity or deficiency or root cause of a near miss is an accident waiting to happen.

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**Appendixes**

Appendix 1Table 1. The First Set of Micro Analysis of Accident Reviews

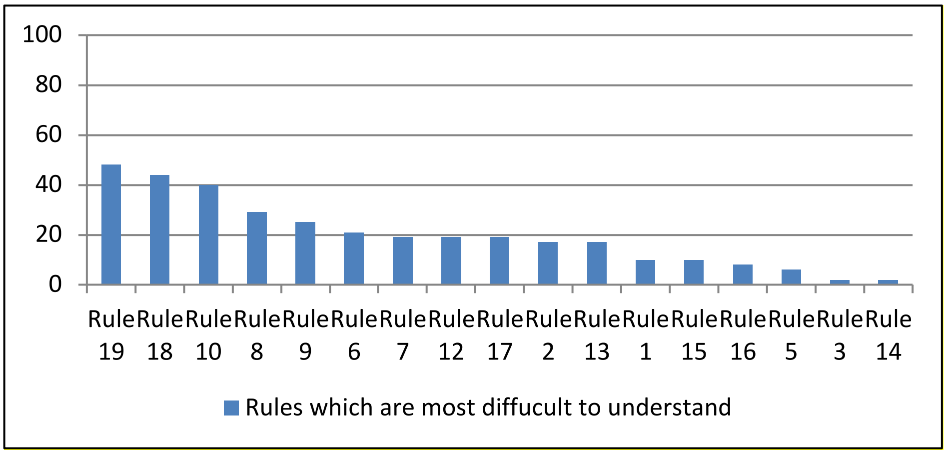
| IMO Number | Type | Accident | Mistake | Error | Human vulnerability | Decision making | Communication |
|---|---|---|---|---|---|---|---|
| 9307358 | Ro-Ro Ferry | Grounding | x | | x | x | x |
| 9198721 | Ro-Ro Ferry | Fire in the ER | | x | x | x | x |
| 9036430 | Bulk Carrier | Collision | | x | x | x | x |
| 9191369 | Offshore Supply ship | Sinking | | x | x | x | x |
| 9218650 | Container | Containers overboard | | x | x | x | x |
| 9473468 | Car Carrier | Collision | x | x | x | x | x |
| 9370185 | Bulk Carrier | Lifeboat falling | | x | x | x | x |
| 9030682 | Life Boat safety latch | Lifeboat falling | | x | | | x |
| 815254 | Ro-Ro Passenger | Lifeboat falling | | x | x | x | x |
| 9212008 | Oil Tanker | Engine room fire | x | | x | x | x |
| 9101584 | General Cargo | Drowning of 3/O | x | x | x | x | x |
| 9234123 | Container/Cargo ship | Collision | x | x | x | x | x |
| 8308147 | General Cargo | Fall and death | | x | x | x | x |
| 9316036 | Bulk Carrier | Fall and death | | x | x | x | x |
| 8408894 | Reefer | Fall and death | | x | x | x | x |
| 9452608 | Bulk Carrier | Mooring rope death | | x | x | x | x |
| 9300374 | Bulk Carrier | Drowning of bosun | | x | x | x | x |
| 9363417 | Bulk Carrier | Oiler died | | x | x | x | x |
| 9116876 | Cruiser | OS drowned | | | x | x | x |
| 7907661 | Ro-Ro Passenger | Passenger died | x | x | x | x | x |

Appendix 1 Table 2. The Second Set of Micro Analysis of Accident Reviews

| IMO Number | Type | Accident | Mistake | Error | Human vulnerability | Decision making | Communication |
|---|---|---|---|---|---|---|---|
| 9334155 | Container | Collision | x | | x | x | x |
| 9480382 | Gas Carrier | Collision | x | | x | x | x |
| 9119414 | Ro-Ro Ferry | Grounding | x | | x | | x |
| 8403569 | Cement Carrier | Capsize/Sinking | | x | x | x | |
| 7721263 | Bulk Carrier | Grounding | x | x | | x | |
| 9208629 | RoRo Passenger | Fire | x | | | | |
| 9506227 | Ro-Ro Ferry | Grounding | | x | | x | x |
| 9414072 | Chemical tanker | Explosion | | x | | x | |
| 9706889 | ULCC | Grounding | | x | | x | x |
| 9132002 | Ro-Ro Ferry | Collision | x | | x | | x |
| 9138329 | Cruise Ship | Grounding | x | | x | | x |
| 9310159 | Oil Tanker | Fatal accident | | x | x | | |
| 9237383 | Bulk Carrier | Fatal accident | x | x | | x | x |
| 9589229 | Bulk Carrier | Fatal accident | | x | x | | x |
| 9714642 | Gas Carrier | Fatal accident | | x | x | | |
| 9669627 | Bulk Carrier | Fatal accident | x | x | | x | x |
| 9314600 | General Cargo | Collision | x | x | | x | x |
| 9468085 | General Cargo | Collision | x | x | | x | X |
| 9486192 | Chemical Tanker | Grounding | | x | x | | |
| 9333541 | General Cargo | Fatal accident | | x | x | | |
| 9612296 | Bulk Carrier | Fatal accident | | x | | x | |

Appendix 2. Sample of problem areas – Collision Rules which are most difficult for students to understand

The application of the Pareto analysis when reviewing the ISM audits and port inspection data clearly showed that non-compliance with rules and regulations was a major non-compliance or deficiency. The analysis in this respect showed, for instance, that the understanding of the collision rules (COLREGs) and their correct application is unsatisfactory, hence a weak link in the safety chain. Therefore, any research in this field can be fully justified if it increases knowledge and understanding of safety issues. The scenarios which have been developed in the ACTS+ project[7] present even more complex cases of encountering ships when the correct application of the Rules is even more demanding. One of the very good principles for solving such complex cases is the principle of "Divida et Impera". It is important to emphasize that this principle can be applied to any complex case of encountering ships, and the result (possible collision avoidance actions) obtained in this way is in compliance with the Rules. Complex cases, which cannot be solved in this way, belong to the category of "special cases" and will require further research in this field. In ACTS project, the most significant finding was to identify the rules that were found to be most difficult by the students as reported by the instructors such as Rule 19 (Figure 1 below). It is not just COLREGs which require attention but ISPS specifically cyber security necessitates additional efforts in ensuring safer seas and better marine environment protection.




Appendix 2. Figure 1. Rules which are most difficult for students to understand – answered by lecturers

[7] http://advanced.ecolregs.com

# Navigating the Future: Multi-Stacking Ensemble Learning for Sustainable Maritime Trajectory Prediction

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**Abstract:** In the transformative landscape of maritime applications, Artificial Intelligence plays an inevitable role in revolutionizing the shipping industry. The accuracy of vessel trajectory predictions becomes paramount for ensuring safety, operational efficiency and informed decision-making. This research introduces the Multi-Stacking Ensemble Learning (MSEL) model, a novel Artificial Intelligence driven approach designed to not only enhance the precision but also to promote sustainability in vessel trajectory predictions within the Maritime Transportation sector. The research undergoes meticulous data preprocessing by eliminating the limitations of using raw Automatic Identification System (AIS) data for collision avoidance. By concentrating on route pattern extraction, port extraction and trajectory clustering, the research aims to enhance the reliability of predictions for sustainable Maritime Transportation. MSEL is an innovative ensemble framework which integrates diverse prediction models by combining route pattern classification and trajectory forecasting. Experiments on open source AIS dataset after pre-processed the raw information was carried out and the results showcased the novel architecture MSEL's superior performance over benchmark models in long-term prediction accuracy. The ensemble learning paradigm equips MSEL to effectively capture intricate vessel movement patterns and contributing to its outstanding performance in diverse maritime scenarios. MSEL architecture will acts as a significant contributor to sustainability-driven forecasting within maritime trajectory prediction methodologies

*Keywords*: Vessel Trajectory; Predictive Analytics; Ensemble Learning; AIS; Artificial Intelligence

## 1. Introduction:

Over 70% of the Earth's surface is encompassed by oceans by forming an expansive domain that not only hosts abundant resources but also serves as a crucial connector between continents and nations. Maritime transportation plays a pivotal role in sustaining the international economy. Reports indicate that sea routes handle over 80% of global goods trade that surges further for many developing countries. The paramount importance of safety and efficiency in maritime transportation extends benefits to human life, the global economy and the marine environment. By forecasting a vessel's future movements on both short and long-term scales; aids in various functions which includes assessing collision risks, avoiding accidents, estimating destinations, travel times and planning optimal routes. As a result, precise vessel trajectory predictions significantly contribute to a well-organized and efficient maritime transportation system.

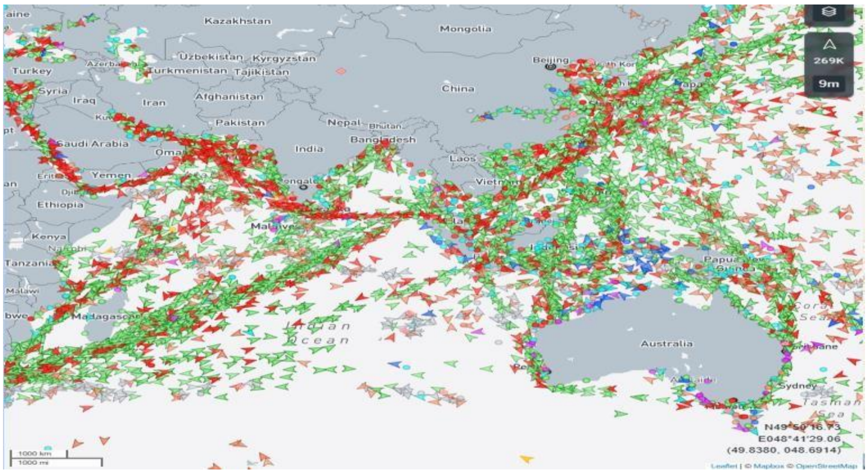


**Figure 1: Marine Vessel Traffic in the Indian Ocean and Asia Pacific Region [24]**

The advent of the Automatic Identification System (AIS) has provided invaluable insights into vessel movements. Figure 1 depicts the Marine Vessel Traffic in the Indian and Asia-Pacific region obtained from Marine Traffic.com. AIS mandates ships to periodically transmit their current status to receivers aboard nearby vessels, terrestrial base stations and even satellites. Each AIS transmission comprises both static and dynamic information that offers details on the vessel's identity and behavior. Static data includes the Maritime Mobile Service Identity (MMSI), vessel type and size while dynamic data encompasses parameters such as timestamp, latitude, longitude, Speed over Ground (SoG) and Course over Ground (CoG). Organizing AIS data chronologically yields voyage trajectories and the proliferation of AIS transceivers has led to a significant enrichment of AIS datasets available online.

Despite the strides made in data mining technologies and the prevalent availability of AIS data, vessel trajectory prediction faces several challenges distinct from those encountered in predicting human trajectories. These challenges can be succinctly categorized as follows: (1) Ambiguous Origin-Destination (OD) information which stems from inaccuracies or omissions within AIS data particularly in delineating departure and arrival ports that complicates the modeling of vessel routes for long-term predictions. (2) Absence of established road networks; unlike urban settings which results in vessel trajectories susceptible to the dynamic marine environment thereby introducing instability into predictions. (3) Sparse periodic movement patterns exhibited by vessels compared to human mobility which makes it arduous to discern consistent daily or weekly movement patterns that are observed in container ships by prioritizing financial efficiency over predictable routes.

This research endeavors to overcome the challenges inherent in vessel trajectory prediction by introducing a novel methodology Multi-Stacking Ensemble Learning architecture. The proposed approach involves meticulous preprocessing of historical AIS data to extract typical routes. Utilizing recorded AIS speed and anchoring status, maritime journeys are segmented. Various factors such as starting and ending locations, time duration, moving speed, direction distributions and covered waypoints are then considered to extract route patterns exhibiting similar moving behaviors through clustering techniques. These identified route patterns serve as foundational knowledge for vessel trajectory prediction. Furthermore, the paper presents an innovative framework named Multi-Stacking Ensemble Learning (MSEL) model which employs multi-stack learning to simultaneously classify route patterns and predict future vessel movements.

**2. Related Works:**

The literature review encompasses three key domains: vessel trajectory prediction, moving trajectory clustering and the Multi-Stacking ensemble learning technique. In the domain of vessel trajectory prediction various methodologies have been explored by focusing on three primary approaches: physical model-based, learning model-based and knowledge-based methods (Enmei Tu et al, 2017). Physical model-based strategies such as the Constant Velocity Model (CVM) and curvilinear model rely on mathematical equations and physical laws for trajectory calculation. However these methods are often limited by their simplicity and idealized assumptions particularly in long-term predictions. Learning model-based approaches employ deep neural networks such as Recurrent Neural Networks (RNN) and Seq2seq models to capture spatial-temporal dependencies in vessel movement data (Nicola Forti et al, 2020), (Lan You et al, 2020) and (Samuele Capobianco et al, 2021). While these models show promising results in trajectory prediction tasks they necessitate meticulous data preprocessing and parameter tuning for optimal performance. Knowledge-based methods extract movement patterns from historical AIS data and represent them probabilistically (Ioannis Kontopoulos et al, 2021). These approaches which includes cluster-based pattern extraction and Gaussian process modeling offer valuable insights into trajectory prediction and anomaly detection. The synergy between learning and knowledge-based methods; the proposed model in this paper seeks to integrate pattern knowledge into neural networks to enhance prediction accuracy.

Moving trajectory clustering involves the extraction of mobility patterns from various targets to comprehend their dynamic behaviors. Unlike human, vehicle and light trajectories which commonly exhibit periodic daily or weekly patterns, vessel tracks lack such regularity. However different vessels often share similar routes between specific ports that are influenced by geographical features, weather conditions and navigational choices. Thus clustering diverse trajectories into patterns is essential for deriving valuable insights into voyaging behaviors. Trajectory clustering aims to categorize tracks based on their route shape and distance between them which can be computed using either distance-based or vector-based approaches. Distance-based methods such as Longest Common Subsequence (LCSS), Hausdorf distance and Dynamic Time Warping (DTW) compare trajectory segments or align sequences to assess similarity (Michail Vlachos et al, 2004). LCSS identifies shared parts between trajectories while Hausdorf distance measures the maximum relative pairwise distance. DTW aligns sequences iteratively to find the optimal match by considering both time order and trajectory shapes. However these methods may not always accurately distinguish trajectories especially when directions differ. Vector-based methods represent trajectories as low-dimensional representations that are converting trajectory clustering into a vector grouping problem. Researchers have utilized sliding windows to extract space and time-independent moving behavior characteristics and employed seq2seq frameworks to learn fixed-length representations of these features (Di Yao et al, 2018). These representations encode movement characteristics and can be applied to classic clustering algorithms like K-means that are resulting in significant performance enhancements over distance-based methods. A method combining spectral clustering with a modified Hausdorf distance for trajectory clustering was proposed which showed superior performance compared to LCSS and DTW (Stefan Atev et al, 2010). Partition of trajectories into segments before categorizing them using the Minimum Description Length (MDL) principle and density-based line segment clustering (Jae-Gil Lee et al, 2007). These approaches illustrate different methods for computing distances or representing trajectories as vectors for clustering. Vector-based approaches offer an alternative by transforming trajectories into low-dimensional representations for clustering.

Multi-task Learning (MTL) has emerged as a successful strategy across various domains which includes computer vision, natural language processing and reinforcement learning (Michael Crawshaw, et al, 2020). MTL involves the simultaneous learning of multiple tasks within a shared model framework that exploited hidden representations shared among relevant tasks to enhance performance. It can be realized through either hard or soft parameter sharing schemes. In hard parameter sharing tasks share hidden representations while maintaining separate output layers thereby reducing overfitting and capturing characteristics of all functions. Soft parameter sharing maintains similar hidden layers across tasks based on specified distance metrics. In sequence-related MTL problems strategies like one-to-many, many-to-one and many-to-many parameter sharing have been developed for frameworks such as seq2seq and LSTM recurrent networks (Pengfei Liu et al, 2016). Employed a Variational Recurrent Neural Network (VRNN) and a four-hot representation of AIS data for maritime surveillance tasks that includes vessel trajectory reconstruction, anomaly detection and vessel type identification (Duong Nguyen et al, 2018). This approach considered various temporal granularities and achieved enhanced performance by simultaneously learning multiple tasks. (Pim Dijt et al, 2020) introduced an MTL seq2seq model for vessel trajectory prediction by incorporating AIS data, radar images and Electronic Navigational Charts (ENC) as inputs. This model demonstrated improved prediction accuracy by leveraging diverse types of information by highlighting the efficacy of MTL in vessel trajectory prediction tasks.

## 3.Methodology

### 3.1 Vessel trajectory prediction:

Predicting vessel routes faces challenges due to the dependence on human decision-making which can lead to errors especially in complex navigational environments (Silveira et al, 2019). Although AIS data is valuable it comes with limitations such as irregular time intervals and route diversity (Tu et al, 2020). Maritime routes exhibit repetitive patterns that reflect traffic characteristics by enabling the formulation of prediction concepts covering direction, speed and statistical analysis (Bautista-Sánchez et al, 2021).

A comparative study on route extraction methods indicated that semantic-based approaches yield significantly more routes than grid-based methods thereby enabling a more comprehensive identification and analysis of routes (Yan et al, 2020). Methods that merge semantic routes with graph theory have emerged to tackle route extraction that provided advantages over traditional clustering and grid-based methods. Statistical analysis of route densities can assist in identifying busy routes and areas by forming the basis for route prediction. Optimizing route planning enhances voyage safety, streamlines navigation and reduces unnecessary costs, contingent upon vessel characteristics and operational conditions (Cheng et al, 2019) and (Knapp et al, 2010).

Figure 2 depicts the different methods to extract the maritime traffic routs by Yan’s method in 2(a) and by Cheng’s method in 2(b). Integrating algorithms and geographical data facilitates the generation of optimized routes for reducing risks of accidents, economic losses and environmental crises (Karim et al, 2021). Effective route prediction also contributes to collision prevention especially in port areas and narrow passages prone to accidents (Fang et al, 2020). Autonomous vessel navigation systems can leverage AIS data for proactive route generation, bolstering safety by anticipating and avoiding potential collisions. Vulnerabilities like spoofing and cybersecurity threats emphasize the importance of addressing risks associated with relying on AIS data in autonomous navigation systems (Karim et al, 2021).

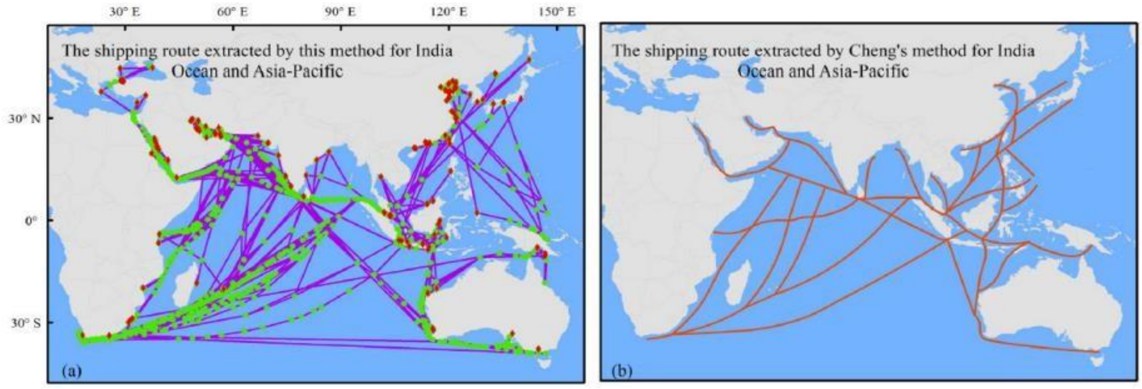


**Figure 2: Comparison of different methods to extract maritime traffic routes. (a) the maritime traffic routes in the Indian Ocean and Asia-Pacific region extracted by Yan's method [17]. (b) the maritime traffic routes in the Indian Ocean and Asia-Pacific region extracted by Cheng's method [18]**

**3.2 Moving Trajectory Clustering:**

Vessel Moving Trajectory Clustering is a technique used to extract significant patterns from vessel movements by leveraging the recurring routes and consistent navigational behaviors observed in vessels (Hakola et al, 2020). This method relies on the outcomes of vessel trajectory clustering where clusters representing substantial numbers of vessels are retained while smaller clusters are disregarded as noise due to their limited representation of routes. The methodology comprises various essential steps which includes data preprocessing, port extraction and trajectory clustering each contributes to the extraction of route patterns from vessel movements.

During the initial data preprocessing phase, lengthy vessel tracks are divided into shorter sub-tracks at points where notable temporal gaps occur by indicating potential interruptions in continuous voyages. Trajectories commencing and concluding at mooring status which are typically indicative of port anchorage that are singled out while anomalous speed points are discarded to improve data quality (Xinqiang Chen et al, 2022). Subsequently a linear interpolation method is utilized to ensure a uniform time interval between consecutive trajectory points and trajectories with insufficient sequence lengths are removed to focus on robust data subsets. Port extraction involves identifying low-speed points within each sub-track that serves as indicators of vessel mooring status. These points are then categorized into clusters using the K-means and Density-Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm which distinguishes core points based on their proximity to neighboring points within a specified radius. Figure 3 depicts the k-means clustering for the moving trajectory and Figure 4 depicts the DBSSCAN for moving trajectory. This clustering process is crucial for automatically and efficiently identifying port locations that are particularly when manual port matching is impractical due to unavailability or complexity.

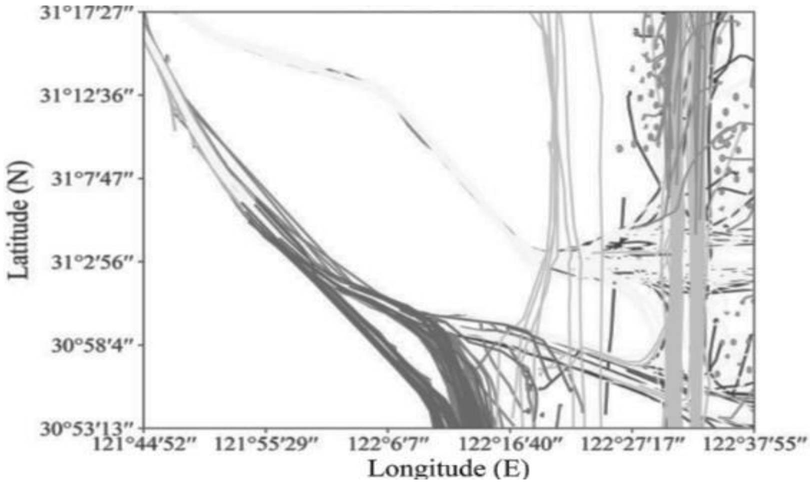


**Figure 3: K-means clustering for the moving trajectory**

Subsequent to port extraction, trajectory clustering is conducted to group trajectories based on their departure and arrival ports. This representation incorporates geographical positions that provides a concise indicator of vessel traffic patterns. Trajectories with similar shapes and dynamic attributes within each origin-destination (OD) group are further clustered using DBSCAN in a higher-dimensional space. This multidimensional representation encompasses trajectory length, time duration, speed statistics and directional information by enabling a comprehensive analysis of vessel movements. The resulting trajectory clustering outcomes unveil distinct patterns wherein vessels demonstrate similar behaviors along their routes. These patterns consider both temporal and spatial aspects, reflecting vessels' navigational tendencies and route preferences (Hakola, 2019). By examining these patterns, insights into vessel movement dynamics are obtained, facilitating enhanced route prediction, navigation optimization, and management of maritime traffic.

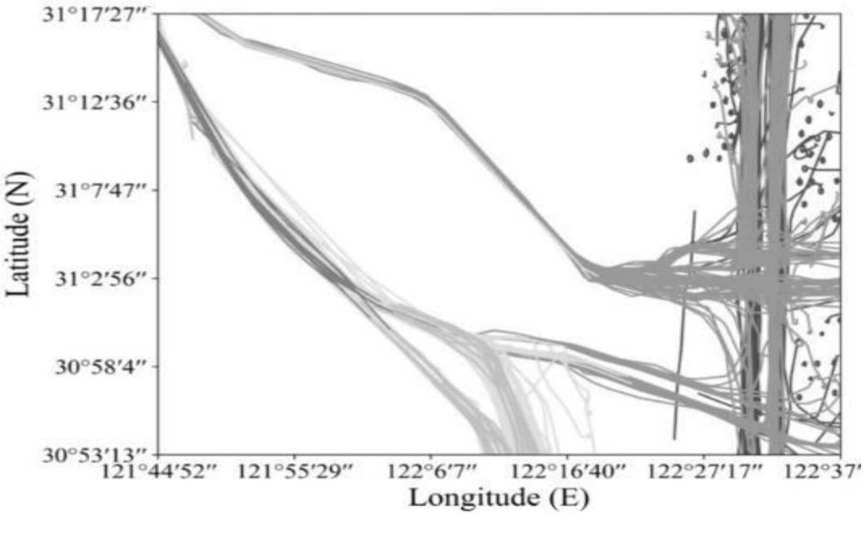


Figure 4: DBSCAN for the moving trajectory

### 3.3 Multi-Stacking Ensemble Learning Architecture for Route Pattern Classification:

The ResNet101 architecture holds great significance in solving classification problems which includes route pattern classification. ResNet101 is a deep residual network that consists of 104 convolutional layers. These layers are organized into 33 layers-per-block with 29 blocks directly utilized in the earlier layers of the network.

In the context of this research work, the ResNet101 model is adapted to perform route pattern classification. The original fully connected (FC) layer of the ResNet101 which was designed for 1000 object classes is replaced with a new FC layer that corresponds to the number of patterns in the selected route that results in four classifications for the fully connected layer as depicted in figure 5. By customizing the FC layer, the ResNet101 model becomes specifically tailored for route pattern classification. The new FC layer is designed to capture the distinctive features and characteristics of the different patterns present in the route. This allows the model to learn and extract meaningful representations of the route pattern information and enabling accurate classification.

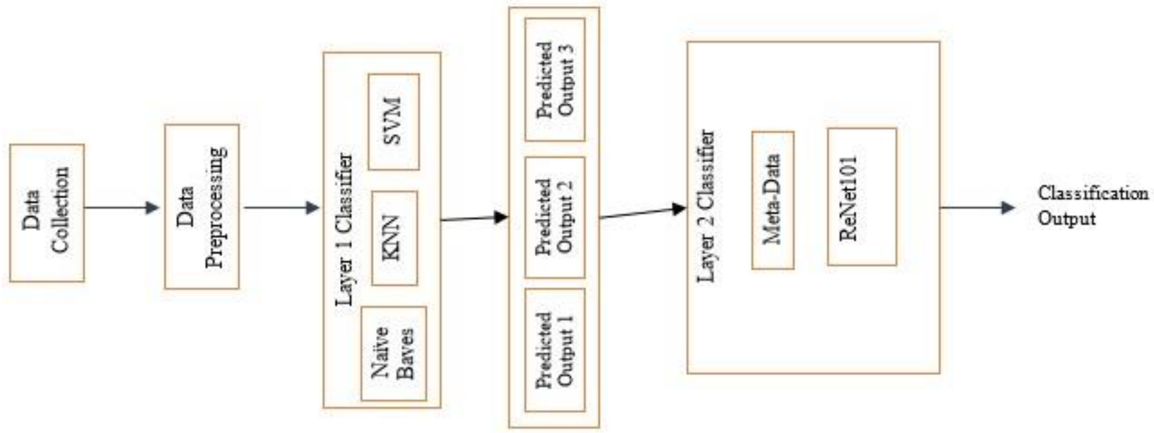


**Figure 5: Multi-Stacking Ensemble Learning Architecture for Route Pattern Classification**

Table 1 Evaluation metrics for models

| Models | TP (Z) | FP (Z) | TN (Z) | FN (Z) | Precision (%) | Accuracy (%) | Recall (%) | F1-Score (%) |
|---|---|---|---|---|---|---|---|---|
| Naïve Bayes | 489 | 251 | 1543 | 233 | 66.12 | 80.73 | 67.69 | 66.88 |
| KNN | 328 | 243 | 1236 | 320 | 57.08 | 73.39 | 50.45 | 53.57 |
| SVM | 513 | 173 | 1586 | 87 | 74.54 | 88.87 | 85.34 | 79.57 |
| LSTM | 522 | 16 | 1704 | 21 | 96.85 | 95.96 | 95.94 | 96.40 |
| Seq2Seq | 533 | 25 | 1709 | 20 | 95.68 | 96.27 | 96.22 | 95.94 |
| **MSEL** | 540 | 17 | 1720 | 21 | 96.77 | 97.25 | 96.06 | 96.43 |

These evaluation metrics collectively offer a comprehensive assessment of the proposed method's performance in route pattern classification. Precision and recall provide insights into the model's ability to classify route patterns accurately while accuracy offers an overall measure of correctness. F1-Score balances precision and recall by providing a single metric to gauge the model's performance across both aspects. By analyzing these metrics, the proposed method named Multi-Stacking Ensemble Learning Architecture provided valuable insights and iteratively refine it for enhanced performance. The MSEL method outperforms all existing methods in terms of precision, accuracy, recall, and F1-Score. MSEL achieves the highest precision and accuracy among all methods, indicating its superior ability to classify route patterns accurately. MSEL also demonstrates competitive recall and F1-Score, indicating its effectiveness in capturing positive instances while minimizing false negatives.

**4. Conclusion:**

The research concludes that the integration of Artificial Intelligence (AI) particularly through the MultiStacking Ensemble Learning (MSEL) architecture significantly advances maritime trajectory prediction and route pattern classification. By addressing challenges such as reliance on human decision-making and irregularities in data, the research enhances prediction accuracy by contributing to safety and operational efficiency in maritime transportation. The MSEL architecture built upon the ResNet101 model outperformed existing methods by capturing intricate vessel movement patterns and improving long-term prediction accuracy. Leveraging ensemble learning techniques, MSEL enhances route planning and navigation optimization by facilitating sustainable maritime practices. Overall the research underscores the transformative potential of AI in the maritime industry.

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# Enhancing Realism in Maritime Simulators through Operational Data and Machine Learning

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**Abstract:** The aim of this paper is to set out a method to improve the accuracy of ship handling simulator models by applying operational data. The forces acting upon the ship, its mass and dimensions are different for every ship model. In Kongsberg simulators ship-specific coefficients are stored in a Ship Database file and are normally calculated using formulas. The method in this paper selects coefficients that result in the simulator model to reflect the real ship's behaviour most accurately, instead of first aiming for 'correct' coefficients only to make arbitrary alterations (based on expert observations) in the validation phase. The focal point to develop the method was to improve the accuracy of the Turning Circle. The making and execution of variations of the Ship Database file was automated. Multiple coefficients in the Ship Database file that influence the relevant forces and the mass were selected to vary. To optimize, inspiration was drawn from genetic algorithms. Each generation is a sample around the best solutions of the previous generation. After completion, the best model's Turning Circle resembled that of the real ship. This innovation project represents a step forward in the integration of hydrodynamics with data science optimization techniques.

*Keywords*: Maritime Simulator; Machine Learning; Operational Data; Optimization; Realism

## 1. Introduction

Ship manoeuvring simulators are important tools to train (future) maritime professionals in various skills and to optimize safety, stability and capabilities of (designed) ships. There are various simulators on the market currently, of different brands and different in size. A much discussed topic around simulators is the accuracy and realism. "Accuracy is defined as the degree to which a simulator's real object representation is precise and is normally associated with an objective measurement; it is about exactness" (De Oliveira et al., 2022). "High simulator realism means that the participants experience the training as resembling real situations from their fields of interest. This is (likely) assumed to result in higher involvement and motivation. A high level of realism is also expected to positively affect transfer of training. If the participants do not see the training as being realistic, this could in turn affect their commitment to the training and the learning outcome" (Saus et al., 2010). Because the accuracy and realism have a positive effect on the transfer of training, and transfer of learning is one of the goals of using simulators, a logical step forward is to see how more accuracy and realism can be achieved. The students' perspective when working on a simulator is from the bridge of a ship's model, therefore the accuracy of the simulator largely depends on the quality of the model.

For this innovation project the Kongsberg simulator development tools and simulators of the Maritime Simulator Training Centre (part of Maritime Institute Willem Barentsz) were available. The rough version of the Ship Database file (normally proprietary) of a ferry to and from the island Terschelling, The Netherlands, is open to work with as it was developed in house. In the real world two of these vessels are in operation, called the Willem Barentsz and the Willem de Vlamingh. The most basic operational data, trial manoeuvres, as well as ship's particulars were made available, by the shipping company that operates the ferries ('Rederij Doeksen'), for the development of the model. No other sensor data was collected apart from the speed-, power- and manoeuvring trials. The ferries are catamarans and are equipped with contra-rotating azimuth thrusters, this means it is a complex ship to model. The aim of this paper is to set out a method to improve the accuracy of ship models by exploiting the limited available operational data.

**The challenge of simulator model development**

Before getting into the development of models, it is important to understand their working principles. The speed over the axis (surge, sway and heave) are derived from Newton's second law. The acceleration of an object (ship) depends on the mass and the amount of force that is applied. Force equals mass multiplied by acceleration. For rotation (yaw, roll and pitch), the force equals the mass multiplied with the radius of the circular path multiplied by the angular acceleration. This means that if (angular) acceleration is integrated once, the (angular) speed is found. Integrating once more provides an orientation and position. Each orientation and position is visualised over small time increments to give the trainee in the simulator the idea of a moving ship. Reasoning the other way around, this means that, as simulation time progresses, the orientation and position of the ship is updated depending on (angular) speed. The speed depends on the (angular) acceleration. The acceleration depends on force, mass and ship dimensions. Two large (opposing) forces, for instance, are propeller force and ship resistance. As ship resistance increases when the speed increases, an equilibrium of forces is found, and at that point, the ship will be at a steady speed at a certain steady propulsion setting.

In figure 1 the simplified development process of simulator models is shown in 4 steps. The forces acting upon the ship, mass and dimensions vary for every model. Inside the simulator core the forces, such as propulsion, steering, resistance, aerodynamic, squat, ship-to-ship interaction and other forces, are the product of formulas containing ship-specific coefficients. The simulator model developer uses a large variety of mathematical formulas and empirical estimations based on collected ship information (step 1) in order to calculate these coefficients. Models are usually based on the particulars of an existing 'real world' ship. The determination of ship-specific coefficients is a labour-intensive and highly specialised job (step 2). To approximate resistance, as example, the method of Holtrop and Mennen (1978) could be applied, which is based on the regression analysis of a vast range of model tests and trial data.

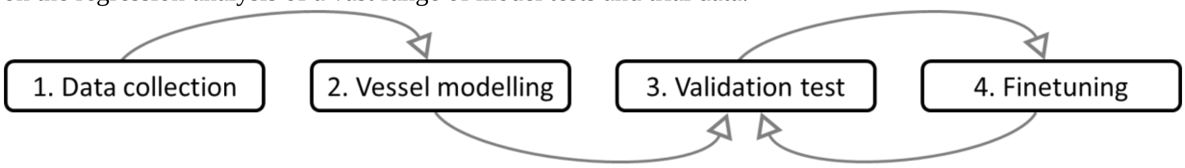


Figure 1. Simplified simulator model development steps

For Kongsberg simulators, the coefficients are stored in a Ship Database file (Zaikov et al., 2015). This part of ship model development is, apart from the graphic design of the model, another labour-intensive job that influences the realism of the simulator. The graphic design, however, is not part of this paper, this paper will only elaborate on the determination of the ship-specific coefficients. The practical validation test (step 3) currently depends on ship handling experts performing manoeuvres on the simulator, to be able to determine how accurate the model reflects the real ship. Together with a comparison of the model behaviour against manoeuvres of the manoeuvring booklet, the model's validity is determined. But this is somewhat subjective. Finetuning the coefficients (step 4) to achieve more accuracy on one area, means that on another area the behaviour might become less accurate. This results in a further deviation from the calculated coefficients. Through innovation, however, it is perhaps possible to aim directly for the simulator model behaviour that most accurately reflects the real ship behaviour, instead of first aiming for the 'correct' coefficients only to make "gut feeling" alterations when finetuning. This means that the way of determining the ship-specific coefficients in steps 2 and 4, resulting in forces acting upon the model, could perhaps be partly combined in one step.

The real ship's behaviour can be captured in operational data, of which the trial manoeuvres are the most common and simple example. Modern ships continuously collect various data for multiple applications, for instance voyage monitoring, real-time trim optimization calculations and engine room watchkeeping. Operational data about ship position, orientation, movement, wind, rudder, propulsion and other parameters can also be very valuable when constructing a simulator model. The necessary data is lacking to replace the formulabased simulator core with another prediction method such as Support Vector Regression (Finnema, 2024) or a Neural Network based on operational sensor data. Because besides the fact that the simulator core (force equals mass multiplied by acceleration) is basically fixed, it is not feasible to change, it is also still the only way to take into account all possible forces. For example, there are no sensors fitted on board ships to measure the distance between the own and another ship in order to be able to model ship-to-ship interaction. Conclusion, the determination of coefficients is (for now) still required.

## 2. Innovative approach

So, the challenge is to find a method to transfer available operational data into coefficients for the Ship Database file that result in the simulator model to reflect the real ship's behaviour most accurately. Because a rough simulator model was available, it was decided to try to improve the existing rough model with various techniques. A known defect in the model was the initiating and rate of turning, the focal point to develop the method was to improve the accuracy of the Turning Circle. "Starting from an established course and speed, the turning manoeuvre involves turning the ship using the rudder, which is placed at a given angle. The ship then moves obliquely, a kinematic action which begins with a combination of lateral movement (drift) and a rotation around the centre of gravity, and ends with a turn at constant speed" (Baudu, 2014). A sketch of a standard Turning Circle is seen in figure 2.

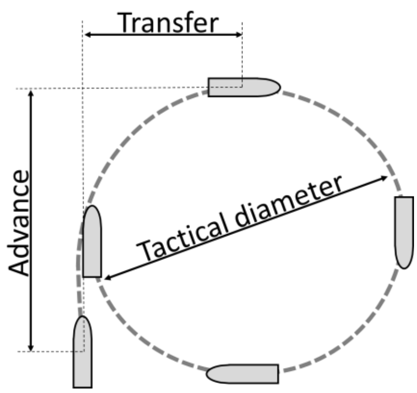


Figure 2. Turning Circle

First of all, creating variations of the Ship Database file (which is an ordinary text file) was automated by programming (in Python). Because there was no access to the functions within the simulator software directly, another program was developed to execute the manoeuvres by operating the Graphical User Interface (GUI) of the software. This enabled the execution of many variations of the same ship in the same manoeuvre automatically and tirelessly. Approximately 10 Ship Database files can simulate a Turning Circle each minute, equalling 600 per hour or 14,400 per 24 hours. Because the path of the turning circle depends on the (angular) speed of the ship, control over the acceleration is required. Multiple coefficients in the Ship Database file that influence these forces and the mass were selected to vary: Mass, Moment of Inertia (yawing axis - Izz), Propeller Diameter and Pitch, Propeller Thrust Coefficients (normally depending on modified propeller advance and drift angle at propeller location) and the Longitudinal, Lateral and Yawing Resistance Coefficients. In fact, the last four are complete tables depending on drift angle and Depth/Draught ratio. These tables are multiplied by a factor to alter as a whole. Mass is normally accurately known, but is used to compensate shortcomings in other parts of the model. Of course, there are many more coefficients, such as Added Mass, that impact the Turning Circle, but for now these 8 parameters are assumed to have enough impact. Because the aim here is to develop a method and not achieve the highest possible accuracy for this particular model, and the complication that more parameters might bring, it was decided to limit the amount of parameters to these 8. The challenge is now reduced to an optimization problem, because the question is what combination of values for these 8 parameters result in the simulated Turning Circle closest to the real ship's Turning Circle. The search for this combination is constrained by time. A brute-force approach, trying all possible variations, is nearly impossible, considering the enormous amount of possibilities and required time (6 seconds each) to test them all. If all 8 parameters would be tested for 10 values only, the required time is $10^8$ multiplied with 6 seconds, equalling 19 years.

## 3. Considered optimization methods

The ability to try so many variations automatically, in such rapid succession, gave the idea to model the influence of each parameter with the help of machine learning techniques like Support Vector Regression or Neural Networks. Machine learning is, according to Arthur Samuel (as cited by Géron, 2022), the field of study that gives computers the ability to learn without being explicitly programmed. But this was proven difficult, even with over one hundred thousand Turning Circles with different parameters as input. This otherwise would have enabled to predict the required parameter values for a certain Turning Circle. Another application would be to predict the Turning Circle of a set of parameters of a model with the machine learning model, enabling a much faster simulation than via the GUI of the simulator software. Over- and underfitting occurred, the modelling proved too complex. Another considered technique is reinforcement learning. "In reinforcement learning, a software agent makes observations and takes actions within an environment, and in return it receives rewards from the environment. Its objective is to learn to act in a way that will maximize its expected rewards over time" (Géron, 2022). Although the transition from one model (rough) into another model (more accurate) could perhaps be grasped by this technique, there is a slight mismatch. The problem discussed here is how to find the single best reward for the set of parameters, not the highest cumulative reward for a streak of environment states.

Efforts to optimize the parameters with a nonlinear derivative–free constrained optimization algorithm (Powell, 1994), COBYLA from the NLopt Python library, resulted in local optima only. This stresses the importance of finding a method that explores the solution space, parameter values between certain limits, both thoroughly as well as efficiently. To overcome the challenge of exploring the solution space, inspiration was drawn from genetic algorithms. Genetic algorithms are an abstraction of biological evolution, using mutation and selection (Yang, 2021). For example, you could create a first generation of 100 solutions and try them out, then ‘kill’ the 80 worst solutions and make the 20 survivors produce 5 offspring each. An offspring is a copy of its parent(s) plus some random variation. This is the next generation. You can continue to iterate through generations this way until you find a good solution (Géron, 2022, p. 686). If the generations would be created completely random between the limits of the parameters, it might occur that the sample is skewed because certain parts of a parameter’s space is over- or underrepresented. According to Martins & Ning (2021), random sampling tends to exhibit clustering and requires many points to reach the desired distribution. Latin Hypercube Sampling (LHS) is a popular sampling method that is built on a random process but is more effective and efficient than pure random sampling. So in random sampling, each sample is independent of past samples, but in LHS, we choose all samples beforehand to ensure a well-spread distribution (Martins & Ning, 2021).

**4. Prototype and validation test results**

In order to test the genetic inspired algorithm combined with LHS, a prototype was programmed. The first generation (0) is a large sample between sensible limits of the parameters. These variations are tested on the simulator and rewarded with a score based on the path of the simulated turning circle relative to the path of the Turning Circle of the real ship. A certain amount of best solutions (‘elites’) are selected, around which new, smaller, limits are set. Within this bandwidth a new sample is created. All these new solutions together (a new generation) are tested on the simulator and rewarded. The initial limits, amount of generations, generation size, amount of elites and bandwidth per generation can be tuned to achieve the highest possible score. The runtime of the algorithm is impacted by most of these aspects, this remains a limiting factor. A final way of tuning is the way the path of the simulated Turning Circle is rewarded.

The performed manoeuvre was a combination of 1 minute of sailing straight (at full ahead), directly followed by a Turning Circle over starboard with the azimuth thrusters at a 35 degree angle. This ensured the maximum speed of 14 knots was maintained by the model on the straight stretch, balancing resistance and propulsion forces. After 1 minute simulation time, the first position was reported back. At four more points in time the position was recorded, at the times in which the real ship was oriented 90, 180, 270 and 360 degrees away from the initial course. For all five points the difference in position, in relation to where the real ship would be, was used to calculate a score (*R*). A perfect match will result in a score of 500 points. A misalignment (*d*) of 5 meters for one position results in a deduction of 0.25 points, 10 meters in 1 point and 20 meters in 4. points. This is expressed in formula 1:

$$R = 100 - 0.01 \times d^2, \tag{1}$$

The initial parameter limits, the minimum and maximum values for each parameter, are listed in table 1.

Table 1. Initial limits

| Parameter | Min | Max |
|---|---|---|
| Mass (tons) | 200 | 1000 |
| Moment of Inertia (t·m²) | 15000 | 45000 |
| Diameter (m) | 1.0 | 3.5 |
| Pitch (ratio) | 0.1 | 0.9 |
| Thrust coefficient table (factor) | 0.5 | 1.5 |
| Longitudinal resistance table (factor) | 0.5 | 1.5 |
| Lateral resistance table (factor) | 0.5 | 1.5 |
| Yaw resistance table (factor) | 0.1 | 1.0 |

Initial attempts failed to optimize the Turning Circle. Further analysis of the resistance tables showed that the Yawing Resistance table was in fact erroneous, resulting in a choppy angular acceleration. This table was replaced by a simpler table found in another version of the model, one that actually predicted a Turning Circle much smaller than the real ship. Mixing the coefficients of these two 'inaccurate' models resulted in a model that had a tactical diameter of only 105 meters (184 meters smaller than the real ship). This meant the need to optimize the model still persisted. The total runtime of the algorithm was 37.5 hours (on an ordinary laptop with i5 processor). An overview of the progress over the generations, including the average score and standard deviation per generation, is in table 2.

Table 2. Overview of validation test

| Generation | Size | Elite number selected | Bandwidth (%) | Best score | Average score | Std. Dev. (σ) |
|---|---|---|---|---|---|---|
| 0 | 3600 | 6 | Initial limits | 424.0 | -3740.9 | 3602.3 |
| 1 | 3600 | 6 | 25 | 466.2 | -97.4 | 1466.8 |
| 2 | 3600 | 3 | 20 | 472.3 | 289.1 | 807.7 |
| 3 | 3600 | 3 | 15 | 475.4 | 63.5 | 1665.4 |
| 4 | 3600 | 3 | 10 | 476.7 | -134.6 | 2053.2 |
| 5 | 3600 | 1 | 5 | 477.4 | -375.6 | 2376.5 |
| 6 | 300 | 1 | 1 | 477.6 | 477.2 | 0.3 |
| 7 | 300 | 1 | 1 | 477.7 | 477.3 | 0.2 |
| 8 | 300 | 1 | 1 | 477.8 | 477.5 | 0.2 |
| 9 | 300 | Optimum selected | 1 | 477.9 | 477.6 | 0.2 |

The predicted Turning Circle in relation to the real ship's Turning Circle is shown in figure 3. Both dotted lines are 4th degree polynomial fits, as not all datapoints of the real Turning Circle were available. The lines are based on the 5 compared points and are meant as rough indication only. The start of the Turning Circle (after 1 minute of sailing a straight line at full ahead) is matching, meaning that the maximum speed of the model is matching the real ship. The positions in which the real ship had an orientation of 90, 180, 270 and 360 degrees show 21.0, 16.4, 12.6 and 36.5 meters difference respectively. The tactical diameter of the Turning Circle of the optimized model is 267.6 meters, 21.4 meters smaller than the real ship. A simulator instructor, who frequently used the rough model, confirmed the behaviour is now more accurately reflecting the real ship.

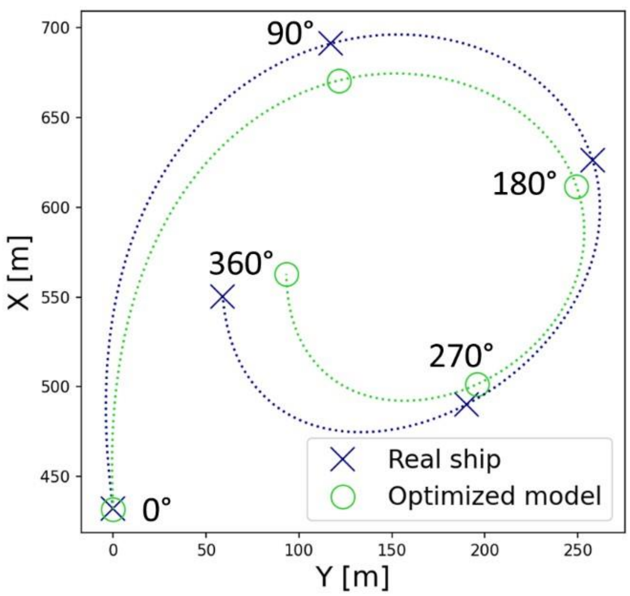


Figure 3. Turning Circles (polynomial fits)

Final validation of the model happened on a full mission simulator in order to find out if any negative side effects occurred after optimizing the Turning Circle. This did not appear to be the case, although it must be highlighted that this was neither a complete nor a thorough test. Another important aspect is that the result found in the validation of this prototype might be a local optimum, instead of the absolute optimum. A larger generation 0 could prevent this, but time is still a limiting factor. This is partly because the algorithm depends on the use of the Graphical User Interface, as the functions within the software cannot be called on directly. Also, the possibility exists that there are multiple solutions with the same result. Brief experimentation with the pyGAD library (Gad, 2023), a typical genetic algorithm in which solutions blend and mutate randomly, resulted in a score of 463 points in a time of only 5 hours. This indicates that there is a potential to optimize faster. The application of nonlinear derivative–free constrained optimization algorithms showed that the local optimum can be reached from a relatively nearby solution within roughly 20 minutes.

## 5. Discussion and outlook

The original objective of the innovation was to apply operational data in order to work towards accurate model behaviour directly, while not relying on arbitrary adjustments based on operational experience in the validation phase. The algorithm came up with parameter values that resulted in a Turning Circle that resembles the real ship's Turning Circle, while still achieving the same maximum speed. It must not be overlooked that the values might represent a local optimum, as well as that perhaps more than one combination of parameters may have the same result. Also, a comparison (figure 3) of the Turning Circles still shows a difference. It is likely that this difference still exists because not all (only 8) parameters were selected to optimize. A validation on the simulator did not immediately indicate any negative side effects. However, the model's performance as a whole is not completely explored. Also important was to work with the simulator as it is, not having to change anything to the simulator software itself. This challenge was overcome, but the Yawing Resistance table had to be replaced by an alternative to make it work. So it still remains important to calculate the coefficients correctly, although to a lesser extent. The methodology of simulator model development is hard to grasp and may vary between individual developers, each bounded by the brand of simulator they are using. Therefore it is hard to say how well this method generalizes to the development of models in general and another unknown outcome is how much time can be saved when using this method instead of the original way of finetuning.

Future developments of this innovation would include the use of more parameters, more operational data (not limited to the standard trial manoeuvres) and perhaps the use of a larger variety (and combination) of machine learning and optimization techniques. Furthermore, as brief experimentation with the pyGAD library and the nonlinear derivative-free constrained optimization showed promising results, the application of these algorithms should be investigated further. A combination of these methods should be considered too. Another essential consideration is the application of machine learning models such as Support Vector Regression and Neural Networks to replace (part of) the simulator's prediction model, although the challenges as described earlier in this paper, are still to overcome. The integration of hydrodynamics with optimization techniques, a key aspect of data science, offers benefits in achieving accuracy in model development process. This was proved by the observed similarity of the model's Turning Circle and that of the real ship. Notably, the actual runtime of the algorithm was 37.5 hours, perhaps enabling simulator model developers to save time. This innovation project represents a step forward in the integration of hydrodynamics with data science optimization techniques to enhance the accuracy of simulator models and therewith potentially providing for the future demands of accuracy and realism in maritime simulator training.

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