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IAMU | AGA23

Helsinki, Finland | 18-21st October 2023

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

IAMU International Association of Maritime Universities

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Preface

The IAMU Conference (IAMUC) is the part of the 23rd Annual General Assembly (AGA 23) of the International Association of Maritime Universities (IAMU). The IAMUC offers its members the global platform to share their experience and to plan the development of maritime education and related research.

IAMUC 23 invites international experts to disseminate their latest research results. As the hosting university, Satakunta University of Applied Sciences provides face-to-face in the Assembly activities. First time in IAMU Conference history, the Conference is organized on a ship between Helsinki, Finland and Stockholm, Sweden.

"Quality of the Education of Global Maritime Professionals" is the theme of the AGA 23 IAMUC.

The IAMUC program covers the whole range of maritime domain incorporating Environmental, Technology, Economic, Social and Policy sections. The Conference topics deal with Breakthrough Technologies for Seafaring and MET, Managing Maritime Safety and Security, Environmental Sustainability in Seafaring and Education of Global Maritime Professionals. During the conference, site visit to the ships deck and engine room are made.

IAMUC 23 participants are offered to take part in technical workshops and to discuss a wide range of scientific research with keynote and invited speakers.

"The International Association of Maritime Universities (IAMU) Conference Book" contains information concerning the organization and program of the IAMUC 2023 and the abstracts presented at the IAMUC in Helsinki, Finland on 19th and 20th of October 2023.

Submission of 99 high-level abstracts from 25 countries and 40 IAMU universities resulted in 26 oral and 24 poster presentations.

The oral presentations at the sessions are followed with the poster presentations held during coffee/tea breaks. First time, the posters are displayed electronically on screens.

We express our gratitude to the reviewers for their partnership with the authors and contribution in improvement of the quality of submitted papers.

We are very grateful to the International Program Committee, Session Chairs, IAMUC supporting team and SAMK Administrative assistants, who selflessly contributed to the success of the Conference. Also, we are thankful to all the authors who submitted the papers and shared their experience.

Last but not the least, we express our most heartfelt thanks to the IAMU Secretariat for the greatest support and inspiration at each stage of the IAMU AGA implementation.

We hope that experience, shared at IAMUC 23, will promote quality of global maritime professionals' education and research.

Adjunct professor Minna Keinänen-Toivola

IAMUC 23 Program Editor

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IAMUC Chief Program Editor

Theme

Main theme Quality of the Education of Global Maritime Professionals

Sub-Themes

Breakthrough Technologies for Seafaring and MET
Managing Maritime Safety and Security
Environmental Sustainability in Seafaring
Education of Global Maritime Professionals

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Content

IAMUC 2023

Proceedings of
The International Association of Maritime Universities (IAMU) Conference

Session

Environmental Aspects

Life Cycle Assessment to Determine the Relevance of Including Absorption Cooling Plants in the Curriculum for Marine Engineers

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Abstract: The need for a sustainable transition of energy and shipping industries necessitates a methodological approach to determine the most environmentally relevant content and learning objectives of educational programs within technical engineering. One approach is application of Life Cycle Assessments (LCA); a methodology suitable for evaluating environmental performance of technologies, product systems or practices.

To evaluate this approach, a case study comparing conventional cooling for air conditioning onboard cruise ships with absorption cooling is undertaken by the authors, where a consequential LCA using inventory data from a market supplier and a life cycle inventory database is conducted. Eighteen environmental impact areas are considered in the study, with no external normalization or weighting of results. The results are proven using two types of fuel, marine diesel oil and methanol.

The impact assessment results uniformly identify the absorption cooling plant as having the best environmental performance with potential impacts averaging 20% of the conventional plant in most categories. These results indicate that absorption cooling plants should be included in the curriculum for marine engineers.

A more widespread adoption of the methodology to evaluate or qualify course content will likely require further qualification of teaching staff, due to prerequisite knowledge requirements for conducting LCA's.

Keywords: Environmental Assessment; LCA; Course Content Qualification; Sustainable Transition

1. Introduction

Marine engineers are at the forefront of technological development and advancements. While not necessarily taking direct ownership in new product development, the ongoing management and assimilation of new technology in operations is a cornerstone of the profession. This is also evident from the title of the bachelor's program in Denmark: "Bachelor's Degree Program in Technology Management and Marine Engineering" (BTME).

The exponential growth in technology, and the urgent need for decarbonization of all sectors requiring novel solutions and optimizations, empathize that educational institutions should remain vigilant in ensuring that curricula are updated to reflect current and future needs (Cassard & Hamel, 2018). The overall content of the BTME is defined in the pertinent law act and the International Convention on Standards of Training, Certification and Watchkeeping (STCW). While STCW lists specific requirements for a number of subjects, the law act stipulates high level requirements and intended learning outcomes in a number of technical and management fields, thus allowing the professional colleges offering the program considerable flexibility in determining the taught subjects and technologies covered.

A frequently utilized data source to determine updates to the curriculum is dialogue with shipping companies and maritime authorities. In this study we propose an alternative methodology, in which suggestions for changes to the curriculum may be qualified via their change to the potential environmental impact for a given use case or service. The methodology proposed is Life Cycle Assessment (LCA), a tool used for comparative assessment of different technologies (Bjørn et al., 2018).

Rather than relying on a reactive, qualitative approach, where new technology must first be adopted by the industry, which in turn requests said technology included in the curriculum, we propose a data-driven method governed by the urgent need for a sustainable transition of the industry to determine if a technology should be included in the bachelor's program.

Energy efficiency improvements have been identified as one of the lowest cost mitigation pathways to limit global warming due to anthropogenic greenhouse gas emissions (GHG) (IPCC, 2022). For ship designs, continual improvements to energy consumption are stipulated by the International Maritime Organization (IMO) via the Energy Efficiency Design Index guidelines (MEPC, 2011). In cruise ships, most of the energy is used for propulsion and HVAC purposes (Barone et al., 2020). In both areas, energy consumption may be optimized via new and more efficient technology, or by behavioral changes, e.g., changed comfort settings or better route planning. Adopting more eco-friendly behavior can have substantial impact, but requires backing in policy for efficient implementation, as exemplified by the banning of CFCs (Haas, 1992) (Skinner, 1987).

While regulatory changes to the operation of cruise ships could potentially change environmental impacts from said ships, this paper focuses on the difference in impact from two different technologies to provide the same service on the basis that novel alternatives to established technologies should provide superior environmental performance to be included in the curriculum.

Thus, in this paper an LCA comparing two technologies for the provision of cooling for HVAC and evaluate their environmental performance is presented. Specifically, a conventional compressor driven chiller to an absorption chiller.

Absorption chillers, or heat pumps, utilize waste heat from main and auxiliary engines to produce cooling. While the absorption cooling process was invented in 1858, few such plants presently exist onboard ships due to various technical matters (Hafner et al., 2019). Recent innovations, however, are likely to increase the applicability in the coming years (Lundsgaard, 2016). From an environmental and sustainability viewpoint, absorption chillers offer lower electricity consumption and do not contain ozone depleting refrigerants with high global warming potential, but the plants are larger and heavier and thus consume more materials (total mass) in the construction phase (Nikbakhti et al., 2020).

The present study serves two purposes; 1) assessing the potential environmental impact of the compared technological solutions; 2) presenting a novel approach to qualifying subject matter included in an educational program. As such, the LCA carried out in this study serves as a pilot study to illustrate the validity and relevance of the methodology while offering concrete decision support to determine the best environmentally performing cooling solution in a concrete use case.

2. Materials and Methods

Goal and scope definition

This study compares two technologies for air conditioning onboard cruise ships using a consequential LCA covering cradle (extraction of raw materials) to grave (disposal or recycling of used materials).

By assessing the potential impacts across a range of impact categories, the compared systems may be evaluated against each other on their environmental performance during their life cycle stages. Unless otherwise explicitly mentioned, all inputs and emissions above a 1% threshold (cutaway) are included. Usage scenarios may vary across specific ship technology and sail routes, this is not considered in the present study.

The result of the study may be used to a) determine the environmentally best performing technology b) evaluate the importance of including learning objectives specific to absorption cooling plants. The latter based on a principle, that environmentally superior technologies should be included in the education program. The target audience of the study is professors at maritime and technical universities and maritime engineering professionals as well as other engineering professionals working with processes where both waste heat and cooling demand is present.

The functional unit (FU) towards which all flows are normalized is defined as the provision of 1 MWh of cooling for air conditioning purposes, specifically in the form of chilled water at a temperature of 12-19˚C. The lifetime of either plant is set to 25 years with an average daily cooling production of 5 MWh. The reference flows are thus defined as a) one absorption cooling plant using waste heat from ship engines and b) one traditional compressor cooling plant using R134a as refrigerant. Plant size is set to 300kW cooling capacity in both cases.

Validity of results is evaluated using scenario analysis with two types of fuel: marine diesel oil (MDO) and bio-methanol (MeOH). Emissions to air from burning of MeOH are not included.

Technology process overview

In a traditional cooling plant, an electrically driven compressor increases the pressure in an evaporated refrigerant which is then condensed, thereby releasing thermal energy, and subsequently expanded and evaporated, thereby absorbing thermal energy.

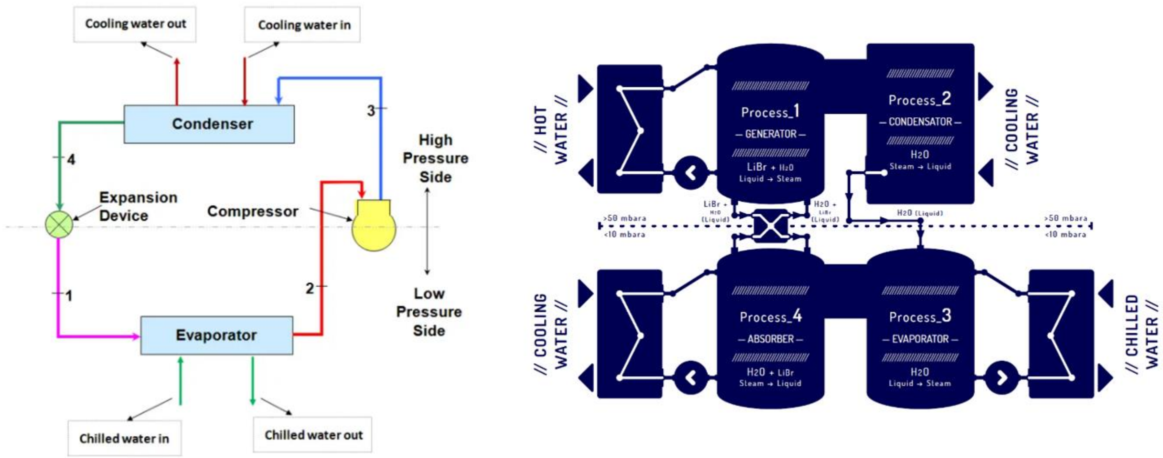

Figure 1 – Conventional compressor driven cooling plant (left) and absorption cooling plant (right)

Conversely, an absorption cooling plant utilizes waste heat, e.g., from engine cooling water, to concentrate and boil a refrigerant, which is then condensed using cooling water. The condensed refrigerant is evaporated, absorbing energy. There is no compressor in the plant, only pumps to transport the refrigerant between the process steps. Various pairs of absorbent and absorbate may be considered in an absorption cooling plant, e.g., H_2O-NH_3 or LiBr-H_2O, however, for industrial use cases where intermediate temperatures are needed, LiBr-H_2O is the preferred fluid pair due to superior performance (Nikbakhti et al., 2020). From an energy balance perspective during operation, the difference between the technologies is the needed electrical energy input and the utilization of waste heat. Figure 1 illustrates the two principles.

Inventory analysis and modelling

Table 1 lists main material and energy flows used in the modelling. A maintenance factor of 5% is included in all material input. Material recovery from recycling at EOL is set to 90%. Emissions related to transport and installation of plants are not included in the modelling. For the reference plant, no loss of refrigerant during the use stage is considered, apart from the maintenance factor.

Table 1 – Inventory of materials and energy for the compared systems

Material / energy input	Reference Plant	Absorption Plant
Steel, low alloyed [kg/FU]*	13,81e-3	20,38e-3
Steel, stainless [kg/FU]	n/a	123,3e-3
Copper [kg/FU]	15,19e-3	0,489e-3
Plastics [kg/FU]	690,4e-6	25,32e-3
LiBr [kg/FU]	n/a	18,41e-3
R134a [kg/FU]	2,133e-3	n/a
Electricity consumption during operation [MWh/FU]	0,2[1]	0,04[2]
Electric efficiency of generating set[3]	40%	40%

*FU is defined as 1MWh of cooling as per goal and scope definition

[1]An electrical COP of 5 is estimated for the reference plant

[2] A conservative estimate of electrical COP is set to 25 for the absorption plant

[3]As very limited research is available relating to MeOH as fuel, the same electrical efficiency is assumed for the generating set for both diesel and MeOH.

The consequential approach chosen for this study requires the identification of marginal suppliers to avoid burden shifting, which occurs when alternative fates or uses of materials or energies are not considered (Finnveden et al., 2009).

For the absorption cooling plant, primary data have been used to determine material composition and masses as well as energy flows during operation (Hansen, 2023). Reference plant data and background data used in the study stem from the consequential Life Cycle Inventory (LCI) database ecoinvent 3.8 (Wernet et al., 2016). As a consequential database it includes secondary services in individual processes. Modelling is carried out in SimaPro v.9.5.

In the scenario with MeOH as alternative fuel, a motor/generator set is used for electricity production. Bio-MeOH is considered, meaning that GWP for combustion is set to 0kg CO2eqv/kg.

The Life Cycle Impact Assessment (LCIA) method chosen is ReCiPe 2016, including 18 midpoint impact categories (Huijbregts et al., 2016). Results presented in this study do not include category endpoints or weighting of scores. Results are internally normalized by comparing impacts from the absorption chiller to the reference system.

3. Results and discussion

LCIA results are presented in Table 2. Environmental impact is shown for reference plant using MDO as source of energy for electricity production, with percentages in remaining columns stating impacts relative to this. In nine impact categories, use of MeOH as fuel results in considerably higher impacts (a factor two in freshwater and marine ecotoxicity to a factor 25 in marine eutrophication and water consumption and a factor 36 in land usage). Though not a focus point of the present study, these findings point to the general challenge when replacing fossil fuels with bio-fuels, that although the GWP of bio-fuels may be lower, there may be considerable environmental downsides in other impact areas if performing a 1:1 replacement (Osman et al., 2021).

Table 2 - LCIA results

Impact Category	Unit	MDO **Ref. Plant**		**Abs. Plant**	MeOH **Ref. Plant**	**Abs. Plant**
Global warming	kg CO2 eq	157,5	100%	20%	37%	8%
Stratospheric ozone depletion	kg CFC11 eq	2e-04	100%	20%	3%	1%
Ionizing radiation	kBq Co-60 eq	1,194	100%	21%	-361%	-71%
Ozone formation, Human health	kg NOx eq	2,608	100%	20%	3%	1%
Fine particulate matter formation	kg PM2.5 eq	0,669	100%	20%	45%	9%
Ozone formation, Terrestrial ecosystems	kg NOx eq	2,632	100%	20%	3%	1%
Terrestrial acidification	kg SO2 eq	1,159	100%	20%	27%	6%
Freshwater eutrophication	kg P eq	0,022	100%	23%	475%	99%
Marine eutrophication	kg N eq	2e-04	100%	41%	2.648%	550%
Terrestrial ecotoxicity	kg 1,4-DCB	310,7	100%	20%	53%	11%
Freshwater ecotoxicity	kg 1,4-DCB	2,33	100%	16%	212%	38%
Marine ecotoxicity	kg 1,4-DCB	3,053	100%	17%	213%	40%
Human carcinogenic toxicity	kg 1,4-DCB	0,297	100%	101%	1.639%	409%
Human non-carcinogenic toxicity	kg 1,4-DCB	21,82	100%	29%	711%	151%
Land use	m2a crop eq	2,332	100%	22%	3.656%	733%
Mineral resource scarcity	kg Cu eq	0,065	100%	79%	175%	94%
Fossil resource scarcity	kg oil eq	49,53	100%	20%	26%	6%
Water consumption	m3	0,072	100%	28%	2.426%	493%

The negative impacts calculated for ionizing radiation where MeOH is used as fuel should be disregarded, as the direct emissions from burning MeOH are set to nil in the modelling. A graphical representation of the internally normalized results is shown in Figure 2. The reference plant has higher scores

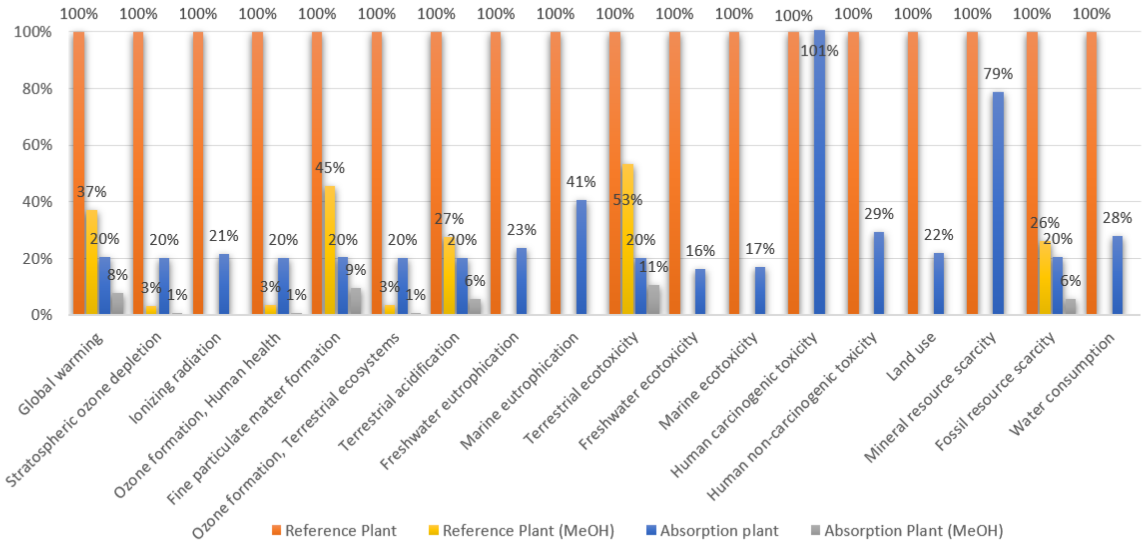

Figure 2 – Internally normalized LCIA results (impacts from reference plant is set to 100%) – the nine impact categories where MeOH performs worse than MDO are excluded from the graph to improve readability

in all but one impact category. Human carcinogenic toxicity is impacted by the chromium used in the large quantity of stainless steel for the absorption plant. Assuming a higher recycling efficiency for stainless steel would negate this impact.

With impact categories affected very differently when using MeOH as alternative fuel, the absorption plant has superior environmental performance with both types of fuel as illustrated in Figure 2 and Table 2.

Cooling is an energy intensive application, with Figure 3 illustrating that the energy consumption from the use stage is dominating across most impact categories. An increase of the conservatively estimated electrical COP of 25 for the absorption plant would be reflected in further improved environmental performance compared to the conventional plant.

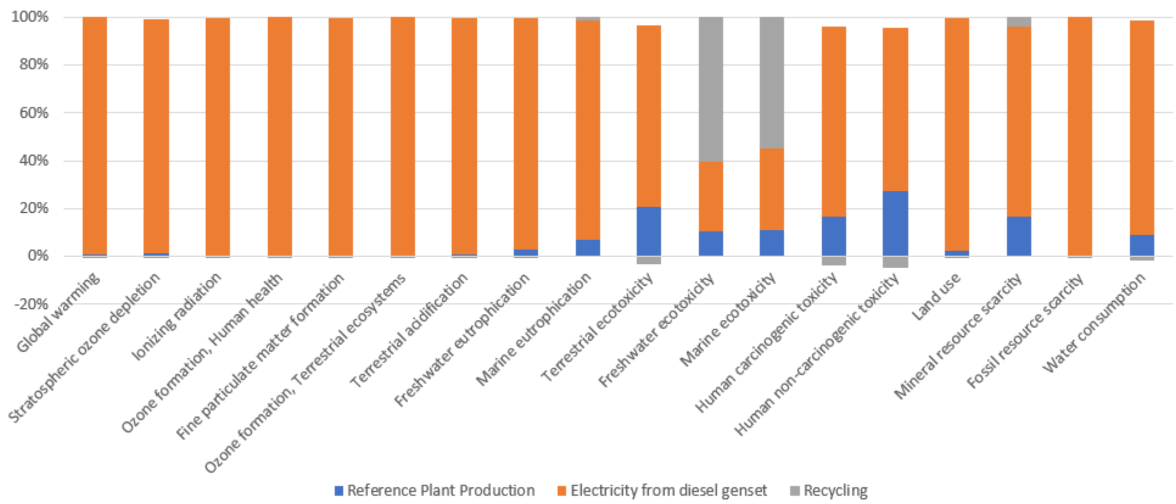

Figure 3 - Impact distribution for reference plant

While no LCA research on specific to the use case of cooling for HVAC onboard hotel ships have been identified during the literature review, other LCA studies comparing absorption plants to conventional cooling have found similar results (Nitkiewicz & Sekret, 2014).

Conclusions and further research

On the premise that technologies with superior environmental performance should be included in the curriculum, the results presented in this study clearly indicate that absorption chillers using LiBr should be included. It is also clear that the electricity consumption during the use stage of cooling plants have the largest environmental impact, indicating that improvements to COP or lowered cooling requirements would have significant effect. The consequential LCA methodology is well suited for decision support, and while time-consuming to conduct, provides a quantitative alternative or supplement to industry interviews. While the use of LCI databases facilitate the creation of LCA's, some experience and prerequisite knowledge is required in constructing the necessary inventory, assessing data quality, and performing the impact assessment and assessment of results. As such, we see a future application of the methodology would entail having a one or more expert LCA practitioners at the professional colleges to facilitate the studies.

In this study, an internal combustion engine is considered for electricity production from bio-MeOH. Further research should be carried out to determine implications of using fuel cells as an alternative. Other pathways for MeOH production or other non-fossil fuels, should be investigated as well.

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Breakthrough simulator technologies for seafaring, education, and training

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Abstract:

The behavior of ships and people in different situations can be modelled in many ways in simulator environments at the Satakunta University of Applied Sciences. The maritime learning environment is equipped with state-of-the-art navigation, engine room as well as hydrostatistics and stability simulators which are combined to one training entity. SAMK's Maritime Training Centre has the only 360-degree bridge simulator in Finland. With the present software, it is possible to simulate all sea fairways in Finland, and in addition it is possible to model any fairway in the world. In our simulator it is possible to perform port maneuvers, fairway steering practicing, operating of different types and sizes of vessels, familiarization, line pilot examinations (half of the fairway navigation practicing can be done on a simulator). In Finland, we are highly skilled in ice navigation, and with SAMK simulator it is possible to arrange audited ice navigation courses: Polar Code/Azipod and DP (meets audited IMO DP3 requirements).

Keywords: navigation simulator, maritime training, maritime know-how

1. Introduction

Given the international nature of shipping, it is important to look at the autonomous impacts of shipping in a wide range of transport areas. Coastal areas in Finland provide a good perspective for the specific characteristics of the region in terms of narrow passages. Around 70% of the international fleet operating in the region is non-Finnish flagged vessels. Most of Finland's shipping traffic is liner-oriented and destined for European ports. There is also some tramp traffic in bulk. Of the non-Nordic and non-Baltic vessels, vessels flying Dutch flags and some of which are flags of convenience visit Finland relatively often. [1] In liner shipping, vessels are piloted in many ways, often the vessel engaged in line traffic has a line pilot. However, a wide range of piloted vessels arrive in Finland, from tramp freighters to passenger ships of various sizes. For vessels where the pilot is asked not only to give instructions but also to drive the vessel, remote pilotage will be a major challenge in the future. The reliability of autonomous vessels in island conditions has not been verified for cargo or passenger vessels in the archipelago. Autonomous vessels must always be placed under the control of qualified personnel.[2]

2 Methodology

The data for the article has been collected by interviewing SAMK´s simulator managers about different training sessions and by conducting a literature review on the various possibilities of simulators. A mapping of the business field in the use of simulators has been carried out as background work for the project. Qualitative interview methods have been used in this paper. The interviews have involved maritime educators from both the deck and engineer side. In addition, simulator managers from the Maritime Logistics Research Center have been interviewed and a table has been coded regarding the current state of simulators and future possibilities from a customer perspective. The interview material consists of interviews within the organisation as well as interviews with domestic shipowners and pilot officers. The methodology of the article is entirely qualitative, so in addition to the interviews, the material is based on the strata studied in the MeriLoki project. The strata studied are mixed-data and based on a literature review in Finland and Europe. The conclusions of the literature review produced during the project are summarized in this full paper.

3. Frame of reference

EU Member States are largely free to define the framework for remote sensing in their own legislation. Domestic legislation and plans for the coming years will support the development of remote sensing in shipping. Also internationally, autonomous shipping has taken significant steps towards more and more remotely operated vessels in the freight transport sector. However, freight markets and transport are international, so the adoption of remote pilotage requires not only legitimacy but also a consensus on the issue among the various stakeholders. In addition to shippers, the view of P&I insurers, for example, is a determining factor in the overall chain. [3] International development and research in the field can be seen as valid in a broader international perspective. The environmental impact of remote sensing should be assessed in detail and the cost and labor implications of remote sensing should be examined.

In Satakunta, Finland, it is possible to model remote sensing conditions: weather, chains of command, communication, in a collaboration between the ISTLAB (Intelligent Shipping Technology Test Laboratory) simulator and a 360-degree simulator. The MeriLoki project is mapping stakeholders' interests in different intelligent simulator solutions. [4]

4. The use of simulators

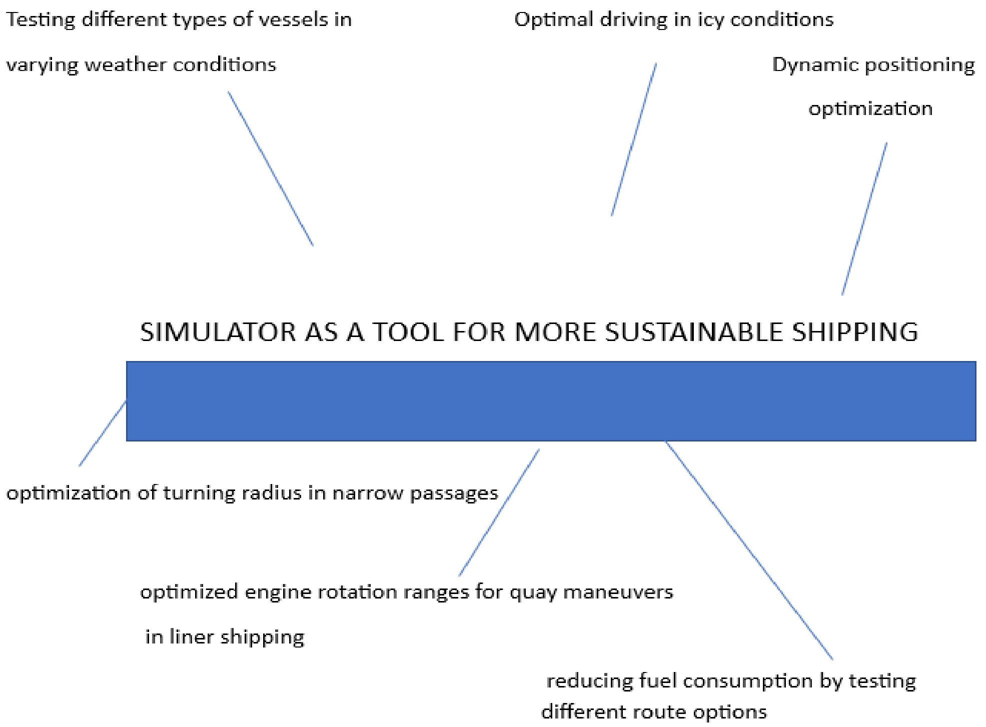
On the navigation side, ice navigation and dynamic ship positioning modules are the most important features of the simulators at SAMK. The management of different navigation situations under varying and changing current and wind conditions and the examination of port sections for planned industrial installations can be modelled in a simulator environment. The effects of different sea conditions on cargo handling equipment can be modelled with the help of the NAPA software. In a 360-degree navigation simulator, the manoeuvring of a ship can be practiced, before moving to the boom of a real ship in different ports in Finland and Europe. The equipment supplier's library makes it possible to obtain different types of vessels and ports for the customer's needs if they are not already on the list.

Through interviews with the most senior pilots, the study has revealed that remote pilotage still requires significant investment in Finland, for example in real-time current, wave, and sea level data. Real-time and lag-free data transfer between shore station and ship is also important in Finland's congested shipping lanes used by merchant vessels. Verifying and testing these things by adding the full potential of 5G networks to exercises is a major element in the development of networks. There is already significant development work on railways in Finland with the Finnish Transport Agency and commercial radio operators [5]. Research data on this issue, combined with the needs of the maritime sector, could be one rational solution. Finland is a pioneer in the development of train control, so the use of the data sets learned on inland waterways would be an important step in the development of maritime transport. Using a simulator to test the challenges, combined with research results from elsewhere, could be seen as an element worth experimenting with.

Investing in the development of chains of command by exploiting better cooperation between deck and engine simulators is one way of identifying problems in shipping and communication. Responding to and communicating problems is another area where cross-departmental cooperation is relevant. Setting up a command centre and practicing rescue operations and going through search patterns with students, maritime officers and crew can be done in a simulator. Especially on passenger vessels, falls into the water occur with regularity, so it is important to have a Williamson reversible translation in the backbone for different types of vessels.

5. Modelling carbon neutrality in shipping

Ship owners and communities have been actively working towards a lower carbon footprint. In addition to major technological changes and fuel options, shipowners are working hard on issues such as route optimization or optimal speeds. Smart port concepts are looking for opportunities to reduce ship anchorage times where charter contracts allow. In liner shipping, ways of optimizing routes can be seen in terms of optimal port calls, route options and economy speed. Experiments have been widely adopted by ship owners and simulators allow for cost-effective modelling on a vessel-by-vessel basis. In SUAS, it is possible to optimize the routing of different types of vessels in different weather conditions. In addition to weather



conditions, ice navigation and dynamic spot-fixing can be verified in advance, for example when modelling port infrastructures (Figure 1).

Figure 1: Optimizing the running of different types of ships is an important task for simulators.

6 Conclusions

The maritime simulators can help reduce the risks associated with on-the-job training, such as accidents, injuries, and environmental damage. They can also provide a controlled environment for practicing emergency response scenarios. The role of simulators is manifold: in addition to route planning, the initial parts of safety and accident training, as well as further work on the practical parts, can be carried out in a variety of ways in simulators. The development of infrastructure and the suitability of different types of ships for different ports can be verified using simulator solutions. In addition, cooperation with the authorities and on-board cooperation between the engine room and the bridge are topics that are generally being considered for the further use of simulators. The construction of different sub-systems for the business environment is nowadays easily feasible. More research on the benefits of simulators is needed. It is also important to model the CO2 savings of the role of simulators. It would be important to map the emissions of simulators on a simulator-by-simulator basis and include this in the company's environmental protection programme. Aiming for zero emission electricity and the ICT sector's low-carbon communication is key as simulators and smart technologies proliferate. Automation and remote pilotage can play a major role in certain forms of transport. Complete remote sensing requires the ship's crew to have considerable detailed knowledge of the fairway. The role of simulators as a teaching and research tool is a step that would reveal the precise challenges in different geographical areas. The second part is the role of simulators in modelling ship consumption data. The role of different fairway sections in liner shipping may play an important role in the future as shipowners collect their data for EU and IMO collection systems. [2]

Acknowledgements

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A STUDY ON THE EFFECT OF SHIPPING POLLUTION IN THE PORT AND TERRITORIAL WATERS OF VISAKHAPATNAM

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Abstract: Shipping contributes to air, water, and soil pollution in coastal and port communities. Pollution caused by the vessels in mid-ocean and the ports differs in terms of causes and effects. Visakhapatnam Port, the second largest port by volume of cargo handled in India, has seen substantial growth in cargo throughput over the past decade, handling 69.84 million tons in FY2020-21. Such bustling port facilities can contribute significantly to pollution due to the extensive ship traffic, cargo, fuel, and waste associated with port operations.

Air Quality is analyzed using the calculation of Air Quality Index (AQI) from data collected of NO_x, SO_x, CO_2, and Particulate Matter $(PM)_{2.5}$ in the ambient atmosphere along the port vicinity. Governing factors of water quality, such as salinity, temperature, turbidity, pH, dissolved oxygen (DO), nutrients, and oil traces, are examined to calculate Water Quality Index (WQI). A Cetacean C57 hydrophone and a TASCAM Recorder are used to detect and test the frequency and intensity of anthropogenic noises. Through the analysis of the data collected, the study aims to generate reliable data for water, air quality, and underwater noise, providing a better understanding of shipping pollution and creating a vision towards adopting green initiatives at Visakhapatnam port

Keywords: Air Quality Index (AQI), Water Quality Index (WQI), dissolved oxygen (DO), underwater vibrations, shipping pollution

1. Introduction

The vastness of the oceans has long been a mystery to humans, with early seafarers afraid to stray into the uncharted waters for fear of disappearing off the edge of the earth [4]. However, with the advancement of science, humans have gained a deeper understanding of the oceans and their immense significance. Having seen an exponential increase in the volume of shipments over the last two decades, the maritime industry and ports have become cornerstones in globalization, managing 90% of the world trade measured in weight and volume [10]. With 13 major ports and 176 notified non-major ports scattered around the 7517 km coastline of India on the eastern and western shelf of the mainland, they act as crucial economic provision units, serving as a vital hub facilitating exchange of goods between sea and land transport modes. The Indian Ocean hosts one of the most important trade crossings connecting the Far East with Europe, becoming the epicenter of economic activity with nearly 50% of the world maritime trade, 50% of container traffic, and 70% of energy trade, with various cargo handling analysis from 2000-2018 predicting a steady increase in the coming years [13] [11].

2. Background

The growth of the Indian ports and increasing ship traffic, despite being critical to the country's economic expansion has affected the coastal and territorial waters with emissions of noise, odors, volatile organic substances, and pollution of water and soil by oil chemicals, hull paint, and other hazardous materials [7]. The dense arrangement of roughly one port every 28 km, along the 7517km coastline makes it one of the most fragile eco-zones in the country, arguably facing a greater threat due to pollution compared to the open waters [15]. The entire port industry has faced mounting pressure to ensure that its operations have a minimal environmental impact and to establish social credibility by adhering to standards for compliance, risk reduction, and sustainability due to the growing recognition of the significant of environmental checks [12]. Understanding the dearth of documentation, it is crucial to adopt a long-term approach when estimating emissions from ports [16].

Visakhapatnam Port spreads over approximately 2000 hectares of land and plays a crucial role in India's economic growth and development. The emissions from ships during loading and unloading at the jetty contribute most to the air pollution at the port, in addition to the open stockyard of coal cargo exposed to elements releasing particulate matter, which can be harmful to human health when inhaled. This study aims to assess the air and water quality likewise, noise levels at Visakhapatnam Port. By understanding the level of pollution caused by the port, policymakers, port authorities, and other stakeholders can take necessary measures to mitigate the adverse impacts and promote sustainable practices. In the current study, the measurements and data collection are performed at two locations, - one where major port activities occur, termed the "port area", and the waters about 20 nautical miles along the coast and free from the port and shipping activities, termed "territorial waters".

3. Site Details

For air quality measurements, the residential area, Gnanapuram side of the port was chosen. For water quality measurements, water samples were collected from five different locations inside the port, namely the turning circle(C), fishing harbor station 1(F1), fishing harbor station 2(F2), east berth Q7(E), and west berth Q7(W). The East Q7 handles commodities such as thermal coal, scrap, and fertilizers whereas, the West Q7 handles manganese ore, limestone, gypsum, bauxite, blast furnace slag, and steel. Underwater noise was measured and recorded by deploying a hydrophone in the inner harbor region of the port. The coastal waters of Bheemili, a coastal town near Visakhapatnam is chosen as the site for territorial waters (T).

3. Air, Water and Noise Analyses

3.1. Air Quality Analysis

The ambient air quality was regularly examined in the surroundings of Visakhapatnam Port for the month of January, 2023. The study assessed the presence of common air pollutants such as NO_x, SO_x, and $PM_{2.5.}$ World Health Organization (WHO) has provided Air Quality guidelines which comprise of scientifically supported suggestions for capping the amount of airborne toxins to keep the environment and public health safe [17].

AQI is calculated using Equation (1).

$$AQI=\frac{C}{C_s}\times 100, \quad (1)$$

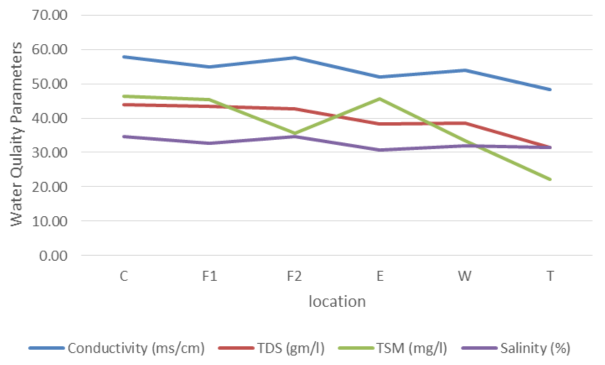
where,

C= Observed value of the air quality parameters pollutant ($PM_{2.5}$, SO_2 and NO_2)

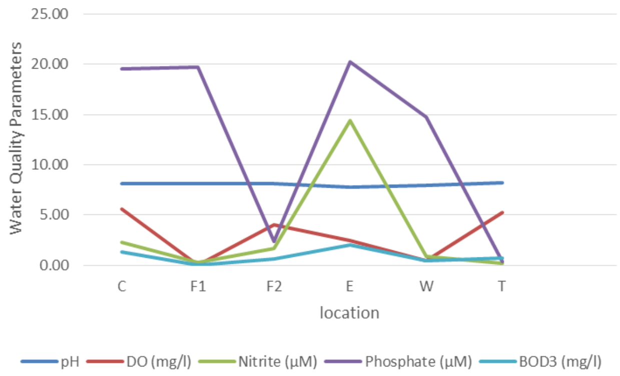
C_s= Central Pollution Control Board (CPCB) standard for industrial area [6].

3.2. Water Quality Analysis

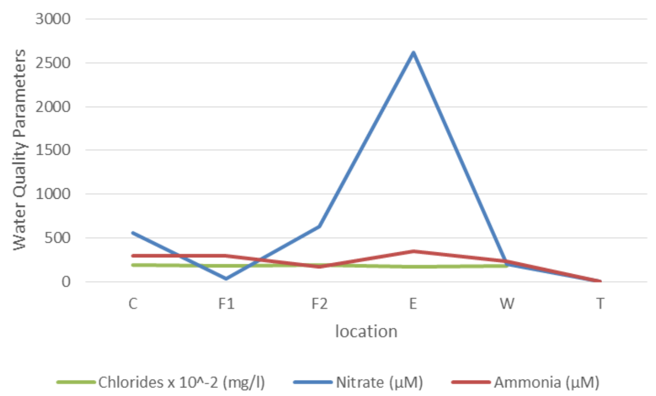
Water samples collected from the sites have been subjected to hydrochemical analysis at the marine biology laboratory of Andhra University, Visakhapatnam, India. Some important parameters have been analyzed and presented as shown in Figure 1.



(a) Conductivity, TDS, TSM and Salinity



(b) pH, DO, Nitrite, Phosphate and BOD_3



(c) Chlorides, Nitrides and Ammonia

Figure 1. Variation of Water quality parameters at various site locations

Important parameters governing water quality - pH, temperature, conductivity, total dissolved solids (TDS), total suspended matter (TSM), dissolved oxygen (DO), and biochemical oxygen demand (BOD) alongside nutrients like ammonia, phosphorous and nitrate were analyzed from the collected water samples [18].

WQI is calculated using the National Sanitation Foundation Water Quality Index (NSFWQI) method using Equation (2).

$$WQI = \sum W_i Q_i = W_{Temperature} Q_{Temperature} + W_{DO} Q_{DO} + W_{pH} Q_{pH} + W_{Nitrate} Q_{Nitrate} + W_{Turbidity} Q_{Turbidity} + W_{TDS} Q_{TDS} + W_{Phosphate} Q_{Phosphate} + W_{BOD} Q_{BOD} \quad (2)$$

Where,

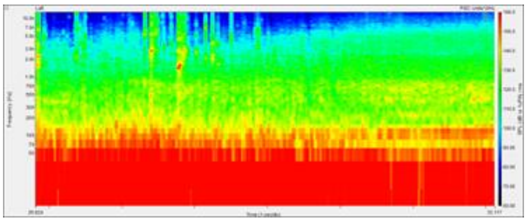
W_i is the weight associated with the i^{th} water quality parameter; Q_i is the sub-index for the j^{th} water quality parameter.

3.3. Underwater Radiated Noise (URN) Analysis

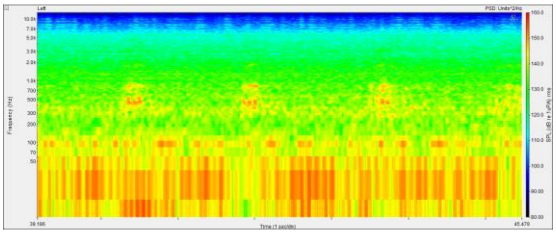
The underwater noise levels of the inner harbor region, one of the points with maximum vessel movements have been measured using Cetacean C57 and TASCAM recorder hydrophones, and, have been compared with those in territorial waters. The hydrophone was lowered in the water to 2m and was connected to the recorder for 30 sec (3 recordings has been taken). Three cases of measurements with calibrated sensors have been taken, first in ambient condition during the loading and unloading from a ship, the second one is taken when tug operation to tow the larger vessels near the jetty is going on, and the third one while the pile driving is being done during the construction work for port expansion. When the frequency of the transmitted noise becomes same as the frequency of the communication signals of marine animals, it affects them adversely [2].

Generally, tug boats generate sound level of 80 dB to 100 dB during normal operations and 120 dB during high maneuvers and emergency conditions [5]. Pile driving is one of the common activities at ports, which can also affect the marine life [8]. A comparison of noise levels at the port during port operations and that in territorial waters is made and presented in Figure 2.

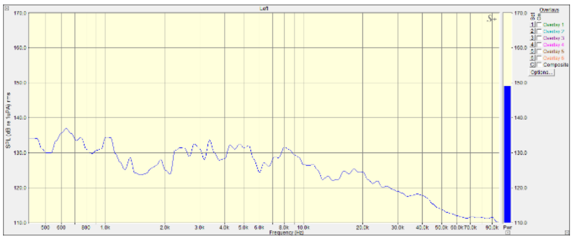
(a) Noise Spectrum in Ambient Conditions



(b) Noise Spectrogram during Tug-boat operations



(c) Noise Spectrogram during Pile-driving



(d) Noise Spectrum in Territorial Waters

Figure 2. URN levels in port and territorial waters

4. Results and Discussions

The data obtained from territorial waters of Bheemili proved that the territorial waters are not affected either by a near-by port or shipping activities, serving as a benchmark for pollution-free port and shipping operations.

The calculated AQI at the port area is 108.33, which falls in a range calling for health-concern. While comparing these values with that of territorial waters it is noted that the average AQI in the month of January 2023 is 81.5 which is in the satisfactory levels. Moreover, in these areas PM_{10} is a concern as against $PM_{2.5}$ in the port. The WHO guidelines set the limit and provisional objectives for typical airborne contaminants, which states that NO_2, SO_2, and $PM_{2.5}$ should not exceed by 25 µg/m^3, 40 µg/m^3 and 5 µg/m^3 respectively [9]. The average amount of SO_2 measured on the basis of 4-hourly value for a short-term exposure of 24 hours is 11.4 µg/m^3. Whereas, the average amount of measured on the basis of 4-hourly value for short-term exposure of 24 hours is 24.7 µg/m^3. Average amount of $PM_{2.5}$ present for 24 hours, on the other hand is 40 µg/m^3. NO_x and SO_x are present within the limit, but at the same time $PM_{2.5}$ exceeded the acceptable range.

Through the analysis, it is found that the turning circle had a WQI of 76.35, Fishing harbor station 1 of 58.2054, Fishing harbor station 2 with 78.2243, East Q7 berth with a WQI of 56.3983 and a WQI of 60.3239 at West Q7 berth. The territorial waters, T have a WQI of 87.7 It can be stated that the quality in territorial water is good and that in various port facilities has not deteriorated owing to port and shipping operations yet needs attention. The pH range is within the acceptable range of 6.5-9.0 [9][3], peaking at 8.15 in the turning circle, indicating no signs of acidification in the local waters or any negative impact on marine creatures, like those from the mollusk family. The data collected on BOD showed a variation of 0-2mg/L, peaking at 2.10mg/L in East Q7, indicating that the organic pollution is also in control [9][3]. The water temperature also meets the regulation set by Association of South East Asian Nations (ASEAN) [1].

The Underwater Radiated Noise (URN) levels in ambient condition with loading and unloading operations performed on the ship is about 148 dB re 1µPa at a frequency of 70 Hz. According to the data collected at ambient conditions, the frequency range has no ill effects on aquatic life, but it remains close enough to potentially interfere with their natural communication system. The tug boat URN levels are about 162 dB re 1µPa at frequency of 50 Hz. Tug boats use their powerful engine to push or pull the ships into their place emitting loud noises. The pile driving pings observed during jetty expansion work with peak Sound Pressure

Level (SPL) of 160 dB re 1µPa at an interval of 1 second. To mitigate the potential harm caused by pile driving, the port authorities may impose limits on the sound pressure levels allowed during construction activities. The noise levels in territorial waters are quite low. The ambient levels are around 135 dB re 1 µPa in the lower frequency. Noise level restrictions are recommended in port areas, for example, the U.S. National Marine Fisheries Service (NMFS) recommends an SPL limit of 160 dB for most marine mammals and sea turtles indicating the need to setup limits for URN in ports.

5. Conclusions

Shipping pollution has been a major concern for the International Maritime Organization (IMO) [14]. The analyzed data and results indicate that the environmental conditions at the port are currently satisfactory. However, due to the swift escalation of shipping traffic, there is potential for these conditions to deteriorate rapidly. The development of a green belt in and around the port as a barrier to pollution is underway. To address these concerns, proactive measures have been implemented, such as regular monitoring of noise levels and the adoption of preventive measures to avoid contamination of harbor water. One such measure includes the collection and storage of oily bilge water in dedicated tanks to prevent its release into the surrounding environment. Despite the pre-existing measures for sustenance of environment, the port authorities need to be vigilant towards balancing the environmental status. Therefore, this study has produced data source concerning air quality, water quality, and underwater vibrations in ports, resulting in a greater comprehension of shipping pollution and cultivating a vision for embracing environmentally friendly initiatives at Visakhapatnam port. A time series study will enable tracking the pollution. Future studies will aim at developing an integrated pollution index in ports through continuous monitoring.

6. Acknowledgements

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Session
Technological Aspects

A Comparative Analysis of Workload for Navigation Tasks Performed onboard and at Simulated Remote Control Centers for MASS Using NASA-TLX

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Abstract: The maritime industry is on the verge of dramatic technological change as the maritime world transitions to the development of Maritime Autonomous Surface Ships (MASS). The development of MASS will affect how the maritime workforce is trained and how it operates. Remote Control Centers (RCC) for MASS will be the main work environment during the MASS era. Many potential human factors, technical, and regulatory challenges have already been analyzed. In this study, a comparative analysis was performed between real life navigation task workload and simulated RCC navigation task workload. NASA-TLX (Task Load Index) was used to measure the task load of navigators while underway compared to a similar simulated voyage. Results showed that there are significant differences in perception of workload between onboard and both simulated monitor and mockup-based workplaces with the largest difference consisting of the mental demand of being on a bridge versus being in a monitor or mockup workplace. Topics for future studies include layouts of future RCCs and engagement of operators.

Keywords: Workload, Remote Control Center, MASS, NASA-TLX

1. Introduction

Maritime education and training (MET) institutions are important stakeholders in the maritime transportation system. MET institutions must prepare, equip, and support students to successfully adopt the technology needed to operate and manage MASS ships in the coming highly competitive and changing workplace. RCCs will be the main work environment during the MASS era. The transition of deck officers from ship's bridges to RCCs will change important human performance factors including workload, stress, and fatigue (Wahlström et al. 2015), and the state of operator situational awareness (Porathe et al. 2014; Man et al. 2015; Mackinnon et al. 2015). Additionally, the uncertainty related to both the human-machine and human-human interactions will affect operations (Kari and Steinert 2021), operator's stress in different levels of workload (Kari et al. 2019), ship-sense and harmony (Man et al. 2014), design criteria for the Human-Machine Interface (HMI), safe and secure transfer of very large data quantities (Porathe 2014), operational, regulatory, and quality challenges (Komianos 2018), cybers risks (Andersen 2018), and autonomous system design to meet the STCW requirements (Dittmann et al. 2021).

1.1 Remote *Control Centers*

As MASS develops, there will be a need to create shoreside RCCs where a human will be able to remotely monitor and/or operate one or more vessels simultaneously, and where some or all vessel functions can be executed (AUTOSHIP 2023). An RCC, also called Remote Operation Center, implies that responsibilities related to planning operations, maintenance activities, and logistics can be included (AUTOSHIP 2023). The RCC should allow for a remote operator to monitor, and if necessary, to take control of all operational functions of the vessel including navigation, VHF communications, and ship's systems via a real-time, reliable communications system. The IMO defines four degrees of autonomy for ships, ranging from Levels 1 and 2, where a seafarer is present on the ship and RCC is used to assist in decisions (Level 1) or take over if necessary (Level 2) to Levels 3 and 4 where no seafarer is present and the ship is operated by remote control (Level 3) or is fully autonomous (Level 4) (Table 1).

Table 1. Levels of autonomy and RCC requirements for MASS as defined by IMO.

LoA (Level of Autonomy)	**Seafarer on board**	**Function of seafarer**	**Who makes the decisions and takes actions**	**RCC required**
1-Ship with automated processes and decision support	yes	to operate and control / ready to take control of shipboard systems and functions	Seafarer	no
2-Remotely controlled ship	yes	available to take control and to operate the shipboard systems and functions	RCC and/or Seafarer	yes
3-Remotely controlled ship	no.	N/A	RCC	yes
4-Fully autonomous ship	no	N/A	The operating system of the ship	yes, implied

Source: Based on IMO, 2021

1.2 Workload

Workload is an essential factor to consider for any task including standing watch in an RCC. Lysaght et al. (1989) defined workload as the relative capacity to respond. Hart and Staveland (1988) describe workload as the perceived relationship between the amount of mental processing capability or resources and the amount required by the task. According to Hoonakker et al. (2011), workload is a complicated relationship between operator, external physical or cognitive demand, and performing a certain task. Other factors, including environmental, organizational, and psychological also play a role in this process.

There are many examples of accidents related to both high and low levels of workload in the shipping industry. High workload can overwhelm a watchstander, reducing performance and leading to accidents. Low workload can cause inattentiveness and complacency as demonstrated by accidents that have occurred in good visibility in daytime and in open water with low traffic conditions. Simply said: too little workload can be just as detrimental as too great a workload (Koester, 2002; Lysaght et al, 1989). What is needed in an RCC is to create an environment where an operator has a moderate workload that will keep them engaged and attentive while not being overloaded. This has implications on how workstations are designed and how many vessels an operator should be responsible for simultaneously.

2. Research Methodology

2.1 Objectives of the study

In this study a comparative analysis was performed to determine the navigation task load of watchstanders between real life and two different settings of simulated RCC workspaces by using NASA-TLX. The monitor based RCC workplace was made up of eight monitors; and the mockup RCC was a fully simulated ship’s bridge with ECDIS, radar, VHF and other hands-on ship controls. Although there are other tasks that were performed by cadet watchstanders, the focus of this study is on the task of navigation which consists of route monitoring, execution of a passage plan, keeping proper lookout, maintaining internal and external situational awareness, checking the performance of navigational equipment, surveillance of the ship, and collision avoidance in compliance with the COLREGS. Research into workload is necessary as part of the design development of RCCs to guide the physical design of the workspace.

2.2 Data collection

NASA-TLX is a widely used, subjective measurement tool used to assess workload on operator(s) in environments with various human-machine interface systems such as aircraft cockpits; command, control, and communication workstations; supervisory and process control; and simulations and laboratory tests (NASA 1986). NASA-TLX compares six factors; namely the mental demand, physical demand, temporal demand, performance, effort, and frustration levels (Hart and Staveland 1988). The literature shows that the NASA-TLX is the most cited, reliable and valid survey-based workload measurement instrument (Sugarindra et al. 2017; Grier 2015; Bjørneseth et al. 2012; Hoonakker et al. 2011).

The study was comprised of two phases. In the first phase, real life navigation tasks were performed by eight cadets aboard the T/S *State of Maine* during the summer training cruises of 2019 and 2022. A voluntary response sampling method was applied. The same cadets took part in the second phase of the study at Maine Maritime Academy's Bridge Navigation Simulator Center in two types of simulated RCC workplace environments (mockup and monitor). The onboard ECDIS recordings and screen shots were saved; and similar area, traffic, visibility, time and date, and sea state conditions were reproduced in Wärtsila, NTPRO 5000 navigation simulator. The cadets in this study had each finished their first-year training cruise, their sophomore cadet shipping experience, and were currently performing their junior training cruise, before entering their senior academic year. According to the Maine Maritime Academy (MMA) Institutional Research Board (IRB) requirements, all participating students were informed about the research and then asked to sign a consent form. The paper and pencil version of NASA-TLX was completed immediately after the completion of the navigation task.

2.2.1 NASA-TLX application process

The experimental procedure of NASA-TLX employs two steps in the evaluation process including source of loads (weights) and magnitude of loads (ratings). Cadets were asked to read the scale definitions and instructions of mental demand (MD), physical demand (PD), temporal demand (TD) performance (PO), effort (EF) and frustration level (FL) from the NASA-TLX instructions. Cadets then performed navigational tasks onboard the T/S *State of Maine* and then again in two different simulated RCC workplace settings.

Determining the source of loads (weights) was performed by completing the NASA-TLX "Sources of Workload Comparison Card". In this stage a pair-wise comparison was performed. Six factors contribute to the workload for a specific task at different weights. These contributions (weights) are calculated by pair-wise comparison among six factors (e.g., mental demand or effort) by circling one factor which contributes more to the workload of the task that was performed. Then the number of times that each factor was selected was tallied and the weight of each factor was calculated. The results were compiled using a source of workload tally sheet. Determining the magnitude of loads (ratings) consisted of completing a rating sheet. Cadets were asked to mark the rating scale sheet for each factor to get the magnitude of that factor for the task they performed. The overall workload score for each cadet is calculated by multiplying each "rating" by the "weight" given to that factor by that cadet. Then the sum of the weighted ratings for each task is divided by 15 which is the sum of the weights. Interpretation of the score of NASA-TLX results are performed as low (0-9); medium (10-29); rather high (30- 49); high (50-79); very high (80-100) (Sugarindra et al. 2017).

3. Findings and Analysis

Descriptive statistics about the environmental conditions where navigation tasks were performed revealed that 62.5 % of the areas are open sea, 50 % of the traffic is low, 75% of the time is nighttime, 75 % of the visibility is clear, and 87.5 % of the sea state is less than or equal to Douglas Scale 4 with winds less than or equal to Beaufort Scale 4.

Mean TLX score for navigation tasks performed on board is 60.289 (SD: 11.917). This value is in the range of high workload. Mockup TLX mean score is 32.703 (SD: 14.187) and Monitor TLX mean score is 30.621(SD: 14.923). These correspond to both scoring in the "rather high" range.

Weighed ratings of each workload factor are found for each participant by multiplying source of loads (weights) and magnitude of loads (ratings), then the average weighted ratings were determined. The results for each factor for three different workplaces are shown in Figure 1. Mental demand has the highest weighted rating onboard (M=23.5), where physical demand has the lowest weighted rating for monitor TLX (M=0. 40).

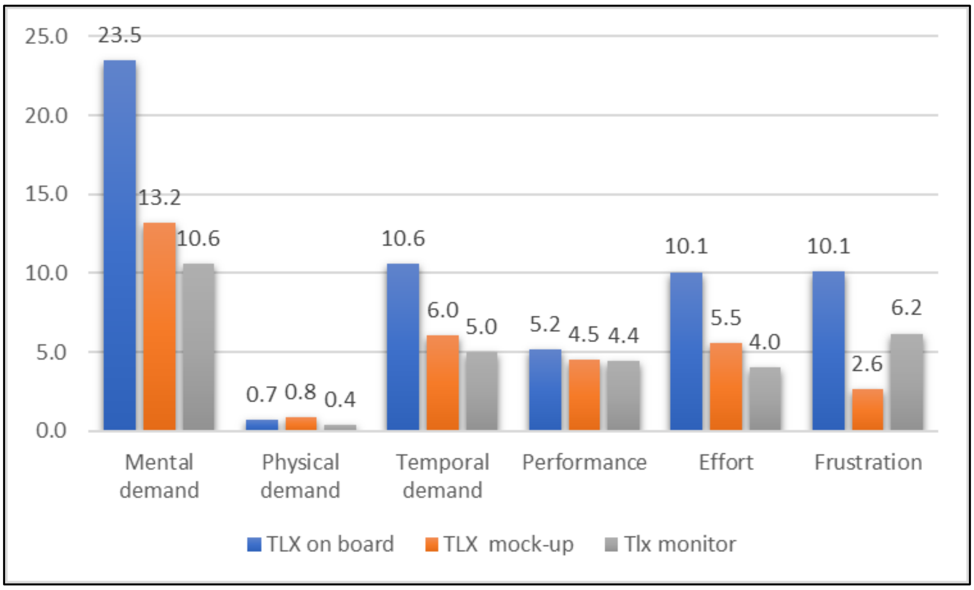

Figure 1: Comparison of weighted ratings of TLX factor scores.

SPSS v:29.0 (Statistical Package for the Social Sciences) program was used for the statistical analysis of the data. Three null hypotheses were developed to determine if there are significant differences between TLX scores of real-life, mockup, and monitor based RCC workplace settings. Hypotheses were tested by paired-samples t-test where scores were taken from the same individuals.

Paired-samples t-test results revealed that there is a significant difference in the scores for onboard TLX and mockup (p = .003). On average, onboard TLX scores were 27.6 points higher than monitor and mockup TLX scores. There is also a significant difference in the scores for onboard TLX and monitor TLX (p = .002). On average, onboard TLX scores were 29.7 points higher than monitor and mockup TLX scores. However, there is not a significant difference in the scores for mockup and monitor TLX conditions (p = .44). On average, mockup TLX scores were 2.1 points higher than monitor TLX scores (Table 2).

Table 2: Results of paired-samples t-test.

Comparison Pairs	**Mean**	**Deviation**	**Error**	**CI lower**	**CI upper**	**t**	**df**	**p**
Onboard/Mockup	27.586	17.463	6.174	12.987	42.186	4.468	7	0.003
Onboard/Monitor	29.667	17.52	6.194	15.02	44.315	4.789	7	0.002
Mockup/Monitor	2.081	7.261	2.567	-3.989	8.152	0.811	7	0.444

4. Conclusion

A comparative analysis of results revealed that there is a significant difference in TLX scores between onboard and those of both simulated RCC mockup and RCC monitor environments. The real-life, on-board workload TLX score is higher than the workload TLX score in both simulated workplace settings. This result is consistent with the earlier findings of Hertzum (2021). Although the mean mockup TLX score is higher than TLX monitor scores, there is no significant difference between RCC mockup TLX scores and RCC monitor TLX scores.

Considering the sub-factors of TLX individually, physical demand was rated similarly across all three workplaces. However, the other TLX sub-factors (mental demand, temporal demand, performance, effort, and frustration) were all rated the highest in the real-life watchstanding environment. A comparison of the mean values of the sub-factors between monitor and mockup alone showed higher values for all sub-factors in the mockup than the monitor except for frustration. Frustration was the only sub-factor higher in the monitor as compared to the mockup. The NASA-TLX manual (1986) defines “Frustration” as “*How insecure, discouraged, irritated, stressed and annoyed versus secure gratified, content relaxed and complacent did you feel during the task*.” The mockup environment is more familiar to cadets, but working in front of the monitors is something new to them. This may cause a higher level of frustration and could be the explanation for the higher frustration in the monitor environment.

Narrative statements of participants revealed that they felt more engaged and involved in the mockup than they did in the monitor. As a result, operators may experience “out-of-the-loop" performance problems while performing tasks in monitor-based workplaces. This leaves operators of automated systems handicapped in their ability to take over manual operations in case of automation failure (Endsley and Kiris 1995) which may result in loss of navigational skills, situational awareness, and complacency problems during emergency situations. Since the monitor environment is more likely to be used in future RCCs, more research needs to be done on the impact of frustration on operators as monitor environments provide less involvement and engagement than mockup environments.

5. Future Research

This study opens the discussion about improving the workplace organization, layout and procedures, and competency considerations of operators at MASS RCCs. Further research is needed in developing training requirements and non-technical skills of RCC operators as well as the impact of RCC design on operator workload. Future study should include a larger sample size, more experienced watchstanders monitoring several vessels simultaneously as well as assessing workload during routine vs emergency vessel operations.

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Need to implement an automatic reporting system related to the supply and dispensing of pharmaceuticals onboard ships

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Abstract: In recent years, with the advent of digitalization, many spheres have changed their way of working, and it has been felt most strongly in healthcare and pharmacy. It has sparked a new wave of innovation and a significantly accelerated pace of digitization in this sector. This transformation requires a new, more dynamic, and flexible system. Depending on the situation, sometimes this means improving processes, for example, through automation. Therefore, the main objective of this paper is to explore the importance of the digitization process through the implementation of an automatic reporting system related to the supply and dispensing of pharmaceuticals onboard ships. The article also introduces a sample digital application for enhancing traceability and digital management of pharmaceuticals onboard ships.

Keywords: ship pharmacy, digitization, mobile health, ship medicine chest, maritime pharmacy management

1. Introduction

After 2005, the costs of medicines in Bulgaria increased dramatically. Despite the country's relatively small territory and population compared to other EU members, the market has grown significantly, and the pharmaceutical sector is characterized by fast rates of development in the Bulgarian economy. Some of the main reasons are the country's economic growth and high pharmaceutical prices (Dimova et al. 2022). The role of pharmacies during the pandemic has expanded significantly. They now include additional services such as providing health information, training, patient monitoring, supplying consumables, and vaccinations, among others. Some more key trends are expected shortly. These include the use of digital technologies to enable online prescription refills, AI solutions for predicting the demand and supply of pharmaceuticals, streamlining order fulfillment and supply chain management, and supporting the implementation of digital telehealth solutions (Deloitte 2020, Morrison et al. 2022).

By definition, the main task of health care and those working in the field is to provide services to inform, educate, improve, maintain and monitor the public's well-being, focusing on their needs and wants. But to build a complete and adequate working system, it is necessary to include all participants in it - medical specialists, patients, employers, and state and private institutions.

Healthcare professionals, locally and globally, strive to develop and facilitate procedures related to medical information processing and digitization of collected data. Access to them through individual electronic health records supports the maintenance and expenditure of medical supplies, primarily in medical facilities for hospital and pre-hospital care within a country. To make it possible, it is necessary to build several computer systems for hospital treatment, mobile applications for self-monitoring, communication with medical specialists, and programs supporting the application, consumption, and reporting of medical supplies from hospital pharmacies to medical institutions.

This information resource would be helpful in their application in different sectors outside the medical one - such as shipping (Fedotova,et.al, 2019, Gancheva, 2019). The highest form of accountability, tracking the availability of medical supplies and checking the medical status of personnel, is of fundamental importance in the sector.

The requirements of good health, the administration of medication, and the reason for this by the crew are part of the control by the institutions related to the ship's orderliness (flag state). Realizing the growing need for medical assistance at sea in recent years (the COVID-19 pandemic and the frequent problems with the mental health of ship crew members) create a prerequisite for improving the medical training of seafarers, as well as increasing the variety of available medical supplies (MLC, STCW, Ordinance No. 6/2021).

In this regard, the present paper discusses the role of pharmacy digitization processes on board ships. The goal thus set is achievable by performing the following tasks:

(1) presenting the requirements for medicines and first-aid kits on the ship;

(2) presentation of methods for providing medical information on board;

(3) presentation of a conceptual framework of an illustrative application of digital technologies in the domain of ship medical supply management.

The research methods in the article include a literature review, data analysis, and qualitative studies.

2. Ship's Medicine and Marine First Aid Kit Requirements

The ship's medical service includes services for the provision of medicinal products and consumables, communication or the presence of a doctor in the crew, and providing first aid to the injured until the time of access to medical assistance from the shore. The availability of the ship's first-aid kit and medical store is determined depending on the category of the ship, the duration of the voyage, the number of crew members, expected ship commitments during the voyage, the type of cargo, and the areas intended for sailing (Ordinance No. 9 of 23 February 2022).

According to Ordinance 9, on medical services on ships, it is necessary to store medicinal products in the original packaging with the patient information sheet and with a remaining shelf life when purchased no less than the expected duration of the voyage. It is mandatory. Medicinal products are stored per the brief characteristics of the product and medical appliances – are according to the requirements set by the manufacturer. They have to be replaced per their expiration date.

A duty of the ship's captain or a person designated by him is to prepare an up-to-date list of available quantities and types of medicinal products and medical appliances. The list is signed by the master of the ship and is part of the documents subject to inspection. As for medicines containing narcotic substances or precursors, it is necessary to draw up a separate list of available types and quantities.

In 1967, the World Health Organization published an International Medical Guide for Ships for the first time. It presents international approaches to problems and situations that ship captains would encounter in the event of accidents or illness. There is also information about the ship's first aid kit, a description of the necessary medications according to the ship's type, the total number of crew members, and the ship's flag (Moskova et al. 2020). Over the years, the guide has been corrected several times. Currently, the requirements described in the International Medical Guide for Ships: Include a ship's medical first aid kit with medicines - third edition are applied (International medical guide for ships, 2021). It is not an official international instrument, but the handbook provides information on types and quantities of pharmaceuticals that would be a good minimum on any ship. The third edition of the International medical guide for ships gives the list of the recommended drug quantities (International medical guide for ships, 2021).

The latest edition of the guide, includes up-to-date lists of recommended drugs, deriving from the WHO Essential (Schlaich 2009, International medical guide for ships). In the lists, the necessary quantities for a crew of up to 10 people exceed 800 pieces of various tablets and injectable preparations.

And since the field of health care is constantly developing, through the creation of electronic health records, systems for organizing the hospital stay of patients, writing of online prescriptions, communication with medical specialists in real-time, the introduction of electronic reporting of income and expenditure of medicines as part of the tracking process is inevitable.

3. Digitization of the information regarding the necessary stocks of medicines in the ship's pharmacy

In the health care field by 2022, several terms are imposed - mobile health, telemedicine, telerehabilitation, and electronic health record (Revieve, 2020). All of them are united by entering data and transmitting information between different characters and institutions electronically. Many of them can and are successfully used to inform, improve, track and control the health of ship crews. Some would help save a human life.

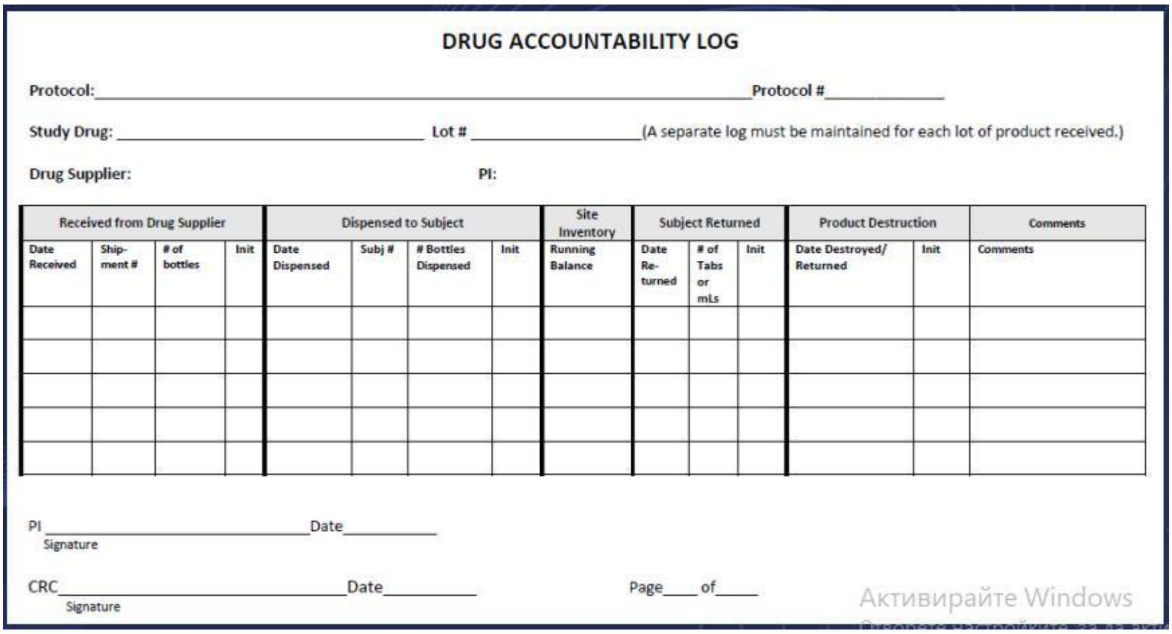
Diagnosing and treating casualties onboard ships is one of the many challenges in the shipping field. Each member of the ship's crew goes through several medical examinations and consultations before departure. Because voyages are of varying duration, some situations occur randomly, unexpectedly, and despite good general health. A person who does not have the knowledge and experience is placed in the role of a doctor or medical specialist (Mednikarov et al. 2019). Despite everything, it is necessary to take responsibility for the medical care of the injured. Judging by this, a major goal for many companies is to create and upgrade applications and digital programs to increase the health literacy of the captain and the ship's crew, provide guidance for improving and maintaining health, and control the availability and consumption of pharmaceuticals (Pharmacy Automation: Technologies and Global Markets 2021-2026).

Each medical facility has software for the automatic management of activities related to the registration of medical and non-medical data for patients, supplemented during their stay and keeping stock of medicinal products. In Bulgaria, this program is mandatory when starting a medical facility for hospital or pre-hospital medical care. Its application creates transparency in the stage of diagnosis, treatment, and follow-up of each patient (Dimitrakiev, Molodchik, 2018, Gamma Consult, 2022).

In 2014, the International Maritime Medical Association (IMMA) launched a free app for iOS and Android that lists all the medical and health-related items needed on board ships. The Marine Medical Stores Catalog lists over 5,000 items that IMMA believes are critical to the health and well-being of crew members, including a "medicine bag" of medications that must be available at all times. All drugs listed have an IMMA number that can be quoted when ordering supplies (The International Maritime Medical Association, 2022).

These two projects for facilitation and digitization of work help the health system work better. And since every single person is part of this process regardless of the sector of work; in addition, it is possible to apply analog to paper, to a digital product on the ship, for accounting of the pharmacy store, a file of each of the crew and the drugs used for him, procurement and distribution of medicines and materials, tracking their application in quantities, dosages, expiration dates, etc with or without internet access.

As a basis for building the system, it would be good to use the opiate drug reporting form which includes all the details we have mentioned (Figure 1).


DRUG ACCOUNTABILITY LOG

Protocol:____________________ Protocol #________

Study Drug: ______________ Lot # __________ (A separate log must be maintained for each lot of product received.)

Drug Supplier: PI:

Received from Drug Supplier				Dispensed to Subject				Site Inventory	Subject Returned			Product Destruction		Comments
Date Received	Ship-ment #	# of bottles	Init	Date Dispensed	Subj #	# Bottles Dispensed	Init	Running Balance	Date Re-turned	# of Tabs or mLs	Init	Date Destroyed/ Returned	Init	Comments

PI ______________ Date_______
Signature

CRC______________ Date_______ Page____ of____
Signature

Figure 1. Drug accountability log (Rinaldi, 2017)

The main problems with using previous practices, namely paper reporting, create several issues. Examples are the lack of up-to-date information on the suitability of all products, the impossibility of determining the exact quantities of all medications (given their number), and the lack of documentation on which crew member has been given a drug and the reasons for it. From here arise several other problems shared by many retired ship captains related to the prevention of ignorance of the new additions to the crew and the stock of medicine that they carry with them, which is not allowed (Bhargava, 2019).

It is important to note that there is currently no system to support the electronic reporting of the ship's pharmacy and warehouse and to support the resolution of the mentioned issues and cases.

4. Development of digital technologies in the field of pharmacy informatics

Panda & Satapathy (2021) describe a system model of a medical supply chain. However, a centralized organization handles the current medical supply chain system which is not trustworthy. With online resources the biggest problem is the same - diversity and lack of credibility. The data must be verified and secure when it comes to medical information. In shipping, the methods of obtaining information about medical products and drugs by unqualified non-medical persons are precisely from these sources. The Internet and the various mobile applications created are becoming the leading resource for dealing with a crisis peak situation, intending to make a life-saving decision.

On the other hand, a challenge for the ship's crews is the frequent running out of essential medicines from the ship's pharmacy network and the problematic administrative work of layout paper forms. This also leads to wasted hours searching for important consumables. Many authors, including Agarwal et al. (2020), describe how mobile device strategies are currently being used to improve reporting and digital tracking of health commodities. So, the answer lies in digital transformation. It offers many advantages such as efficiency, quality, time, and cost savings.

A new mobile application would help unify the existing ones and facilitate the application, consumption, ordering, and reporting of medical supplies onboard ships. We propose a dedicated digital app designed to facilitate maritime medical logistics. We will call it "Maritime MedSupply." Maritime MedSupply is a ship-specific mobile application tailored to meet the unique needs of maritime medical supply management. It simplifies the process of applying for medical supplies, monitoring consumption, placing orders, and generating reports.

This app is an essential tool for the crew members because its main functionalities include:

○ Digital Medical Supply Catalog - Comprehensive catalog of approved medical supplies and equipment; Search and filter functionalities to quickly locate specific items; Detailed product descriptions, including usage instructions and precautions.

○ Inventory Management - Real-time tracking of medical supply inventory onboard; Barcode scanning for easy addition and removal of items; Alerts for low stock levels and impending expiry dates.

○ Consumption Monitoring - Crew members can log the consumption of medical supplies; Reports on consumption patterns and trends.

○ Application for Medical Supplies - Crew members can submit digital requests for required supplies; Customizable request forms with fields for quantity.

○ Order Placement - Accurate and up-to-date product information; Order history tracking for reference and reordering.

○ Notifications and Alerts - Receive notifications for order approvals, supply shortages, and critical alerts; Alerts for items nearing their expiry dates to prevent wastage.

○ Multi-Platform Access - Accessible via mobile devices, tablets, and desktop for flexibility; Synchronized data across all devices for real-time updates; Offline mode.

○ User Permissions and Security - Access control to ensure data security; Encryption and authentication protocols for secure data transmission.

The benefits of this application should be considered in two directions. The first provides the benefits of unified information related to the technical characteristics of the ship's pharmacy, namely the availability of drugs by type, quantity, expiration date, information on new additions, and their consumption to each crew member. That will help with organization and order in the ship's pharmacy. On the other hand, the benefits will be related to constant and unlimited access to instructions for the use of the medications themselves - symptoms and diseases for which to apply, dosage and intake, information on allergies, as well as the possibility of combination with other medicines from drug groups.

In Bulgaria, every hospital needs to have such a system for monitoring the dynamics of the income and expenditure of medicines (Gamma store, 2022). It contains comprehensive information on all medications available to a medical facility. Each introduction of new additions is based on the date of receipt and changes to this product. The characteristics on which the program is based are the name of the medicine (current, renewed), expiration date (from the package with the shortest to the one with the longest), the purchase price (old, new), availability, and person to which the medication is prescribed. Some medical facilities also record the package numbers. This type of application, in the absence of such a significant dynamic as in medical facilities, would support the overall organization of the ship's pharmacy.

Among the practical benefits is the information about the ingredients of each product, provided by the platform. It aims to familiarize the user with the characteristics of the drugs. The process is quick and easy, making it an essential assistant in the busy daily life of ship crew members. Moreover, data integration throughout the lifecycle ensures accurate and consistent information transfer. Vertical integration connects the various levels, from production and automation systems to management, transforming process and product data into critical information that supports the decision-making process. The maximum effect is achieved when automation hardware and industrial software work together. It means that both elements are seamlessly integrated and perfectly aligned with the technological requirements of the pharmaceutical and marine industries. Telepharmacy services will play an essential role in increasing patient access to pharmaceutical care.

4. Conclusion

The crisis has exacerbated long-standing problems related to the lack of digitization in healthcare and pharmacy, including maintaining the availability of medicines. Digital solutions can bring us much-needed flexibility and enable monitoring and immediate response. It will improve operational excellence by optimizing supplies, resources, and workforce.

Therefore, the article has attempted to present an analysis of relevant literature and provide information on the need to implement an automatic reporting system related to supplying and dispensing pharmaceuticals onboard a ship.

It also establishes a potential research framework for a future empirical study of the introduction of an application to facilitate the management of the onboard ship pharmacy and the maintenance of the availability of pharmaceuticals and medical supplies required by flag state regulations. Maritime MedSupply is a vital tool in ensuring that ships are effectively managing their medical supply inventory. And above all it supports compliance with maritime healthcare standards.

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Navigating the Future: Integrating AI into Maritime Education

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Abstract: Nowadays, new technology like artificial intelligence (AI) has been applied extensively to the maritime industry. The AI adoption results in a huge increase of the efficiency and productivity of maritime companies. To keep pace with these developments, it has become crucial for maritime institutions all over the world to integrate AI into the conventional maritime education and training. Hopefully, graduating cadets will obtain the proficient knowledge and specialized skills to navigate through a new era of AI-powered technology. The paper examines what the maritime institutions should do to meet challenges imposed upon them at the new AI age. The paper also explains how to integrate the current maritime education with the emerging technological breakthrough like AI so that the graduating cadets will be highly qualified and well-trained when they enter the workforce.

Keywords: Artificial Intelligence; maritime education; shipping industry.

1. Introduction

In recent years, there has been an exponential growing in the adoption of artificial intelligence (AI) in the maritime industry. According to the report of Ship Technology: "The maritime industry is forecast to spend $931 million USD on AI solutions in 2022. That figure is forecast to more than double in the next five years to $2.7 billion USD by 2027, a compound annual growth rate of 23%". AI-powered technologies are rapidly expanding across the shipping industry, including autonomous ships, route optimization, green energy, and logistics chain management, all of which are spearheading a massive increase in productivity and efficiency of maritime companies.

While stakeholders applaud the positive impact AI brings upon the shipping industry, they are also acutely aware of the high level of expertise required to effectively apply advanced algorithms and data analysis to achieve optimization objectives. As a result, it has been paramount that we support a call for maritime universities to enhance their AI Maritime Education and Training (MET), so that cadets may obtain proficient knowledge and specialized skills to navigate through this new era of artificially intelligent machines.

This paper intends to examine the important role maritime institutions play in the assimilation of AI-powered technologies to the established MET. Using Massachusetts Maritime Academy (MMA) as an illustrative example, this paper examines the challenges and barriers that have hindered the extensive integration of AI learning into the existing MET curricula of maritime institutions. The paper further explores strategies for maritime institutions to effectively leverage available resources in order to address the complexities posed by technological advancements and the application of AI in the maritime sector.

This paper is structured as follows: Introduction describes the research purpose and contextual background information; Section 2 highlights insufficiencies in integrating computer science with existing maritime curriculums; Section 3 reviews the effective methodologies and results to incentivize maritime universities to implement trainings that promote computational informatics skills and technical literacy for their cadets; Section 4 offers discussion and concluding remarks on maritime preparation for the future of automation.

2. Integration of Conventional Maritime Education with AI Elements

The technological advancements in AI and its various applications in the maritime industry offer a wealth of opportunities for optimized efficiency. However, an increasingly noticeable fact is the widening disconnect between the rapid distribution of AI innovations being implemented in professional practice, versus AI Computer Science (CS) courses being built into the MET curriculums at maritime institutions. In this section, we will discuss current MET methods and reasons for the ongoing discrepancy between MET reality.

2.1 The insufficient AI presence in curriculums of maritime institutes

Despite the buzzing excitement regarding the untapped potential of the AI revolution, in maritime industry, we are unfortunately experiencing limited integration of AI, machine learning (ML), and fundamental CS courses offered in maritime institutions. Computationally capable cadets interested in developing AI tools should have access to courses such as: big dataset collection and statistical analysis; ML predictive forecasting using validated training datasets; and programming computational models with a maritime interface, to the same degree of availability as traditional MET courses for maritime institutions. Additionally, robust funding and expertise is required to maintain high powered local servers, well-equipped CS research laboratories, and the necessary hardware and software to properly support resource-intensive AI-based MET.

This paper uses MMA as our in vivo example. Looking at the current term (Fall 2023), only one in-depth AI course is offered by the academy: AI Programming for Engineering Applications. This course applies computer programming to solve common engineering problems, including: engineering modeling and simulation; motion animations; image processing; network communications. A limited number of ancillary courses do combine AI elements with established curriculums, such as the “Business Data Analysis” class. Additionally, several engineering classes now utilize software applications as an integral part of course requirements. Software examples include computer-aided design (CAD) and Geographic Information System (GIS). Expert command of industry specific software raises the ceiling for cadets who choose to hone these skills, expands their potential job horizons, and benefits maritime optimization.

2.2 Accounting for the Disconnect between industry demand and supply of maritime institutions

It is clear that gearing MET towards AI-oriented framework requires the collaboration of administrators, faculties, and cadets of maritime colleges. While the maritime industry benefits hugely from the application and commercialization of new AI technologies, maritime institutions are not feeling a strong sense of urgency to transit from convectional MET to AI-oriented setups. This is partially due to the fact that graduating cadets are typically well-trained with necessary skills, and already in demand for employment from maritime companies. Using MMA as an example: senior cadets normally receive multiple job offers upon graduation, and procure such competitive entry level salaries amongst all college graduates across the USA, it becomes challenging to justify a dramatic change to basic educational frameworks and curriculums. Furthermore, the implementation of AI courses requires substantial funding from tight school budgets, adding financial complexity to the transition process.

Faculty members also play a significant role in successful progression and integration of AI into MET for maritime institutions. A general shortage of specialized AI knowledge and formal AI training amongst faculty members remains a critical issue. AI is a relatively new field, and its complex nature demands a particular set of skills that may not be readily available among the professors of maritime colleges. At MMA, for instance, zero of the approximately 100 faculty members hold a doctorate in Computer Science. Professors whom offer AI/ML classes, such as computer programming, data analysis, and quantitative analysis, have solid backgrounds in science, math, and engineering that facilitate transference to CS. It is certainly an undeniable fact that the lack of AI expertise among faculty members remains a considerable hurdle for maritime institutions to efficiently revise their METs and incorporate maritime CS and AI training to keep abreast of global demand.

Instating mandatory AI classes, like Computer Programming and Quantitative Methods, may increase the burden on cadets who are already heavily loaded. As a result, an AI overhaul would require significant changes to the curriculums to ensure compatibility between traditional courses and AI elements, which may be arduous for maritime institutes.

Inadequate financial support for AI education can pose an obstacle for maritime colleges as well. The resource-intensive nature of AI classes would require that colleges allocate special funds to guarantee access and ongoing support to maintain the necessary hardware, software, and infrastructure required for effective AI education and training.

3. How maritime institutions should prepare for AI education

As we meet the AI revolution, maritime colleges must confront the crucial challenges of how to offer students AI fundamentals, such as machine learning, data analysis, computer vision, language processing, and robotics. The seamless integration of AI into maritime education holds the potential to revolutionize industry logistics, offering companies the opportunity to harness the unparalleled power of computer optimization. By doing so, they can enhance their operational efficiency and competitiveness in an increasingly data-driven and automated world. This not only equips them with the cutting-edge skills demanded by the industry but also positions them as valuable contributors to the ongoing transformation of the maritime sector.

The primary objective of higher educational institutions is to empower graduates with the essential skills and qualifications required to ensure success in their future careers within the maritime industry. In the following section, we will delve into strategies and approaches that maritime institutions can adopt to best prepare cadets for acquiring AI knowledge within their MET programs.

3.1 Identifying the most relevant AI trends and integrate them in MET curricula

The realm of artificial intelligence is expansive and intricate, defined by the amalgamation of technologies that blur the boundaries between the physical, digital, and biological realms. Even within the maritime sector, AI applications are influenced by various distinct trends, such as clean energy, maritime robotics, maritime internet of things (IOT), big data & analysis, etc. Therefore, maritime institutions have to determine which trends bear significance for their industry and the feasibility to effectively infuse the trends into their MET.

Here, we will employ MMA as a case study to demonstrate how the academy places emphasis on a key AI trend - big data analysis- and diligently integrates it into its curriculum. MMA authorities, faculties and cadets acknowledge that big data analysis stands as the predominant AI trend pervading the maritime industry. Big data analysis supports various applications in diverse sectors such as supply chain optimization, port management, security and safety, weather routing, vessel routing monitoring, and numerous other critical facets of the shipping industry. Subsequently, in May 2022, department of Maritime Business proposed, for the first time, an AI-powered algorithms class called Data Science and Machine Learning Using R. at MMA.

Data Science and Machine Learning Using R. is a fully explored AI course, designed for business major seniors, using in-depth approach to big data analysis. "The class starts with an introduction to the popular statistical software and programming language, R, and then delves into machine learning algorithms such as classification, nonlinear regressions, generalized additive models, etc" (MMA Registrar Records, 2022). While this class is currently in the midst of formulating proposals and conducting evaluations, several other classes have efficiently incorporated AI components, including R programming and various machine learning techniques, into their curriculum requirements. Courses, such as Business Computation, Data Analysis, and Quantitative Analysis, have made R programming an integral part of their syllabi, with the intention of acquainting students with this statistical computing and graphics language. The MMA experience shows that the progressive integration of AI elements, however gradual, in addition to a fully explored AI course, are evidently proving successful at the MMA campus, altering the classroom environment and standard curriculums.

3.2 To mobilize all resources to maximize the outcome

The 2019 "Global Maritime Professional Body of Knowledge (GMP BoK)" report highlights the top three imperative skills for future mariners and maritime professionals: technical awareness, computing and informatics expertise, and technical competency. In order to empower maritime cadets with these essential proficiencies, maritime institutions must leverage their resources, mainly administrators, faculties and cadets, to seamlessly integrate AI into the established MET framework. Administrators must demonstrate vision and commitment to drive the change, faculties master the required knowledge to keep up with the trends, and cadets exhibit their determination to acquire new skill sets and be ready for the more testing workforce.

Understanding the significance of the AI revolution and its applications in the shipping industry is crucial for leaders of maritime institutions. This knowledge empowers them to make informed decisions regarding the integration of AI into both their operational processes and educational curricula. The leaders of maritime institutions should encourage their universities develop a practical curriculum that seamlessly blends existing coursework with AI education. Given the demanding academic workload typically found in most maritime programs, crafting a well-rounded curriculum that covers all essential aspects of maritime education, including AI learning, can be a formidable task. Furthermore, these leaders should allocate financial resources for the establishment of AI laboratories, procurement of necessary software, recruitment of new computer science faculty members, and the facilitation of curriculum adjustments to embrace this emerging trend.

Maritime faculties should play a critical role in the transition and change. However, many faculties, particularly those who were trained conventionally, struggle to keep up with the latest technological advancements. To overcome this, faculty members should keep themselves informed of the latest developments in AI and related technologies. Faculties should be engaged in continued scholarship, such as attending conferences, reading research papers, and keeping in touch with industry experts. To stay on the top of trend, faculties can gradually incorporate AI into their coursework by developing AI-related assignments and projects, and assigning relevant case studies and collecting real-life examples into their lectures.

There are several measures maritime cadets can take to prepare themselves for successful career developments at the new AI era. First of all, they must take AI-based courses, such as machine learning and data analysis. Cadets should be familiar with commonly used computer programs like R, Java, Python, etc. This will help them develop the skills to tackle the problems like route optimization, which requires sophisticated AI-powered algorithms to figure out the efficient shipping routes, using the data on weather patterns, sea currents, shipping traffic, and port availability. Secondly, they should gain hands-on experience by participating in research projects related to AI technologies. One good example is that one statistical course project gained big popularity among students when they were required to finish the assignment with three key requirements: a linear regression modal, a randomly generated dataset and the R programming language. Thirdly, cadets should collaborate with industry partners through internships to stay current with the latest developments. As we move into the AI age, maritime colleges are confronted with a critical challenge of offering students AI fundamentals, such as machine learning, data analysis, computer vision, natural language processing, and robotics. The ultimate goal is to equip graduates with essential skills and qualifications to make sure of their successes in the future careers. How much the objective can be achieved depends very much on the collective efforts of school leaders, faculty, and students of maritime institutions.

4. Discussion

The aim of this research is to understand that, while AI-powered algorithm technology can lead to significant industry-wide improvements in shipping efficiency and increasing profitability, they also impose huge tasks on maritime institutions to make compatible changes. Maritime colleges feel the urge to scrutinize the sustainability of ME. This would enable the future maritime workforce to possess the necessary skills, expertise, and requisite knowledge to embrace the challenges brought about by a new horizon of AI-powered technology. To achieve the goal, it is instrumental for administrators, faculties and cadets of maritime institutions to make the continued efforts to incorporate the new technology into established MET.

The AI-powered algorithms are unquestionably effective tools that provide substantial benefits to the shipping industry, and as a result, maritime institutions are eager to incorporate more AI and machine learning into their curriculums. Nevertheless, it is equally essential to instill ethical and social awareness among students regarding the consequences and obligations of employing AI in maritime settings and even in daily life. For instance, some educational institutions have expressed concerns about the potential for new technologies like ChatGPT to enable plagiarism. Given the recent introduction of this technology, it is helpful to have a comprehensive discourse regarding the advantages and disadvantages of adopting AI-powered algorithms and AI technology more generally.

It is certainly exciting to live at the age of this huge AI revolution, which bring about amazing changes constantly, such as higher productivity, and faster growth. At the same time, we do feel the responsibility of thinking through the possible issues associated with the implementation of AI-powered technology and impose proper rules to regulate their applications. We hope to elegantly optimize the advantages of machine learning developments, while foreseeing and proactively mitigating disadvantages.

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Developments in Engine Room Simulator Training Technology for Future Ships: Facilitating Training in Context

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Abstract: Recent developments in ship engine room simulator technology support the more contextualised high-fidelity training and facilitate the transition to training for future ship operations. With the gradual adoption of automation and digitalization onboard, modern ships are increasingly equipped with remotely monitored unmanned spaces such as the modern engine room. Marine engineers are no longer required to be co-located within the boundaries of the engine room to carry out their duties. Maritime Education and Training (MET) needs to evolve and reflect the developments in the changing work context wherein the marine engineer is removed from the physical work locale. Advancements in engine room simulator training are suited to modern and future ship operations. Situated in-context training has been the mainstay of competence development in shipping. Previously seafaring training took the form of on-board apprenticeships and gave way to shore-based MET provision over time. This led to an increase in the distance between the training environment and the context of work. This paper presents the recent developments in engine room simulator technology, the walk-through engine room simulator, and argues that the immersive training experience afforded by this novel technology facilitates near-context training especially for the technologically advanced and future ships. We envisage that in the future, the digital twin of the engine will be part of the digital space that constitutes the future workplace of autonomous ships. We discuss that utilizing the walk-through engine simulators affords a bridge between the current and the future autonomous engine room training.

Keywords: Maritime Education and Training; Marine engine room simulator; Future ships; MASS; Walk-through engine room; Digital Twin

1. Introduction

Maritime Education and Training (MET) has evolved tremendously from when formal structured maritime instruction commenced onshore as a move away from the onboard apprenticeship training. This move, physically separated teaching and learning from the workplace environment, adding distance between shore-based MET provision and the shipboard work context and between the employers and their seafaring workforce. Near-context, on-the-job workplace training has been considered the gold standard of training (Billett, 2020) and attempts have always been made in MET to make the training relevant and effective (Emad & Roth, 2008). Over the last half a century there has been an increasing introduction of technology onboard ships reflected in today's modern integrated technologies, automated systems, and unmanned spaces. The developments in technology in the shipboard workplace have been reflected in MET with the increasing incorporation of simulator technology in the design and delivery of seafarer training. Simulator training is known to bring the training close to the context of work, thereby contributing towards the relevance and the efficacy of the training. The Global Maritime Professional (GMP) (IAMU, 2019) will benefit from immersive high fidelity engine room simulator training technologies that support near-context training and enable the trainee to vicariously experience the workplace in the virtual world (Baldauf, Schrder-Hinrichs, Kataria, Benedict, & Tuschling, 2016).

Due to diverse factors, including the efficacy of technological advancements in simulator training technology, there is an increasing demand from some countries to consider simulator training in lieu of sea time in maritime training requirements for certification (Nautilus-International, 2020). Work on identifying sea time equivalence is already being undertaken whereby the required sea service time can be reduced by up to thirty days in certain niche maritime sectors such as dynamic positioning vessels in the offshore operations (Sea-Maritime, 2022; STC, 2023). This reduction in sea time is extremely attractive for the maritime industry although it raises questions regarding the efficacy of the training. Previously, the proposal of simulator training in lieu of sea service was largely motivated due to the lack of training berths available on-board ships. Currently, however, the developments in simulator training technology make it a powerful pedagogical tool that can facilitate enriching near-context training. This paper presents the developments in engine room simulator training technology and argues that the immersive training experience afforded by this novel walk-through engine room simulation technology facilitates near-context training. The technology also facilitates the transition to future ship operations wherein the workplace itself would be digitally re-imagined as the digital twin technology of a vessel would be the future workplace for marine engineers.

2. Technology-intensive MET environment for modern and future shipping

With respect to modern and future ship operations, the International Maritime Organization (IMO) has delineated 4 degrees of Maritime Autonomous Surface Ships (MASS) underpinned by technological advancements in operations, control, and the presence/absence of humans onboard. Modern ships of today are in degree 1 of MASS with some automated processes and decision support systems (DSS) onboard where seafarers can take control when required. Degree 2 of MASS is imminent and denotes a vessel that is remotely controlled, but with seafarers present onboard to take control if required. Degrees 3 and 4 of MASS do not have seafarers onboard. While the ship is remotely controlled and operated in stage 3; stage 4 is characterised by a fully autonomous ship capable of independent decision-making and action.

The MET environment for modern and future shipping will be technology and resource intensive. Three current and complementary trends in the maritime industry will inform and shape the training environment of future shipping operations. Trend 1 is the increasing adoption of technology onboard ships that has led to increased digitalisation and automation that will culminate in autonomous ships of the future (Emad, Narayanan, & Kataria, 2022; Narayanan & Emad, 2020); Trend 2 is the increasing uptake of technology in MET such as continually advancing simulator training technology (Emad & Kataria, 2022); Trend 3 is the blurring of the physical and the virtual workspace in MASS stages 3 and 4 wherein human operators will not be present on board and the workplace itself will be digital in nature. In future, where the shipping industry embraces the autonomous shipping, the training of the future workforce utilising the digital twin of a vessel appears to be a logical pedagogical development in the MET continuum (Kataria & Emad, 2022). There is a significant distance between the current degree of MASS and the advanced integrated automated systems and autonomous ships. Advancements in simulator training technology such as the walk-through marine engine room can be mapped to the training requirements of MASS degree 1 and 2 ships and provide a pathway for future training of MASS degrees 3 and 4.

3. The walk-through marine engine room

The walk-through marine engine room simulator is a new development for the training of marine engineers that provides an immersive environment and affords access to different spaces, systems, and equipment of the ship's engine room. The technology permits trainees to undertake realistic actions and see consequences in real time (Lokuketagoda, Miwa, Ranmuthugala, Jayasinghe, & Emad, 2017) (see figures 1 and 2).

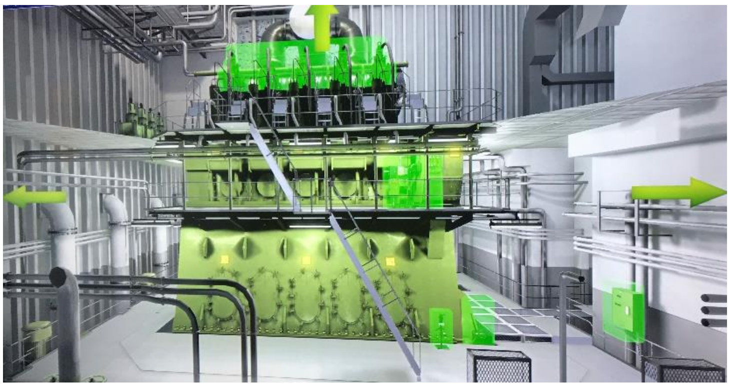

Figure 1. A view of the main engine in the marine engine room simulator.

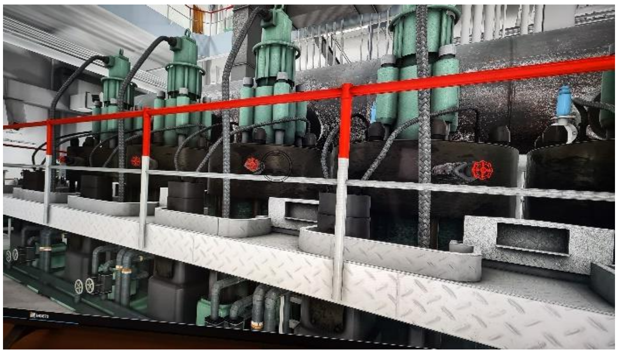

Figure 2. Different views of the main engine.

Figure 3. A view of the auxiliary engine in the marine engine room simulator.

3.1 Key features and affordances

The walk-through engine room simulator comprises engine room simulator software which enables the students to walk through the virtual reality view displayed on a wide-screen monitor (usually a 65-inch Television) with the aid of a handheld controller. The gamified environment facilitates student engagement with learning. The placing of a series of large monitors along the walls of a teaching-learning space encompasses the entire engine room and transports the students to an immersive learning environment. The inclusion of the sights and sounds of the engine room including the sounds of equipment and alarms adds to the realism/high fidelity of the teaching-learning environment. Students develop an attraction to these video-game-style moves navigating through a real engine room, as it gives an immersive learning experience in a real-life environment and work situations. The interactions between the students and the equipment and spaces inside the walk-through marine engine room simulator closely mimic real life. For instance, the virtual environment provides options for nuances such as wiping a dipstick after checking the level of oil in an equipment. The students can toggle between the 2-dimensional (2D) schematic diagrams and the 3-dimensional (3D) models of the engine room equipment and spaces. This movement enables them to holistically take in the teaching-learning engine room environment at a glance and then navigate to the equipment or space they would like to take a closer look at. The touch screen TV monitors facilitate ease of navigating. The entire virtual engine room is available at the touch/click of a button or alternatively through the handheld controller device. The students can navigate to, and closely examine a particular equipment/space utilizing the stylus. The students are in control of the engine room machinery and plant which synchronizes with the future remote operation of the ship's machinery with the ‘digital twin’.

Figure 4. Steering gear and the purifiers in the marine engine room simulator (left to right).

The walk-through marine engine room simulator is suitable for all degrees of MASS ships to varying degrees. A limited number of degree 1 MASS ships have unmanned engine rooms and the simulator presents the opportunity to familiarise the engine room crew with the space, equipment, and training requirements. Additionally, the principle of this simulator is to vicariously experience the engine room and take remote action and see consequences in real-time. It is also suitable for degrees 2, and 3 of MASS operations where the vessels are remotely monitored and operated. Estimates suggest that the widespread implementation of MASS for oceangoing vessels is about two decades away. In this scenario, the walk-through marine engine room simulator is a powerful and relevant pedagogical tool to support the training of marine engineers for the next few decades, or as long as degrees 1, 2, and 3 of MASS vessels ply the oceans. In degrees 3 and 4, the workplace would be digitally reimagined as the physical workplace would no longer require human presence. In this case, the development of the digital twin of a vessel will be a gamechanger for MET as training can be then provided in the digital workplace itself.

4. Research study

In recent years the affordability and accessibility of state-of-the-art technologies at maritime training institutions afford engineer trainees with access to a learning environment close to real life. In this study, the walk-through marine engine room simulator was used at the Australian Maritime College (AMC), in combination with desktop-based systems for the delivery of the simulation related component of the unit – Ship and Engine Resource Management. The simulator-based component includes developing competence in a series of simulation exercises that prepare the ship for sailing, starting from a cold ship to ensuring readiness for full away. This study is part of a larger ethnographic study on competence development of maritime workforce. The data for this preliminary study comprises research fieldnotes, interviews, audio-video recordings, and pictures. The data was analysed using Thematic Analysis that identifying, analysing, and interpreting pattern of meaning is at the centre of making sense of qualitative data. The experience at the Australian Maritime College with the real-life application of simulation in teaching clearly showed the trainees' preference in learning was always centred around the Full Mission engine room simulator with virtual reality views rather than the desktop systems. The desktop system exercises with the 2-D mimic diagrams provide trainees with the basic equipment and tools to develop an understanding of how the engine room systems work. However, the visual effect with the virtual reality views of the full mission provided a whole new level of student experience. This includes practicing different tasks with ‘full mission’ exercises with a mix of mimic diagrams, virtual reality views, and hardware such as main engine controls and electrical switchboard touch screens. The introduction of ‘walk-through’ with 3-D views of machinery in high fidelity engine room settings revolutionised the students' expectations and experiences. Students' feedback highlights that the 3-D views and settings are significantly more realistic and immersive. The identified advantages of utilising the walk-through marine engine simulator room were realism, immersive nature, increased student engagement, improved student interest, kinetic nature of learning utilising the learner's physical body as a resource, and motor cognition (Sellberg, 2017).

What the walk-through engine room simulator provides to students' learning goes beyond the addition of useful new features. It fundamentally changes the concept of learning for engineers. The pragmatic addition to learning allows the 'motor cognition' of students to develop by allowing them to experience the actionability of their body in the process of learning. The concept of motor cognition refers to the notion that cognition and thinking is embodied in action. It refers to the ability of humans to learn by doing. This not only refers to the processes of performing a task but includes the mental processes of social interaction as it happens in teamwork in workplaces. The affordability of walk-through engine room simulator allows students to relate their cognitive processes of their planning and decision making with the affordability and consequences of their actions. The simple tasks such as opening/closing a valve would involve different cognitive processes compared to thinking, planning, and deciding about the action. Accident investigation into maritime accidents such as Amoco Cadiz (Bonnieux and Rainelli 1993) shows how a simple planning for switching to alternative steering gear provides unpredicted consequences leading to disaster.

As the industry moves toward implementation of MASS degree 2 and 3, it is expected that the remote-control centre (RCC) ashore would provide a workplace similar to the walk-through simulators. This also provides an opportunity for the maritime training institutions, by utilising walk-through engine room simulator, to not only elevate the training of current marine engineers by providing immersive seamless learning environment but to prepare the future workforce with an authentic near-real-life experience training (Emad, Enshaei, and Ghosh 2022; Emad and Ghosh 2023).

In the transition to autonomous shipping of MASS degree 2, where remote controllers would be utilised for the operation of ships from ashore, the walk-through engine room simulator will be a powerful teaching and learning aid in the near future. The authors suggest that the 'walk-through' simulation platform in combination with 'full mission' would be the foundation for the future 'Digital Twin' of a vessel.

5. Digital twin in MET for future shipping

The digital twin of a vessel is a virtual, (largely cloud-based) digital representation of a physical asset. In the maritime industry, the digital twin is being deployed to optimise the vessel's lifecycle from ship design, ship building, to ship operations, and maintenance, to the end of the ship's life. Its uses are being seen in maritime security and safety, the optimisation of supply chains, parameters of ship operation, port and terminal optimisation, and fleet optimisation. In addition to the aforementioned benefits of the digital twin in the industry, a key benefit of the technology is in MET. The digital twin can be utilised as a powerful pedagogical tool that affords the provision of training within the context of work itself. In stages 3 and 4 when the digital space *is* the workspace, it would be beneficial to utilise the digital twin for training. Utilising the digital twin for both working and training implies the merging of the gap between the context of training and work.

6. The context of work and the teaching-learning context

Shore based MET provision separated the context of teaching-learning from the context of work. Simulator training with advanced technologies help to bring the work context back into training. The adoption and integration of advanced technologies into MET bring the context of work closer to the context of training due to their high fidelity and affordances. The affordances of technologies such as the walk-through marine engine room simulator support near-context training – the access to virtual spaces, realistic engine room acoustic environment, opportunities for navigation, interaction, and realistic action and reaction help the students to see the consequences/outcomes of their actions embedded in the work context in real-time, thereby re-enforcing the learning. Technologies such as the walk-through marine engine simulator room facilitate the transition to tech-saturated training for future ship operations by supporting the training for remotely monitored and controlled unmanned engine room spaces. Advanced training technologies bring the hitherto separated work context and the context of teaching-learning closer until there are no boundaries between the digital and the physical workspace as in the case of the digital twin. With the advent of the digital twin, MET provision can take the leap into the technologically saturated future of training. The MET move to utilise the digital twin of a vessel is momentous as in the future the digital space will *be* the workspace/context of work. The MET pedagogical shift to the digital twin blurs the boundaries between the context of work and the context of teaching-learning until they merge and are indistinguishable. Training for future shipping operations will take place in the digital workplace. This development brings MET full circle; from moving away from the context of work to incorporating the work context back into training.

7. Conclusion

This paper suggests that simulator technology developments in MET such as the walk-through marine engineering simulator bring the trainee as close to the context of work as possible. This is extremely valuable in current modern ship operations with increasingly unmanned engine room spaces to give the marine engineer the opportunity to vicariously immerse in the context of work. Not only does it help the marine engineers to familiarise themselves with the space, but also enables them to interact with diverse components and see the effects in real time as they would in a physical engine room. The remote monitoring and controlling work required of the marine engineer is well supported by this technology contributing to its relevance. Furthermore, technological advancements such as the digital twin when incorporated into training would enable the trainee to train in the (digital) workplace itself, thereby bringing the context back into training and positively impacting its relevance and efficacy. This paper highlights the advancements in marine engine room simulator training technology that would serve MET well into the few coming decades. Additionally, it highlights the value of incorporating the digital twin into MET. Embracing these novel developments will enable MET to remain relevant for the coming decades by being abreast of the developments in the industry. The authors note the limited scope of the study. Further research would need to be carried out to unpack the teaching-learning affordances and efficacy of novel technologies in preparing the workforce for rapidly evolving modern and future shipping.

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Simulator as a Critical Training Tool for Autonomous Ship Operators

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Abstract: In the era of Industry 4.0, the maritime industry is going through a profound evolution by introducing smart and autonomous shipping. This evolution is driven by advanced technologies such as the Internet of Things (IoT), Additive Manufacturing (AM), Artificial Intelligence (AI), and more importantly, Virtualization, including digital twin and simulation. Indeed, the implementation of these technologies and their transformative nature has changed the environment of workplace onboard ship and ashore, requiring the new and innovative training tools and systems. As defined by the International Maritime Organization (IMO), the shift from traditional shipping to autonomous shipping will take through four degrees. In this classification, as the ships progress to degrees two and three, seafarers/operators require to be trained for the skills and competencies that enable them to remotely work with advanced systems and intelligent machines through a Remote Operation Center (ROC). These novel workplaces onboard ships and ashore accordingly are redefining new training tools and programs for seafarers. Simulators as a central and indispensable component in training systems from past to present has the capability to make a paradigm shift, bridging the gap between traditional onboard training and the SCC training environment to meet the autonomous ship operation requirements for seafarers. This paper represents part of result of an IAMU-funded qualitative study on simulation training programs for future autonomous ship operators. The research highlights the critical role of advanced simulators in training the next generation of seafarers/operators and strongly recommends the gradual shift from onboard training to simulatortraining.

***Keywords*:** Autonomous Ship; Industry 4.0; Seafarers; Simulator; Training; MASS

Background

The Fourth Industrial Revolution is reinventing all industries. The main driver of Industry 4.0 is the digitalization and automation (Shahbakhsh, Emad, & Cahoon, 2021). Like other industries, the shipping industry has gradually embraced the Industry 4.0 framework and technologies with the result of the introduction of autonomous and unmanned ships (Emad & Shahbakhsh, 2022). IMO has proposed four degrees of autonomy to facilitate and outline the shift from traditional shipping to autonomous shipping. The IMO degrees of autonomy represent how the seafarers' roles and responsibilities with the deployment of advanced technologies onboard ship will alter (Emad & Ghosh, 2023). An ROC is a control center/room where an ROC operator remotely monitors and controls one or more MASS ships and if necessary intervene. Even for the degree 2 of MASS where seafarers are still on board, the ROC's operators' roles in collaboration with seafarers onboard in the case of emergency and other dangerous or critical circumstances would be immense. The progress of ROC design, equipment, and functions depends on the Degree of MASS and the level of automation of the ship. Thus, the operator's role and level of human-machine interaction will change as workplaces gradually transfer from onboard ship to the ROC (Emad, Khabir, & Shahbakhsh, 2020). Therefore, the maritime education system needs new and non-traditional programs and facilities to make the operators ready for future shipping operations (Emad, Enshaei, & Ghosh, 2021). Here the simulators can play an essential role during the transition phase.

From its inception simulators always had a fundamental role in training systems of the maritime, aerospace, aviation, and forestry industries. Although has its roots in Industry 3.0, simulation matures with virtualization as one of the main Industry 4.0 technologies (Gunal, 2019). The Maritime Education and

Training Institutes (MET) first began the utilization of simulators in the training of passage and route planning in 1950. However, the simulator is currently used extensively for different training purposes for pilots, offshore operations, engine control, crane operation, and vessel traffic services (VTS) training. The Standard of Training, Certification and Watchkeeping for Seafarers (STCW) convention has regulated simulator use in the MET.

Additionally, the new generation of training simulators employ technologies such as augmented reality and virtual reality (AR/VR) to provide immersive experiences and better human-machine interaction. Virtualization employs AR/VR, CPS, cloud computing, and IoT, to construct digital twins for seamless human-machine interaction (Chen, at.al. 2023; Emad & Kataria, 2022). The digital twin is a virtual model of a physical system. It is a simulation system with the variable input from a physical entity such as a ship or part of a system, for example, the ship's engine. The future simulators and digital twins will be used by seafarers to operate the ship and perform different tasks such as navigation and maintenance (Sellberg, 2017). Whilst the digital twin is the future workplace of the ship operators, it will provide an unparalleled opportunity for the training providers to replicate the digital twin of the actual ship for the benefit of training seafarers of the future. Indeed, access of future trainee seafarers/operators to these technologies in the training environment assist emerging new operators as intelligent operator to interact and collaborate with smart machines in the Industry 4.0 era (Emad, 2020; Ferreira, Armellini, & De Santa-Eulalia, 2020).

As MASS matures and seafarers' role shifts to remote operators in ROC, there will be an opportunity for maritime training institutions to use simulation/digital twin-based training models for remote ship operators. This allows for transferring a major part of onboard training to a simulation-based training (Ahvenjärvi, Lahtinen, Löytökorpi, & Marva, 2021; Emad & Shahbakhsh, 2022; Klement, 2017; Moraes, Kipper, Hackenhaar Kellermann et al., 2022).

Currently, maritime universities across the world are facing a major challenge in responding to maritime industries' needs of providing them with quality seafarers who are not only competent to work onboard ships of today but are prepared to operate the ships that need to be remotely controlled. To fill this gap the authors designed a qualitative research project titled "Simulation Training Program for the Future Autonomous Ship Operators". This project is funded for the 2022-2023 period by the Nippon Foundation through the IAMU Organizational Development Project scheme. The project investigates and tests the application of MASS simulation technology for training future seafarers. The result of this research illustrates how the technology progression helps to gradually shift onboard training to simulator training as the onboard workplace shifts from onboard ship to ROC. This paper presents part of the research findings of the project.

Method

This paper presents part of the outcome of a qualitative research study on a simulation training program for future autonomous ship operators. The research project has employed the Intelligent Shipping Technology Test Laboratory (ISTLAB) at SAMK University, Finland's ROC simulator. At first, the research team designed different scenarios where participants initially work with the traditional simulator. Subsequently, participants complete a scenario on the ISTLAB simulator as the replication of degree two MASS. The scenarios, through traditional and ISTLAB simulators, provided a unique testing and research platform that enabled the research team to collect and analyze data in different scenarios. In the second stage, each team divide into two groups of three participants. One group played the role of seafarers onboard the ship, and the other one played the role of seafarers at ROC. The two groups exchanged their positions and repeated the test. The data also collected from research participants from different groups of stakeholders including seafaring students, experienced seafarers, pilots, simulator instructors, maritime lecturers course coordinators, and researchers, with a diverse range of experience, rank, and age.

Participants were one-to-one interviewed after their consent by a set of standards, clear, and open-ended questions to avoid acquiescence, social desirability, and habituation biases. The semi-structured interview was conducted through online platform (Zoom application), and it was recorded with participants approval. . To analyze the recorded data set and understand the participants' experiences and behaviors, this research utilizes the thematic approach to analyze the data (Kiger & Varpio, 2020; Lune & Berg, 2017). The collected data was transcribed verbatim, and then the initial codes were extracted. In the next stage, the major codes were extracted, and a theme map was created. The researcher team rechecked the supporting data to confirm each theme's coherence and consistency with the data. Moreover, the research detailed notes and memos were reviewed for connection between themes that performed as an audit trail to support the trustworthiness of the research findings. Accordingly, the researcher labelled and named each theme to answer the identified gaps. And basedon that the final report was written.

Results

This paper aims to illustrate one part of the research findings related to the simulator's role in training programs. The research questions for each scenario are designed to assess the participants' viewpoints and experiences on how the simulator as the training tool can be utilized in training current and future seafarers/maritime operators. Each scenario is designed to serve different purposes. The first scenario aimed to evaluate the participants' experience working with the traditional simulator and how the training through this simulator can be replaced with current onboard ship training. On the other hand, the ISTLAB scenarios aim to assess the participants' perspectives on the SCC simulator and autonomous shipping. The following sections present the summary of research findings related to participants' perspectives on how seafarers can benefit from simulator training to be ready for real-life onboard ship operations.

Section 1: Utilizing traditional simulator

This section's present analysis of the interview questions centered around participants' experience working with the traditional simulators and its comparison with actual ship experience. The participants were interviewed about their experience with practical elements of traditional simulator training and the possibility of its replacement with onboard ship training.

The analysis shows the critical role of the simulator in training systems in enabling seafarers/maritime operators to be prepared for different circumstances and situations onboard ships. In this regard, most participants pointed out how the current simulators are more realistic and closer to real ship experience compared to some years ago. Indeed, the fidelity of current modern simulators is progressing exponentially with the exposure of advanced technologies that provide a safe, secure, realistic practice environment for seafarers to be ready for current ships with advanced technology. Some participants mentioned that practicing with modern simulators is similar to playing video games. Additionally, the participants' viewpoints centered around how the current simulators in the maritime training institutes provide seafarers/maritime operators an opportunity to exercise unique and diverse scenarios in different operation areas with various kinds and sizes of ships. This provides an opportunity for seafarers/maritime operators to work as team members and develop confidence and also communication and leadership skills. Moreover, simulator training offers seafarers/maritime operators a valuable opportunity to prevent risks, learn from mistakes, and build up talent and experience to be ready to accept the responsibility for people's lives, cargo, and ship safety and security in real-world scenarios.

A pilot participant with 25 years of experience points out that:

You can create an environment in the simulator that looks almost like the real world, and that makes it more realistic and more relevant. Because it feels more like you're on a real ship, thenyou will perform more like you would do in reality. So, I think that's one of the most importantthings you can simulate if you will be stressed in a situation or how you will react in real life.

While participants acknowledged the strength of the current modern simulator in the training system, they noted that some features of onboard ship training could not be completely replicated in the simulators. For example, navigation in ICE or the latency in command time in some specific ship size and model in these cases the simulator is not reacting precisely similar to the actual ship. Moreover, participants discussed the concept of seafaring skills and the lack of environmental factors in the simulator and seafarers' responses. In this regard, a participant as a marine project manager with 20 years of experience noted that:

You are still missing the kind of environmental factor and you are missing of course the tiredness that you have on board. You haven't been running watches for a week, or two or so.You are always kind of a fresh-minded when you go to a simulator.

Participants were interviewed about replacing current simulator training with onboard ship training.

According to the current STCW Convention, cadets must have a minimum of 360 days of onboard ship training to obtain the official license. Most participants acknowledged that current modern simulator training is close to real ship experience. Thus, replacing some parts of onboard training with simulator training is possible. Moreover, countries such as Finland and the Netherlands have started replacing simulator training with part of onboard ship training. All respondents mentioned that simulator training has the potential to partially replace onboard ship training. Seafarers need the combination of both training to acquire essential knowledge and expertise in a *"hybrid model"*. The hybrid model can be a combination of a simulator and onboard ship training. The research data analysis show that one year of onboard ship training has immense value considering the below factors:

- Onboard ship training can be completed on just one or two ships, while with simulator training, the seafarers can practice with different types of vessels.
- Onboard training can be completed in open sea conditions with few moorings, traffic, and environmental factors. In contrast, simulator training provides a facility to practice in congested areas with heavy traffic and different weather conditions in the safety of a simulated environment.
- One day of onboard ship training could be just nonrelated duties, while one of the simulators can be passage planning and practicing in different scenarios.

The data analysis results indicate that the one year of training onboard ship can be reduced by partly replacement with simulator training. Accordingly, combining simulator and onboard ship training can foster a unique training regime for seafarers to be familiar with and ready for real-world scenarios. This new hybrid model can facilitate the introduction of autonomous ships and SCC concepts to the current and new generations of seafarers. However, this simulator training replacement with onboard ship training requires a massive evolution that includes:

- Designing new dynamic training content and models based on the practice objectives.
- Designing and testing different scenarios based on the various weather conditions and traffic situations.
- Designing dynamic emergency situations that include mishaps such as collision, grounding, fire, etc.
- Constant deployment of new generations of technologies on simulators to authenticity level up practice
- Setting up certain hours and programs per day for simulator training to cover onboard ship training.
- Creating the standard in terms of promoting leadership, effective communication, safety, and security in the simulator to replicate the onboard ship environment and atmosphere.
- Designing advanced training scenarios and adding skilled captains and officers to the team to replicate the natural onboard ship environment and atmosphere so seafarers can engage and collaborate with the professional team members and learn and ask their questions.
- Revision of current STCW convention in alignment with changes

This part of the research outcomes indicates how deploying advanced technologies such as VR, AR, cloud computing, and AI result in simulator development. It gradually has shifted the mindset of seafarers and their trust in technologies. Moreover, the research data analysis shows how the hybrid training model could be efficient in terms of time and quality training for training current and future seafarers.

Section 2: Working on ISTLAB simulator

This section illustrates the result of research questions related to participants' viewpoints about ISTLAB and how this ROC simulator could help seafarers to gain knowledge about autonomous shipping.

Participants mentioned that the ISTLAB simulator is a good start for developing knowledge about the remote operation of ships. However, there is a need for constant development of authentic scenarios for ROC simulators. Most participants acknowledged that working with ISTLAB created another level of experience with advanced technologies and tools such as big screens, eye tracker glasses, cameras, and topography maps. The ROC simulator, such as ISTLAB, helps seafarers develop knowledge about autonomous ships and ROC. However, there is a critical need for continuous improvement with the deployment of Industry 4.0 advanced technologies in addition to other related factors.

In response to questions related to how many hours of the ISTLAB simulator can assist seafarers in developing enough knowledge about different factors of ROC. The data analysis indicates that the training hours depend on factors such as:

- The seafarer's learning abilities
- The seafarer's previous experience
- Availability of exercise areas
- The level of seafarer's ICT knowledge
- Validity and variety of scenarios
- How technology and technical-oriented a person is

For instance, our data shows that skilled seafarers can learn faster compared to a newcomer in the maritime industry because of previous experience and ability of visualizing of the situation in their minds that leads to making a decision and controlling a ship in real time. In contrast, some young seafarers who are experts in computer and online gaming have the minds that are aligned with the ROC concept. They are more capable of embracing technologies and the ability to control a ship remotely. Accordingly, operating a ship remotely in congested areas like rivers with high traffic and on the shore is more complex and challenging compared to open sea conditions, which require more hours of practice to develop knowledge about ROC. In this regard, one of the participants with 20 years of experience noted that:

It depends a lot on the background of a person. Like how technically oriented one is. Let's put it very simply if you are familiar with using a computer. You will get used to that environmentvery quickly. If you are not, it will take time.

The data analysis indicate how Industry 4.0 has transformed simulator training and resulted in ROC simulators such as ISTLAB. As mentioned, the learning process for each person is different, requiring the maritime training institutes to design the course and then personalize the courses based on each group or person's experience and learning ability. However, the data indicates that the training hours with traditional simulators should increase. Along with this shift, working with SCC simulators should be added to training programs to give the seafarers/maritime operators the remote ship operation experience and to develop knowledge about autonomous ships as one of the participants with extensive experience stated *'I think there needs to be some kind of this remote operating center simulator in the schools'.*

Moreover, the data analysis outcomes illustrate that the maritime training institutes should develop courses about autonomous ships, new technologies, ICT, and the SCC concept in addition to SCC simulator implementation in the training centers. Most participants directly or indirectly highlighted the importance of the regulatory bodies, shipping companies, and training providers' collaboration to prepare seafarers for changes in response to autonomous shipping. A simulator instructor with 24 years of experience noted that:

There should be subjects about autonomous vessels and, of course, remote-control vessels as well. And maybe the idea for this kind of subject is what is the situation at the moment? And what are possible ways to proceed in the future?

This section's data analysis highlighted the importance of SCC simulators for developing knowledge and skills about autonomous ships and SCC.

Conclusion

The shipping industry is not traditional anymore. Industry 4.0 is penetrating all aspects of shipping and thus the seafarers/maritime operators need to be competent for the new roles and responsibilities resulting in new technologies and autonomous shipping. The simulator, as a critical training tool that was in the training system from Industry 3.0, is getting mature through Industry 4.0 and advanced to the next level of simulation. This new advanced simulator can be a game-changer in training systems. The data analysis results indicate that some parts of onboard training could be replaced with simulator training to benefit the shipping industry and seafarers. We suggest the *hybrid model* of training that combines onboard ship training and simulator training could help seafarers gradually shift their mindset to work with and trust advanced technologies. Moreover, the research data presents the importance of the SCC simulator in developing knowledge and experience about autonomous ships and SCC. At the same time, the training could be different based on a person's previous experience, learning ability, technology orientation, and operation areas. Accordingly, the analysis strongly suggests that the training providers should implement and utilize the SCC simulator in addition to the traditional simulator to prepare seafarers for the concept of autonomous ships and SCC.

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On-line ERS

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Abstract: The shipping industry has been significantly affected by the COVID-19 pandemic, and whilst the biggest challenge has been visible in change of crew changes, the impacts of the COVID-19 pandemic on maritime education and training and the supply of qualified and certificated seafarers is a growing area of concern for the industry. The MERSol – project (Maritime Engine Room Simulator on-line) was created due to the Covid-19 pandemic, that made face-to-face simulator lessons mostly impossible and focuses mainly on the horizontal priorities of supporting individuals in the maritime sector to acquire and develop key competences.

The main issues with implementation of simulation technologies virtual reality in combination with e-learning in professional training of future seafarers have been revealed. The e-learning system based on Moodle, which helps to provide information, technology and professional training support for future seafarers has been created during MERSol - project. WÄRTSILÄ, which is one of the biggest simulator manufacturers in the world, has recently begun to offer online engine room training, though the training is only available to students by purchasing pr. hour training.

Keywords: engine room simulator, online, Moodle platform, SWOT-analysis, Guidebook

1. Introduction

The European Education and Culture Executive Agency, EACEA, opened an additional call for proposals as part of the measures supporting recovery from the coronavirus crisis. The funding in the additional call was granted to Erasmus+ KA2 strategic partnerships. The application period was limited, as it took only two months to complete. The MERSol consortium was initiated by Satakunta University of Applied Sciences (SAMK) from Finland, as they have an excellent network due to a long history and 20+ years of experience with maritime projects. SAMK invited maritime training partners from Spain, Universitat Politecnica de Catalunya (Nautical Studies of Barcelona) Lithuania, Lietuvos aukstoji jureivystes mokykla (Lithuanian Maritime Academy, Klaipeda), Turkey, T. C. Piri Reis Universitesi (Maritime University of Piri Reis, Istanbul) and Ukraine (Kherson State Maritime Academy, Kherson) to join the MERSol Consortium [3]. Finnish simulator manufacturer Image soft Ltd was invited as a simulator manufacturer and Spinaker from Slovenia as an awarded online teaching specialist.

The outcomes were achieved approximately in accordance with the project plan. As the war of aggression on Ukraine began on February 24th, 2022, it halted the project for a considerable amount of time, as the Ukrainian partner's work was heavily challenged by the circumstances, despite this the project progressed forward with determination.

Through the project eight study and assessment modules were developed by the maritime engineer partners and the platform Moodle was chosen as the platform on which the modules were to be stored. Whilst the Finnish simulator manufacturer Image soft Ltd, had already developed an early stand-alone engine room simulator model of the research vessel M/S MIRABILIS, which had been delivered to the Namibian Ministry of Fisheries and Marine Resources in 2012, the vessel was constructed at the shipyard in Rauma, Finland. This ERS version was modified to work online and the SAMK server was chosen as the home base of the simulator, to which all the partners could connect. This paper will present all the abovementioned research which has been collected and presented in the ERS guidebook. This guidebook serves as the last output of the project [4] introducing difficulties met and problems solved.

2. Submission

The MERSol-project has developed new ship related, high class and up-to-date study modules followed with assessment study modules which are set in the Moodle-platform [5].

Modules are as follows (table 1).

Table 1. List of study modules (Maritime Engine Room Simulator on-line application).

Study module	Topics	Develop	Check
Electricity	Electric motors (electric propulsion), electric power plant, diesel generator, emergency generator, shaft generator, shore connection, batteries, and fuel cells	KSMA	LMA
Steam, thermal oil, ventilation of machinery systems, air conditioning	Steam, thermal oil, ventilation of machinery spaces	PRU	LMA
Auxiliary systems 1	Fuel- and lubrication oil (bunkering, storage, transfer, purifying, feeding), exhaust gas scrubbers- cooling (sea water, LT & HT), starting air, air pressure systems	LMA	KSMA
Auxiliary systems 2	Bilge (main bilge, oily bilge), ballast water treatment, fire protection systems (water fire extinguishing, CO2)	LMA	PRU
Operations of engine	Monitoring, controlling, automation	PRU	SAMK
Water systems	Fresh water, technical water, water production	KSMA	PRU
Connection to deck systems and bridge connection	M/S MERSol connections to deck and bridge through classification notations. M/S AURORA BOTNIA as an example of a new building ship from 2021.	SAMK	SPIN
Vocabulary (with explanation)	Vocabulary from modules 1-7	ALL	

Designing and developing the study modules and assessment modules on a specific e-learning delivery platform allows cadets and seafarers to access the training programme and learning materials over the Internet at any time and any place. This is particularly relevant in the Maritime sector where seafarers are highly mobile and have less opportunity to take long face-to-face training courses whilst they are working.

During the application phase the topics of the modules were set and at the beginning of the project only minor adjustments were accomplished and all the main topics remained unchanged. In the beginning of the project study and assessment roles were agreed among the project partners taking the best expertise into consideration and the first commenting partner set.

A total of 35 online partner meetings were convened to address the modules in question, with each module's respective partners conducting multiple online meetings of their own. The ultimate approval authority for each module rested with the UPC.

Due to the Russian attack on Ukraine on 24th of February 2022 project on-line meetings became very sensitive and other partners could only show their full support to the brave Ukrainian partners. One multiplier event was planned in Kherson but due to the situation in Ukraine it was firstly planned to arrange in Odessa but soon found out that also impossible so agreed with the financer, Finnish National Agency of Education (OPH), that this multiplier event will be shared amongst the capable partners.

The large earthquake that struck Türkiye in the early spring of 2023 impacted the final conference of the project, as it was scheduled to be held in Istanbul, Türkiye. By approval of the OPH, the event was moved to Helsinki, the capital of Finland.

The development of the online engine room simulator followed a structured process flow, which can be broken down into the following key stages [4]: Conceptualization and planning, collaborative design, technical development, testing and refinement, implementation, and integration, evaluation, and continuous improvement.

The development of the online engine room simulator can be further divided into the following stages: requirements gathering, content development, software and infrastructure development, quality assurance and testing, deployment and integration, monitoring, evaluation, and improvement.

The development of the online engine room simulator involved the use of a variety of technologies, software, and tools, including:

1. Cloud-based infrastructure. To support the scalable, accessible, and reliable delivery of the simulator, a cloud-based infrastructure was utilized. The cloud-based infrastructure supports simulation software, user identification and communication.

2. Simulation software. Specialized software was used to create high-fidelity, physics-based simulations of engine room operations, ensuring a realistic model of the simulated ship. The simulation software also handles the training scenarios.

3. User identification software. Software for identifying the simulator users was created. Each trainee is assigned with a unique identifier and simulator station on connecting the cloud-based simulation server. The responses from the cloud-based server are arranged using the above-mentioned credentials.

5. User interface. User interfaces were created for both trainees and instructors. Instructor interfaces contain the modules for controlling the simulation. Instructor interfaces display the online trainees and offer functions for controlling the simulator usage. Trainee interfaces contain the essential controls for operating the simulated ship systems.

6. Communication. Communication between simulator users and cloud-based server was established. Cloud-based simulation software sends simulation status changes to online users. User interfaces that visualize the simulated ship constantly listen to and display the attributes evaluated by the physic-based model of the simulated ship.

7. Low-latency data transmission protocols. To ensure real-time interaction and responsiveness in the simulator, low-latency protocols were implemented for data transmission between the user’s device and the cloud-based server.

To comprehensively analyze the work of the Engine Room Simulator and to clarify how the changes in physical lectures, workshops, simulators, and other practical classes that arose amidst COVID-19 pandemic would affect the evolution in the long term, a strengths, weaknesses, opportunities, and threats (SWOT) analysis was performed in this project discussions as well as related research results.

Strengths, weaknesses, opportunities, and threats of the MERSol project are listed in table 2.

Table 2. SWOT-analysis of the MERSol project [4].

Strengths	**Weaknesses**
Flexibility and accessibility	Limited Tactile Experience
Cost-effectiveness	Dependence on Stable Internet Connectivity
Scalability	Technological Learning Curve
Customizable Learning Experiences	Integration with Existing Curricula
Realistic Simulation Environment	
Opportunities	**Threats**
Expansion into New Markets	Traditional Training Heritage
Technological Advancements	Regulatory Challenges
Collaborations and Partnerships	Technological Obsolescence
Increasing Adoption of Online Learning	Cybersecurity Risks
Innovative and Attractive Training Solution	Economic Uncertainties

By conducting a SWOT analysis, we have identified the key strengths, weaknesses, opportunities, and threats associated with our online engine room simulator. This analysis provides valuable insights into the areas where we excel, areas that need improvement, and potential avenues for growth and development.

The MERSol project is designed to provide realistic training for marine engineering students and professionals. Some recognized challenges that this project may face include [4], technical challenges ensuring stable and reliable connectivity for all users. Latency, the migration to the cloud introduced additional latency due to the increased distance between users and the server hosting the simulation.

Ensuring consistent server reliability, frequent server downtime or performance issues could have severe consequences for training schedules and user satisfaction. To address this issue, we suggest adopting a multi-server architecture with automatic failover mechanisms, which would ensure that if one server encountered issues, the system would automatically switch to another server, maintaining the simulator's availability. Geographic issues arose due to the diverse locations of users and institutions participating in the online engine room simulator training.

Although the online simulator provides an interactive environment for learning engine room operations, it is essential to ensure that trainees also gain a strong theoretical foundation. To address this challenge, we worked closely with maritime school partners to integrate the simulator into a comprehensive curriculum that combined theoretical lessons with practical exercises in the simulated environment. This allowed trainees to apply their theoretical knowledge in real time, enhancing their understanding of the subject matter and developing their practical skills simultaneously.

Maintaining trainee engagement and promoting active learning was another challenge we faced. The online nature of the simulator could potentially lead to trainees becoming passive observers rather than active participants. To overcome this, we collaborated with our maritime school partners to design engaging learning activities and scenarios within the simulator.

To address accounting for the diverse learning needs and preferences of trainees, we worked with our maritime school partners to develop a flexible and customizable learning environment that could cater to individual trainee needs. By incorporating a range of learning resources, the trainees can focus on the areas where they needed the most improvement.

Another challenge was the ability to assess trainee progress and provide meaningful feedback as traditional assessment methods may not be easily applicable in an online simulation environment.

Ensuring that the online simulation provided an accurate and realistic representation of actual engine room operations required close collaboration of the maritime school experts and engineers to develop a simulator that captured the nuances and intricacies of real-world engine room operations. In the end we succeeded at refining the simulations based on the feedback to ensure that the experience closely mimicked the behavior of actual equipment.

Although the online simulator offered an immersive environment, it could not fully replicate the tactile sensations associated with physically manipulating machinery. This would need to be mitigated in the future by having the online training supplemented by the hands-on training on the actual equipment.

The challenge of the integration of our online simulation with existing maritime training curricula was met having close collaboration with maritime schools to identify possibilities in their current programs, as well as different opportunities to enhance learning outcomes using our online engine room simulator.

Conclusions

MERSol – project brought together experienced engine room simulator lecturers, engine room simulator manufacturer and on-line teaching specialist.

Introduction of the latest technologies, such as virtual simulation technologies reality, distance, and electronic learning, will improve quality educational process, make it modern and accessible to everyone and, most importantly, ensure verification of acquired professional competences.

The strengths of the online Engine Room Simulator are flexibility and accessibility, cost-effectiveness, scalability, customizable learning experiences and realistic simulation environment.

Along with the strengths, weaknesses were also identified, such as limited tactile experience and stable internet connectivity. The simulator requires trainees to be proficient in using digital technology, which may present a learning curve for some individuals, particularly those with limited experience in using online learning platforms. According to the project partners the positive thing is that weaknesses were fewer than the strengths. Same findings were done in opportunities versa threats.

Developed study and assessment modules in the moodle-environment can effortlessly be updated when new versions of equipment are installed onboard. New mooring methods like suction pads, mooring without ropes, are already presented but as digitalization is progressing rabidly new semi-autonomous shipping modules may soon need to be added.

The online Engine Room Simulator does have limitations on the number of users participating simultaneously, as the exercises are stored on a single server. By being aware of these limitations, it is still an exceptional package for METs to utilize in their training of cadets.

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Conceptual Modelling of the Use of Artificial Intelligence in Maritime Education and Training: An Exploratory Approach

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Abstract: The maritime industry has been experiencing a digital revolution and the high pace of digitalization is expected to continue with enabling new generation artificial intelligence (AI) utilization. There is no doubt that the impact of AI on maritime transportation in the future will be substantial. Therefore, it is important to have seafarers having the technological thinking and savoir-faire in the merchant fleet. In this study, an exploratory approach has been taken to establish a conceptual framework on AI utilization and implementation in maritime education and training (MET). A set of questions on AI application in simulator training, theoretical classes as well as mandatory safety of life at sea and ship security training were asked to experts and decision makers in the MET comprised of ship captains and academics. Furthermore, the same set of questions were asked to the recently popularized chatbot of the AI company OpenAI's ChatGPT to make a comparison of the answers. Acquired answers from both parties have been analyzed with respect to the maritime education and training literature to set up a framework regarding the utilization of AI in MET. Concludingly, the benefits, challenges, and limitations of using AI in MET were presented through an exploratory approach.

Keywords: artificial intelligence, maritime education and training, e-learning, continuous learning, simulation training.

1. Introduction

The maritime industry handles around 80% of global trade (UNCTAD 2022). This immense transportation capacity, this system is non-comparable to majority of other modes of transportation regarding the impact on global economics. Therefore, safe, and efficient maritime transportation is one of the focus areas of international organizations, governments, and other regulatory bodies as well as stakeholders all around the world. For such a system, digitalization is inescapable with concepts such as industry 4.0, blockchain, smart contracts and autonomous ships being the leading trends in the maritime domain (Dede et al. 2021; Köseoğlu et al. 2021). IT systems are expected to impact the maritime domain in the following years considering the increase in the number of vessels and complexity of operational processes (Alop 2019).

In addition to logistics outsourcing services, AI is considered to be playing a crucial role in the maritime sector in the upcoming years in line with the aforementioned trends. (Işiklar et al. 2007; Sharma et al. 2022). The next generations of seafarers are expected to be able to comprehend and communicate with AI powered decision support systems (Alop 2019). This comes with the requirement of establishing the mentality of future seafarers with ethical concepts as well as legal thinking by bringing innovative solutions and while creating an education and training environment that enables balancing soft and hard skills such as engineering and humanities (Allam 2016; Simmons and McLean 2020). As stated by Jo et al. (2020), the industry shows the tendency to enable new competencies for keeping up with the changes and remain relevant. Although maritime industry is expected to be at low risk to be automated completely, the implementation of technology is imminent. As Lee et al. (2019) presented, many aspects of the maritime industry including law, management, education, and operations is under the influence of automation to some degree, while International Maritime Organization encouraging the automation as well as trying to provide a framework for technical, safety and operational aspects of automation under the concept of industry 4.0.

MET required to be handled with a differentiating approach to be able to keep on track with these changes (Burke and Clott 2016). For preparation of seafarers for the digital transformation and digitalized seaborne trade environment of the near future, the Standards of Training, Certification, and Watchkeeping (STCW) regulations and competency list within it needs to be updated as well as stakeholders in maritime industry are required to reconsider conventional means of MET for enabling development and upbringing skills and supervised learning for the digital competency and technological tendency by AI implemented MET (Baldauf et al. 2016; Munim et al. 2020; Sharma and Kim 2021; Laperrière-Robillard et al. 2022). It can be argued that the main challenge remains between incorporating digitization opportunities and still being able to build necessary skills for a marine engineer and maritime transportation engineer (or deck and engine officers in general) which are strictly outlined by STCW model courses.

AI has been steadily increasing in utilization and implementation in various fields with beneficial functionality recently while being able to provide improvements in the field of education and training and setting new learning outcomes surpassing conventional methods (Pedro et al. 2019; Sharma et al. 2022). Currently the utilization of AI implemented systems made available with the developments in computer technology is influencing and changing conventional education delivery (Chen et al. 2020). There are various research of AI induced education proposals in the recent literature of MET including theoretical classes (Säljö 2010; Strijbos 2011; Mallam et al. 2019; Sharma et al. 2019; Bartusevičienė 2020; Simmons and McLean 2020; Scanlan and Hopcraft 2022) and practical training (Hontvedt and Arnseth 2013; Castells et al. 2016; Sellberg 2018; Hjelmervik et al. 2018a, b; Sellberg and Lundin 2018) as well as inclusion of virtual or augmented reality (Buttussi and Chittaro 2018). One of the better examples of AI utilization have been in the form of AI chatbot for Collision Avoidance Regulation (COLREG) by Sharma et al. (2022), where the authors have developed and utilized a custom chatbot named FLOKI and tested its applicability as a teaching aid for COLREG in addition to the study of Choi et al. (2018) on the development of chatbot framework for ship safety education. Even though it is still a long way for AI implementation, the concept exists and needs to be explored for creating a satisfactory and sufficient curriculum. Additionally, the importance of having competent deck and engine officers with technological tendencies and savoir-faire can be discussed to be substantial in the near future with the increasing applications of digitalization such as maritime autonomous surface ships.

In this study, an exploratory approach has been taken for evaluating the implementation of artificial intelligence as a tool in MET through the conceptualization of the use of AI in MET, while researching the benefits, challenges, and limitations of the involvement of such technology into conventional ways of education with qualitative data analysis.

2. Conceptual Framework

The role of artificial intelligence in maritime education and training is analyzed in a broad way within an explorative approach through the development of a conceptual framework. This framework for this study explores and brings the key concepts for the use of AI in MET by providing a structure and a guide for the researchers to have a clear understanding of these concepts. As also provided within the methodological background, the conceptual contexts are generated to bring more depth to the analysis of the use of AI in MET and major components within the conceptual framework are illustrated in Figure 1 and 2 by also considering the analysis of the results stemming from the interviews.

3. Methodology

To establish a framework on AI integrated MET, a set of questions was prepared regarding adoption (questions 1-3), implementation (questions 4-8) and evaluation (questions 8-10) dimensions and were asked to experts and decision makers in the MET comprise of ship captains, MET experts and academics. Furthermore, the same set of questions were asked to the recently popularized chatbot of the AI company OpenAI's ChatGPT to make a comparison of the answers. Four separate replications have been carried out for ChatGPT, where two of them with 3.5 Legacy version and two with GPT4 March 2023 version. Acquired answers from both parties have been analyzed with respect to the literature to set up a framework regarding the utilization of AI in MET. For the analysis process within the methodology, keywords and phrases matching with each other received from the human experts and AI were conceptualized for showcasing common concepts while different opinions of both parties have also been noted for further discussion. The demographics for the voluntary participants are given in Table 1 below.

Table 1. Voluntary Participants' Demographics.

Latest Rank	Experience in Maritime Industry	Education	Current Profession
Master	15+	Master	Maritime Lecturer
Chief Engineer	15+	PhD	Academic
Marine Engineer	5-10	PhD	Academic
OOW	5-10	Master	Academic
OOW	5-10	PhD	Academic
OOW	5-10	PhD	MET Specialist
OOW	5-10	Master	Maritime IT Engineer

The following questions have been asked to experts and decision-makers in MET field for exploring additional aspects of AI integration in MET, promoting a deeper understanding of the potential opportunities, challenges, and limitations.

1. What collaboration opportunities exist between AI researchers, maritime experts, and educational institutions to advance the integration of AI in maritime education training?

2. What are the potential long-term implications of adopting AI technologies in maritime education and training, both for the industry and individual seafarers?

3. What ethical and legal considerations should be taken into account when implementing AI technologies in maritime education and training, and how can stakeholders work together to address these challenges.

4. How can AI be used to facilitate remote and distance learning opportunities for supporting continuous professional development and lifelong learning (i.e., online courses, virtual reality simulations) for seafarers ensuring they remain up to date with the latest industry standards and best practices and what challenges must be addressed to ensure successful implementation?

5. What are the key factors to consider when designing and implementing AI-driven simulation training in order to ensure maximum effectiveness and accessibility for trainees?

6. How can AI-driven adaptive learning systems be used to tailor maritime education and training (including theoretical classes, practical classes, and simulator training) for individual trainees' needs, and what impact might this have on knowledge retention and skill development?

7. What are the potential applications of AI-driven scenario generation in survival at sea, cargo handling and navigational training, and how might this lead to more engaging and realistic training experiences?

8. How can AI be employed to analyze historical accident and incident data in order to develop more effective survival at sea, cargo handling and navigational training scenarios.

9. How can AI be used to help identify and address common challenges in practice (i.e., during emergency situations, cargo handling, watchkeeping) such as improving communication, coordination, situational awareness, and decision-making?

10. How can AI-powered data analysis be used to identify trends in trainee performance (i.e., areas of weakness, skill gaps) and develop targeted interventions to enhance the effectiveness of practical training (simulation training) outcomes?

4.Results and Discussion

Development of a conceptual framework for the integration of AI in the maritime education and training within an exploratory approach has led the results to bring solutions and make interpretations under different conditions to increase understanding, expanding knowledge, clarifying significant issues, exploring, and examining existing situations, and providing further research suggestions. AI integration to MET has been evaluated under three dimensions, adoption, implementation, and evaluation, which are given in Figure 1. Adoption refers to the collaborations between AI experts and specialists, industry stakeholders and academy, regulatory, ethical, and legal aspects, and potential effects on seafarers. Implementation dimensions comprise of continuous learning, practical training (simulation training) and theoretical classes. Finally, evaluation dimension represents the AI utilization for evaluating trainee performance and AI application performance.

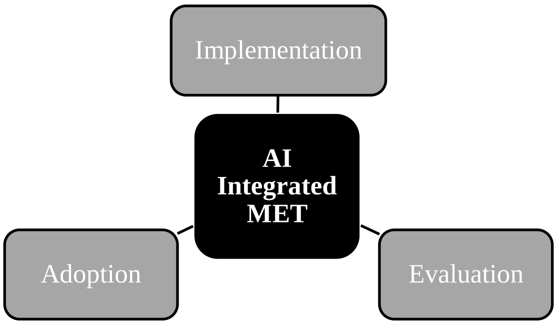

Figure 1: Dimensions of AI integrated MET.

4.1 Adoption

Common statements from both experts and chatbot included the collaboration between MET specialist and AI specialists for developing and optimizing the learning algorithm for AI for each task:

"…The maritime industry's unfamiliarity with AI applications can be resolved with the collaboration of AI researchers and MET specialists for enabling a complete digitalization of MET."

While this approach would also enable setting the minimum standards in the quality of the trainers, utilizing an unsupervised AI training module in the recent future will not be enough for a complete MET environment. Fast information access and transfer may allow an intensive education model with trainees acting as assistant teachers rather than students since AI offers brief and practical information which can be verified.

Regarding practical training, generating simulated environments is costly and procedural generation of onboard virtual reality environments with the AI is possible event with current technology. Development and integration of AI-powered simulators will help seafarers to maintain their employability. AI integration will surely enable a sustainable scientific infrastructure for academy and industry collaboration as well with reduced cost and time, opening new opportunities for experiments and measurements as stated:

"…Procedurally generated simulation trainings should provide the necessary randomness for evaluating the decision-making capabilities of seafarers as well as reduces the amount of work MET experts need to put in for scenario generation. They may just train the AI and provide a random seed with minor interventions."

Ethics and regulations are another important criterion for AI adoption, while AI can also enable objective approaches:

"...AI is unaware of ethics and should provide an objective approach while human factor poses a danger for ethical breaches currently…"

On the other hand, establishing data privacy and protection is a must with accountability. Establishing independent audit and service approval processes with clear definition of legal limits and liabilities and compliance with these laws and regulations must also be considered before generalization of AI integrated MET.

4.2 Implementation

The introduction of supervised AI training tools may provide cost effective MET with increased efficiency by personalized continuous learning and distance learning. AI-prepared training aids also contribute to this argument. This combined with learning tracking with MET experts increases the efficiency of MET even more. The experts meet in the common ground of supervision and combined AI learning with conventional methods of MET, without any qualified person to supervise AI induced learning whether it is distance or in-class, one participant states:

".... Who will decide if the AI says it wrong?"

For simulation training, AI-driven scenario generation has been emphasized by the majority of the participants and chatbots as well. Combined with adapting learning, simulation training can be adjusted according to the requirement of the trainee. AI-enhanced simulation training is a more generalized concept, that supervising MET experts and AI experts working together to optimize the training experience, including difficulty levels, deficiencies realism as well as scalability, interoperability, and user-friendliness. This can be further enhanced by collaborating with shipping companies, which can feed event data such as near miss, accidents, type specific applications and rare events, which may provide a valuable experience for each seafarer prior their working onboard.

4.3 Evaluation

AI-enhanced evaluation for MET establishes an environment for achieving the goals of education by determining the measurement and evaluation criteria more accurately and more precisely. Optimum performance evaluation can be achieved by eliminating human element, hence biased evaluation, and it reduces prediction error for weaknesses and strengths of the trainee, uncovering performance trends and skill deficiencies. Enabling tailored training paths, targeted interventions and setting new training outcomes based on performance are the strong suites of AI integration to MET according to participants.

Utilizing AI for evaluating the performance of the trainees also provides feedback on the performance of the training elements, which can further enhance the effectiveness of lecturers that can be correlated back to the re-planning of training parameters in a perfect loop of planning-monitoring-execution-analysis.

4.4 Limitations

Certain limitations have been stated by participants considering three proposed dimensions of AI integrated MET. Regarding data availability:

"... AI should be trained continuously with a healthy data stream while the data will be gathered from the stakeholders in maritime industry, who shy away from sharing their data. This would affect the sustainability of AI applications in MET. The stakeholders must be convinced that AI will reduce the cost of MET and beneficial in the long-term, then maybe IMO or other regulatory bodies can find a way for data sharing."

Another limitation emphasized is the vocational necessities of MET, which is discussed as follows:

"…Working on a ship is unlike any other job, it requires discipline, self-confidence, and most importantly, knowledge and attention.…Maritime training is not just vocational training; it is personality training."

"…It is necessary to educate students from different cultures in the same way of thinking. If one of them interprets, for example, COLREG rule 13 differently, it will cause accidents. Even in the classroom, we have a hard time training as it is."

The participants also discuss that these concerns for AI applications in MET are also present for conventional MET. It should be noted that a one-size-fits-all solution is not available for MET, but AI integration is to be surely able to open new ways of preparing seafarers for the future of maritime transportation as the framework given in Figure 2 sets out the criteria and concepts deemed necessary.

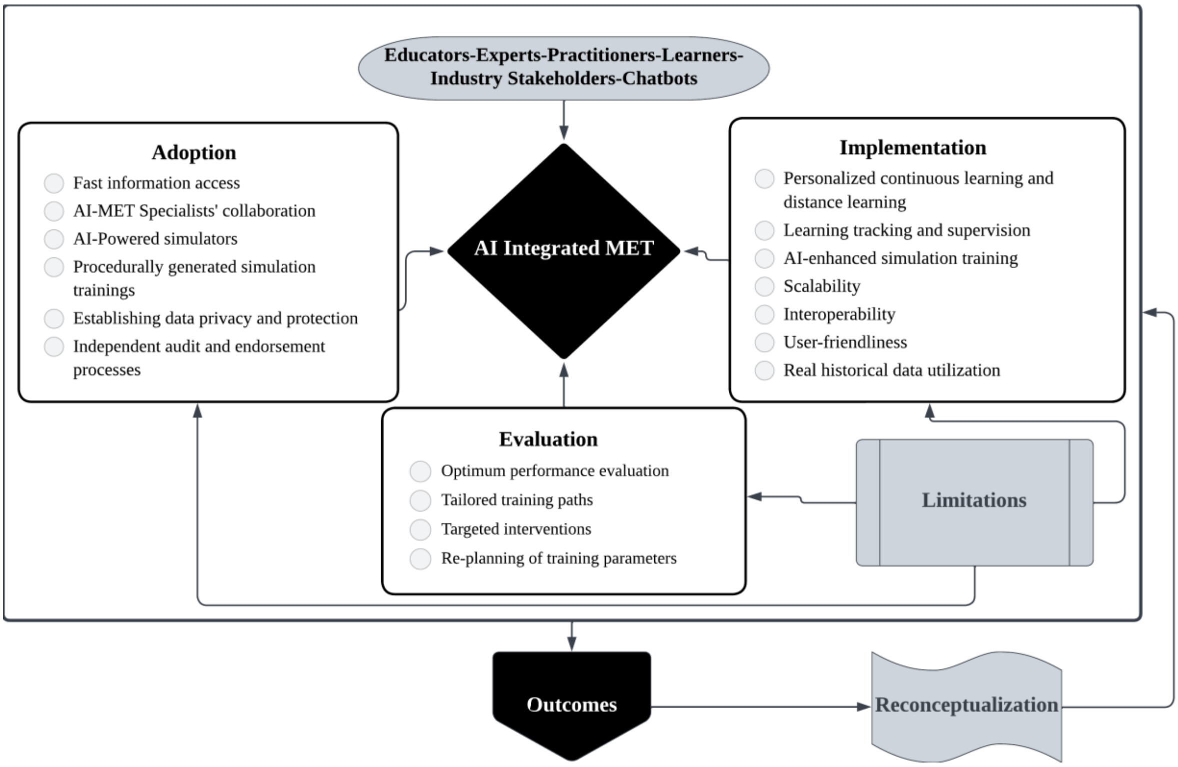

Figure 2: Conceptual framework of AI integrated MET.

5. Conclusion

Concludingly, the benefits, challenges, and limitations of using AI in MET were analyzed and examined by using data received from human experts and ChatGPT through an exploratory approach. When compared, MET experts and both legacy version of ChatGPT and recent GPT4 version answered the questions similarly, with expected answer quality between ChatGPT versions. The results indicate that in the current conjuncture of MET, AI may provide benefits and support to a certain extent on providing perspective to students in the form of research, basic knowledge, project development and career pathing. For MET lecturers, AI tools enable to develop multiple scenarios for simulator training, analyze big data packs and ensure interactive class environments and the tools can also be used as a personal teaching assistant. One of the major current challenges for the lecturers is considered that the information acquired from the AI tools may not be reliable and valid, hence it may cause a cumbersome workload for the lecturer to check the information received from the AI platform as opposed to researching the information from the already acknowledged sources and academic material. Overall, although it is clear that there will be benefits of using artificial intelligence platforms in maritime education and training, as in many other fields, it still is considered to be a situation that requires improvement and progress.

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Data acquisition differences between two AIS receiving antennas

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Abstract: Raw AIS messages are key to interpret the validity of AIS messages used in science for maritime spatial planning purposes. The Barcelona School of Nautical Studies has hosted two AIS antennas, storing raw messages systematically since 2019. Surprisingly, the number of received messages differs from one antenna to the other one. This manuscript aims at identifying the differences between the messages received by each antenna and the origin of these differences. Raw data from March 2023 is used and compared to meteorological variables in the range of the antennas. The older and worse located antenna seems to provide more and larger-distance messages. Results suggest there is no correlation between meteorological variables and the observed differences between antennas.

Keywords: AIS; maritime spatial planning; signal analysis; vessel traffic services;

1. Introduction

The analysis of spatial use made by merchant vessels has received an increasing attention in the past decades. It was first the IMO who introduced the mandatory regulation for merchant vessels over 300 GT on international voyages and all passenger vessels to have an on-board Class A AIS transceiver in 2002 (International Maritime Organization, 2002). The SOLAS convention of 2002, was agreed by 167 states, which flag 99% of merchant vessels (considering gross tonnage), and the introduction of the AIS transceivers was done under the safety concern. Later on, in 2014 all fishing vessels with Length Over All (LOA) above 15m and operating in the European Inland Waterways were also required to have a Class-A AIS onboard system.

The AIS is a tracking system used by Vessel Traffic Services. Messages are broadcasted primarily on two dedicated VHF channels and can be detected either by terrestrial antennas or using satellite-based receivers. Satellite AIS (S-AIS) solves the main coverage problem of terrestrial AIS (T-AIS) in open sea but, according to Greidanus et al., (2016), the high-temporal-resolution provided by T-AIS can be lost when transmitting the data to satellites.

Although AIS was originally designed to improve safety in the sea (Silveira et al., 2013), researchers have identified the great capacities it provides to develop Maritime Spatial Planning tools. For instance, Aarsæther & Moan, (2007) performed sea traffic analysis using AIS data. In the same line, March et al. used S-AIS data to demonstrate how the global pandemic of Covid-19 had an important impact on maritime traffic (March et al., 2021) . J. P. Jalkanen et al., (2012); J.-P. Jalkanen et al., 2009) developed a method (Ship Traffic Emission Assessment Model, STEAM) to estimate vessel-related pollutant emissions using AIS data as the main dynamic source and Lloyds registry data to obtain engine-related variables. They have later used the STEAM method to model underwater noise (J. P. Jalkanen et al., 2018) and have recently included a module to estimate pollutant discharges to water (J.-P. Jalkanen et al., 2021). Other work used T-AIS to assess new methods on mitigating propeller scouring action (Castells-Sanabra et al., 2020; Llull et al., 2020). O'Hara et al., (2023) detail the state of the art of researchers using AIS for assessing the impact of vessel traffic on marine ecosystems. In particular, McWhinnie et al., (2021) propose the use of S-AIS in the Salish Sea to propose specific spatial management policies to reduce impact between vessel activity and a specific species of cetaceans (Southern Resident Killer Whales). Finally, in the field of nautical applications, Xu et al., (2019) use AIS historic data as a guidance for autonomous vessels.

However, the use of AIS data has yet to be extended to port management, with some incipient work published in the last 2 years. Mujal-Colilles et al., (2021) presented an initial work on harbour basin occupancy rates. Fuentes, (2021) makes use of AIS data to generate bunkering activity statistics, which usually take place nearby the ports. Also, using the same technique (Density-Based Spatial Clustering of Applications with Noise, DBSCAN), Lee et al., (2021) used the trajectories generated by T-AIS transceivers in the Port of Busan, South Korea, and its vicinities. Steenari et al., (2022) follow the same path but uses the DBSCAN to detect mooring sites. Also, Mujal-Colilles et al., (2022) used raw T-AIS along with the STEAM method to compare the reduction in maritime traffic due to Covid-19 and the correspondent pollutant emissions in the Port of Barcelona and its surroundings.

AIS data can be acquired through several world-wide commercial providers, although the data might be preprocessed to avoid duplicates between antennas, eventually with time standardization, and is usually an expensive product. It contains both terrestrial and satellite AIS data with world range coverage. In parallel, raw AIS messages can be recorded using local antennas, which is a much cheaper process but with less coverage (mean range ~50nm; maximum range ~120nm). The processing steps of the raw data provide the user with the detailed knowledge of the data filtering and mining process. However, the installation of the antenna is key to obtain high quality data. The Barcelona School of Nautical Studies (FNB) hosts two AIS terrestrial antennas installed in different locations and heights. This manuscript aims at finding the differences between the two antennas.

2. Methods

The Barcelona School of Nautical Studies has hosted an AIS antenna for the last 10 years. After an update on the recording system, data is hourly stored since September 2019 and is decoded using an open source code (pyAIS.py) and preprocessed following the standards described in (ITU-R, 2014). An acquisition of a new antenna in 2021(AIS2) located in an apparent better position both in plane and vertically, see Figure 1, was originally thought as a renewal of the old antenna. However, previous to the final removal, a comparison study is being carried out in order to see if both antennas are complementary.

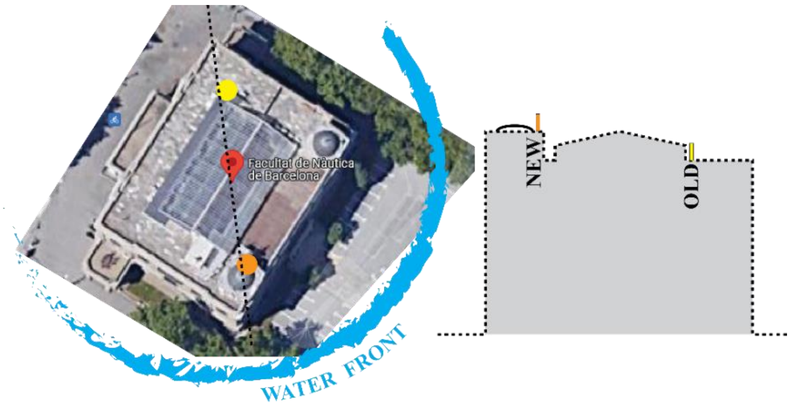

Figure 1. Location of the new and old antenna in plane view (left) and in vertical view (right).

Old AIS antenna is a VHF antenna connected to a SeaTraceR AIS Class B Transponder S.287. The new AIS antenna, provided by IHS-Markit, is a Cardiod Dipole Array Antenna connected to a Comar SLR-350N receiver. The pipeline to decode and run an initial pre-process step is shown in Figure 2. Raw data from the both receiving systems is decoded using a python script to access the specific information contained in each of the messages. Therefore, the information can be manually selected from raw messages based on the fields contained in each message type. AIS broadcasts 27 different messages. The details of the information contained in each message can be found in (ITU-R, 2014). So far, only dynamic messages of type 1-3 and 18, and static messages 5 and 24A&B have to be decoded using 70% of the information contained. For instance, Communication State, RAIM Flag, from messages 1-2-3 and 18 and AIS Version Indicator or Call Sign from messages 5 and 24B are not considered. Once decoded from raw messages, the information is stored in ASCII files ready to be used for detailed analysis, each type of message in a separate file. As an example, one month of data in raw messages is ~1GB . Afterwards, each type of message is filtered following the instructions given in (ITU-R, 2014) for bad data in each field, which represented a total of 2% of the initial data.

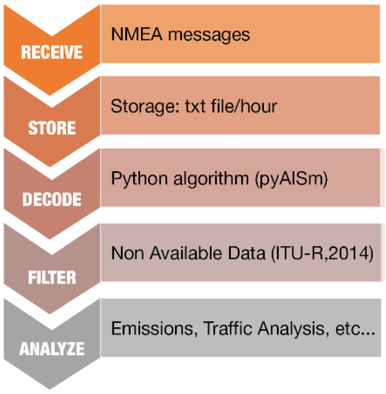

Figure 2. Pipeline for the storage and initial cleaning process of the raw AIS messages

The initial analysis of raw AIS messages led to a key parameter that is normally granted by researchers using non-raw AIS data: the time stamp. According to the (ITU-R, 2014) dynamic messages only contain the second in which the message was broadcasted by the AIS vessel antenna. The entire UTC time stamp is sent through messages 4 with a frequency of 4 minutes. The coordination between dynamic messages (with a broadcasting frequency ranging from 2 seconds to 3 minutes) complicates the merging of the time-stamp. This problem was solved by including four digits at the end of each NMEA message, including the raspberry local minute and second when the message was received. Comparing these two time-stamps, 15 % of the messages are received apparently after they are sent -which is physically impossible-, of which a 12% are messages with 1 second of error. Hence, we added a 1-second tolerance to our pipeline to include these messages (Mujal-Colilles et al., 2021).

3. Results and Discussion

Table 1 shows the comparison of the number of messages initially received by each antenna starts and the evolution of the total number of messages in the different steps contained within the initial pre-process script. The Old-AIS records 18% more Class A-dynamic messages than the New-AIS. Similarly, the Old-AIS captures 14% more Class A-static messages. The evolution of the dynamic messages filtered throughout the process does not change significantly between the two antennas, indicating, for instance that any of the antennas records more points on land than the other.

Table 1. Evolution of the number of messages in the first pre-process data. Data from March 2023

			Old-AIS	**New-AIS**
Class A	Dynamic	Initial number of messages	8914426	7537810
		Remove all NaN’s	8903505	7529370
		Remove duplicates	8875421	7511744
		Points on land	8834420	7476788
	Static	Initial number of messages	632820	557857
		Remove duplicates	4880	4621
		Remove daily duplicates	4262	4018
Class B	Dynamic	Initial number of messages	3618691	705876
		Remove all NaN’s	997508	694243

		Remove duplicates	996764	693762
		Points on land	967763	676476
	Static	Initial number of messages	346016	226608
		Remove duplicates	4145	3449
		Remove daily duplicates	4134	3431

Conversely, there is an important difference between antennas regarding Class B messages: the Old-AIS records 5 times more dynamic messages than the New-AIS. However, when messages containing all NaN's are removed this difference is reduced significantly with Old-AIS having 1.5 times of Class B dynamic messages compared to New-AIS. This means that Old-AIS receives up to 80% of Class B-dynamic messages with missing values, rendering these messages unusable to extract information on the vessel information.

Looking into detail on the temporal evolution of the differences between antennas, Figure 3, there seems to be a clear anticorrelation between AIS classes. This is, the days with maximum differences on Class A AIS, are coincident with the days with minimum differences on Class B, and vice-versa. Moreover, days with maximum differences between Old and New AIS are the days with more Class A messages (usually mid-week) whereas Class B has peaks of maximum messages at the beginning of the weeks (Mondays and Tuesdays).

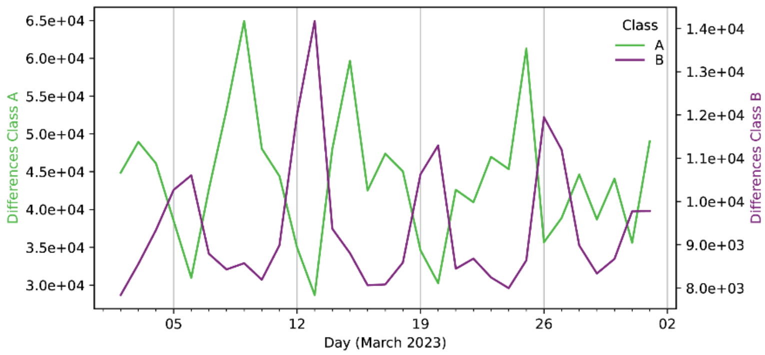

Figure 3. Absolute daily differences evolution on messages received between Old-AIS and New-AIS depending on the AIS Class during March 2023. Vertical lines indicate Mondays.

Figure 4 shows the georeferenced differences between messages received by each antenna depending on the AIS class. Apparently the range from Old-AIS antenna seems also larger than the range of the New-AIS antenna. We have selected two specific days from Figure 3, specifically 9th of March, when differences between Old and New-AIS are maximum for Class A, and 13th of March for Class B, to see if the differences in ranges are also significant and, if so, check any possible correlation with weather variables.

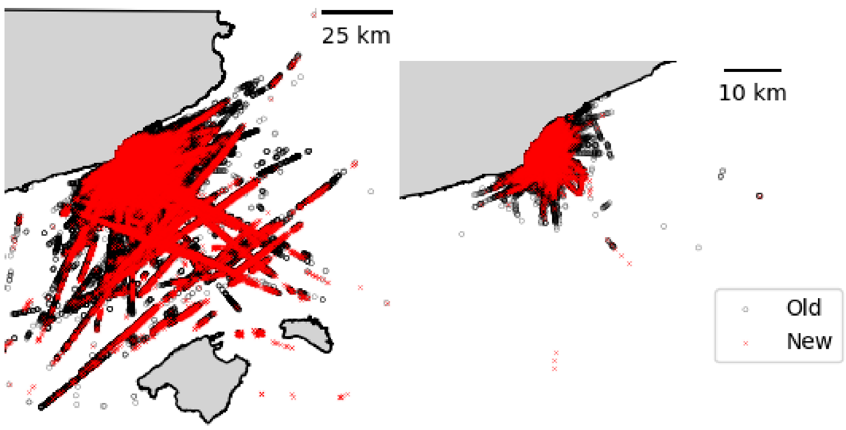

Figure 4. Comparison of georeferenced dynamic messages between Class A (left) and Class B (right). Messages received March 2023.

Figure 5 (top figures) shows the hourly evolution of maximum range for each antenna on the selected days.

Clearly, Old-AIS has larger maximum range, 5 nm on average, which represents around 10% of the maximum range in the day. Although from Figure 5a, it apparently seems that the maximum range is correlated with maximum wind speed with wind coming from the North-East, Figure 5b contradicts the former conclusion because maximum range does not coincide with either wind-speed or wind direction. In fact, in Figure 5b, when wind direction is maximum and comes from the North-East, the maximum range on March 13th is reaching the lower values on the day.

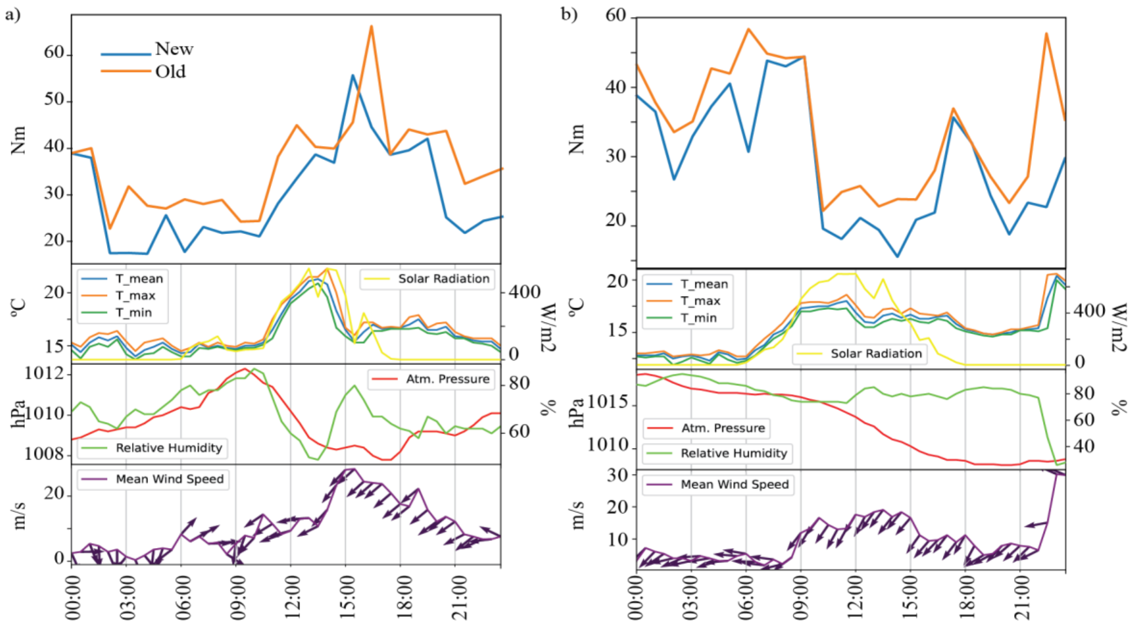

Figure 5. Maximum hourly range for each antenna and weather variables on a) 9th of March 2023 and b) 13th of March 2023. Weather data obtained from the Servei Meteorològic de Catalunya, station Port de Barcelona - ZAL Prat

The spatial distribution of maximum range differences between antennas might be helpful to see if the difference between antennas comes from the directionality of the antenna itself and is related to its orientation. This is plotted in Figure 6, where no clear differences in direction can be observed.

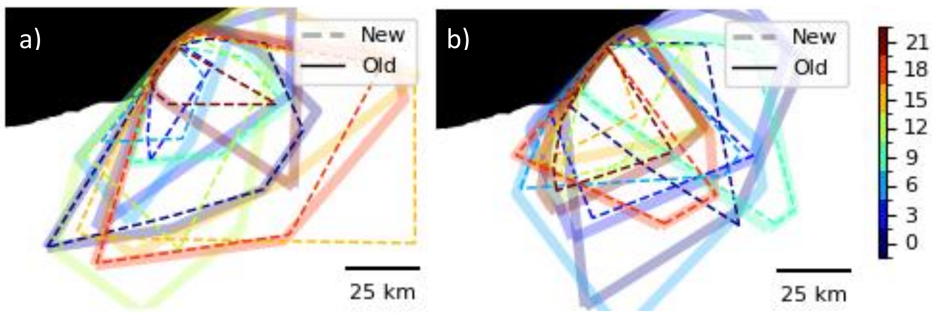

Figure 6. Convex hulls of hourly ranges for a) 9th of March 2023 and b) 13th of March 2023. Discontinuous lines from convex hulls created using New-AIS messages. Continuous thicker and transparent lines from convex hulls created using Old-AIS messages.

4. Conclusions

AIS data is becoming an important source for scientists and stakeholders to monitor the impact of maritime traffic industry. So far, studies mainly rely on data from private providers with no control on the initial processing of the AIS raw data. However, the real knowledge on raw AIS data is key to understand the gaps, the outliers and the processes to filter and interpolate it.

This manuscript has compared raw AIS data from two different antennas located at the same building in the Barcelona School of Nautical Studies. The Old-AIS antenna is located closer to the ground and further from the coastline, whereas the New-AIS antenna is in a better position. However, data from March 2023 suggests that the Old-AIS antenna is getting more messages and with a wider range.

When comparing the maximum ranges within a day with the meteorological conditions (temperature, wind speed and direction, relative humidity, atmospheric pressure and solar radiation) there seems to be no significant correlation that could indicate the source of the differences. Also, the antennas are not recording messages with a direction bias.

More research is needed to understand the differences between the antennas to optimize the position and orientation in order to get more and further messages.

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Concepts and Applications of Eye Tracking Technology in Maritime Shipboard Operation with Pilot Case Study

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Abstract: Despite advanced technologies on modern ships, accidents are nevertheless influenced by human factors [1]. Several key characteristics have been recognised as significant contributors to events, specifically fatigue, inadequate communication, inadequate maintenance practises, insufficient training, improper situation assessment, high mental workload, limited situational awareness, and high stress levels [2,3,4]. In order to investigate the risk analysis pertaining to human factors in marine accidents, it is essential to examine and assess variables that pose challenges in quantification within accident reports. These variables include mental workload and situational awareness. Eye-tracking technology has been widely utilised across several disciplines for a range of objectives. In a broad sense, eye-tracking technologies offer a method to collect a diverse range of eye movements that serve as indicators of various cognitive, emotional, and physiological states in humans, all in real-time. This technology can facilitate a more comprehensive comprehension of the human brain across a range of settings. Eye-tracking technology, an objective measurement, is a recently developed methodology within the marine industry. The present study offers a valuable chance to enhance comprehension of eye-tracking applications within the marine sector by conducting a pilot experiment in a bridge simulator. The pilot research findings and the subsequent analysis of ideas and applications of the eye tracker make a valuable contribution to the ongoing development and exploration of eye movement studies as an objective indicator in maritime operations.

1. Introduction

The significance of the human factor is crucial within industries characterised by high levels of risk, such as the maritime, aviation, and nuclear sectors. This is primarily due to the potential for human errors to result in severe consequences that endanger safety, the environment, and human lives [5]. These industries encompass complex and advanced systems, with human beings playing a crucial role in various capacities, such as operators, pilots, crew members, or engineers. Human variables may considerably influence the functioning and interaction of these systems, hence playing a crucial role in managing risks.

In maritime operations, accidents are commonly related to human error, which is often identified as the primary cause. Factors including fatigue, inadequate training, and breakdowns in communication are widely recognised as significant contributors to these incidents [3]. Similarly, within the aviation industry, pilot error frequently emerges as a significant contributing element in accidents. Similarly, in the context of nuclear power plants, human errors possess the potential to result in safety breaches and accidents with grave consequences. Hence, it is essential to consider the human element in risk management, including factors such as human behaviour, cognition, decision-making, communication, and training [6]. By comprehending and acknowledging the influence of human factors inside these industries, it is possible to reduce risks and improve safety measures.

Maritime operations rely significantly on human performance and decision-making; hence, understanding the various factors that impact crew members' behaviour during shipboard operations is crucial. Eye-tracking has emerged as a promising technique in studying human behaviour and cognition in recent years. Eye-tracking technology can provide valuable insights into crew members' visual attention, workload, and decision-making during shipboard operations. This technology allows researchers to identify possible safety hazards and chances for optimisation and get a better knowledge of human reactions [7].

This research aims to investigate the theoretical foundations and practical implementations of eye-tracking technology within the context of marine shipboard operations. A case study example is presented to demonstrate the potential of eye-tracking technology to enhance maritime safety and performance. First, the fundamental principles of eye tracking and its significance in maritime operations are investigated in depth. Next, different applications of eye tracking in the maritime industry, including training methods, apparatus design enhancements, and safety analysis activities, are examined in detail. In addition, a case study demonstrates how eye monitoring can be used to evaluate the performance of crew members during shipboard duties. This study examines the potential benefits of eye tracking in maritime operations, enhancing safety and efficiency. It also provides a comprehensive framework for future research in this discipline.

2. Eye Tracking Technology

The origins of eye-tracking technology stem from the "eye mind" concept proposed by Just and Carpenter in 1976. This hypothesis states that a direct link exists between where someone is looking and their concurrent thoughts. Eye tracking technology can record and analyze eye movements, transforming them into data streams. These data encompass various metrics, including pupil size, gaze direction, and specific fixation areas. Bojko and Tatler et al. assert that eye movements provide crucial insights into human behaviour due to two primary factors [7,8]. Initially, the locations that we opt to concentrate our attention on provide insights into our behavioural requirements for a particular moment.

2.1 The methodology behind the eye tracker's functioning.

Understanding the structure and function of the eye is crucial in capturing this phenomenon [9]. The photoreceptor cells in the retina, namely the rods and cones, are responsible for the absorption of light reaching the eye through the pupil. Subsequently, these cells transfer the visual information they capture to the brain. Cones facilitate the perception of high-resolution and colour vision, mainly concentrated inside the fovea region, which is characterised by its superior acuity. In addition to the fovea, the region of highest visual acuity, peripheral vision exhibits diminished clarity, necessitating ocular motion to acquire precise visual data [9]. Eye tracking commonly uses pupil-centre corneal reflection. Illuminators are used for capturing the pupil centre and corneal reflections [10]. Gaze calculation requires exact pupil locations and reflections. Given the possible difference between self-reported data and real-life activity, eye-tracking technology provides a reliable and unbiased way to examine gaze patterns [8].

2.2 Types of eye trackers

Researchers utilise various eye-tracking devices, such as wearable eye trackers and screen-based eye trackers. A screen-based eye tracker is most appropriate for the purpose of presenting stimuli on a monitor, projector, or TV screen within the context of an eye-tracking investigation. This particular eye tracker can be mounted in front of the display using a tripod, or alternatively, it may be secured to the lower portion of the display via a magnet. Nevertheless, due to its confinement of human behaviours within the screen, it is deemed unsuitable for examining naturalistic watching. In contrast, wearable eye-trackers enable participants to navigate their realistic surroundings without constraints, rendering them well-suited for capturing eye movements in authentic, real-world settings. Hence, the choice of a suitable eye tracker is contingent upon the research objectives. The development of mobile eye-tracking devices has facilitated the ability of researchers to capture eye movements during unregulated and authentic tasks. Technological progress has yielded valuable information on the correlation between visual perception and motor behaviour [11].

In a specific experimental study, the Tobii Glasses 3 facilitated the participants' engagement in a real-time bridge simulator. The participants were required to operate the simulator utilising realistic electrical navigation equipment, concurrently monitoring several screens, and physically moving inside the simulated environment. The Tobii Glasses eye tracker is a non-invasive video-based eye identification and monitoring device. It has a sampling rate of 50 Hz and a frame interval of 20 milliseconds. Based on the provided description, the Tobii 3 device is outfitted with eight Infrared illuminators, which serve the purpose of illuminating the eyes and assisting the eye-tracking sensors (Figure 1).

Figure 1. Tobii Glasses 3 (retrieved from https://www.tobii.com/products/eye-trackers/wearables/tobii-pro-glasses-3).

2.1 Types of eye movement

Researchers have employed numerous measures to investigate the phenomenon of eye tracking. However, ascertaining the most effective metre for assessing situational awareness, attention, and effort poses a considerable challenge. The interpretation of data is subject to variation depending on the task at hand and the researcher's perspective [11-17].

- Pupil size variation reflects changes in lighting, attention, and cognitive load. Pupil size measures workload, attention, and mental state in both lab and real-world settings [11]. Greater pupil diameter changes occur during visually demanding planning tasks versus verbal working memory tasks [12]. However, lighting changes also affect pupil size [13].
- Blink rate, or blinks per minute, indicates when data may be affected by blinking—blink rate and duration decrease during high visual workload, measuring mental workload [14,15]. Blink frequency drops during demanding prolonged tasks [16]. Air traffic control and flight simulations also show lower blink rates with higher visual demands [17].
- Fixation duration, the time viewing a point before moving the eyes, indicates interest in a stimulus [12]. Dwell time is similar but includes pre-fixation. It decreases with increased flight task demands [12]. After high cognitive load, prolonged blinks may occur until decisions are made [13].
- The fixation rate, or fixations per minute, reflects interest in a stimulus [14]. The saccade rate, the number of rapid eye movements per minute, drops as task difficulty or fatigue increases [15,16].

In summary, many metrics provide insight, but interpretation depends on the task and researcher. Awareness of these factors aids in utilizing eye-tracking data.

3. Eye tracker in Maritime Studies

The use of eye-tracking technology has the potential to provide significant contributions to the maritime industry. This technology enables the measurement of crew members' visual attention and perception throughout various activities, hence offering important insights [17-20]. The utilisation of this data has the potential to discern potential safety hazards and enhance the efficacy of training programmes and the design of equipment. Identifying and analysing key applications in determining the human reaction is crucial in understanding and studying this phenomenon. The assessment of attention and workload may be conducted by tracking eye movements, which enables the identification of locations that get the highest level of focus. This method also detects distractions and high workload instances [17]. The utilisation of eye response models has demonstrated the potential to accurately forecast mental effort in many jobs, including the management of naval engines. The identification of exhaustion can be facilitated by observing the occurrence of prolonged fixation and decreased blinking, as both behaviours are commonly associated with fatigue. The utilisation of real-time eye-tracking equipment enables the identification of fatigue symptoms in crew members [18]. Using eye tracking to measure attention and performance during training reveals specific areas that require development for enhancing the training [19]. It facilitates increased trainee involvement with the subject matter. Another study aims to improve equipment design by assessing visual attention patterns to bridge, cargo, and engine control room layouts and displays. The study identifies modifications in design to enhance performance and ensure safety [20].

In conclusion, eye-tracking technology in maritime operations offers a means of obtaining unbiased observations of human reactions to various jobs and activities. The primary advantages are improved safety measures, expanded training programmes, and optimization of equipment design.

4. Pilot Case Study

Human factors and crew response plays a crucial role in mitigating maritime accidents. An experiment was undertaken in bridge simulators and eye-tracking technology to examine the behaviours of crew members and their eye movements in simulated emergencies. This facilitated the identification of potential consequences and the enhancement of safety practices. The participants were adequately informed, provided their consent, and completed training in accordance with the ethical requirements for the study. The experiment participants were informed about the study, and their compliance with the EU's General Data Protection Regulation (GDPR) was ensured.The scenarios were designed to be adaptable in order to elicit a range of responses. The calibration of eye tracking preceded the simulations. Areas of focus were established for critical bridge equipment. The first findings indicated that radar displays received the highest level of visual attention. Participants consented and were briefed on the experiment, including ethical considerations. They were trained on operating the bridge equipment and eye tracker. Simulations began with participants alone on the bridge. Before starting, participants received scenario instructions and training. Eye tracker calibration and synchronization preceded the simulations. The 20-minute scenarios had a 3-minute baseline before introducing targets, whose timing depended on reactions. Scenarios were flexible to elicit varied responses. Areas of interest (AOIs) were defined on critical bridge equipment for quantitative eye-tracking analysis. AOIs outlined features for calculating gaze metrics over time. This evaluated officers' overall visual patterns following good seamanship principles, Figure 2 illustrates the AOIs that represent critical equipment on the bridge.

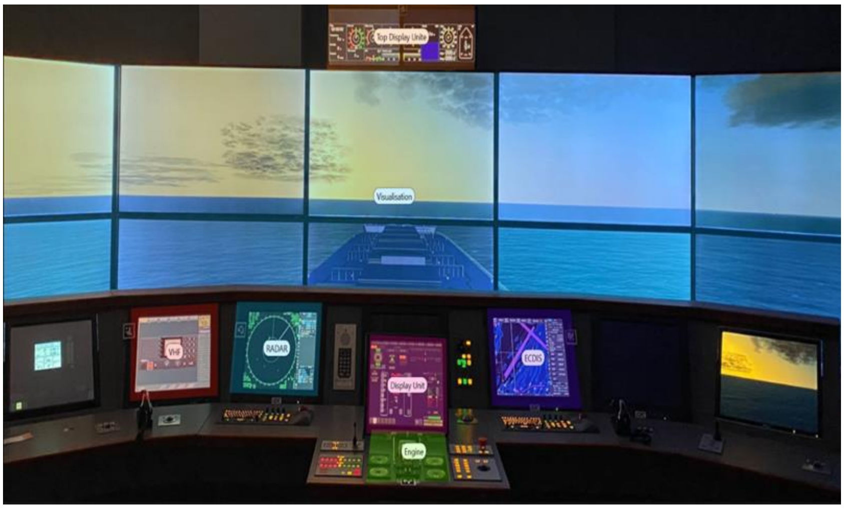

Figure 2. Areas of Interest (AOIs) in the bridge system.

In this particular context, mixed-methods user research was done utilising a bridge simulator and eye-tracking technology. A total of thirteen participants were engaged in the experimental procedures, and the outcomes obtained from these studies are displayed in Table 1. To analyse the metrics, the average pupil size, number of fixations, average time of fixation, number of saccades, average time of saccades, and number of blinks, a comparative approach will be employed within a hypothesis-driven framework. Statistical analyses will be carried out to examine the differences between the two groups. Hence, this study encompasses an initial assessment pertaining to the frequency of impacts on the bridge apparatus, namely the Areas of Interest (AOIs).

The number of hits for Areas of Interest (AOIs) on the bridge was normalized by scenario duration and averaged. The results of the simulator study indicated that participants directed their attention primarily to the radar equipment, followed by visual displays, and finally to the upper display unit.

Table 1. Results of the eye tracker metrics

Characteristic	Pilot Experiment N = 13
Average pupil size	0.51
Number of fixation	2,470
Average time of fixation	1,663
Number of saccades	270
Average time of saccades	50
Number of blinks	96
Display unit	***157***
ECDIS	**130**
Engine	24
RADAR	**1,034**
Top Display unit	*27*
VHF	13
Visualisations	***415***

5. Conclusion

Human factors play a crucial role in ensuring the safety and effectiveness of maritime operations. Integrating eye-tracking technology into maritime activities provides promise for gaining insight into seafarers' visual attention, perception, and mental workload. By implementing eye tracking, businesses can identify hazards, improve training and design, and boost overall performance and safety. To integrate eye tracking, choose a device that meets the requirements of the operation. Then, combine it with existing vessel monitoring systems to analyze seafarers' attention and workload in real-time. Additionally, eye tracking should be incorporated into training programmes to enhance efficiency and evaluate crew performance. Eye tracking provides valuable insights into seafarers' visual attention and mental workload, improving safety, training, and equipment design.

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Coupling CFD and VR for Advanced Fire Training in Ship Engine Room

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Abstract: Fire hazards on marine structures and vessels affect significantly the structural design, engineering decision making and crew training procedures. An on-board fire is extremely dynamic and case dependent phenomenon. New technologies, such as virtual reality (VR) offer a valid alternative for training in such dangerous situations. Fire and smoke exhibit fluid like behavior so computational fluid dynamics (CFD) modelling approach is necessary to ensure the realism of fire models in VR. A CFD and VR integration methodology for development of improved fire hazard marine training, comprising of ship engine room vector and bitmap model generation, CFD fire behavior analysis, results validation and CFD/VR integration, is presented here. SMARTFIRE, an advanced CFD software package, is used to calculate fire parameters, analyze its development and spreading. Heat and smoke progression in a ship engine room environment are visualized in a VR system based on Unreal Engine. The evaluated model is then transferred to the VR environment by linking the fire visualization parameters to the CFD analysis data. In this first phase of the research the CFD-VR integration is done on case to case scenario basis, using the CFD time dependent results with the goal is to produce an interactive dynamical VR simulator realistic fire training environment.

Keywords: marine fire training; CFD fire modeling; VR engine room

1. Introduction

Various documents, rules and recommendations issued by regulatory organizations like International Association of Classification Societies (IACS) (Cowley 2002; Olsen 2023), International Convention for the Safety of Life at Sea (SOLAS) (IMO 2009) cover basic principles of the design, construction, use, and maintenance of firefighting and fire safety systems on marine structures and vessels. The main points of ship firefighting safety drill procedures are designed to ensure that the crew members are prepared to handle fire emergencies at sea. The fire hazard response procedures typically involve the following actions:

- alerting the crew,
- activating the firefighting systems,
- assessing the situation,
- evacuation of the affected area,
- using firefighting equipment.

Great emphasis is given to the fact that “every member of the crew has a personal responsibility to be competent in identifying the presence of fire, of knowing the correct actions to take in raising an alarm, in taking actions to ensure the safety of passengers and in taking the necessary actions to prevent fire spread whilst ensuring the utmost precautions for personal safety”. Extensive training is performed on regular basis on every marine structure and vessel with crews in order to achieve the necessary knowledge level, competence and confidence necessary for adequate behavior during the stressful fire hazard situation.

It is quite self-explanatory that experimental real fire hazard training is not an option for safety reasons due to the unpredictable and dynamic case to case dependent nature of the fire phenomenon. On the other hand, the development of emerging technologies such as virtual reality (VR) may open opportunities for training in dangerous situations (Cha et al. 2012; Ting et al. 2018; Ooi et al. 2019; Lovreglio et al. 2021). The quality and realism of the computer-generated simulation of a fire environment used in VR that adheres to the actual characteristics of a real-life fire (Huang et al. 2014) is paramount if applicability of the VR model for training is to be achieved (Vukelic et al. 2021). Special attention needs to be given to the realism of flames, heat, smoke, user interaction with the virtual environment and the accuracy of the physics simulation of the dynamic behavior of the fire in the VR model. Using a VR training system crew members can be trained in a safe and controlled environment, which effectively simulates the challenging and hazardous conditions of a real fire emergency in various scenarios. In addition, the trainees can practice different firefighting techniques and strategies on the actual layout of the marine structure or vessel, i.e. tryout different fire extinguishing materials, apply different firefighting equipment, thus accumulate knowledge and experience without exposing themselves to real danger.

A CFD and VR integration methodology for development of improved fire hazard marine training, comprising of ship engine room vector and bitmap model generation, CFD fire behavior analysis, results validation and CFD/VR integration, is presented here.

2. Methodology

2.1. Geometry modeling

A ship engine room CAD model, comprising of two main and two backup engines, two generators and various auxiliary equipment, has been built and then loaded to the SMARTFIRE case specification tool. The dimensions and layout are shown in figure 1.

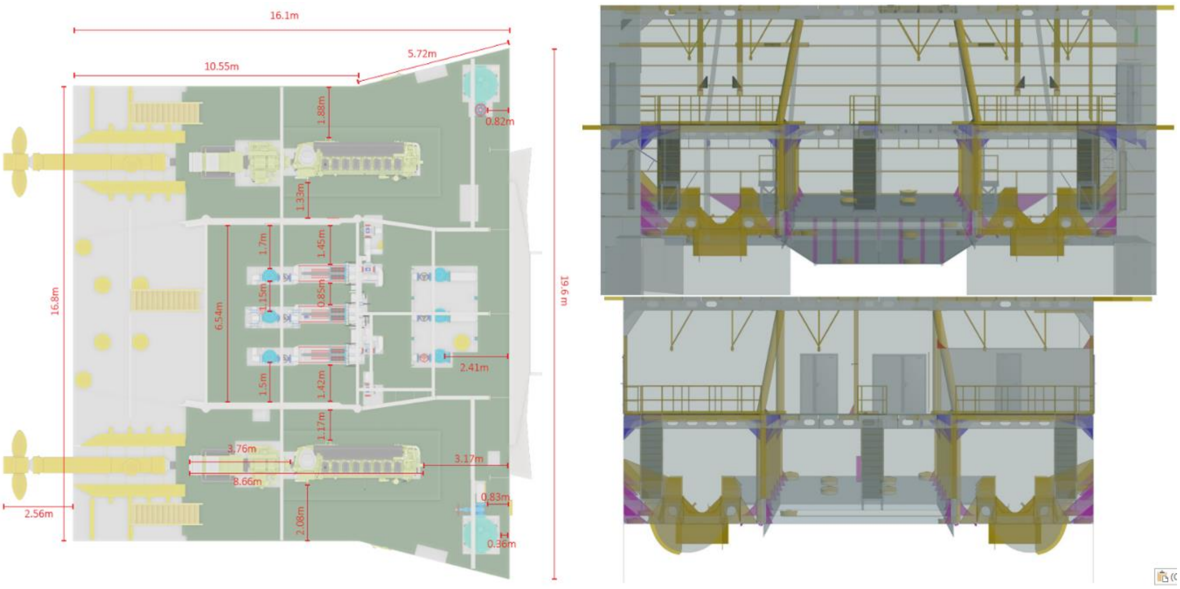


Figure 1. Ship engine room CAD model

2.2 CFD fire model

As fire and smoke in real life behave as a fluid, Computational Fluid Dynamics (CFD) approach in best suited to physically model fire (Solmaz and Van Gerven 2022). The CFD model must be based on fluid dynamics simulation of fire spreading, heat transfer a combustion of the material present in the environment, accurate representation of the environment geometry including the boundary conditions (temperature, humidity ventilation outlets etc.).

An advanced CFD fire simulation environment SMARTFIRE (Greenwich), developed by the Fire Safety Engineering Group (FSEG) at the University of Greenwich, is used to simulate fire in a ship engine room. The definition of a CFD simulation fire model consist of the following steps (Galea and Patel 2013):

1. Pre-Processing
   1.1. designing the case scenario,

    1.2. defining environment specificities,
    1.3. mesh definition and generation)
2. CFD Computational Analysis
    2.1. solution process parameters definition calculation
    2.2. run-time data generation,
    2.3. results data generation.
3. Post-processing
    3.1. data visualization
    3.2. results analysis.

The previously developed engine room CAD model has been imported to the SMARTFIRE scenario designer and case specification tool and used as definition of geometrical boundary conditions. The software's Case Specification Environment is then used for advanced configuration (physics options, transient effects, detailed object configuration) and meshing. The meshing strategy and parameters are defined based on the engine room geometry type, additional physical features as walls, vents, inlets, outlets, fans etc. as shown in figure 2.

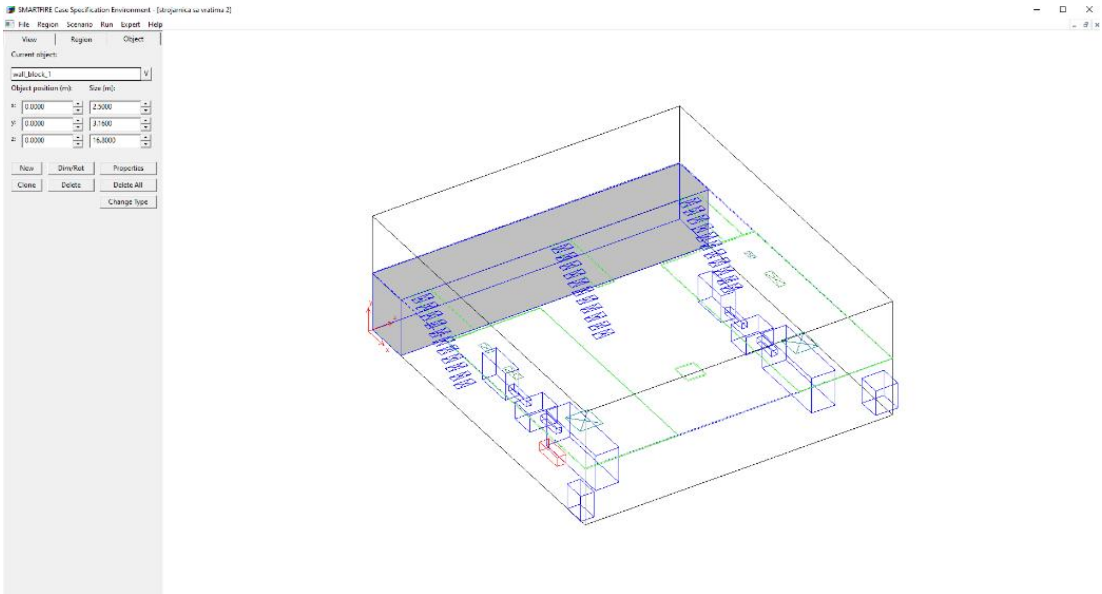


Figure 2. Engine room in SMARTFIRE

The mesh consisted of 301320 cells (elements) defining the domain for the CFD analysis, figure 3.

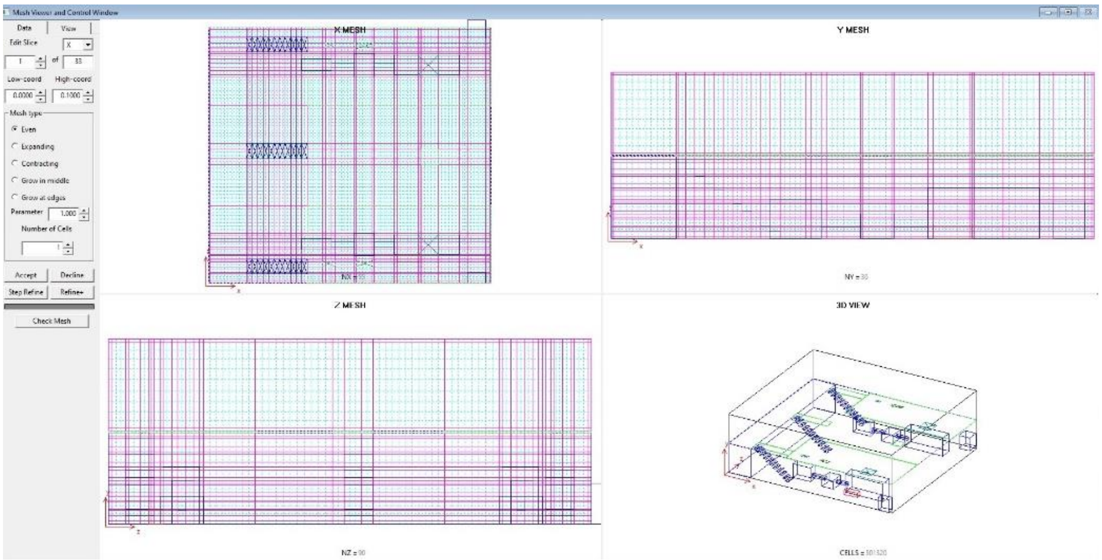


Figure 3. Meshed environment

Next, a fire scenario and fire model are defined. The fire source can be simulated using a volumetric heat release rate or as a mass source of combustible material. The later was used in this case, resulting in a modeled fire with characteristics shown in table 1.

Table 1. Fire properties.

Property	Value	Units
Peak fuel output	0,0898201	kg/s
Total fuel	8,9865	kg
Equivalent peak heat output	4491	kW
Equivalent total heat output	449,33	MJ
Equivalent maximum rate of heat rise	59,8	kW/s
Equivalent average heat output	1497,75	kW
Theoretical peak smoke output	0,0013473	kg/s
Total smoke	0,134798	kg

The initial location and size of the fire is defined during the geometry input phase (red outlined block in figures 2 and 3). The solver accounts for all burnable material in the environment. All geometry surfaces have combustion properties attributes (surface ignition temperature, flame spread rate, critical temperature and critical heat flux) assigned to them, so surface heat flux exposure, pyrolysis front and flame envelope propagation can be used to determine the spreading dynamics of the fire in the engine room. All the combustible material becomes new fuel for the fire during time. A so called, simple fuel generation rate governing quadratic equation is used as a fire growth model, in the form of:

$$P = 10^{-6}\, t^2, \qquad (1)$$

where:

- P fuel generation rate
- t – time, seconds.

The CFD engine component of SMARTFIRE is a C++ code based that uses a 3D unstructured mesh enabling irregular geometries to be meshed. The tool uses SIMPLE pressure correction algorithm and can solve coupled turbulent (two equation k-epsilon closure with buoyancy modification) or laminar flow problems under transient or steady state conditions (Ewer et al. 2013). The basic physical rules used during calculations are mass, momentum and energy conservation laws. The dynamic movement of smoke is calculated using the buoyancy modified two-equation (k-ε) turbulence model (Ewer et al. 2013). Heat transfer and energy balance are considered by convection (transport equations) and radiation modeling (radiosity, the Six-Flux Radiation model and Multiple Ray Radiation models).

The analysis parameters considered are time-dependent temperature and smoke density at various points throughout the entire engine room volume. This data is to be used as input for modeling of fire propagation it the VR environment.

3. Results

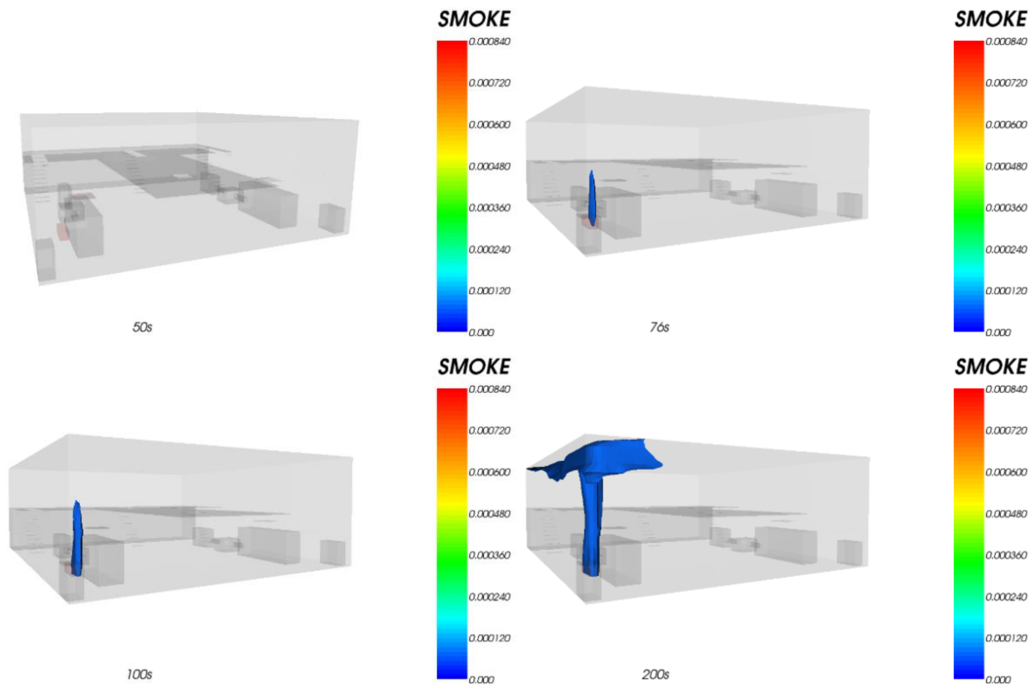
3.1 Virtual reality integration

The engine room CAD model has been converted to a virtual environment in Unreal Engine. The results are illustrated in figure 4.

Figure 4. Ship engine room in the VR environment

3.2 CFD analysis

The simulation yields time dependent smoke density (concentration) and heat propagation (temperature distributions) dynamics. The evaluation of the simulation results comprises of visual analysis of the fire behavior using a software generated video animation. In this case a 10-minute analysis time period is chosen. Figure 5 shows the changes in smoke density during time using frame from the video file. For clarity of depiction, only 4 smoke density time dependent values variation have been chosen for display.



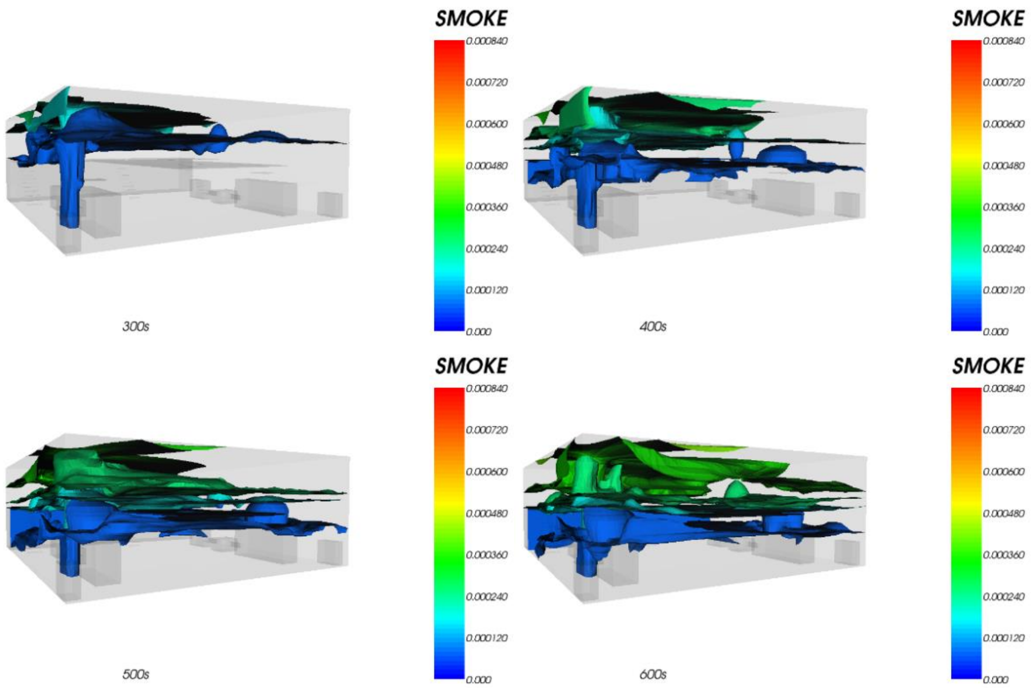


Figure 5. Smoke concentration in 10-minute period after ignition

3.3 VR environment fire display

The CFD calculation results are used to model the fire and its dynamic growth realistically. A rendering of the fire initial phase is shown in figure 6.

Figure 6. Virtual fire

4. Discussion and Conclusion

A methodology for integrating CFD and VR for enabling advanced fire hazard training possibilities in ship engine room is proposed in this paper. Fire hazard on marine structures and vessels is an extremely important issue equally for crew members, shipowners and regulatory bodies and organizations. Great care an effort is given to training procedures to raise the adequacy and quality of crew members reaction in this dangerous situation. Introducing new technologies such as VR can contribute to both safety and realism of the fire training itself. Numerical CFD analysis using well established tools yields the necessary data to enable realistic fire modeling in VR environment. Initial trails of the VR fire training system have shown promising results and elevated acceptance of the proposed training methodology on behalf of trainees.

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The factors affecting cruise ships' evacuation efficiency

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Abstract: In the maritime industry, the full evacuation of cruise ships is considered one of the most dangerous tasks. The evacuation's effectiveness may be described as a function of the crew's readiness at a given time because it changes during the 24-hour periods, but it also depends on the ship's activity at the time (sailing, berthing/unberthing, manoeuvring, etc.). The evacuation's effectiveness may also be understood as the time required to rescue all persons on board. In both cases, the critical factor is the crew's ability to perform as a team under exceptional circumstances. The crew's ability to perform effectively is demonstrated in timely decision-making and proper execution of the required actions. The SOLAS Convention and IMO Resolution MSC/Circ. 1533 specifies the maximum allowable duration of the evacuation to be achieved by evacuation drills.

The research's main objective was to identify the current state of affairs on large passenger ships (knowledge and procedural gaps) and the key factors that may jeopardise evacuation effectiveness. It mostly focuses on crew readiness as the most critical factor. The research activities lasted from September 2020 through September 2021 and involved questionnaires and interviews of 81 seafarers from 24 cruise companies.

The paper to be presented demonstrates the research methodology, assumed and actual restrictions, and findings. Finally, the paper also indicates the main conclusions and recommendations, particularly those that may be included in the international regulatory framework.

Keywords: cruise ship, evacuation, factors affecting evacuation process

1. Introduction

The safety of passengers and crew is a top priority on cruise ships. The organisation of the crew and the implementation of rescue measures in the event of incidents at sea prevent the loss of life. 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. The IMO "Guidelines for a Simplified Evacuation Analysis for New and Existing Passenger Ships" MSC Circ. 1238, 1533 (IMO 2007, IMO 2016) 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. Wang et al. list unique characteristics of HEPS (Human Evacuation from Passenger Ships) (Wang 2022). They define four characteristics of evacuation at sea that differ from evacuation on land. The first characteristic is the preparedness of the ship's master and crew, with the master assessing the risk and the crew organising the evacuation; secondly, the evacuation process is extremely complicated due to the LSA organisation; thirdly, weather conditions and ship movement affect it; and finally, passengers are not sufficiently familiar with abandonment drills, so panic and overcrowding may occur. Li et al. present an optimisation model to improve the efficiency of the evacuation process by avoiding congestion during fire accidents, taking into account the length of the routes, the density of people and the type of routes (Li et al. 2018). The IMO, through its regulations, recommendations and guidelines, as well as amendments to the SOLAS, has established a legal framework for improving the safety of persons to verify the success and level of preparedness when abandoning ships.

Based on the ISM Code, shipping companies should increase the number of drills to strengthen the organisational and team structure in emergencies (ISM Code 2018). A cruise ship as a whole is a highly complex system that goes through different states of readiness during its voyages. Many important factors affect the ship evacuation performance. The objective of this paper is to highlight some of the factors that affect evacuation. The ship evacuation is highly dependent on the crew's readiness. It is generally influenced by the training of the crew members, the initial position of the crew members, the time needed to reach the muster station, influenced by the psychological state, i.e. the presence of panic, insufficient assistance, then the congestion of the escape routes as a result of the passenger unpreparedness. The readiness of the crew also depends on the timely information and reaction of the passengers. According to Finiti, human behaviour is a complex phenomenon influenced by experiences, emotions, interactions and the environment (Finiti et al. 2021). Therefore, these psychological aspects are important for decision-making in a situation not experienced before, such as an emergency on board. Some of the findings of Poole and Springett regarding the behaviour of ferry passengers in emergency situations are as follows: group dynamics affect the way people move, age and previous experience affect the speed of reaction, and the unknown situation affects the ability to react (Poole et al. 1998). Boulougouris and Papanikolou point out that the stress involved in disembarking is difficult to predict **(**Boulougouris et al. 2008). Too much stress often leads to panic and can also lead to injuries and changes in the speed of movement.

2. Methodology

The authors have attempted to analyse the different viewpoints of crew members on the factors that influence the evacuation process via survey. The survey, therefore, examines the factors that affect evacuation, and the questions have been divided into six categories according to these factors: (1) General Condition of Safety Equipment on board (GCSE) – 2 questions, (2) Vessel safety familiarisation training (VSF) – 8 questions, (3) Crew experience (PE) – 3 questions, (4) Competence of Safety Training Officer (CTO) – 4 questions, (5) Safety drill (SD) – 3 questions, and (6) Travel time extension (TTE) – 6 questions. They were designed to avoid stereotype bias. A pilot survey was conducted before the final survey. The survey was available via Google Forms. Participation in the survey was voluntary, and anonymity and confidentiality were guaranteed. The questions were measured on a 10-point scale (0 = strongly disagree, 1 to 3 = disagree, 4 to 6 = neither agree nor disagree, 7 to 9 = agree, 10 = strongly agree). A total of 81 seafarers working in 24 companies participated in the survey. Twelve nationalities were represented, with most respondents coming from Croatia (79.0%), followed by respondents from Italy, the Philippines, the United Kingdom, Sweden, Turkey, Panama, Romania, Bulgaria, Ireland, Finland and Montenegro. The participants are mostly between 25 and 34 years (50.6%) and between 35 and 44 years (36.7%). The years of experience on cruise ships are distributed as follows: 1 to 3 years - 24 %, 4 to 7 years - 24 %, 8 to 11 years - 18 %, 12 to 15 years - 15 %, and more than 15 years - 19 %. More than half of the respondents (67 %) are masters, staff masters or vice-masters, first officers or safety officers. The participants have 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 over 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 less than 100 m long.

3. Results and Discussion

The survey conducted focused on the factors affecting the effectiveness of the evacuation. For each factor, several questions were asked of the crew members, based on which the conclusions were drawn.

The GCSE factor affects the success of rescuing people and the ship's safety awareness. Although the equipment is subject to strict control, it can fail. The survey questions related this factor are as follows:

$Q1_{GCSE}$ - Safety representatives are familiar with all potential issues on equipment that may cause delays in a real emergency.

$Q2_{GCSE}$ - Deficiencies and remarks are duly and on time noticed by shore inspection staff. Concerning $Q1_{GCSE}$, 43.6% of respondents strongly agree, and 51.2% agree, showing high awareness and caution. We can attribute the high percentage of familiarisation to effective reporting of deficiencies in meetings, especially Safety committee meetings, according to recommendations from Safety working practice 13.3.4 and MLC Convention Rule 4.3. On the other hand, the answers to $Q2_{GCSE}$ show that 7.7% of the respondents disagree, 11.5% neither agree nor disagree, 44.8% agree, and 33.3% strongly agree. This shows that the shore inspection staff is not as responsive. Deficiencies in the equipment (lifesaving and firefighting equipment operability) are often imperceptible to the ship's crew. Furthermore, human error by the authorised coastal service is possible and could be later noticed.

The VSF factor - The STCW Convention requires in section A-VI/1 that each crew member must be familiarised with the safety procedures and the use of survival equipment at sea upon boarding the ship before commencing work. The survey questions related this factor are as follows:

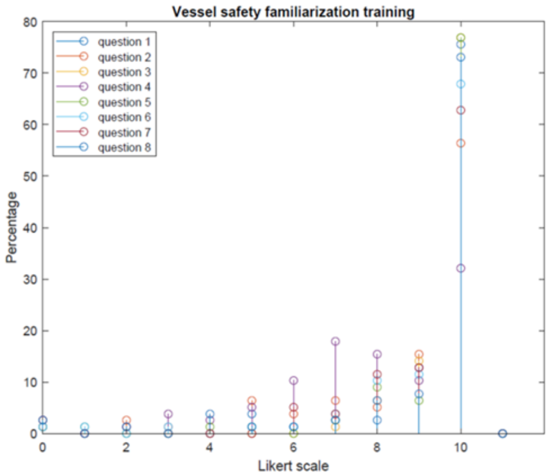

Figure 1 Vessel safety familiarisation training

Q1 VSF - All crew members possess a valid Basic Safety Training certificate.

Q2 VSF - All crew members possess a valid Crowd and Crisis certificate.

Q3 VSF - All crew members participate in at least one fire and abandon drill every month.

Q4 VSF - All crew members are familiar with emergency duties before the vessel's departure.

Q5 VSF - All crew members participate in onboard training using LSA and FF equipment within two weeks after enrolment.

Q6 VSF - All crew members with assigned responsibilities participate in the Damage Control drill carried out every three months.

Q7 VSF - All crew members participate in drills within 24 h of the ship's departure if 25% of the crew have not participated in an abandon and fire drill in the previous month

Q8 VSF - All crew members are required to pass a safety examination.
The answers to Q1 VSF and Q2 VSF show that most crew members have appropriate certificates. However, uneven training and different ship equipment and procedures can cause certain difficulties. It is highly recommended that despite the certificates, refreshments should be taken for every single crew member on board the ship. Regarding Q3 VSF, almost all respondents agree that all crew members participate in at least one fire and abandon ship drill every month. The same applies to Q5 VSF, Q6 VSF, Q7 VSF and Q8 VSF. However, there are discrepancies in the answers to Q4 VSF, with 32.1% strongly agreeing, 43.6 % agreeing, 18% neither agreeing nor disagreeing, 5.1% disagreeing, and 1.3% strongly disagreeing. Hence, there is no doubt that crew members participate in various drills on board, even if they are not familiar with the emergency tasks before the ship's departure. It is noticeable that the respondents are not satisfied with the amount of their knowledge and abilities. Sometimes due to the volume of work (hotel staff), the importance of the ability of the crew members in emergency situations is overlooked.

The **PE factor** refers to the crew's experience at sea, focusing on similar exercises previously conducted on ships and the knowledge a crew member has acquired before boarding the ship. The survey questions related this factor are as follows:

Q1PE - Crew members already served on different ship types (e.g. merchant, navy, yacht).

Q2PE - Crew members already served in the same emergency position on the same cruise ship (or a sister ship).

$Q3_{PE}$ - Crew members do not have sea experience.

$Q1_{PE}$ shows the diversity of responses, 14.1% strongly agree, and 47.5% agree that they served on different types of ships. Shipping companies often hire their crew based on previous work experience. Such experience is most desirable. Today, after COVID, the crew is wanted regardless of previous experience. The recommendation to safety officers on board is to keep a record of previous sailing experience to get a better picture of the ability of the ship's crew. Quite often, such a crew knows how to avoid the usual training, which can be counterproductive to safety. In $Q2_{PE}$, most respondents indicated that they served on the same cruise ship in the same emergency position (16.7% strongly agree, 53.8% agree), while 25.7% neither agree nor disagree with this statement. $Q3_{PE}$ shows that 11.5% of respondents strongly agree that crew members have no experience at sea, 24.4% agree, 39.7% neither agree nor disagree, and 19.2% disagree. For the mentioned question, it is clear that more and more new crew members are on the ships. This should be a sign of how important training and proper training are for their professional development.

The **CTO factor** implies the promotion of safety through training and motivation of the crew. Knowledge, skills, abilities and experience are the basis for successful drills. In practice, shipping companies assign this responsibility to an officer based on sailing experience, a specific CoC (Train the Trainer) and a prior assessment sheet from the ship's master. The survey questions related this factor are as follows:

$Q1_{CTO}$ - The Training Officer has attended the Train-the-Trainer and Assessor courses (Model course 6.10).

$Q2_{CTO}$ - The Safety Officer needs more thorough knowledge, understanding and proficiency in different areas.

$Q3_{CTO}$ - The Training Officer is well-educated and fit for duty.

$Q4_{CTO}$ - Crew recruitment and further development opportunities are the sole responsibility of the company's shoreside team.

Regarding $Q1_{CTO}$, 42.3% of respondents strongly agree and 35.9% stated that the training officer attended the IMO Model Course 6.10, 11.5% neither agree nor disagree, 5.2% disagree, and 5.1% strongly disagree. On the ships, there is uneven training and inconsistency in how exercises are performed. We can relate this to previous experiences but also to cultural background. Vujičić et al. suggested that those without teaching experience should attend appropriate IMO Model Courses or any other courses that provide teaching knowledge regarding group work education (Vujičić et al. 2021). In $Q2_{CTO}$, 26.9% of the respondents strongly agree, 33% agree, 16.7% neither agree nor disagree, 18% disagree, and 5.1% strongly disagree with this statement. Most respondents either strongly agree (42.3%) or agree (53.8%) that the training officer is well-trained and fit for the service ($Q3_{CTO}$). For $Q4_{CTO}$, 20.5% of respondents strongly agree, and 44.8% agree with Q4. In contrast, 20.5% neither agree nor disagree, 10.3% disagree, and 3.8% strongly disagree with this statement.

The **SD factor** - The awareness of the crew members also depends on the actions of the department head and his attitude towards safety. On cruise ships, it is impossible to simulate real situations, but it is possible to conduct unannounced drills. In this way, it is possible to test the speed and readiness of the ship's crew to increase attention and safety awareness. In addition, passengers should be encouraged to cooperate as much as possible during the exercises. Cruise ships carry passengers with different physical conditions, ages and sailing experiences. When passengers have sailing experience, they often communicate with the crew members on board to assess their knowledge and get a sense of security. This is especially true for the part of the passengers who have experience of working on ships. Such passengers will react more quickly. The survey questions related this factor are as follows:

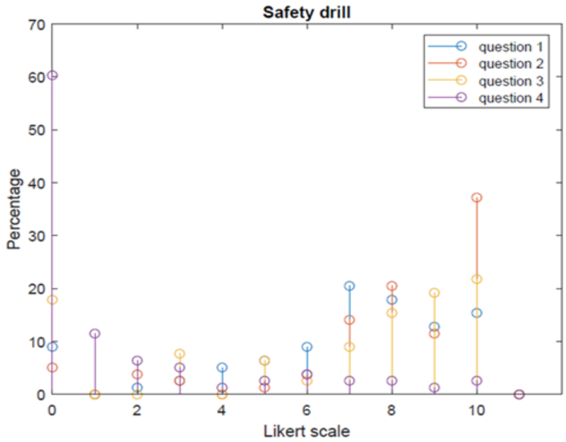

Figure 2 Safety drill

Q1SD - All crew members are present at every drill with no excuse

Q2 SD - All management staff are present at every drill with no excuse.

Q3 SD - All passengers are present at every drill.

Q4 SD - Crew members with multiple contracts on the same ship can be exempted from the drill.

The answers to Q1SD (15.4% strongly agree, 51.2% agree, 20% neither agree nor disagree, 3.9% disagree, and 9% strongly disagree) show that not all crew members are present at every drill with no excuse. However, all management staff (Q2SD) are present at every drill (37.2% strongly agree, 46% agree, 6.4% disagree, and 5.1% strongly disagree). In contrast, the survey in Q3SD shows that not all passengers are present at every drill. Although 21.8% of respondents strongly agree, 43.6% agree, a significant number of respondents strongly disagree with this statement (17.9%), and 7.7% disagree. The answers to Q4SD indicate that safety drills are a very important segment on board ships, as most respondents either strongly disagree (60.3%) or disagree (23%) with the statement Q4SD.

The **TTE factor** refers to the time it takes the crew and passengers to get from their current position to the cabin. When the general alarm signal is announced, each crew member is required to put on a lifejacket and act following their duties. It is necessary to lay out an additional number of life jackets for all crew members and passengers at the muster stations, as the evacuation flow may be impeded if the crowd is going in all directions. In addition, it is necessary to discourage the consumption of alcohol on board as it affects the psychophysical abilities of the crew. Also, if instructions were given in several languages on the ship during evacuation, elderly passengers who have difficulty walking would be taken to their destinations in advance. Hence, passenger reaction time would improve. The survey questions related this factor are as follows:

Q1TTE - Some crew members intentionally or unintentionally leave their life jackets in their working place.

Q2 TTE - In a real emergency, life jackets stored in cabins may cause corridor congestion.

Q3 TTE - Typically, the passengers on board cruise ships are from many different nationalities, and language barriers are a real issue.

Q4 TTE - Passengers are mostly older than 50

Q5 TTE - Crew members consume alcohol after working hours despite company policy requiring zero tolerance.

Q6 TTE - Crew members practice physical training in the gym.

The answers to Q1TTE are inconsistent. Namely, 25.6% of respondents strongly disagree, 24.3% disagree, 21.8% neither agree nor disagree, 20.6% agree, and 7.7% strongly agree. The responses to Q2TTE also vary widely, with 15.4% of respondents strongly disagreeing, 10.3% disagreeing, 33.3% neither agreeing nor disagreeing, 26.9% agreeing, and 14.1% strongly agreeing that life jackets kept in cabins can contribute to congestion in corridors. The responses to Q3TTE (the passengers are of many nationalities and language barriers are a real issue) also vary, i.e. 7.7% of respondents strongly disagree, 23% disagree, 32% neither agree nor disagree, 29.5% agree, and 7.7% strongly agree. $Q4_{TTE}$ refers to the age of passengers, and the answers indicate that most passengers are older than 50 (38.5% strongly agree, 44.8% agree). Regarding alcohol consumption by crew members ($Q5_{TTE}$), the results show that zero tolerance for alcohol does not apply. This is confirmed by the different responses (19.2% of respondents strongly disagree, 28.2 disagree, 25.6% neither agree nor disagree, 15.4 agree, and 11.5 strongly agree that crew members consume alcohol after working hours despite company policies. A very important element in the evacuation process is the physical preparedness of the crew. The responses show that 15.4% strongly agree, 34.6% agree, 28.2 neither agree nor disagree, 17.9% disagree, and 3.8% strongly disagree that crew members engage in physical training in the gym ($Q6_{TTE}$).

4. Conclusion

In this paper, the authors identify the current state of affairs on large passenger ships (knowledge and procedural gaps) and the main factors that may affect the effectiveness of evacuation. These are the general state of safety equipment on board, vessel safety familiarisation training, crew experience, competence of safety officers and safety drills. As far as safety equipment is concerned, the survey showed that in practice all equipment is checked, defects are reported immediately and repaired by the crew or shore-based technical assistance. As far as safety training is concerned, the survey results show that crew members have appropriate certificates and participate in drills. In addition, the previous sailing experience of crew members is desirable and inconsistent training and non-compliance with the training plan and schedule by the training officer may jeopardise the overall safety and efficiency of the evacuation. In addition, passengers must be encouraged to participate in safety drills. All responses given in the survey on the travel time extension factor show inconsistencies. This indicates that more precise rules should apply to the donning of life jackets, alcohol consumption, physical preparation of the crew and solving the problem of language barriers. All these findings can be used to improve the efficiency of evacuation management and avoid congestion. For further research, the study needs more factors, some of which are alarm, leadership behaviour, the influence of crew and passenger culture.

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Hydrogen Shipping Cost Evaluation for Potential Routes

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Abstract: Shipping is a critical component of international hydrogen (H2) supply chains, and H2 can be transported in various forms or media, including liquid hydrogen (LH2), ammonia, methanol, dibenzyl toluene (DBT), and methylcyclohexane (MCH). To compare the costs associated with shipping H2 in different forms or media, this study develops an evaluation model to assess the H2 shipping costs on nine potential international shipping routes. The results indicated that the Australia-East/Southeast Asia, West Africa-Europe, and Middle East-Europe routes have more competitive H2 shipping costs when compared to the Australia-Europe and Middle East-East Asia routes. Additionally, methanol has the lowest shipping cost among all H2 forms or media, followed by ammonia, DBT, MCH, and LH2. However, it is important to note that the higher cost of producing methanol may offset this advantage when considering the pricing of H2 for end users.

Keywords: maritime; hydrogen; transportation; shipping; cost

1. Introduction

The Paris Agreement signatories have submitted their Nationally Determined Contributions (NDC) to address climate change. According to the online database "Net zero Tracker" [1], as of May 2023, 128 countries had set or proposed net-zero greenhouse gas (GHG) emissions targets. Most countries set targets to achieve net-zero by 2050 or 2060. To this end, the use of hydrogen (H2) is expected to be one of the key deep decarbonisation options. The main reason is that H2 is an excellent carrier of renewable energy, such as wind, solar and hydropower, which can be released as heat through combustion, or as electricity using fuel cells, in both cases the only other input needed is oxygen, and the only by-product is water. Therefore, H2 has the potential to replace fossil fuels in several scenarios. Many countries issued their H2 strategies, for example, sixteen out of the top 20 GHG emission countries, responsible for 78.11% of global emissions [2], have clearly raised H2 to the level of national energy strategies and have formulated relatively straightforward timetables and roadmaps. According to the predictions, H2 could account for 10-18% of the global energy consumption mix by 2050 [3-5].

The worldwide H2 demand, the renewable energy resource endowments, unbalanced H2 production costs, and geopolitical factors drive the formation of international H2 trade [6, 7]. Therefore, the potential of the international H2 supply chain is vast, and it is expected to form a new international energy supply pattern. The main pillars of the H2 supply chain are production, storage, transportation, and utilisation. The H2 supply chain is more complicated than others because of numerous permutations of how H2 being produced, stored, transported, and utilised, all of which differ in technology, infrastructure, and safety.

Ports and shipping are essential in the international H2 supply chain. Some ports in such countries as Australia, Japan, South Korea, Singapore, and the Netherlands are preparing for international H2 trade. The previous study by the authors identified twenty possible early H2 ports, including twelve exporting and eight importing ports [8]. The H2 shipping routes could appear between these ports. H2 shipping cost, being a costly part of the supply chains [9], will be a key factor in determining each route's competitiveness. The H2 shipping cost varies depending on the H2 media used. Liquid hydrogen (LH2), ammonia, methanol, and liquid organic hydrogen carriers (LOHCs), including dibenzyl toluene (DBT) and methylcyclohexane (MCH), are considered suitable H2 international transportation forms or media. This paper aims to evaluate H2 shipping costs on different potential international H2 shipping routes considering different H2 forms and media.

2. Methodology and Data

2.1 Methodology

Figure 1 illustrates the scope of the H2 shipping cost evaluation, which encompasses the costs of H2 storage and loading at the exporting port, as well as sea transport cost. The outcome of the evaluation is the levelised shipping cost of H2 prior to unloading at the importing port. To facilitate this evaluation, this study develops a cost estimation model in Figure 2. The levelised cost of H2 shipping is calculated by dividing the total annual cost by the annual quantity of H2 delivered. The total annual cost is comprised of both annualised capital expenditure (CAPEX) and operational expenditure (OPEX). The annual quantity of H2 delivered is determined by a range of factors, including the chosen H2 form or media, ship capacity, shipping route, and number of annual trips. The currency unit used in this study is US dollars ($).

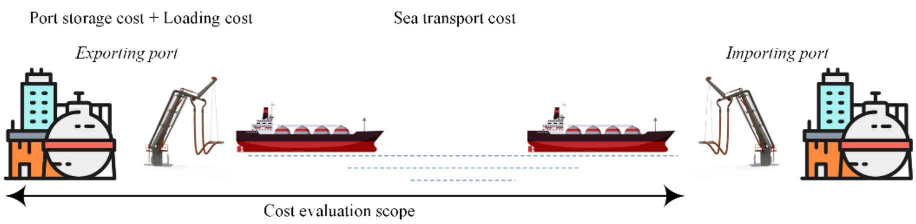


Figure 1. Hydrogen shipping cost evaluation scope.

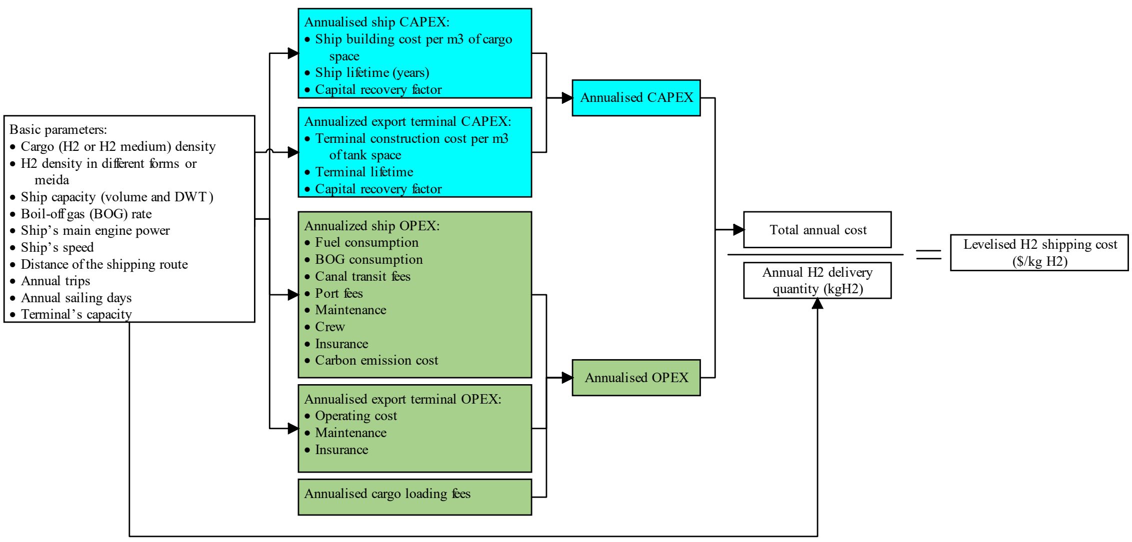


Figure 2. Hydrogen shipping cost evaluation model.

2.2 Data

This study compared the H2 shipping costs using different H2 forms and media, including LH2, ammonia, methanol, DBT, and MCH, across different shipping routes. Based on the identification of 20 potential early H2 ports in the previous study by the authors [8], nine potential H2 routes representing Australia-East/Southeast Asia, West Africa-Europe, the Middle East-Europe, and the Middle East-East Asia were selected to compare the costs. They are Hastings to Kobe, Townsville to Ulsan, Hedland to Singapore, Bonython to Rotterdam, San Antonio to Rotterdam, Nouadhibou to Rotterdam, Yanbu to Onahama, and Yanbu to Rotterdam. Figure 3 provides the information on these H2 shipping routes. Table 1 presents the basic input data for the evaluation. To ensure comparability of results, the following basic assumptions were made for the input data:

- The net cargo volume of the ships is assumed to be 100,000 m^3.
- The capacity of the port tank is also assumed to be 100,000 m^3 to match the ship's capacity.
- The ship's effective operating time is 330 days per year.
- The ships for transport H2 forms or media use marine gas oil (MGO) as a fuel.
- The economic lifespan of the ship and infrastructure is conservatively considered to be 20 years for the purpose of evaluating the annualised CAPEX.
- The discount rate is conservatively considered to be 8% in calculating annualised CAPEX.
- The storage and transportation of DBT and MCH use existing infrastructure.

Note: the green port marks represent export ports; the blue port marks represent import ports

Figure 3. Nine hydrogen shipping corridors.

Table 1. Basic input data for the evaluation.

Item	Value	Ref.
Ship capacity / terminal tank capacity (m^3)	100,000/100,000	/
Ship main engine power (kW)	PME = 0.709*DWT − 1963, for DWT < 60,000 tons PME = 0.328*DWT + 27596, for DWT > 60,000 tons	[10]
Ship speed (kn)	16	/
Ship operation days per year	330	/
LH2 ship building cost ($/$m^3$)	1355	[11]
Ammonia ship building cost ($/$m^3$)	1016	[11]
Methanol ship building cost ($/$m^3$)	750	[11]
LOHC ship building cost ($/$m^3$)	0 (using existing chemical tankers)	/
Fuel consumption (g/kWh)	190	/
MGO fuel cost ($/ton)	500	/
Canal fee ($/transit) *	25,000 (LH2); 50,000 (Ammonia, methanol, LOHCs)	/
LH2 terminal tank building cost ($/$m^3$) **	800	/
Ammonia terminal tank building cost ($/$m^3$) **	600	/
Methanol terminal tank building cost	440	/

($/m^3) **		
LOHC terminal tank building cost ($/m^3)	0 (using existing infrastructures)	/
Loading costs: LH2 /ammonia /Methanol /DBT /MCH ($/m^3) ***	0.054/0.00303/0.00303/0.0045/0.0045	[12]
BOG rate of LH2 (%/day) ****	0.5	[13]
BOG rate of ammonia (%/day)	0.05	[14]
BOG rates of methanol, DBT, and MCH (%/day)	0	/
Carbon price ($/ton)	50	[15]

*Note: * The LH2 ship has low DWT, resulting in low canal fees; ** The data was obtained from an interview; *** The loading costs include the CAPEX of the loading facilities. **** The BOG rate of LH2 tank was estimated based on the findings of the literature.*

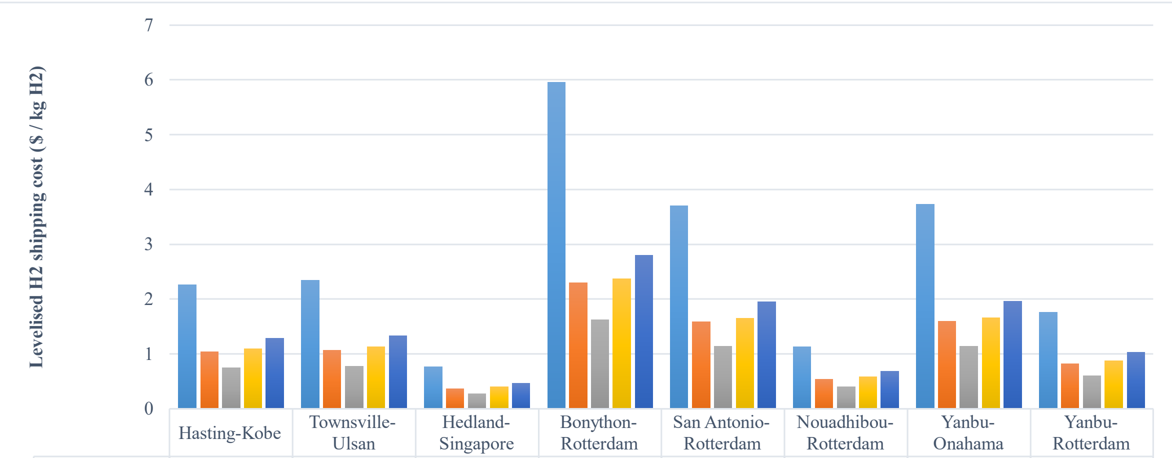
Table 2 lists the physical and chemical characteristics parameters of the H2 forms and media used in the cost evaluation process.

Table 2. Basic properties of hydrogen forms and media.

	LH2	Ammonia	Methanol	LOHC (DBT)	LOHC (MCH)
Composition	H_2	NH_3	CH_3OH	$C_{21}H_{38}$	C_7H_{14}
Molecular weight (g/mol)	2.0	17.0	32.04	290	98.2
Boiling point (°C)	-253.15	-33.15	64.5	353.85	100.85
Density (g/cm^3)	0.071	0.682	0.792	0.91	0.769
Hydrogen density by volume (kg/m^3)	71	121	99	56.4	47.3
Hydrogen density by weight (wt%)	100	17.8	12.1	6.21	6.16
Energy density (MJ/kg)	120	18.6	19.9	/	/

3. Results

Figure 4 illustrates the levelised shipping cost per kilogram of H2, influenced by the shipping distance. The Hedland-Singapore route presents the lowest cost, whereas the Bonython-Rotterdam route is the most expensive. When comparing different H2 transport options, methanol has the lowest shipping cost, followed by ammonia, DBT, MCH, and LH2. The cost of LH2 shipping ranges from 2.7 to 3.7 times higher than that of methanol shipping, and 2.1 to 2.6 times, 1.9 to 2.5 times and 1.6 to 2.1 times higher than that of ammonia, DBT and MCH, respectively.



	Hasting-Kobe	Townsville-Ulsan	Hedland-Singapore	Bonython-Rotterdam	San Antonio-Rotterdam	Nouadhibou-Rotterdam	Yanbu-Onahama	Yanbu-Rotterdam
LH2	2.265545987	2.349916514	0.761260393	5.959261618	3.708676795	1.126632198	3.73269323	1.755911085
Ammonia	1.037503994	1.071700209	0.371831446	2.295111487	1.583595307	0.543935513	1.591601999	0.824239213
Methanol	0.751486974	0.775718849	0.275570777	1.629573599	1.136322568	0.399388091	1.141563304	0.599890418
LOHC (DBT)	1.092478311	1.127797456	0.398808035	2.372608652	1.653590289	0.579277438	1.661034203	0.871519005
LOHC (MCH)	1.289713298	1.331455274	0.469898277	2.802658785	1.952879635	0.683186238	1.961661838	1.028572271

Figure 4. Levelised hydrogen shipping cost per kilogram of H2.

In contrast to DBT and MCH, the benefits of using ammonia and methanol as H2 transport media are that they can be used directly as fuels. If there are ammonia or methanol users at the receiving port, there is no need to extract H2 from these media. Table 2 demonstrates that their energy densities are acceptable, despite being significantly lower than that of LH2. Figure 5 depicts the levelised shipping cost per Gigajoule (GJ) for energy delivery comparison purposes. Methanol has the lowest shipping cost, followed by ammonia and LH2. In terms of delivered energy amount, the cost of LH2 shipping is 3.8 to 5.0 times higher than that of methanol shipping and 1.8 to 2.3 times higher than that of ammonia shipping.

Overall, the H2 shipping costs in the Australia-East/Southeast Asia (\$0.28-2.35/kgH2), West Africa-Europe (\$0.40-1.13/kgH2), and Middle East-Europe (\$0.60-1.76/kgH2) corridors are comparatively more competitive than those in the Australia-Europe (\$1.63-5.96/kgH2) and Middle East-East Asia (\$1.14-3.73/kgH2) corridors.

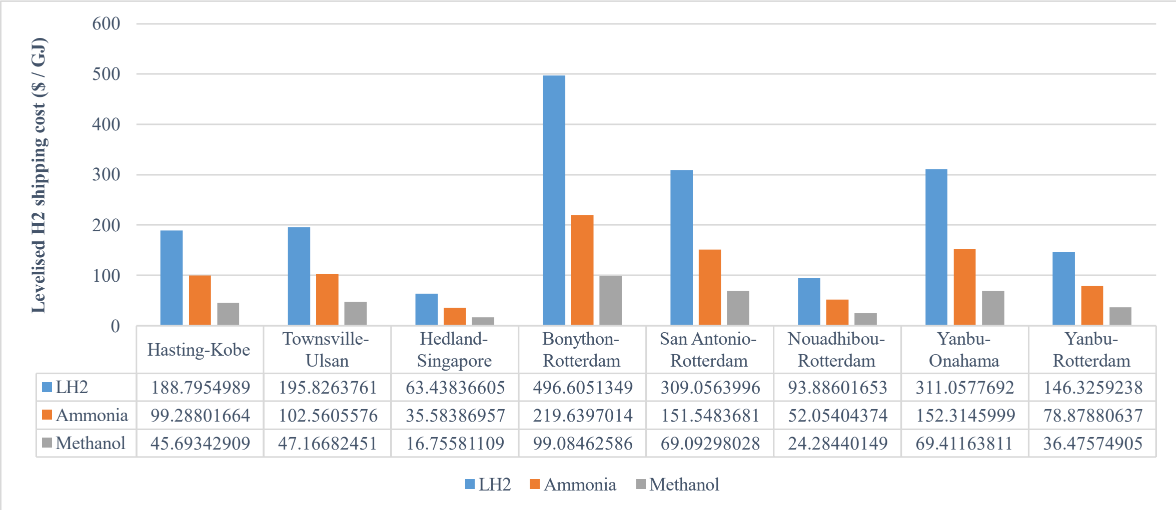


Figure 5. Levelised hydrogen shipping cost per Gigajoule of energy.

4. Discussion

Production, conversion (liquification, chemical compounding, hydrogenation/dehydrogenation), storage, shipping, and distribution costs should be considered when pricing H2 for end-users. However, the cost analysis in this study is limited to H2 storage and loading costs at the exporting port and sea transportation costs. Methanol is found to have the lowest shipping cost, but its higher conversion cost due to higher electricity consumption may offset this advantage. The H2 liquefaction process requires power of 11.11-27.78 kWh/kgH2 [16]. Ammonia production via Haber-Bosch process needs 8 MWh/ton ammonia, equivalent to 44.94 kWh/kgH2 [17]. Although exothermic hydrogenation process of LOHCs needs tiny energy, the endothermic dehydrogenation at the destination requires about 9 kWh/kgH2 [18]. While methanol synthesis using H2 and carbon dioxide requires 10-11 MWh/ton methanol, or 82.6-90.9 kWh/kgH2 [19], which is about 3-8 times, 2 times, and 10 times higher than conversion electricity consumptions for LH2, ammonia, and LOHCs respectively. High electricity consumption implies high cost. In H2 exporting countries with expensive electricity, such as Australia, the drawbacks of utilising high-energy-consumption H2 transport media become apparent.

Projected cost reductions in H2 production from renewable sources, driven by falling costs of wind and solar power and water electrolysers, have the potential to significantly lower H2 production costs. BloombergNEF estimated that green H2 production costs could be as low as \$0.7 to \$1.6/kg in most countries by 2050, with potential exporters achieving costs as low as \$1.5/kg by 2030 [20]. In H2 importing countries, by 2030, the production costs could be around €3/kg (\$3.07/kg) in European countries [21], \$3/kg in Japan [22], \$3/kg in South Korea [23]. Therefore, imported green H2 is more expensive than domestic supply considering production, conversion and port storage and shipping costs. However, given that the domestic renewable energy sources are limited in major H2 demand countries, global H2 trading still has considerable potential.

5. Conclusion

This paper adopts the levelised cost approach to assess the H2 shipping costs on nine potential international shipping routes. The main findings show that the shipping costs for H2 in the Australia-East/Southeast Asia, West Africa-Europe, and Middle East-Europe corridors are comparatively more competitive than those in the Australia-Europe and Middle East-East Asia corridors. Besides, methanol has the lowest shipping cost among all H2 forms and media, followed by ammonia, DBT, MCH, and LH2. However, it is worth noting that the higher cost of producing methanol offsets this advantage when considering pricing H2 for end-users.

The present study is constrained by its exclusive focus on the costs associated with H2 port storage, loading, and shipping. To address this limitation, the next phase of the research will involve extending the model to account for the costs associated with H2 production, conversion, and overland transportation. Such an expanded model would permit a comprehensive analysis of H2 costs across the entire supply chain, thus providing decision-makers with valuable support for pricing H2 commodities.

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Coopetitive game fundamentals and concept model representation for LNG transportation industry

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Abstract: Forming strategic alliances, known as coopetition game, offers operational flexibility and collaborative relationships, where usually carriers cooperate to reduce operational costs. This paper presents a mathematical expression of the coopetition strategy in the LNG transportation segment. Furthermore, in this study, the coopetition game represents game-theoretic mathematical framework for LNG shipping structure in order to better understand motivations when forming an alliance; how do participating companies organize their business models, at which level do they cooperate and what is an incentive for competition, and finally to comprehend strategic decision-making processes when participating in an alliance.

The novelty of this paper is a game theory usage in the LNG market industry for profit maximization. In order to set conceptual model, we define mixed-integer nonlinear problem with iterative heuristics approach. Also, the constraints related to LNG transportation industry for conceptual model framework of coopetition game are presented and elaborated.

Keywords: Coopetition, Game theory, LNG shipping

1. Introduction

In recent years, we can witness large expansion of the world's LNG fleet, mainly due to the positive forecast of LNG market development. In order to prepare for the market growth, ship owners invested in new LNG tonnage early, making the current market congested with available cargo space. Regardless, many ship owners continue to invest in expansion projects to be ready for the chartering opportunities that lie ahead. Even though we do not witness major formation of alliances in the LNG sector, it is evident that the market is taking similar formation as of the container shipping market; therefore, once the capacity turns into overcapacity, carriers will be forced to reduce cost and to service their customers in a different way. Forming strategic alliances offers operational flexibility and collaborative relationships, where usually carriers cooperate to build scale and reduce operational costs. Furthermore, strategic alliances also compete to optimize their profits. Such a strategic alliance is commonly known as coopetition game. Many authors have extensively researched the topic of coopetition in the last decade, however to the best of our knowledge, there is limited number of work related to coopetition in the LNG sector. Authors recently focused mostly on liner shipping and strategic alliances within the container-shipping sector. In order to analyze a coopetition problem, the fundamentals and concept model representation for LNG transportation industry is presented. Therefore, our intention is to apply, at a conceptual level, the fundamentals and concept model representation in order to better understand motivations when forming an alliance, e.g., how do participating companies organize their business models, at which level do they cooperate and what is an incentive for competition.

2. Literature Review

Even though forming of alliances was not a common occurrence within the LNG transportation industry, the number of available vessels on the market increased to form significant mass that will warrant change, especially taking in consideration smaller shipping companies that have to find competitive advantages. This chapter will cover literature overview of strategic alliances, competition, cooperation and coopetition, followed by game-theoretic frameworks within the discipline. There is limited work available that considers

LNG transportation market; therefore following overview is mainly considering liner shipping. Concluding remarks deliver highlights of the previous research and portray opportunities for further development. Intuitively, many authors consider liner shipping industry to be an oligopolistic market. Even though there was a lack of consensus among some of the authors (see further Peters, 1991; Hoffman, 1998), Sys (2009) used empirical methods to present rational evidence of oligopoly. While LNG shipping market was not within the scope of Sys' research, we can safely consider this market to be oligopolistic, taking in consideration industry's recent concentration levels. Examining the available literature, we can notice that the shipping competition has been thoroughly covered by several authors. Namely, Casaca, Ana, and Marlow (2005) investigated various service parameters within shipping operations that influenced competitiveness. Noteworthy mixed-integer programming approach was developed by Gelareh, Nickel, and Pisinger (2010) who investigated competition between novice line shippers and existing operators. Wang, Meng, and Zhang (2014) observed new container shipping market and proposed three game-theoretical models analyzing competition between couple of carriers. Unlike the LNG transportation industry, recent years deliver a number of studies focused on cooperation among liner shippers, formation of strategic alliances, which factors drive success and how is the strength of strategic alliances measured. More broadly, Slack, Comtois and Robert (2002) studied impact of strategic alliances on the development of container shipping market. Applying cooperative game theory framework to liner shipping alliances was studied by Song and Panayides (2002), which delivered better understanding of functional decision-making. Selecting an alliance partner is challenging task with many non-deterministic factorings for which Ding and Liang (2005) developed fuzzy multiple criteria decision-making model. Chang, Lee, and Tongzon (2008) developed an interesting study about slot exchange allocation where partnering carriers exploit surplus of cargo capacity. We can already see similar behavior in the LNG industry ("Qatargas and Rasgas complete first cooloading", 2017). Agarwal and Ergun (2010) completed extensive study of network design and integration by utilizing mathematical programming and game theory in order to achieve optimal collaboration of carriers in strategic alliances. Panayides and Weidmer (2011) completed overview of large strategic alliances in order to verify stability of alliances. Seashipt Oyster System was the company that coined the term Coopetition for the first time in 1913 representing the idea of cooperative competition (Cherington, 1976). Furthermore, first comprehensive overview of coopetition arguing that real sector consists of collaboration and competition mix is delivered. Most of the recent studies focus on finding optimized coopetitive equilibria in product supply chains, but rarely we can see intermodality or multimodality taken into consideration. Within the recent focus of coopetition, ports take a significant weight, starting with Heaver et al. (2000) who delivered study about cooperation agreements that influenced shipping market structures. Also, Song (2003) focused on coopetition of Chinese seaports. The research is based on coopetition among ports with a complex interconnected relations that include both competition and cooperation. Gurnani et al. (2007) studied incentives for investment of coopetition partners and how did product pricing affect the partnership. Intermodal and multimodal freight transportation is commonly described as coopetitive, because partners often compete on tariffs but cooperate when using available cargo space to forward freights as required. Based on the work listed above, it is apparent that cooperation did get a fair consideration among authors; however, most of the authors focused on port operations, or on liner shipping. Furthermore, coopetitive game theory is strongly influenced by research from De Ngo and Okura (2008), as well as Lin and Huang (2017). Both studies examined mathematics of the coopetition game; however, focus of De Ngo and Okura was on coopetitive relationship between semi-public and a private firm, while Lin and Huang delivered more generic and simplified overview of the coopetition game among private carriers without necessary constraints that would allow for practical use of the model. Liu et al. (2015) considered coopetition in the intermodal segment of the container shipping covering extensive mathematical modeling and game matrix that covered possibilities of cooperating and competing on two levels; investment and price decisions, concluding that cooperating at investment stage and competing at price decision stage is unique Nash equilibrium. In this study we will, therefore, consider scenario of cooperation at investment stage and competition at price decision stage. Also, we will deliver notation, basic assumptions and introduce a mathematical model of a single carrier that will be used to solve iterative heuristic coopetition problem.

3. Coopetitive game fundamentals and concept model representation

With the assumption that total demand on the LNG shipping market depends on the level of cooperation between two shippers (can be extended to higher number of carriers), we design profit-maximizing formulation in the two-stage game. Considering that the game is static, in the first stage both shippers chose their cooperative level to increase total market size, and in the second stage they chose competitive level to increase their market shares. In order to ensure practicality, we introduce constraints formulated down below for the concept model representation. For the set of carriers *A* and *B* with the set of users' Origin Destination - OD pairs, the demand function $\boldsymbol{q_{(A,B)}}$ may be written as:

$$q_{(A,B)} = q_A + q_B + \varepsilon, \tag{1}$$

$$q_s = Q^{s,od}\zeta_{\psi}^{s,od} + Q^{s,new}\zeta^{s,new}\frac{x^s}{x^A+x^B} + \theta^s, \tag{2}$$

where $\boldsymbol{Q^{s,od}}$ represents the market demand for carrier $\boldsymbol{s \in S}$ and OD pair $\boldsymbol{od \in OD}$ with $\boldsymbol{S}$ representing a set of carriers (in this example, carrier *A* and carrier *B*); $\boldsymbol{\zeta_{\psi}^{s,od}}$ is a factor that denotes if the selected path $\boldsymbol{\psi} \in \boldsymbol{\Psi^s}$ connects $\boldsymbol{od}$ for carrier $\boldsymbol{s}$. $\boldsymbol{\zeta_{\psi}^{s,od} = 1}$ when the selected path is connecting $\boldsymbol{od}$, while $\boldsymbol{\zeta_{\psi}^{s,od} = 0}$ otherwise; $\boldsymbol{Q^{s,new}}$ represents induced market demand that is a result from cooperation of carriers $\boldsymbol{s}$, and is dependent on various market factors, and cooperation levels; $\boldsymbol{\zeta^{s,new}}$ is a factor that denotes if the virtual path (as a result of induced demand) is used. $\boldsymbol{\zeta^{s,new} = 1}$ when used, $\boldsymbol{\zeta^{s,new} = 0}$ otherwise; $\boldsymbol{x^s}$ is the competitive effort level of carriers $\boldsymbol{s}$ (in this example, it is $\boldsymbol{x^A}$ and $\boldsymbol{x^B}$) and it represents investments in competitiveness, such is marketing. Increasing $\boldsymbol{x^s}$ leads to increased profits for a carrier $\boldsymbol{s \in S}$. The ratio $\boldsymbol{x^s/(x^A + x^B)}$ is concave in $\boldsymbol{x^s}$ while the overall market demand function is linear in $\boldsymbol{y^s}$ which stands for cooperative effort level for carrier $\boldsymbol{s}$. Thus, in order to guarantee the existence of the optimal $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$, we assume that the cost functions of $\boldsymbol{x^s}$ and of $\boldsymbol{y^s}$ are, respectively, linear and quadratic (De Ngo and Okura, 2008); $\boldsymbol{\varepsilon}$ represents error on demand. $\boldsymbol{\theta^s}$ is an administrative surplus that contains political, social, and technological components, which can have significant impact on competitiveness of an LNG shipping company. If a carrier does not have any administrative competitive advantage, the value of $\boldsymbol{\theta^s}$ will be set to 0. Generally, the carrier $\boldsymbol{s}$ profit function can be defined as:

$$R_s = (P^s - C^s)Q - k_x^s x^s - k_y^s (y^s)^2, \tag{3}$$

where $\boldsymbol{R_s}$ stands for carriers $\boldsymbol{s}$ profit function; $\boldsymbol{P^s}$ is the transport price and $\boldsymbol{C^s}$ is the variable cost for carrier $\boldsymbol{s}$. Furthermore, $\boldsymbol{Q}$ is a total market demand; $\boldsymbol{k_x^s}$ is the competitive level unit cost and $\boldsymbol{k_y^s}$ is the cooperative level unit cost for carrier $\boldsymbol{s}$. As stated before, $\boldsymbol{y^s}$ stands for cooperative effort level and $\boldsymbol{x^s}$ stands for competitive effort level for carrier $\boldsymbol{s}$. As noted in De Ngo and Okura (2008), Lin and Huang (2013) and Lin et al. (2017), $\boldsymbol{y^s}$ measures relative efforts carrier made to cooperate with other carriers and can, for example, represent all the additional costs incurred by employing staff to communicate with other carriers in order to establish cooperation. Increase in $\boldsymbol{y^s}$ leads to decrease of average cost and increase of the total market size. Considering carriers $\boldsymbol{s \in S}$; we have following expression for their respective profit functions:

$$R^s = Q^{s,od}\left(P_{\psi}^s - C_{\psi}^s\right) + Q^{s,new}(P^{s,new} - C^{s,new}) - k_x^s x^s - k_y^s (y^s)^2. \tag{4}$$

In order to adapt profit functions to a game theoretic model, we deliver profit maximization formulation for a single LNG shipping carrier with a list of applicable constraints for the model:

$$MaxR^s = Q^{s,od}\zeta_{\psi}^{s,od}\left(P_{\psi}^s - C_{\psi}^s\right) + Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})\frac{x^s}{x^A + x^B} + \theta^S + \varepsilon - k_x^s x^s - k_y^s (y^s)^2, \tag{5}$$

$$P^s \geq C^s \geq 0, \tag{6}$$

$$x^s \geq 0, y^s \geq 0 \quad \forall\, s \in S, \tag{7}$$

$$\textstyle\sum_{\psi \in \Psi^s} \zeta_{\psi}^{s,od} V^{s,od} = Q^{s,od} \qquad \forall\, od \in OD, \tag{8}$$

where $\boldsymbol{V^{s,od}}$ represents the volume for carrier $\boldsymbol{s \in S}$ between OD pair $\boldsymbol{od \in OD}$. Furthermore,

$$\frac{\sum_{n \in S} y^n}{\mu_s} = Q^{s,new} \qquad \forall\, s \in S, \tag{9}$$

where $\boldsymbol{\mu_s}$ is a factor used to convert cooperation/competition level into induced demand for company $\boldsymbol{s}$. Also,

$$\sum_{\psi\in\Psi^s}\sum_{od\in OD}\zeta_{\psi}^{s,od}\delta_{\psi,ij}^{s,od}V^{s,od}\leq \hat{U}_{ij}^{s} \qquad \forall ij\in I, \tag{10}$$

where $\boldsymbol{\delta_{\psi,ij}^{s,od}=1}$ if arc $\boldsymbol{ij}\in\boldsymbol{I}$ is part of the selected path $\boldsymbol{\psi}\in\boldsymbol{\Psi^s}$ that connects $\boldsymbol{od}\in\boldsymbol{OD}$ for LNG shipping carrier $\boldsymbol{s}$, otherwise $\boldsymbol{\delta_{\psi,ij}^{s,od}=0}$; $\hat{U}_{ij}^{s}$ represents upper volume bound for LNG shipper on related arc $\boldsymbol{ij}\in\boldsymbol{I}$. The last set of constraints for the model are:

$$\zeta^{s,new}\geq Q^{s,new}>0, \tag{11}$$

$$\zeta_{\psi}^{s,od}\in\{0,1\} \qquad \forall s\in S, od\in OD, \psi\in\Psi^s, \tag{12}$$

$$\zeta^{s,new}\in\{0,1\} \qquad \forall\, s\in S, \tag{13}$$

$$k_y^s=f(y^s) \qquad \forall\, s\in S, \tag{14}$$

$$P_{\psi}^{s}=f_1\big(q_{(A,B)}\big) \qquad \forall\,\psi\in\Psi^s, s\in S, \tag{15}$$

$$P^{s,new}=f_2\big(q_{(A,B)}\big) \qquad \forall\, s\in S, \tag{16}$$

$$C_{\psi}^{s}=f_3\big(q_{(A,B)}\big) \qquad \forall\,\psi\in\Psi^s, s\in S, \tag{17}$$

$$C^{s,new}=f_4\big(q_{(A,B)}\big) \qquad \forall\, s\in S. \tag{18}$$

The constraint (6) infers that price is higher than cost and that it must have a positive value, which is logical. In order for our model to be feasible, cooperation and competition levels should be positive, which is described with the constraint (7). The constraint (8) is designed to ensure that demand between each OD pair can be serviced with the available capacity. Unlike the general and container shipping, where custom is to ensure volume is related to one shipment (carrier cannot split shippers' volume), in bulk and LNG transport cargo can be split into several shipping volumes. There is also possibility to leave part of the available volume empty. Good example is recent shipment made by Qatargas and Rasgas where one vessel was used for two different buyers and ports (Qatargas and Rasgas complete first cooloading, 2017). Constraint (9) states that the induced demand is a result of cooperation level. In other words, we can estimate how much one dollar spent on the cooperation level increases induced demand. Constraint (10) is related to the flow network of the graph theory and stipulates that the amount of flow on each arc cannot exceed its capacity. Constraint (11) is related to induced demand and states that virtual path exists only when the induced demand is positive. With constraints (12) – (13) we specify that selected path and new market demand path are binary variables. Constraint (14) specifies that the cost of cooperation is the extent of cooperation itself. In other words, higher cooperation level requires higher cooperation cost. Finally, constraints (15 – 18) assume that initial and induced prices and costs are functions of the market demand. In our example, we have LNG shipper *A* and LNG shipper *B* with already existing customers they serve. The approach to solution is through iterative heuristics. For example, the company *A* solves equations (5) – (18) and gets profit maximizing cooperation and competition levels. This will result in new market price and cost that can induce new demand, after which LNG shipping companies of the market service new demand and share profits depending on the competition efforts invested. Based on the information from the company *A*, company *B* solves for equations (5) – (18) and gets its own best cooperation and competition levels. Considering the additional change at the market, the company *A* again solves equations (5) – (18) in order to take in consideration results from the company *B* adjusting its cooperative and competitive strategies. This process continues until no company can benefit from changing its' strategy.

In order to prove that our coopetition game contains unique solution and that both carriers will use same strategy when reaching equilibrium; therefore, we are searching for unique pure strategy Nash equilibrium where all players have incentive to choose cooperation at the first stage and then competition at the second stage, given all the constraints of the model and perfect information. To derive this coopetition game, we use backward induction method adapted from McCain's (2010) work on analysis of strategy. Backward induction is commonly used in game theoretic models, and it requires us to think forward and reason backward. In this case, backward induction requires deriving equilibrium in the second stage on the basis of the first stage even though the first stage was not yet played. After completing this step, we proceed with deriving the first stage with the data resulting from the second stage derivation. We continue with the second-stage derivations below. Given the appropriate $\boldsymbol{x^s}, \boldsymbol{s} \in \boldsymbol{S}$, we have first order conditions:

$$\frac{\partial R^A}{\partial x^A} = Q^{A,new}\zeta^{A,new}(P^{A,new} - C^{A,new})\frac{x^B}{(x^A+x^B)^2} - k_x^A = 0, \tag{19}$$

$$\frac{\partial R^B}{\partial x^B} = Q^{B,new}\zeta^{B,new}(P^{B,new} - C^{B,new})\frac{x^A}{(x^A+x^B)^2} - k_x^B = 0. \tag{20}$$

We can, therefore, define the cost of increasing the competitive efforts for each of the carriers:

$$k_x^A x^A = k_x^B x^B = \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4}. \tag{21}$$

Considering the above, we can deliver the equilibrium competitive effort levels as:

$$x^A = x^B = \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4k_x^s}. \tag{22}$$

Following the competitive efforts equilibrium levels, we further investigate competitive and cooperative efforts relationship. Using equation (22) we calculate following derivatives:

$$\frac{\partial x^A}{\partial y^A} = \frac{\partial x^B}{\partial y^A} = \frac{\zeta^{A,new}\left(P^{A,new}\left(1+\frac{1}{m^A}\right) - C^{A,new}\left(1+\frac{1}{m^B}\right)\right)}{4k_x^s}, \tag{23}$$

$$\frac{\partial x^B}{\partial y^B} = \frac{\partial x^A}{\partial y^B} = \frac{\zeta^{B,new}\left(P^{B,new}\left(1+\frac{1}{m^A}\right) - C^{B,new}\left(1+\frac{1}{m^B}\right)\right)}{4k_x^s}, \tag{24}$$

where $\boldsymbol{m^s}$ represents the market share of carrier $\boldsymbol{s} \in \boldsymbol{S}$. This value is determined by each carrier's competitive level. It is calculated by the ratio $\boldsymbol{x^s}/(\boldsymbol{x^A} + \boldsymbol{x^B})$. When numerator of the equations (23) or (24) is < 0, the competitive level will decrease as the cooperative level increases, so we can assume that $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$ are substitutes. However, when numerator of the equations (23) or (24) is > 0, the competitive level will increase with the increase of the cooperative level. This denotes that $\boldsymbol{x^s}$ and $\boldsymbol{y^s}$ are complements. We can now use backward induction and analyze first stage with the results from the second stage. Using equilibrium competitive effort levels $\boldsymbol{x^A}$ and $\boldsymbol{x^B}$, we calculate updated profit functions for $\forall\ \boldsymbol{s} \in \boldsymbol{S}$:

$$R_s = Q^{s,od}\zeta_\psi^{s,od}\left(P_\psi^s - C_\psi^s\right) + \frac{Q^{s,new}\zeta^{s,new}(P^{s,new} - C^{s,new})}{4} + \theta^s + \varepsilon - k_y^s (y^s)^2. \tag{25}$$

Finally, applying conditions of $\frac{\partial \boldsymbol{R_s}}{\partial \boldsymbol{y^s}} = \boldsymbol{0}, \forall\ \boldsymbol{s} \in \boldsymbol{S}$, the equilibrium cooperative effort levels are:

$$y^A = y^B = \frac{\zeta_\psi^{s,od}\left(P_\psi^s\left(1+\frac{1}{m^A}\right) - C_\psi^s\left(1+\frac{1}{m^B}\right)\right) + \zeta^{s,new}\left(P^{s,new}\left(1+\frac{1}{m^A}\right) - C^{s,new}\left(1+\frac{1}{m^B}\right)\right)}{8k_y^s}. \tag{26}$$

We can now observe that competition and cooperation equilibrium levels are identical for both companies, which implies that both LNG shipping carriers will use the same strategies when reaching coopetition equilibrium and will achieve similar resulting profits. We can conclude that there is a unique solution to the game of coopetition.

4. Conclusion

Even though we do not yet see LNG shipping companies forming strategic alliances in the same way as it is the case in shippers focusing on container transportation, the increasing number of emerging LNG transportation companies and general expansion of the market leads to the higher number of cooperative maneuvers in the near future. An investment is complementary element and companies have strong incentive to cooperate at investment stage. In this paper we set the framework for coopetitive game fundamentals and concept model representation for LNG transportation industry. In order to develop feasible model that will assist maritime practitioners and researchers, we used profit maximization approach of a single carrier in order to resolve coopetition model. With profit maximization problem defined as mixed-integer and nonlinear problem, we approach to solution with iterative heuristics. In this approach, the coopetition game is elaborated from the static perspective; therefore, dynamic direction with asymmetric information is also a feasible methodology that could be considered for future research. Finally, we considered formation of strategic alliances based on competition and cooperation level, but coopetition can be function of other factors, such are various agreements among carriers, special deliveries to multiple customers, or even generation of specific projects that generate new demand. A model that incorporates these factors would produce insightful solutions.

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Session
Social Aspects

Benefits of information technology in the field of primary health care of crew members onboard ships

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Abstract: Automation and digitization are already changing the maritime industry. It is essential for the communication, storage, and exchange of data. The application of digital technologies is only a prerequisite for forming the frameworks for transformation. The hard part is integrating them. Digitization should be the tool, and digital transformation should be the way. The terms eHealth and telemedicine are closely related to this. In this regard, the article examines some of the various applications of digital technologies in healthcare, particularly in the primary healthcare of ship crew members.

Information technology undoubtedly leads to improved planning and automation of routine activities. And in the field of shipping, they will provide even an increased possibility of saving human life. Mobile applications increase the level of competence and provide qualitatively new opportunities to refresh the practical medical skills of seafarers.

An analysis of relevant literature regarding the need for the use of information technologies in modern shipping is provided. It can be concluded that modern mobile technology allows crew members to access information in real time and at any time.

However, digital transformation is not a destination, it is a journey. Keeping up with the latest digital trends is vital.

Keywords: big data, diagnosis, artificial intelligence, data processing

1. Introduction

Digitalization is also a fundamental tool for the development of precision medicine. With this definition, we designate the possibilities for individualized diagnosis and treatment based on results such as genomics, patient data, health information from wearable devices, etc. Precision medicine's achievements are targeted anti-cancer drugs, individualized immunotherapies, or 3D-printed personalized prostheses (Zhukovska et al. 2022). In the future, it will also be ordering bioprinted tissues and organs for a particular patient. As technology advances, precision medicine becomes more widely applied and accessible to patients.

Mobile phone treatment, including education, information, counseling, reminders, and monitoring, can help patients adhere to their treatment plans. Regarding mobile technology and primary health care, researchers created a measure that examines five different constructs: health service efficacy, education, notification, consultation, and following-up. These five factors influence attitudes of public health personnel regarding the use of mobile phones.

Maintaining and improving the health of a ship's crew is significantly more difficult at sea than on shore (Karadencheva, 2022). Healthcare at sea poses several unique challenges and problems due to the isolated and remote nature of maritime environments. Ships may be far from shore, making it difficult to access medical facilities quickly in case of emergencies or serious medical conditions. Also communication with onshore medical professionals can be challenging, particularly when ships are in remote areas with poor or unreliable connectivity. Moreover, long periods of isolation and confinement at sea can lead to mental health problems among crew members, such as depression and anxiety, as well as harsh weather conditions, extreme temperatures, and the physical demands of maritime work can contribute to health problems.

Pauksztat et al. (2022) provide evidence of the need for medical care at sea which has grown exponentially in recent years, and through COVID-19 the demand for mental health care has increased. During the same period, the age of digital technology was developing with full force. Smartphones have appeared, real-time traffic planning is taking place, and users have much more reliable and detailed information about their journeys than transport operators. Shippers can track their shipments through each stage of the transportation process using the so-called intelligent transport systems. But how does digitization impact medical care onboard ships?

In this regard, the present work aims to discuss the role of information technologies in the field of primary health care of crew members onboard a ship. The goal thus set is achievable by performing the following tasks: (1) presentation of the essence and characteristics of digital technologies; (2) role of mobile health applications; (3) their application in the marine healthcare.

2. Navigating the Digital Horizon

The deepening economic, social and demographic crisis in connection with the coronavirus pandemic in the last two years has forced a significant part of global, European and national businesses to accelerate the massive digitization of their economic activities. This process caused severe changes in the way of life, employment, education, consumption, and mobility of the population (Mednikarov et al. 2019). There is a need to improve the knowledge, skills, and qualifications of employed personnel in both the public and private sectors.

Maritime transport is no exception to this process. The COVID-19 pandemic has accelerated digitization in various industries, including maritime transport (Chua et al. 2022). But the application of information and communication technologies is primarily aimed at optimizing the processes of planning and managing cargo traffic, monitoring and control of loading and unloading facilities, as well as secure and safe transmission of data regarding the sending and receiving of customs and other documents.

The negative consequences of the lack of digitization in medical care for ship crew members are a lack of standardized medical data and integration models for accurate health information and creating a predictable and controlled health environment. It leads to questioning the reliability of official health information and medical data. In addition, inability to make informed management and medical decisions for disease control and effective treatment of crew members; obstruct the quality of the treatment process; obstruct the ability to provide first or emergency aid in time.

According to its definition, first aid is the help given by people closest to the injured. First aid does not require specialized medical knowledge, equipment, medicines, and tools. First Aid’s task is to protect the injured from continuing damaging effects and to help preserve his life, which we define as organizing for the injured a maximum neutral environment and an opportunity to maximize the deployment of his protective mechanisms. Every human organism is well-designed and maximally protected. In such a situation, we need to help his chances of survival.

Emergency assistance is provided by specially trained personnel with special equipment and methods. In Bulgaria, this is done by doctors and in almost all other developed countries, by paramedics. The task of emergency aid is to stabilize and, in most cases, transport the injured to a medical facility. In a few words, the emergency service must take the patient alive to the hospital, where the issue is taken over by doctors with different specialties and completely different methods. Urgent medical care is carried out exclusively only in Medical facilities and in Bulgaria, is regulated by Ordinance No. 10 of 6 June 1995 on EMERGENCY MEDICAL SERVICES (Ministry of Health, 2022).

On the world stage, the World Health Organization (WHO) issued the "International Medical Guide for Ships" (World Health Organization, 2007) in 1967, which is still the standard for practical guidelines for maintaining or improving crew health.

2.1 Charting New Waters

Today, digitization means the conversion of analog information in any form (text, photographic material, voice, etc.) into digital format through electronic devices (scanners, cameras, etc.), so that information can be processed, stored, and transmitted through digital circuits, equipment, and networks. Another meaning of this word is the integration of digital technologies (such as digital television) into everyday life through the digitization of everything that can be digitized. In other words, digitization is the procedure where certain operations can begin to be performed through digital media, such as computers or smartphones, with or without the help of an Internet connection. Digitization, worth clarifying, is a process that is not only carried out by companies or institutions. Instead, it is a change in the way people manage all information.

The widespread application of technology and artificial intelligence in the shipping and logistics industry would probably take years to fully implement into work processes. Still, the benefits are clear and significant even at this stage. Among them are:

- Simplification and increased optimization of existing activities;
- Increasing the efficiency of employees;
- Better conditions for transparent communication;
- Significant cost savings;
- Minimizing the risk of human error.

The improvement and ever-wider application of new technologies in every aspect of life significantly impact the development of maritime transport systems (UNCTAD, 2022, Lam et al. 2020, Wang et al. 2021). Although still on a design basis, autonomous ships can be considered a revolution in shipping.

Blockchain technology has gained its fair share of supporters and detractors but is nevertheless being embraced by the maritime industry for its proven ability to optimize costs. Shuyi et al. (2021) demonstrate how the blockchain as a secure, decentralized, and encrypted public ledger is being used in various shipping applications and is revolutionizing the way maritime trade is conducted. The shipping industry has not yet fully adopted blockchain technology. Still, it should be considered that it could be beneficial in terms of organizing, tracking, and reconciling business transactions involving many parties.

In healthcare, blockchain can be used to store patient records securely. This is important because it can help prevent medical errors and fraud.

Big data in healthcare describes the vast and ever-growing volume of healthcare data stored in a cloud (Ragupathi, 2014). Its generation is increasing with the rapid development of digital health solutions. Data systems have evolved to the Internet of (Medical) Things and enable the expansion of the healthcare IT infrastructure through data sharing (Gu et al. 2020, World Health Organization, 2007). Big data in healthcare has also expanded to include health insurance claims, pharmaceutical data, and patient behavioral data (Groves et al. 2022, Morrison et al. 2022).

However, to overcome the challenges that still exist in implementing digital technologies in maritime transport and healthcare, regulators and industries must work together to strike the right balance between encouraging innovation and protection against negative consequences and externalities.

2.2 Mobile Health Applications: The Compass of Care

Heavily regulated, healthcare is digitizing later than many other industries, making it an attractive arena for technological innovation.

The main challenges in the sector are legacy and outdated technology systems and analog processes. Healthcare providers are looking to improve the customer experience, looking for more modernization and integration of technology into a homogenous ecosystem that is easily accessible to the patient.

With different regulations in individual countries, ensuring security and correct use of data are also challenging. Globally, many efforts are being made to improve operational efficiency by focusing on automation and robotics.

All solutions that work through a mobile device are summarized under mHealth. This includes a wide range of apps for smartphones, tablets or smart watches. mHealth (Li et al., 2020) refers to medical and public health actions assisted by mobile devices such as mobile phones, patient nursing devices, personal alphanumeric assistants, and other tuner devices (Li et al., 2020, Rowland et al. 2020). The most crucial goal of mHealth is to improve healthcare quality and access to it. Using mobile phones in healthcare can lead to lower healthcare costs and a change in population behavior towards prevention, which can improve healthcare outcomes in the long term. Information through mHealth can provide health-related information, access to data for physicians in remote areas, more patient self-education, and improved diagnostic practice (Philpott, 2022).

Due to the widespread use of smartphones and other mobile devices, it is easy to use an application. In this way, the user has effortless access to medical services. There are also many opportunities for innovation - the integration of medical solutions is still in its infancy. By using networked measuring devices, for example, to monitor blood pressure, heart rate or other vital signs, applications can offer added value in various areas of health.

"Smart" medical products, services and processes are increasingly entering the medicine. Giants like IBM, Google, Apple, Microsoft, General Electric and many others have been developing their programs in medicine for years. According to data from the research company Venture Scanner (Morrison et al. 2022), more than 800 companies are involved in this sector, the most and most advanced being in the USA, Great Britain and Israel.

3.3. Digital Course for Maritime Healthcare

After the "hybrid" offices, we also have a hybrid provision of medical services. This means parallel implementation, as needed, of traditional in-office examinations and remote health services (for example, online consultation via video chat). The pandemic has clearly shown the benefits of this model in conditions of "social distancing". However, the advantages of remote health services are also a fact under normal circumstances.

But it's no accident that mHealth is seen as a cutting-edge method of delivering care, monitoring patients and disseminating information. The WHO defines mHealth as “the use of mobile or wireless technologies to help people achieve their health goals.”

Seafarers aboard ships are exposed to extreme weather conditions, dehydration, equipment hazards, toxic substances, and more. Their health is constantly affected by loud noise, vibrations, inhalation of harmful emissions and overwork. In this regard, the use of mobile health applications (in first aid) helps to master better the knowledge acquired during their initial mandatory medical training (medical qualification courses) (MLC, 2006, Ordinance No. 6 of 17 June 2021, Ordinance No. 9 of 23 February 2022, Ordinance No. 11 of 30 April 2014). The applications increase the level of competence and provide qualitatively new opportunities to refresh the practical medical skills of seafarers.

Other benefits of using mHealth by seafarers are:

- Quick response from the crew - reducing wandering time from a correct life-saving decision
- Awareness of proper first aid to the patient
- Increasing the crew's sense of security
- Reducing the cost of hiring a medical specialist
- Reducing the risk of wrong decisions and fatal outcome
- Possibility of consultation with a specialist doctor of any specialty (online conversation, a doctor familiar with the details of the peak moment of a given condition and its control)
- Monitoring accompanying diseases of part of the ship's crew
- Ability to send photos to specialists for easier diagnosis
- Provision of mental help/consultation with a specialist, during a long transition

Kanev et al. (2017) emphasize the importance and even critical nature of addressing contemporary human element problems at sea. And since one of the severe problems in medical care for seafarers remains the inability to see a doctor (which can drag on for days and even weeks), modern technologies intervene to help solve this problem (Molodchik et al. 2018, STCW, 2021). One way is through the Mariners Medico Manual, approved by the flag state of Norway as an equivalent national medical manual to the WHO International Ship Medical Manual (World Health Organization, 2007, Gard, 2022). Developed by Gard and the Norwegian Center for Maritime and Diving Medicine to improve seafarers’ health protection and medical care on board ships. The Mariners Medico Guide offers up-to-date, quick-access and easy-to-use medical guidance. A comprehensive symptom-based practical approach is provided, designed and vetted by doctors specializing in marine medicine, providing step-by-step guidance, and advising when and how to seek expert medical advice if necessary (Gard, 2022).

Another example of an intelligent mHealth solution is the Ada application (Ada Health GmbH, 2022). It asks questions, and the patient describes his symptoms. After that, the system searches the database for information about the problem and gives recommendations, and sometimes advises to consult a doctor.

There are other similar developments. Some offer the diagnosis of complex diseases, for example, diabetic retinopathy, or predict possible heart problems in apparently healthy people. The Institute of Oncology in Japan and Fronteo Healthcare has developed the KIBIT system. She analyzes the symptoms of the disease, and the characteristics of the patient's body, "digs" the specialized literature and sends the diagnosis.

In telemedicine, applications offer the possibility of overcoming the spatial distance between the patient and the professional staff. The most significant benefit is provided by optimized communication and practical evaluation of information essential to the patient's health. Both the patient and the specialized staff are registered as users. In diagnostics, these are primarily doctors, in therapy and rehabilitation – patients who benefit from the application.

In the context of the above, it can be concluded that modern mobile technology allows crew members to access information in real-time and at any time.

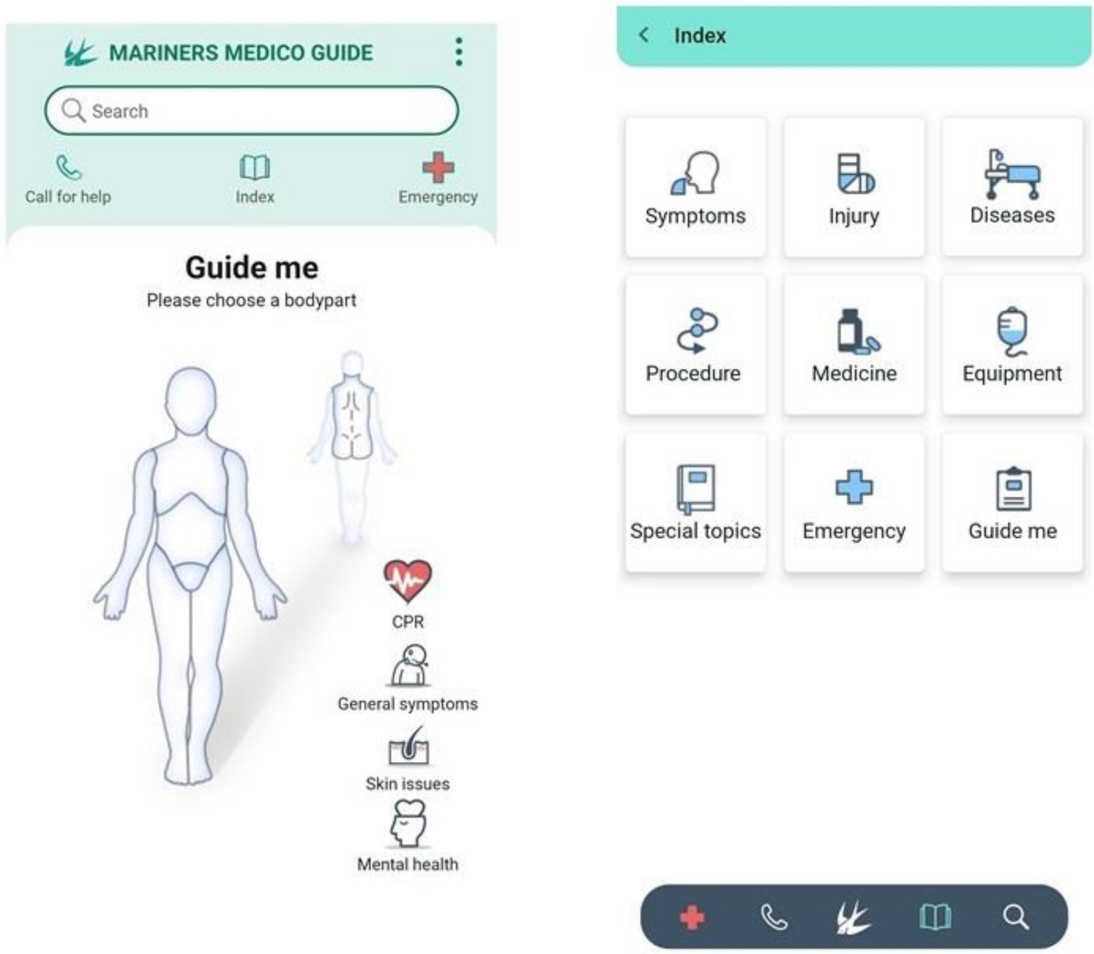

Figure 2. Mariners Medico Guide, (Gard, 2022)

The app has the option to maintain online and offline data in the app.

4. Conclusion

In conclusion, the article underscores the urgency of digital transformation in maritime healthcare. It is essential for providing efficient, timely, and high-quality medical care to seafarers. Digital technologies, driven by the pandemic's impact and trends like blockchain and big data, are pivotal in achieving this transformation.

As in almost every other field, artificial intelligence is playing a growing role in healthcare – not only on shore but also on board ships. Popular wearable devices such as smart watches and fitness trackers will play an increasingly important role. We're about to hear more about this trend in healthcare. According to Research and Markets (IMARC Group, 2022), the global connected medical device market will reach $94.2 billion in 2026, compared to $26.5 billion in 2021, i.e., will mark over threefold growth over this period.

However, any digitization requires the necessary technical infrastructure. It is essential for the communication, storage and exchange of data. In the new environment where medical services are increasingly digitized and can be provided remotely (by option or necessity), healthcare organizations that do not invest in digital technologies are doomed to progressive inadequacy.

The horizon of maritime healthcare has expanded, and the journey towards safer, healthier seas has begun in earnest. The maritime industry must continue to invest in, innovate, and adapt to these technologies to ensure that every seafarer can experience the benefits of a digitalized and connected healthcare ecosystem.

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Challenges to the professional training of cruise industry employees in Bulgaria

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Abstract: Today, the tourism sector is one of the industries that generate some of the highest levels of employment. The tourism industry as part of the whole concept of travel, tourism, and entertainment also annually marks a remarkable growth in its development. The need for well-trained and promising personnel in the sector is becoming more and more tangible, given the desire of the business to recover quickly after the years of the pandemic. In order to meet the global demand, managers in the industry are joining their efforts in the direction of human resource development in order to optimize recruitment processes and study the possibilities of retaining well-trained specialists. The study of the relationship between the two economic activities, tourism, and the cruise industry, in terms of the creation and development of prospective manpower, will highlight the range of professional growth with high importance to the cruise business.

Keywords cruise industry; professional training; tourism; employees; Bulgaria.

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1. Introduction

Professional training is a key element in the development of human resources in the cruise industry. The specificity of the working environment determines the requirement for available complex knowledge and skills of those employed in the sector. The psychological attitude of working away from home, communicating in a multicultural and multinational environment, skills to work under pressure, and insufficient time for rest and free time activities, are some of the challenges facing future employees (Karadencheva, 2022). Furthermore, a gap exists between efficient employment and adequate remuneration, exacerbating staff turnover in the industry.

On the other hand, this modern type of tourism offers a wide variety of work positions in different departments and an extremely wide range of ongoing training and professional development. But a need for improvement is observed to attract more motivated and skilled employees (Fedotova et al. 2019). Changes in working conditions, upgrading the social benefits package, preparing a development plan and goals, and seeking constant feedback are just some of the measures that would increase the profession's attractiveness.

Modern educational training for personnel in the cruise industry worldwide reveals new directions for improving knowledge and skills for teamwork, conflict resolving, multi-tasking, cross-department training, and building sustainable educational habits. However, the use of technological innovations in the educational process has a positive effect on the development of the cognitive and creative activity of the students (Molodchik et al. 2018; Slyusarenko et al. 2021). This modernization is characterized by a combination of traditions with new ideas, which are related to the introduction of digitalization in the maritime industry and logistics (Dimitrakieva et al. 2023; Yotsov et al. 2017). The level of staff training depends on many factors and conditions, but building effective communication between educational institutions and business for the optimal result is determinative.

Moreover, the cruise industry is known for its constant evolution. From technological advancements to changing customer preferences, staying updated with industry trends poses a significant challenge for training programs. Ensuring that students have a deep understanding of industry-specific subjects while also covering broader hospitality and service principles can be a challenge.

2. Aim/Purpose of the study

In this regard, the present study aims to find out how well the personnel and students studying in Bulgaria are prepared to meet the above-mentioned work environment specifics related to the cruise industry and whether operational mechanisms and standards are available to give them the confidence and freedom to make an informed and aware choice of workplace.

The object of the study is both employees in the industry and those who are in the process of training in the following areas:

• Hotel and restaurant management;

• Tourism and leisure management;

• Tourism;

• Management of cruise ships;

• International tourism business;

• Tour operator, agency, and transport activity;

• Food technologies in the culinary arts.

3. Methodology and limitations

The challenges facing new employees are highly polarized, for this reason, a SWOT analysis is performed to create an overview framework and highlight the main areas for improvement of the professional training of personnel with professional qualifications for working on a passenger ship. Thus, the areas in which the representatives of the business will take action would stand out, so that their employees do not just survive until the planned vacation on the coast, but are confident, motivated, and responsible to be present and work in the team. SWOT analysis is not the only approach that is widely used to review strategies, positions, and directions for a specific organization and product, but it is also applicable to any industry (Morrison 2016, Helms & Nixon, 2010).

The process of data collection for the present research contains observation of national statistical data, recruitment companies' job descriptions and publications, news, and feedback received from students studying in educational programs in Nikola Yonkov Vaptsarov Naval Academy and are closely related to the professional field of tourism and cruise industry. The statistical data, primarily sourced from national databases, was used to identify trends, validate the qualitative insights, and gain a broader understanding of the industry's workforce dynamics. Job descriptions were collected through a systematic approach. Sources such as publicly available job postings on websites, recruitment agencies, and industry-specific job boards were also used. To ensure relevance, eligibility criteria considering only job descriptions related to positions within the cruise industry was applied.

Most cruise lines work in partnership with national and regional recruitment agencies to hire the most suitable personnel (Cruise Lines International Association, 2020). Considering the fact that they are key players for both the cruise business and the employees, the present study will be limited to observing the qualification of their candidates. Another reason is that most cruise companies are unavailable for direct contact for information-gathering purposes.

4. Overview of the professional training related to the cruise industry in Bulgaria

The human factor in the cruise industry is undeniably the leading power and regardless of new technologies and the drive toward computerized management, in the travel and tourism service sector, it cannot be replaced.

Modern trends in the development of the cruise sector form high requirements for the organization and content of the training process of specialists, changes in the travel and tourism market also put pressure on the pace of personnel development, in addition, tourists themselves are now more demanding and expect a high quality of the products and services offered (Scherbak 2022). To offer quality services according to the wishes and preferences of tourists and to provide better personal service to functions at different hierarchical levels in tourism enterprises and organizations is required staff with specific knowledge, skills, and competencies in various fields of knowledge, but refracted through the prism of tourism (Yancheva et al. 2016).

The cruise industry faces a number of challenges in terms of recruiting service personnel who can successfully integrate into the dynamic work environment while developing loyalty to the employer company and a willingness to upgrade in the future. In this regard, this research aims to explore the attitudes and difficulties that tourism professionals encounter on their way to a sustainable and attractive career on board.

Bulgaria is a maritime country in Northeastern Europe, bordering the Black Sea to the east. Historically, the direction of the country's development has been and still is extremely strongly determined by its geographical location. In the economic aspect, the construction of the infrastructure and superstructure of the ports supports trade and supply activities growth (Gancheva 2021). In order to provide a workforce in the maritime sector and to prepare qualified specialists for work in national and international companies, maritime educational institutions have been established in the country (Mednikarov et al. 2019). In parallel with this, the development of the tourism sector in Bulgaria contributes to the emergence of specialized educational structures engaged in the education and training of tourism personnel. The territorial concentration of the people employed in the Tourism sector, based on statistical division, follows the flow of tourists, and it is mainly in the Black Sea region - Northeast and Southeast statistical regions (Mileva 2012).

As of March 2023, there are 15 higher education institutions in Bulgaria that train students in the field of Tourism (Table 1).

Higher education institutions	City (Country)	Program
Sofia University St. Kliment Ohridski	Sofia (Bulgaria)	Tourism
University of Forestry	Sofia (Bulgaria)	Management and alternative tourism
Varna University of Management	Varna (Bulgaria)	Hotel Management; Hospitality and Culinary arts; Food Technology and Culinary arts
University of Economics Varna	Varna (Bulgaria)	Tourism; International Tourism
International Business School	Botevgrad (Bulgaria)	Tourism and entrepreneurship
The University of Food and Technology	Plovdiv (Bulgaria)	Tourism and culinary management
New Bulgarian University	Sofia (Bulgaria)	Business and Entrepreneurship Management
South–West University Neofit Rilski	Blagoevgrad (Bulgaria)	Tourism
Agricultural University of Plovdiv	Plovdiv (Bulgaria)	Agricultural Tourism
Veliko Tarnovo University	Veliko Tarnovo (Bulgaria)	Tourism
Nikola Vaptsarov Naval Academy	Varna (Bulgaria)	Management of passenger ships
University Prof. Dr. Asen Zlatarov	Burgas (Bulgaria)	Tourism
University of Plovdiv Paisii Hilandarski	Plovdiv, Smolyan, Kardzhali (Bulgaria)	Tourism
Shumen University	Shumen, Varna, Dobrich (Bulgaria)	Tourism
College of Tourism Blagoevgrad	Blagoevgrad (Bulgaria)	Organization and Management of tourist services; Organization and management of hotels and restaurants
University of National and World Economy	Sofia (Bulgaria)	International Tourism and Economy

Table 1. Bulgarian University Ranking (2022)

A brief overview of the announced programs in Bulgarian higher educational institutions indicates the acquisition of the necessary knowledge, skills, and competencies necessary for successful implementation in the tourism and cruise industry. The main skills are developed in the following directions: Hotel and Restaurant Management; Hospitality Management; Tourism; Customer Service Management; Animation and free time activities; Tour Operator, Travel Agency, and Transport Activity; Food and Beverage service;

Culinary Arts.

It is important to note that, compared to the labor market in the cargo sector, in the cruise industry the diversity of work positions, hierarchical features, and the increasing size of ships results in a more complex organizational structure (Wu 2005). In this regard, the mentioned various skills are extremely important for securing the vacant job positions and can be highlighted as a competitive advantage in favor of Bulgarian students.

The main challenge facing universities and colleges in Bulgaria is how to prepare students who can successfully meet the needs of the business. Educational materials and theoretical concepts must not remain only in academic halls but rather be turned into practice and together with good practical tools to achieve the objectives of society (Dimitrakiev et al. 2010).

A study of the demographics of cruise ship personnel highlights a fact that should not be overlooked, namely that workers from industrialized countries are aware of the terms of the contract for a specific job position, while those from Eastern Europe (including Bulgaria) often do not know to the last detail what work they will be hired for, primarily interested in wage, working hours and contract duration (Bulikhov 2009, Raub, 2006). In the same research, Bulikov mentions that recruitment agencies in Eastern Europe collect fees from candidates for job placement. An observation of the information submitted by the agencies nowadays shows a change in this trend and confirms that recruitment services in Bulgaria are free of charge to applicants.

5. SWOT analysis

The data published by the statistics were used as an analytical tool to determine the opportunities and threats for Bulgarian employees in the cruise industry. While national specificities of a cultural nature supported by feedback from recruitment agencies contributed to the assessment of the strengths and weaknesses of working in the industry.

Analysis of the research results and the subsequent findings and conclusion will be a good basis for future improvements and for creating a successful pathway in the cruise business, prior to safety and well-being, working time, and work-life balance.

5.1 Strengths

- International career development by moving from country to country and becoming part of the experience economy (Hjalager 2003).
- There is an increased interest in pursuing a profession on board a cruise ship. Combining work with travel also attracts candidates who until recently practiced their profession on the shore.
- Obtaining higher professional qualifications on a luxurious cruise ship with high-class service provided.
- Constant feedback and evaluation of the work by the employer. Every employee on a cruise ship is passing through different types of assessments in order to receive feedback.
- Most cruise lines have established and managed orientation kits in order to help employees to become productive more quickly, to instruct them on how to do the job correctly, and create team fellowship and cooperation. This contributes to a high level of consistency in employee training and development

5.2 Weaknesses

- Higher education in Travel and Tourism, passenger ship management, or customer service operations is not a mandatory requirement for applicants. The minimum requirement is a high school education, which calls into question the practical skills of the employees.
- Previous experience aboard passenger ships is optional. Few cruise lines have this requirement as mandatory. This can result in the inability of workers to reliably adapt to the physical, psychological, and social working environment of a passenger ship.
- Recommendations from previous employers are not mandatory, and if they are available, they are not a guarantee of a successful interview.
- Lack of detailed and accessible information on possibilities for conducting “on-the-job” training in the Travel and Tourism, and cruise industries. Providing such information in advance, the employees will be more confident in the work environment.

- The plenty of regulations, checklists, etc. that make everyday responsibilities difficult for staff. In addition to that increased control by on-board supervisors may seem disconcerting to employees (Ariza-Montes et al. 2021).

5.3 Opportunities

- Opportunity to become familiar with widely established management systems, processes, and tools concerning the long-term maintenance of a high-quality tourism product/service.
- Opportunity for quality training and qualification/re-qualification of staff involved in the process of providing high-quality products and services to cruise ship guests.
- Communicating in a multicultural and multinational environment.
- Developing loyalty to the organizations and building trust to the team.
- Opportunity for short-term contracts for students during their education in the field of tourism.

5.4. Threats

- Limited social contacts and the psychological attitude of working away from home are prerequisites for uncertainty in a long-term cruise industry career.
- Insufficient time for rest and free time activities. Feedback from recruitment agencies reveals that the majority of employed Bulgarians are not prepared for long work shifts. Also, working under pressure and the ability for multitasking are required in some situations (Gundić et al. 2021).
- Routine in performing daily duties and reluctance to professional upgrade due to exhaustion. Cruise companies should provide continuous training, extremely important for setting and achieving new goals for employees.
- Lack of preliminary information concerning medical insurance and social benefits while working on board.
- Irregular actions regarding receiving more tips.

The modern educational training of personnel in the cruise industry faces challenges stemming from rapid technological advancements, diverse skill requirements, language barriers, and high turnover rates (Radic et al. 2020, Raub et al. 2023). However, there are numerous opportunities to address these issues and improve the quality of training.

By leveraging e-learning, simulation technologies, industry partnerships, multicultural training, and sustainability education, the cruise shipping educational institutions can develop a highly skilled and adaptable workforce. This, in turn, will enhance the passenger experience, improve safety standards, and contribute to the long-term sustainability and growth of the industry.

6. Conclusion

The cruise industry's rapid recovery post-pandemic underscores the urgency for well-prepared, educated personnel (Brewster et al. 2020). The efforts of the companies are focused and forced to push the business in the direction of upgrading and improving the offered products and services. Furthermore, the cruise HR management faces a number of challenges related to recruit and developing well-educated and trained staff with strong personal intentions to work on a cruise ship.

However, collaboration between educational institutions and industry stakeholders is essential for effective training. Higher education institutions and their subdivisions should establish sustainable communication with the representatives of the business sector in order to ensure reliable student orientation and future possibilities towards „on-the-job" training as a successful path to future professional growth in the labor market.

While employee recruitment and selection are crucial to a cruise organization's success, they do not guarantee that employees will perform well. Cruise companies should provide training to new employees to transform their high potential into high performance. In the cruise industry, service and quality determine the success or failure of a service. Not surprisingly, the employees determine the level of service provided, and, thus, the overall quality of the guest experience. Therefore, well-considered, adequate training should be provided to ensure guest satisfaction and, ultimately, increased profits. Investing in the education and training of cruise industry personnel is not only a necessity but also an opportunity for the industry to set new standards for excellence and innovation in the global tourism sector. Through strategic planning and a commitment to excellence, we can prepare the next generation of cruise industry professionals for a rewarding and fulfilling career at sea.

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Use of modern technologies at Naval Academy Varna

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Abstract: One of the most important guiding documents in shipping, which to a huge extent determines the safety of everyone involved is the Convention on the International Regulations for Preventing Collisions at Sea (COLREGS). The COLREGS are binding rules for all navigational officers and the insufficient knowledge, misunderstanding or non-observance of those rules usually leads to accidents. Often the result of such incidents is the loss of ships and, above all, of human life. The Convention sets out different obligations for shipmasters regarding maneuvering for passing, crossing and overtaking at sea, detailing which ships have priority in these cases depending on the circumstances and types of ships involved and what actions must be taken by ships obliged to give way, as well as rules for signals (lights, figures and sound signals) that ships must display or sound in various situations. This research aims to present the new approach to the maritime safety training at the Nikola Vaptsarov Naval Academy in Varna.

Keywords: Maritime safety, COLREGS, training, electronic platforms, simulators

1. Introduction

Shipping is perhaps the most important industry in the world, carrying according to United Nations Conference on Trade and Development (UNCTAD) statistics over 90% of goods in the world trade. In its report on trade developments for 2022, the conference noted that after a rapid but uneven recovery in 2021, the world economy is in the midst of cascading and multiplying crises, the most serious of which is the war in Ukraine and these crises decelerate global growth. For maritime transport, however, the recovery continues throughout 2022with moderate growth of 1,4% and the forecast for the period 2023-2027 is to expand by an average of 2.1% annually (UNCTAD, 2022).

At the same time, shipping is also among the most dangerous industries, with one of the main dangers being the risk of collision. More than 40 years after the entry into force of the COLREGS, despite improvements in navigational aids, sophisticated bridge equipment and attempts to raise training standards, collisions still occur, and unfortunately they happen quite often. Mistakes are usually made not because of insufficient or inadequate regulations, but because those regulations and standards are often ignored or not adequately understood. In the latest analysis that the European Maritime Safety Agency (EMSA) is doing on the investigated 573 incidents that happened in 2021, collisions between ships were 254 out of them, i.e. just over 44%. The cases of contact between the ships' hulls should also be mentioned here, because they are usually a consequence of non-compliance with the COLREGS – they are a total of 89 (15.5%). Or in summary – 343 (almost 60%) out of all investigated incidents were caused by ignorance or not following the Regulations. Although "human action" is about 78% of the total number of incidents, its distribution is different when it comes to an incident caused by non-compliance with the COLREGS: 83.5% of collisions and 70.8% of ship-to-ship contact. The EMSA study analyses also the factors summarized under "human action": wrong perception and interpretation of the situation - in 28 of the cases, lack of knowledge - in 30 and lack of abilities - in 23 (EMSA, 2022).

Safety at sea almost entirely depends on the professionalism and competence of seafarers, but part of overall safety is compliance with the COLREGS, which is the primary duty of officers in charge of a navigational watch. The development of the above-mentioned competence begins during the training of the future deck officers at Nikola Vaptsarov Naval Academy.

The COLREGS was adopted as a convention of the International Maritime Organization (IMO) on October 20, 1972 and entered into force on July 15, 1977 (IMO, 2018). By the end of 2021, the convention had been ratified by 165 countries, representing 99.03% of the world's merchant fleet tonnage. The Convention consists of 41 rules divided into six parts and 4 annexes.

There are three main documents that determine the requirements regarding competence related to COLREGS in Bulgaria:

The first of them, The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW) requires every deck officer to possess such competence and defines it as knowledge, understanding and skills. Mandatory Part A of the STCW Code states, among other minimum standards of competence for navigational officers, that it is obligatory for every officer in charge of a navigational watch to possess and demonstrate "thorough knowledge of the content, application and intent of the International Regulations for Preventing Collisions at Sea" (IMO, 2011).
The second international document is the Model Course of the International Maritime Organization (IMO Model Course 7.03). The curriculum of the model course covers the requirements of the STCW Convention, Chapter II, Section A-II/1, which sets out in three functions the minimum compulsory requirements which the knowledge, understanding and skills of officers must meet. In the model course a detailed curriculum is developed and outlined, in particular the topics that relate to COLREGS (IMO, 2014). The undergraduate education at the Nikola Vaptsarov Naval Academy is entirely based on this model course, however naturally the topics and number of their classes are expanded.

The third document is the Ordinance No. 6 on the competence of seafarers in the Republic of Bulgaria (issued by Ministry of Transport and Communications), which introduces the requirements of the STCW Convention into Bulgarian national legislation and essentially sets the same requirements (MTITC, 2021).

Although there are many factors that threaten safety at sea, the general conclusion in all the studies mentioned above is that most accidents are the result of poor training and insufficient qualifications. That is why the necessary attention is paid to the education of students in maritime safety, including in COLREGS, at Nikola Vaptsarov Naval Academy. The importance of the Regulations is emphasized by the fact that the topic is studied twice in the undergraduate curriculum. The first time is at the end of the fourth semester (before the students undertake their initial shipboard practice) and consists of theoretical lectures to learn the COLREGS rules, combined with practical classes and simulator training. The second time is in their last eight semester (immediately before graduation and the final seamanship practice) and the training is only practical - solving tests and again exercises on a simulator. In both semesters students' knowledge is assessed in a semester exam. In addition, the first of the five state exams for graduation is of COLREGS. This is also one of the five exams before the Executive Agency "Maritime Administration" for which all applicants for the qualification "Officer in charge of a navigational watch" take part.

In order to increase the effectiveness of training of COLREGS, innovative means are also actively used - the electronic platform e-COLREGS and navigation simulators.

2. COLREGS revolution

The electronic platform e-COLREGS was created under the project "Avoiding Collisions at Sea" (ACTs) and was financed by the European program "Leonardo da Vinci". Its purpose is to create a new way of teaching COLREGS and has led to the development of a modular course for e-learning and e-assessment, available online on www.ecolregs.com. The platform has been developed for 2 levels of training – initial (the basic level) and advanced training.

2.1 Level for initial training

This part of the platform is used in the initial training of students in their fourth semester and is offered in 6 different languages - English, Bulgarian, Spanish, Turkish, Croatian and Slovenian (Dimitrakiev, Conev, 2020).

There are four sections – COLREGS course, assessment, Convention and information about the project.

All 41 COLREGS rules are presented in the course section, and in some places along with the text of the Regulation itself there are added and clarifying comments as well as links to other related regulations.

Part A ("General") includes only of the text of the first three Rules but Part B ("Steering and sailing rules") consists of more than 280 scenarios that could be met in real-life situations. In each scenario except a description of the situation there is also an explanation of which rule(s) to apply and why. When appropriate, the scenarios are accompanied by a bridge view (video), a radar screen view and an electronic chart view.

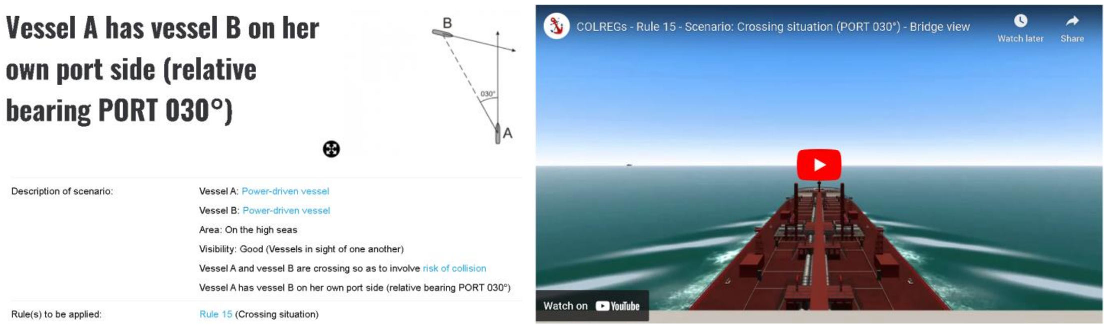

Figure 1. e-COLREGS Rule 15 Crossing situation - one of the scenarios

The rules in the other parts of the platform have been developed in a similar way. For ease of navigation in the platform, if a reference to another rule is indicated, it is made as a link and directly refers to the rule.

In the COLREGS assessment there are tests with 20 randomly generated closed-type questions with four possible answers. After answering each question, a pop-up window informs the participant whether the selected answer is correct or incorrect. The test ends with the final score in percentages and an overview of the participant's answers showing the correct ones.

2.2 Advanced level

This part of the platform is developed in English only and requires registration from participants. At Nikola Vaptsarov Naval Academy it is used to improve students' knowledge after they have already learned the Rules and completed their first internship on board a ship, where they saw their observance in practice.

Here there are also 4 submenus, with only the first one differing from the beginner level. It is called "COLREGS Advanced Course" and there participants can find 18 additional complex scenarios between more than two ships and with necessity to apply multiple rules. These scenarios are designed to demonstrate training in three main types of situations: crossing, overtaking and head-on situation, which can occur in open seas, narrow channels, traffic separation schemes and coastal waters (Dimitrakiev, Conev, 2020).

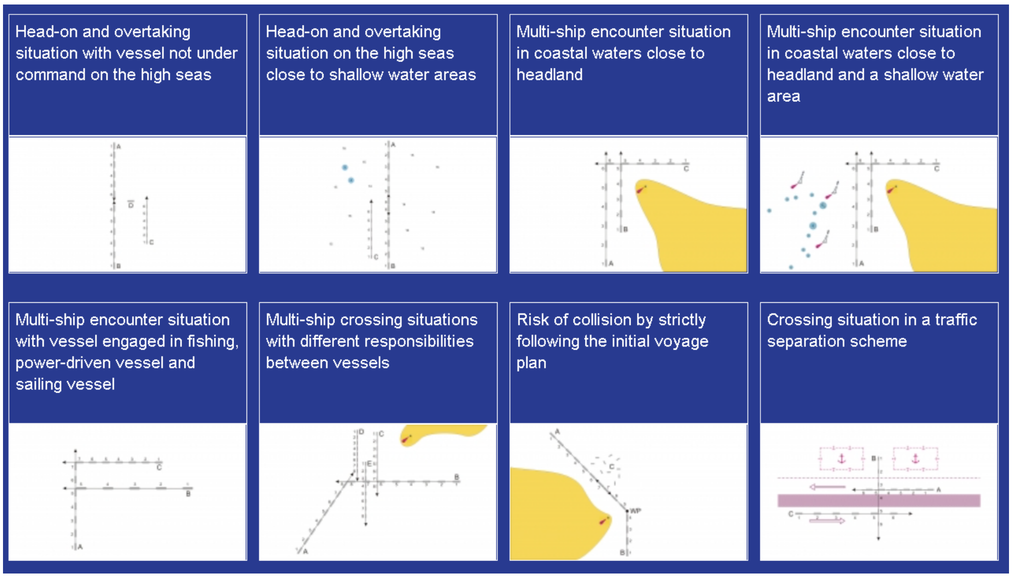

Figure 2. Advanced e-COLREGS – different scenarios

The tests in the "COLREGS Advanced Assessment" sub-menu consist of a closed-type question from four randomly selected scenarios. There are two to six questions for each scenario. After answering each question, a pop-up window informs the participant whether the selected answer is correct or incorrect. The test ends with the user's final score in percentages and an overview of the answers given, showing the correct ones.

3. A digital tide of knowledge

Recently, the importance of simulators in the education of students of technical specialties at Nikola Vaptsarov Naval Academy has been constantly growing, and they have become an indispensable part of the training. In all three regulating documents mentioned in the introduction, the use of simulators is specified, including the possibility of assessing professional competences through simulators. With the development of simulators, the training conditions can be more successfully brought to the actual operation of the ships.

There are a total of 40 navigation simulators at the Nikola Vaptsarov Naval Academy, 8 out of which are full-mission simulators (Class "A" according to the DNV classification (DNVGL 2020) with 360° visualization, and the remaining 32 are equipped with the same software, but with a partial visualization of 120° (Class "C"). They fully replicate the bridge configuration of an actual vessel, with engine and rudder controls and all navigational aids. Virtually all shipping scenarios (even these ones that could hardly happen in real life) can be played out on simulators, practically with any type of ship.

Usually, the simulator exercises are preceded by a session on the e-COLREGS platform (described above) to recall the rules and how they should be applied in complex situations.

The main use of simulators in COLREGS training is maneuvering for safe passing according to the Rules in various areas with certain specifics or with heavy traffic (Bosphorus and Dardanelles, English Channel and Dover, North Sea, Straits of Gibraltar and Singapore, important ports), areas where in practice it is necessary to continuously maneuver for collision avoidance. Students will have to apply the Rules repeatedly: make a correct assessment of the situation and recognize dangerous targets by determining the elements of their movement and the parameters of the passing, then take the right decision and maneuver when necessary - give way, reduce their speed or to stop the vessel if required in order to pass safely.

Figure 3. Maneuvering in a confined area

The exercise can be extremely complicated when such a maneuver has to be planned with several ships (sailing on different courses) at the same time or is carried out in conditions of restricted visibility. The instructor has the option to include other ships as targets to maneuver in the area in a certain set way. They can be ships with a special purpose or in a special condition (restricted in their ability to maneuver or not-under-command), requiring positive and with due regard to the observance of good seamanship actions from the students. There is a possibility that during the execution of the maneuver (i.e. in real time) the characteristics of the targets' movement can be changed, thus complicating the situation even more.

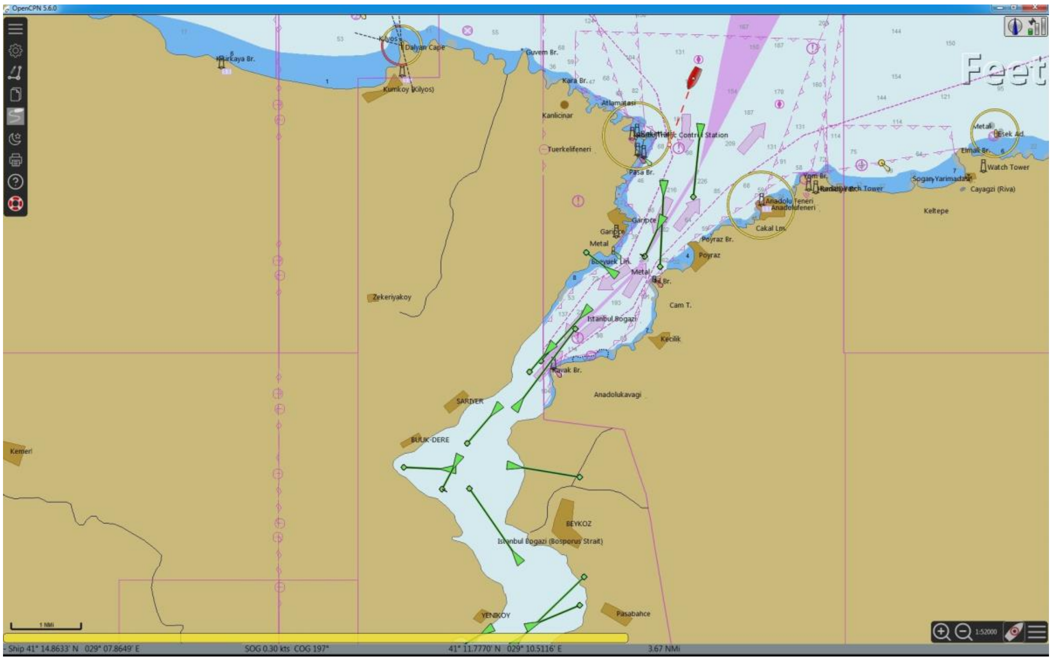

Figure 4. Passing Bosporus Strait with wrongly maneuvering vessels

Depending on the goals and objectives of the exercise, can be developed a scenario in which two training bridges (two ships) maneuver simultaneously in real time in the same area, in sight of each other. One bridge may even be assigned a task to maneuver against the rules in order to check and assess the response of the other bridge in such situation, so the trainees will be required to continuously monitor and evaluate the situation, as well as react timely and in correct manner to avoid collision. An extremely good feature of the simulator is that it can evaluate a large part of the trainees' actions according to pre-set criteria, independently of the instructor.

During the exercise, students have the opportunity to exhibit required lights or sound required signals in accordance with the COLREGS, to use signaling with the flags of the International Signal Code.

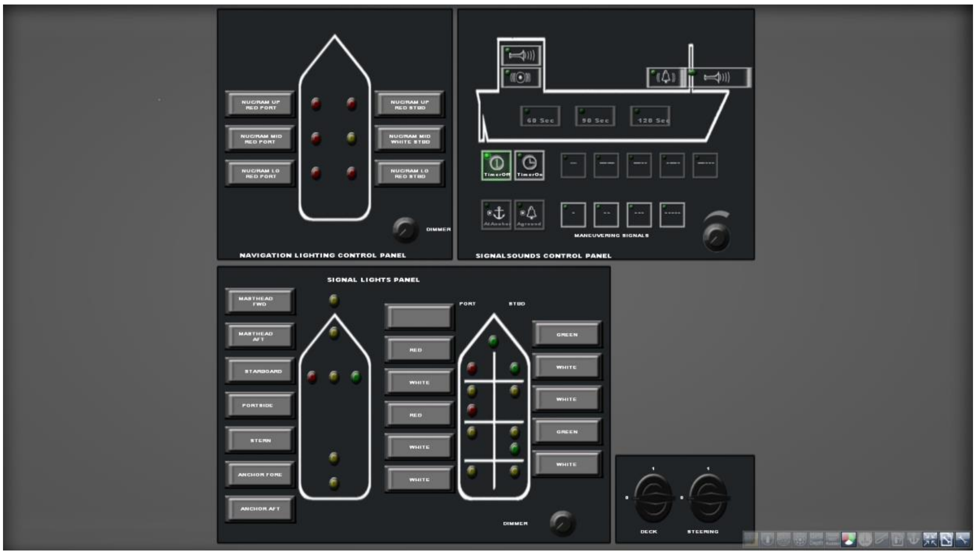

Figure 5. Iterface for exhibiting lights and sounding signals according to COLREGS

The instructor can also include a fault in one of the ship's navigation lights or controllers and assess how the students react. During the exercise they also have the opportunity to communicate through VHF with the target-ship (role performed by the instructor).

4. Anchored in innovation: the educational benefits

The described teaching method involving the use of the electronic platform e-COLREGS and navigation simulators offers several advantages and distinctions compared to traditional methods of teaching COLREGS such as interactive learning, real-time assessment and feedback as well as improved understanding.

Traditional methods, such as textbooks and lectures, often rely on passive learning, where students primarily absorb information through reading or listening, which may be less engaging. Contrary, by using an electronic platform like e-COLREGS, students can engage with the International Regulations for Preventing Collisions at Sea (COLREGS) in an interactive and multimedia-rich environment (Atanasova, 2022, Gramchev et al. 2023). This can lead to a better understanding of the rules and regulations, as students have the opportunity to explore scenarios and view visual representations.

The platform provides immediate feedback on quizzes and assessments, helping students gauge their comprehension and identify areas for improvement (Dimitrakieva et al. 2022, Ivanisevic et al. 2017). This immediate evaluation helps students understand the consequences of their choices and reinforces correct behaviors (Kitada et al. 2018, Suhrab et al. 2023). It also provides instructors with valuable insights into each student's performance. Moreover, the inclusion of navigation simulators allows students to practice applying COLREGS rules in realistic maritime scenarios (Grbic et al. 2021). Simulators help bridge the gap between theory and practical application.

The utilization of contemporary technology and electronic devices is likely to hold greater appeal for today's technologically adept students, thereby rendering the process of learning COLREGS more intellectually stimulating and contextually pertinent. While conventional pedagogical approaches may not fully exploit the expansive capabilities of contemporary technology in facilitating cognitive engagement.

The combination of e-COLREGS and navigation simulators emphasizes the importance of safety at sea (Alop, 2019). Students learn not only the rules but also the practical implications of safe navigation and collision avoidance (Zhao et al. 2019, Wei et al. 2022). This can instill a strong sense of safety awareness, which is crucial in the maritime industry.

In addition, by using an integrated approach with electronic platforms and simulators, training programs can ensure that students meet international and national regulatory standards related to COLREGS knowledge and competence.

5. Conclusions

The integration of electronic platforms like e-COLREGS and navigation simulators into maritime education marks a transformative era in the instruction of the International Regulations for Preventing Collisions at Sea (COLREGS). This innovative approach not only enhances understanding but also bridges the gap between theory and practice, instilling a profound sense of safety awareness among students.

Furthermore, the self-checking features underscore the effectiveness of this combined methodology. This definitely makes the topic more interesting and attractive for the students. Ease of use and convenient interface have turned the platform and simulators into a valuable aid in students' learning. This is also the opinion, which the majority of students expressed during discussions. By utilizing technology and simulations, this approach not only caters to the evolving preferences of technologically proficient learners but also serves as a dynamic catalyst in preparing seafarers for the multifaceted challenges of the maritime industry.

Ultimately, the method provides an engaging, effective, and contemporary educational framework that propels maritime safety training into uncharted waters of excellence.

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People-Centred Clean Energy Transition: The Role of Maritime Education and Training

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Abstract: Seafarers' knowledge and skills to handle new technologies in the environmental field are considered as important in the maritime industry. To prepare for future needs in green shipping, a new concept of "People-Centred Clean Energy Transitions (PCCET)" is relevant as it implies the role of education to support "people-centred and inclusive" clean energy transition within the maritime sector. This paper explores the role of MET to support the concept of PCCET from social sustainability perspectives. This study was inspired by the principles of "just transition" where education is recognized as a tool to create an enabling environment for people to drive the transition towards more sustainable and inclusive societies. The method of this study is to align the concept of PCCET to the existing framework of Global Maritime Professionals (GMPs), enabling the IAMU community to participate in PCCET through the promotion of GMP in MET. By adopting a concept mapping method, the paper identified key linkages between PCCET and GMP and the role of MET. The result would increase the applicability of GMP into an emerging maritime context where the potential of MET can also be expanded towards a sustainable maritime future.

Keywords: People-Centred Clean Energy Transition; maritime education and training (MET); Global Maritime Professional (GMP); just transition; maritime decarbonization

1. Introduction

A growing interest in shifting towards clean energy is a global and cross-sectoral issue to address climate change. This is also the case for the maritime industry where alternative and renewable energy as fuels to propel ships are recognized as a necessary transition in sustainable green shipping. Various technologies are being introduced, such as a variety of fuels made using renewable energy (e.g., methanol, hydrogen and ammonia), but also the introduction of renewable energy conversion devices onboard ships, such as wing sails and photovoltaic panels to harness the energy from wind and sun. Osterkamp et al. (2021) argues that clean energy transition in shipping is still in the emergence phase where at least 5% share of safe and scalable zero-emission fuels (SZEF) is required by 2030 to achieve a successful transition. While such transitions tend to focus on technologies to promote environmental and economic sustainability, social sustainability should also be underscored.

The International Energy Agency (IEA) coined a concept of "People-Centred Clean Energy Transitions (PCCET)", meaning that "all clean energy transitions should be truly people-centred and inclusive, and that this is essential to the success of energy system transformation at the pace and scale required to deliver global ambition for climate change mitigation" (IEA, 2022). This definition opens up a new research paradigm of how education can support "people-centred and inclusive" clean energy transition within the maritime sector. It is timely to discuss this concept in the context of maritime education and training (MET) as the impact and possibilities of emerging technologies, including clean energy related technologies, were addressed in the

Principles of the Comprehensive Review of the STCW Convention and Code during the 9th session of Human Element, Training, and Watchkeeping (HTW) Sub-Committee at the International Maritime Organization (IMO) (IMO 2023).

This paper explores the role of MET to support the concept of PCCET from social sustainability perspectives. This study was inspired by the principles of "just transition" which contribute to three elements of sustainability (i.e., environmental, economic, and social) (Just Transition Centre 2017) and education is recognized as a tool for "just transition". Hence, the method of this study is to align the concept of PCCET to the existing framework of Global Maritime Professionals (GMP), enabling the IAMU community to participate in PCCET through the promotion of GMP in MET. GMP prescribed in the Body of Knowledge (BoK) (IAMU 2019) provides guidance to educate future maritime professionals. The paper begins with reviewing selected concepts of transitions in relation to human element in the maritime sector, followed by the method used and results and findings. Finally, discussion and conclusion are presented.

2. Transitions and human element

When values, perceptions, and ways of being and doing in the world are challenged for change, transitions require people to redefine the situations and self (Wilson 2019). Situation awareness is important in cognitive psychology as it refers to a function of the human mind to be conscious about complex, dynamic and potentially risky situations (Endsley 1995). Transitions are also used in behavioral theories to understand, negotiate, and resolve people's life transitions (Ruthven 2021).

The maritime sector is facing contemporary challenges, such as digitalization, decarbonization, skill gaps, and occupational safety and health. Thus, the notion of human element by addressing these challenges is becoming wider and more complex. In this rapidly changing environment, human element or people-centred approaches are needed to consider how transitions can improve the lives of people and create a just maritime industry for all.

2.1 Just Transition

When considering green jobs to mitigate the impact of climate change, one important transition theory is called "just transition". Just transition began its origins in the 1990s when trade unionists supported unemployed workers that were made redundant as the result of environmental protection policies, however the concept has been evolved to invest in environmentally and socially sustainable economies (Just Transition Centre 2017). Just transition recognizes education as a tool to create an enabling environment for people to drive the transition towards more sustainable and inclusive societies, for example, training and curricular adaptation is a way that educators can take part of the transition (ILO 2015). During the 26th meeting of the conference of the parties (COP 26) to the United Nations climate convention (UNFCCC) in Glasgow, the "Maritime Just Transition Task Force" was set up by by the International Chamber of Shipping (ICS), the International Transport Workers' Federation (ITF), the United Nations Global Compact (UNGC), the International Labour Organization (ILO) and IMO. It is an initiative that shipping's response to the climate emergency puts seafarers and communities at the heart of the solution (Maritime Just Transition Task Force 2022).

In the context of MET, education of seafarers and other maritime professionals who are environmentally minded is a socially sustainable response to just transition. Future maritime sectors need people who can drive the process of maritime decarbonization, blue economy, green port, sustainable shipyard, sustainable supply chain, safe and healthy work environment, and other emerging agendas. PCCET is one of such agendas which has not been well conceptualized in the maritime sector and relates to just transition from human element perspectives.

2.2 People-Centred Clean Energy Transition

A concept of PCCET proposed by IEA (2022) reflects a growing interest in shifting towards clean energy as a global and cross-sectoral issue to address climate change. In the maritime industry, using alternative and/or renewable energy as fuels are the key for a necessary transition in sustainable green shipping. However, the current discourse is to drive a clean energy transition by policy makers and the industry with the emphasis on environmental and economic sustainability.

A "people-centred" approach underscores social sustainability, and thus human element is recognized as important for the successful clean energy transition. Baum-Talmor and Kitada (2022) argue that a technology-centred approach overlooks the human perspective of developing skills and advancing individuals' careers as maritime professionals. Swe et al (2018) discuss the important role of education and training to implement the energy efficiency measures in the Myanmar maritime industry. PCCET will create a space for MET to play a vital role in sourcing skilled professionals for greener shipping.

2.3 Global Maritime Professionals

In the rapidly changing maritime workplace, there was a need of establishing a guideline for future maritime professionals who can demonstrate modern professionalism in the future world of work. To respond to this need, the International Association of Maritime Universities (IAMU) undertook a formulation of a comprehensive guideline for the next generation of leaders, called the Global Maritime Professionals (GMPs). The GMP Body of Knowledge (BoK) was published in 2019, which specifies the 28 knowledge, skills and attitudes (KSA) required by GMPs by four sets of skill categories (I. Foundational knowledge and skills; II. Academic skills; III. Professional - Technical skills; and IV. Professional - Soft skills) and relevant Intended Learning Outcomes.

"Clean energy" related KSA was, however, not specified in GMP BoK and the closest KSA was found in the "environmental awareness, sustainability and stewardship" (KSA No. 25) under the category of "IV. Professional – Soft Skills". To enable PCCET in the maritime sector, educating GMPs with KSA No. 25 as well as other KSAs will be an important contribution to social sustainability from MET perspectives. To maximize the potentials of GMPs for PCCET, key linkages between PCCET and GMP will be identified for further inquiries.

3. Methods

In order to explore the interlinkages between PCCET and MET, a concept mapping technique was used to identify the relationship at the concept level. Concept mapping is a technique to use graphical tools for organizing and representing knowledge (Novak & Cañas 2008). First, several key concepts relating to PCCET and MET were identified from the literature review, such as the triple bottom line (TBL) of sustainability performance (social, environmental, and economic sustainability), just transition, and GMP. Second, the interlinkages between various concepts were explored, which is detailed in Section 4, and conceptualized for visualization. Based on the identification of KSA No. 25 (environmental awareness, sustainability and stewardship) from the GMP BoK as the most relevant to PCCET, KSA No. 25 was further reviewed by four different tier levels (i.e., STCW and academic achievements) as well as three domains of learning (cognitive, affective, and psychomotor). The primary analysis and findings are presented in the following section.

4. Results and findings

Firstly, three dimensions of sustainability performance based on TBL were depicted by linking the concept of just transition. Just transition provides an example of how well managed, transitions to environmentally and socially sustainable economies can be a holistic approach to green and decent job creation, social justice and poverty eradication (Robins & Rydge 2019). The original version of the just transition diagram illustrates that both social sustainability (decent work) and environmental sustainability (climate change) would jointly support economic sustainability (green jobs). In the right half of Figure 1, social sustainability is linked to education which is also emphasized in the concept of just transition. Three relevant UN Sustainable Development Goals (SDGs) are noted: Goal 4 (quality education), Goal 13 (climate action), and Goal 8 (decent work). Figure 1 reflects that transitions are not primarily economic driven, however, economic sustainability (green jobs) is influenced by social sustainability (education) and environmental sustainability (climate action).

Secondly, in the left half of Figure 1, the intervention through education to support social sustainability can be achieved through the promotion of GMPs in the MET context. By reviewing the GMP BoK, the most relevant KSA was No. 25 "environmental awareness, sustainability and stewardship" under the category of "IV. Professional – Soft Skills", which was highlighted in Figure 1. By mapping the concepts of just transition and GMP, the interlinkage between PCCET and MET is identified with three key SDGs.

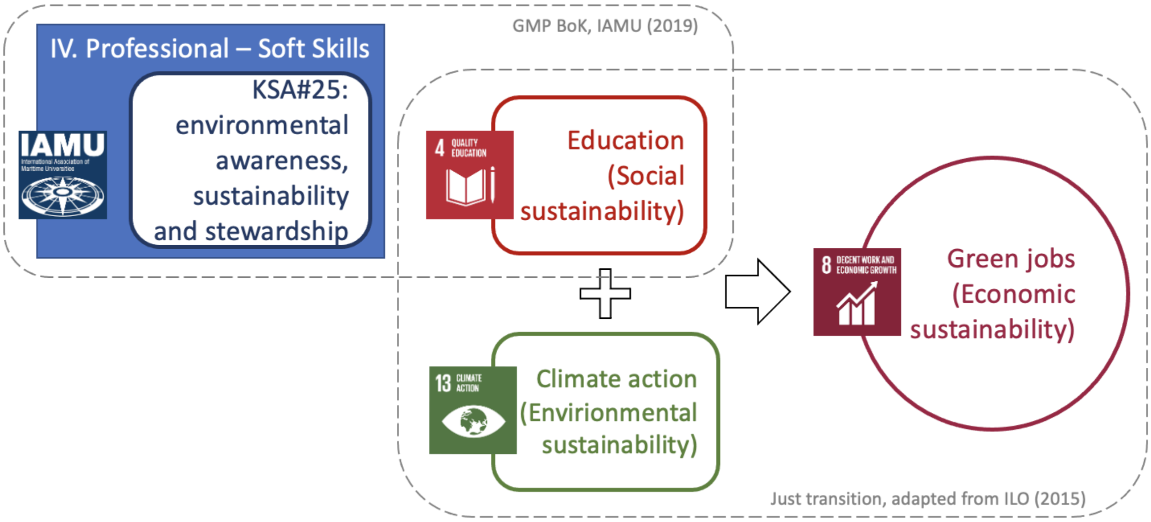

Figure 1. The linkage between GMP KSA#25 and Just Transition (Source: Authors).

Based on the results of concept mapping, the most relevant KSA No. 25 was reviewed according to the GMP BoK which specifies the STCW and academic learning outcomes of four tier levels (Table 1). The cognitive domain of KSA No. 25 relates to knowledge on environmental issues and relevant policies and technologies; the affective domain of KSA No. 25 emphasizes professional commitment to environmental management; and there are no levels of learning outcomes in the psychomotor domain for KSA No. 25 (IAMU 2019). The emphasis on cognitive and affective domains for KSA No. 25 reflects how future green shipping relies on intellectual and emotional knowledge and abilities of seafarers as GMPs. In KSA No. 25, all tier groups are expected to achieve the stated outcomes, because BoK presumes that the achievement of higher level tier outcomes presupposes the achievement of the lower level tier outcomes.

Some questions, however, remain whether: 1) higher cognitive learning outcomes are needed in Tier C and D; and 2) the current practical training for marine engineers are sufficient to green technologies in terms of the psychomotor domain of their skills. These questions are not the scope of this study, yet important to address when optimizing MET for PCCET.

Table 1. Levels of achievement in three domains for KSA#25, Adapted from IAMU (2019).

	Cognitive	Affective	Psychomotor
Tier A (Operational, BSc)	Lv. 1-3	Lv. 1-4	n/a
Tier B (Management, BSc)	Lv. 1-3	Lv. 1-5	n/a
Tier C (Management, MSc)	Lv. 1-3	Lv. 1-5	n/a
Tier D (Management, PhD)	Lv. 1-3	Lv. 1-5	n/a

5. Discussion and Conclusion

In this paper, PCCET was conceptualized in relation to MET from a social sustainability perspective by applying the theoretical concept of "just transition". The findings of this study provide insight into the linkages between just transition, sustainability performance based on TBL, and the promotion of GMPs in the MET context. A concept mapping technique was used to identify the role of MET as a social sustainability drive to promote PCCET with three relevant UN SDGs, namely, Goal 4 (quality education), Goal 13 (climate action), and Goal 8 (decent work). In PCCET, economic sustainability (green jobs) is influenced by social sustainability (education) and environmental sustainability (climate action). It highlights the importance of considering the social and environmental aspects of sustainability, in addition to economic factors, in promoting green job creation and decent work in the maritime industry.

By analyzing GMP BoK, KSA No. 25 (environmental awareness, sustainability and stewardship) was identified as the most relevant skill for the realization of PCCET. The emphasis on cognitive and affective domains for KSA No. 25 reflects the dependence of future green shipping on intellectual and emotional knowledge and abilities of seafarers, according to GMP BoK. Nevertheless, the results show that there are potentially more spaces for MET to educate and train future maritime professionals by identifying higher-level cognitive learning outcomes in Tier C and D. There is also a need for reviewing the current practical training offered in MET institutions as newer green technologies emerge.

This study explored the application of PCCET to the maritime sector with the focus on MET at a conceptual level. A reference to relevant learning outcomes was derived from GMP BoK as the most reliable source of future MET guidelines. Future research can investigate what challenges are experienced by MET institutions and empirical data can be collected and analyzed. It may promote concrete case studies using insights from behavioral science to further design behavior change policies and uphold public awareness and communication in response to the Recommendations of the Global Commission on PCCET. It is also important to understand the meaning of "people-centred" and inclusivity in the process of maritime decarbonization. For example, this presents an opportunity to address gender and diversity issues in maritime workforce to support PCCET. In addition, potential barriers to promoting GMP in MET, such as the availability of resources and the ability of educational institutions to integrate new competencies into curricula, require further in-depth research.

Overall, the study provides further research and development opportunities for the IAMU community to collaborate and contribute to PCCET as an MET intervention. Promoting GMP in MET will help the PCCET process. Social sustainability is an important domain to achieve other sustainability issues and the role of MET clearly exists if not fully explored yet.

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English as teaching language at SIMAC

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Abstract:
This paper examines how to implement more subjects instructed fully in English at SIMAC to improve and develop students' English competences. The analysis reveals that few subjects are instructed in English, and an extended use of material in English. The potential offering more subjects in English is significant and most relevant in the last semesters of studies within Maritime Engineering and Maritime Nautical Science. Also, elective subjects, international and communicational subjects are highlighted as suitable for instructions in English. Results show that students have a positive approach to English as teaching language and find their language skills adequate. Professors are less confident in English and question if they have sufficient language skills to conduct lectures fully in English.
Implementing English in more subjects demands a need for language courses, help centres, longer preparation time and a well-planned strategy. Extra resources are needed, teachers must be involved in the planning, alternatives like Danish/English mix and parallel range of subjects offered should be considered. Also, transforming classes into English needs to be supported by a special pedagogic and didactic approach to scaffolding lectures and learning activities which ensures students' activity, interaction and learning objectives. The pedagogic and didactic transformation requires special attention and possibly upgrading.
Keywords: EMI, Implementation strategies, pedagogic- and didactic preconditions, SIMAC

1: Introduction:

Svendborg International Maritime Academy (SIMAC) – is a maritime education centre which features three educational programs with approx. 900 students, 100 employees and a course department, SIMAC Training, which service approx. 800 course participants every year. SIMAC's objective is to ensure that our graduates are ready for a global world and possess intercultural competencies and master English as a working language. Therefore, this paper examines realisable ways to enhance and promote the possibilities of implementing more subjects undertaken, lectured, and instructed all in English.

The international definition used to describe and define courses and lectures all executed in English is EMI, short for English Medium Instruction, it is officially defined:

> "*English Medium Instruction (EMI) refers to the use of the English language to teach academic subjects (other than English itself) in countries where the first language of the majority of the population is not English.*" *(Oxford University, 2022)*

2: Methodology

The methodological foundation of this project relates to social science in which the need for both quantitative as well as qualitative data is recognized. Furthermore, there has been a need for collecting quantitative as well as qualitative data to fully research, answer the research question and present reliable recommendations for possible strategies of action at SIMAC.

Preliminary research and the systematic gathering of reports, surveys, and reviews of EMI in higher education has been completed via electronic databases, websites and is thus limited to findings made available electronically and of recent date. Sources of articles, reports, surveys, abstract and editorials are listed in the bibliography of this report and has formed the basis and scope of the subsequent quantitative research conducted within SIMAC, in which professors and students have responded to an on-line distributed questionnaire.

2.1: Methodological bias

This report mainly deals with the situation and conditions at SIMAC. Therefore, the analysis is assessed to be biased in this direction but the research question taken into account, the need to collect local data justified the limited scope of the questionnaires and thus the results are valid in terms of relevance to the research question. Concerning the conducted interviews among Danish educational colleges and academies there is also a bias as the respondents have been selected by choice and not randomly. It might be argued that Universities on a broader scale could have been included in the survey, however the argument for not including international universities in the maritime educational sector is that they primarily offer studies and education on a higher level and thus the focus of this report was limited to the level of that of a professional bachelor's degree. Regarding the extensive search for existing, secondary literature it is evaluated that there is very little or no bias to be considered as both national, Scandinavian and International sources, reports and surveys have been included in the outline of the foundation of EMI and the experiences from universities and academies.

3: International research and conclusion on EMI

In this section, some general conclusions about trends, implementation, challenges as well as advantages and disadvantages of EMI in primarily higher educations will be presented.

Over the recent two decades EMI has been expanding within the area of higher education. Universities have used EMI as a strategy for promoting globalization, upgrading national language proficiency and as an internationalization of education but also as means of competitive positioning to attract international researchers and students. (EMI Oxford Research Group, 2022) Hanne Tange, a Danish researcher, claims that EMI at Danish universities etc. is a result of extensive internationalization and a 'must' if researchers and scientists wish to advance and pursue an international career within the academic area (Tange, 2020). She takes a critical stand on the continued growth of EMI programs offered and thinks it's a result of an Americanization, globalization, and an academic system which favours English material and research on the cost of other languages. But at the same time, she recognizes the teaching in English at universities is a fundamental, basic term in the academic world (Tange, 2020)

In Denmark among maritime academies/colleges no full time EMI are offered (Styrelsen for Forskning og Uddannelse, 2018). At DTU a Master of Engineering is offered as full time EMI study. (Børne- og Undervisningsministeriet, u.d.) and a private organization, Danish Shipping offers a full time, all in English trainee program called 'Danish Shipping Education' for students employed in shipping companies within the maritime industry.

A report from 2013 looking into EMI on Nordic universities states that changing the teaching language into English creates multiple challenges for professors as well as students regarding language proficiency, teaching methods and activity levels. The study found a clear indication that classes and lectures took on a more formal shape which resulted in less dialogue between professors and students. Furthermore, it examined and concluded that student activity in general diminished and students tended to take a more passive stand thus the number of questions asked decreased, resulting in a lower level of incentive to enter into a discussion both on teacher/student level and student/student level (Jacob Thøgersen, 2013).

Therefore, it is especially important to focus on didactically preparing and organizing the lessons in a way which promotes student centred multi-didactic learning through discussions, group work, peer feedback etc. and keep in mind that language proficiency includes both reading, listening, and speaking (Jacob Thøgersen,2013). The findings on the didactic organization of lessons are strongly supported by a Danish study, in which teachers at Århus University participated in a program focusing on improving their pedagogic and didactic approach to teaching in English as well as their language proficiencies (Lauridsen, 2017). Following this program called 'super monitoring' Lauridsen and Lauridsen concluded that teaching in English is not just a question of teacher's language proficiency but equally important is the pedagogic and didactic organization of the lessons and therefore the focus must be on both when implementing EMI. (Lauridsen, 2017)

Securing the quality of teaching in EMI is essential to the success of EMI for both teachers and students and this conclusion is also supported by Anne Holmen, who in her book 'English Medium Instruction in Multilingual and Multicultural Universities' states that not only the level of language proficiency among teachers is important but equally important is the pedagogic and didactic level of teachers to plan lessons. Therefore, universities need to improve both teacher's language skills and pedagogic and didactic skills through well planned competence developments. (Lauridsen, 2017). In the article, 'Pedagogy in English-Medium Instruction (EMI): Some Recommendations for EMI Teachers' recommendations for how to plan and organize EMI lectures to secure a more learner-centred instruction (Denchai Prabjandee, 2022) are offered. The article suggests a 6-stage model for planning of an EMI lecture, the technique or EMI pedagogy implies the following scaffolding:Greeting – Review –Directions – Theory - Tasks – Assessment – Delivery.

This model includes also multimodal, interactional strategies as well as consideration about verbal, procedural scaffolding and classroom organization. Finally, it emphasizes the positive aspect of ending classes with reflective practices in which students are encouraged to reflect on learning objectives. (Denchai Prabjandee, 2022).

3.1: Advantages/disadvantages and challenges of EMI from international research

There is a broad consensus that implementing EMI on all levels is costly, time consuming, demands a seriously planned strategy and requires focus on pedagogic and didactic approach to execution of EMI classes otherwise it will damage content learning and students' fulfilment of learning objectives. The advantages of EMI revealed in the reports, surveys and articles are e.g: students experience a positive language proficiency and feel more comfortable in English and EMI improves international career opportunities, intercultural communication and understanding (E. Macaro, 2018) (Danmarks Evalueringsinstitut, 2010), EMI increases internationalization the exchange of international students and does not result in decreased content learning (Jacob Thøgersen, 2013),(E. Macaro, 2018), (Danmarks Evalueringsinstitut, 2010), and EMI attracts better qualified international researchers, scientists, and professors and improves the competitive position of universities in the international competition. (Danmarks Evalueringsinstitut, 2010) Concludingly, the pros and cons of implementing EMI are many and the challenges seem to outweigh the opportunities. However, there is no doubt that the growth in EMI worldwide has been and will continue to be seen as a mean and path towards enhanced internationalization in an increasingly competitive and global academic educational sector.

4: EMI at SIMAC

The internal analysis among professors at SIMAC supports the above findings and shows that at present very few subjects are conducted in English as only 10 % states that they teach 1 or 2 subjects using EMI and more than 76% states 'no EMI' at all. Nevertheless, the survey also discloses that, when you include the use of English books, material and written instructions in the curriculum, the conclusions are more complex and show that to a large extent English materials are used in the subjects. To implement more subjects in English, teachers were asked to identify suitable and relevant subjects and electives relevant for EMI, but no significant conclusions could be deducted from the answers. A marginal tendency towards electives with a communicative, theoretical, and international aspect is noted and the comments point to subjects of especially international maritime relevance being suitable as students, facing careers on increasingly internationally crewed vessels, will need communicative competencies in English to exercise their positions on board.

Looking into semesters, the analysis establishes only a marginal indication of the last semesters on the studies be more suitable, thus the evidence is weak but marginally identifies the semesters 5, 6 and 8 on the marine engineering studies plus semester 5 and 7 on shipmaster studies to most relevant. In contrast, the data shows strongly that across studies the first semesters 1-4 are not well suited for EMI.

When teachers are asked to rank what is important when screening subjects and semesters and assess if they are suitable for EMI, teachers quite clearly state that they want to be involved in the selection process and that the most important criteria for a subject suitable for EMI is its vocational, professional, international, and practical relevance and content. As mentioned earlier, maritime, and communicational subjects which the future seafarers to a large extent will need to fulfil and practice in English are thus the most logical choice. Subjects taught in English should also be examined in English to motivate and emphasise the importance of EMI. The analysis also surveyed fundamental requirements for implementing EMI and found that professors identify more preparation time, upgrading of language skills, and help to produce material in English as essential requirements to be met. In general, teachers at SIMAC feel competent and ready in especially within pedagogic/didactic areas.

The collected data uncover an insecurity in respect of securing quality and learning output in the subjects, primarily because teachers (93,4 %) judge students to be 'not at all' or 'reasonable' ready to receive lectures in English. This conflicts strongly with the views and results of the students' questionnaire as they evaluate themselves to be quite ready to receive lectures in English. Do teachers have too little confidence in the abilities of their students or do students have too high opinions about their own readiness? The data cannot answer this difference, but it remains an interesting divergence, even though teachers' comments reveal concern for students' understanding of vocational content if no explanations are offered in Danish and a concern for weak students who might find it even harder to meet the required learning objectives if lectures are in English.

Generally, students have a very positive approach to English and teaching in English. The results reveal that most subjects, according to students, could be taught in English. Subjects with a maritime, international, and shipping related content are especially appropriate, as students face working and communicating in English in their future careers at sea and in many large, international companies. Additionally, students strongly agree to statements that EMI will enhance their job opportunities, improve international focus, but the success of EMI depends on the language skills of the teachers. Interestingly, students disagree to the statements that EMI will make it harder for them to complete their studies, that EMI should be a requirement, and that English as language of instruction would influence their activity or make them ask fewer questions. Students don't see EMI as a barrier to complete their studies, nor would they deselect subjects due to classes/lectures being conducted in English. Adding to the positive approach of students, they recognize that implementing EMI and conducting classes fully in English would require e.g. up-grading of language skills, more lectures and more time for preparation, homework, and resources allocated into a help-centre, where students could receive help and assistance in relation to language, assignments in English.

Concludingly, the overall findings regarding students' opinions of EMI are positive, they have a positive approach and see more pros than cons, but at the same time they recognize the need for language up-grading, help centre facilities and emphasize that success depends on teachers' language proficiency and ability to convey the content as well in English as in Danish. Thus, the success of EMI depends on these central parameters; namely a well-planned process of selection and implementation.

5: Recommendations for how to implement EMI at SIMAC

The experiences collected among other colleges and academies show that like SIMAC few subjects are offered in English but those actually offered are popular among students and appeal to students' wish for an international perspective. These experiences are used in the development of 3 strategies for implementation of EMI at SIMAC.

The first strategy suggests **selection of one or more semesters where all subjects are offered in English**. The decision and selection of semesters should be taken in collaboration between the teachers involved in the semesters, management and it is essential that the involved teachers are included in both the selection, planning and implementation to secure alignment, motivation, commitment, and success. This scenario might not appeal to a lot of international students as it might be difficult for international students to incorporate a whole semester in their own individual educational plan.

The second strategy comprises a **more limited selection individual subjects and electives which are suitable for teaching in English because of the international, vocational, communicative, and professional relevance.** These subjects and electives should be offered continuously and permanently in English by teachers who have volunteered and committed themselves to conducting the subjects and electives in English thus gaining confidence and experience in teaching these subjects using EMI. This scenario might offer a broader appeal to international students who might possibly find it easier to include single subjects into their educational plans and thus be attracted to apply for a stay at SIMAC

A **third strategy** proposes offering **parallel studies, subjects and the selected semesters in both English and Danish**. This includes double up on classes, lectures, teachers and physical facilities. However, it would leave the students with a broader choice and appeal to students who are less confident to receive classes in English. This alternative requires a stronger and more extensive investment into the implementation. However, this option has been suggested by several teachers as a good way of introducing and incorporating EMI at SIMAC

6: Conclusion

Regardless of choice of strategy, the decision must include economic investments; money allocated into e.g., more preparation time for the teachers involved, more lectures allocated to the subjects on the chosen semesters, resources for language courses, pedagogic and didactic up-grading, help center and support functions for both teachers and students. Otherwise, the prospects of lack of success will be too high. Thus, the above-mentioned strategies must contain plans and resources for the mentioned preparations and functions for both teachers and students as well as evaluation and follow up programs to continuously investigate the need for adjustments. International and national research show that transforming classes into EMI needs to be supported by an EMI pedagogic and didactic approach to scaffolding lectures and learning activities which will ensure students' activity, interaction and securing learning objectives. EMI pedagogic and didactic approaches require a special attention from teachers and possibly upgrading. The success of EMI depends not solely on language skills but as much on initiating the adequate teaching forms and lay-out of classes which facilitates the use of English as means of instruction.

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The Impact of Master's Degree Programmes in Logistics on Career Development and Professional Performance

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Abstract: Master's degree programmes in logistics are crucial for undergraduates' career development because they provide valuable skills, knowledge and experience. The objective of this study is to analyse and evaluate the effectiveness of master's degree programmes in logistics by focusing on their correspondence to the requirements of business and their impact on the career development and professional performance of graduates. Seven variables are discussed and analysed: the effectiveness of the programme with respect to career development, the programme's contribution as a factor for employment, the impact of the skills and knowledge obtained on salary, the sufficiency of the practical experience of the programme, the programme's relevance to business, satisfaction with the existing programme and the intensity of the programme updating. The research methodology includes a survey of recent graduates of master's degree programmes in logistics from Nikola Vaptsarov Naval Academy in Bulgaria as well as interviews with industry experts and employers hiring logistics specialists. The results of the factor analysis show a strong positive relationship between most variables, especially between the intensity of the programme updating and the practical orientation of the programme for the career results of graduates.

Keywords: logistics, master's degree programmes, career development, professional performance

1. Introduction

Logistics is a field of crucial importance and a critical component in the management of the multilayered supply chain, which deals with the effective transportation, storage and distribution of goods and services. Several studies have concluded that the increasing growth of global trade has also led to the continued growth of demand for specialists in the field of logistics (Chawla et al. 2023; McKinnon 2021; World Trade Organization 2023). Studying logistics as part of master's degree programmes is important for two primary reasons. First, master's degree programmes provide deeper insight into logistics systems and help students develop their critical thinking and analytical skills for the management of processes that could be beneficial for logistics companies. Second, these programmes can help students develop specialised skills and knowledge in fields such as transport management, stock control and supply chain optimisation (Mentzer et al. 2007). There are two conditions that are of critical importance for realising the potential of master's degree programmes in logistics: they should be linked to practice, and they should be flexible. Practical experience in the form of internships and consultancy projects helps students pursuing a master's degree face real challenges while acquiring essential skills and developing their own professional networks and career paths.

Logistics systems are constantly evolving and changing, and the changes are complex and nonlinear (Bakalov et al. 2018; Dimitrakieva et al. 2022; Gligor and Holcomb 2014; Ivanov and Dolgui 2020; Pettit et al. 2019; Stoyanova and Stavreva 2022). These dynamic changes in the sector and their long-term unpredictability hinder educational institutions from being proactive and anticipating changes by adapting to them in a timely manner and following them by taking the initiative and preparing even before the changes emerge (Nurhas et al. 2022; Pauliková and Chovancová 2022). Due to the conservative nature of university education, however, its basis in the "bachelor's degree – master's degree – work until retirement" model lags dramatically behind the changes, and the distance between these changes and their reflection in teaching programmes is increasing. In higher education, a period of two years is necessary to start a programme, and a period of between two and four years is needed to introduce a programme. For these reasons, the programmes feature beliefs, understandings, resources and technologies that are already outdated from their introduction. The solution to this problem is to make education in logistics flexible by offering possibilities for continuous upgrading of the content and by allowing graduates to seek professional realisation with skills, knowledge and experience that are adequate for market changes.

Previous research papers have studied the impact of master's degree programmes in logistics on career development and professional performance (Cameron et al. 2013; Baker et al. 2023; Pacher et al. 2022). A study performed by Cebeci et al. (2015) concluded that graduates of master's degree programmes in logistics have higher salaries and higher employment satisfaction than those who do not hold a master's degree. The study also found that master's degree programme graduates are more likely to take senior positions in their organisations. Schoenherr (2022) study examined the impact of knowledge of the supply chain on the career performance of students. The study concluded that master's degree programme graduates are more likely to find a job and more likely to take positions involving greater responsibility and higher salaries. Based on a comparative study of higher education graduates in 13 countries, Støren and Aamodt studied the relationship between the quality of higher education and fitness for employment. The study concluded that the characteristics of the curriculum have a significant impact on graduates' fitness for employment, whereas quality indicators have a minor impact on getting a job but a significant impact on performance at work (Støren and Aamodt 2010). Perez-Encinas and Berbegal-Mirabent (2023) studied the factors that predetermine the time needed by master's programme graduates to find a job by focusing on three dimensions – acquiring competence, teaching methods and the characteristics of the programme.

Much scientific research suggests that master's degree programmes in logistics have a positive impact on career development and professional performance. However, there is still a need for additional research and study of the specific skills and knowledge acquired by logistics master's programme graduates in the Bulgarian educational system and how these skills translate into a successful career.

This study aims to analyse and evaluate the effectiveness of master's degree programmes in logistics by focusing on their correspondence to the requirements of business and their impact on the career development and professional performance of graduates. The objective of the study is to answer questions related to students' preparation for entering the work force and the value placed on their education by employers from the logistics industry.

2. Methods

The research methodology included a survey of the ideas and attitudes of different logistics managers and experts about the effectiveness of master's degree programmes in logistics. The analysed data were collected by questionnaires distributed among recent graduates of master's degree programmes in logistics from Nikola Vaptsarov Naval Academy in Bulgaria as well as industry experts and employers hiring logistics specialists. The questionnaire on which the study was based is shown in Table 1.

Table 1. Questionnaire of the study

Based on the scale from 1 to 5, please provide responses to the following questions	
Q1- In your opinion, how effective would the curriculum be for preparing students for career development in the field of logistics? (1 = not effective at all, 5 = extremely effective)	1☐ 2☐ 3☐ 4☐ 5☐
Q2 - In your opinion, what is the contribution of the education received as a factor for employment and the potential for income from the working salary? (1 = not a factor at all, 5 = main factor)	1☐ 2☐ 3☐ 4☐ 5☐
Q3 - How useful do you think the skills and knowledge students acquire through education are as a potential for success in the logistics business? (1 = not useful at all, 5 = extremely useful)	1☐ 2☐ 3☐ 4☐ 5☐
Q4 - How much practical experience do students obtain as part of their logistics education? (1 = very little, 5 = quite a lot)	1☐ 2☐ 3☐ 4☐ 5☐
Q5 - In your opinion, how relevant is the curriculum to the current needs of the logistics industry? (1 = not relevant at all, 5 = extremely relevant)	1☐ 2☐ 3☐ 4☐ 5☐
Q6 - How satisfied are you with the logistics higher education programme you graduated from? (1 = very dissatisfied, 5 = very satisfied)	1☐ 2☐ 3☐ 4☐ 5☐
Q7 - In your opinion, how intensively should higher education programmes in the field of logistics be updated to prepare students for their career development? (1 = they should not be intensively changed – once every 8 years, 5 = extremely intensively – at least once every 2 years)	1☐ 2☐ 3☐ 4☐ 5☐

The survey contained seven questions with 5 possible answers each based on a Likert scale. The questions concerned problems identified from a preliminary discussion with experts in the field. After the questionnaire was completed, a discussion was held with the participants in focus groups. Fifty-nine potential participants in the survey were contacted via telephone, and information about the objectives and the methodology of the survey was provided. Preliminary confirmation of agreement was obtained from all participants. The final number of participants in the survey who completed the questionnaire was 50, which was 85% of the total number (59) of participants who completed the survey. Some of the survey participants participated in the focus groups but refused to complete the questionnaire (9 participants). The data collected from the completed responses to the questionnaire were divided into a sample of recent master's programme graduates who took managerial positions in logistics companies before starting their studies (from 1 to 22) and logistics experts (from 23 to 50).

The results from the survey were analysed using the statistics software XLSTAT (Lumivero 2023) with the application of factor analysis. The different aspects of the programme with respect to career development were 7 variables: V1 - effectiveness of the programme with respect to career development, V2 - contribution of the programme as a factor for employment, V3 - impact of the skills and knowledge obtained on salary, V4 - sufficiency of practical experience in the programme, V5 – the programme's relevance to business, V6 - satisfaction with the existing programme, V7 - intensity of the programme updating. The factors constituted several independent measurements that summarised the information obtained from the variables. There were two factors in the data provided: F1 and F2. They were derived by using the primary component analysis (PCA) approach and showed the correlations between the variables and the factors. This method allowed us to identify the models and relationships in a set of factors that predetermined the result from the variable impact by using statistical analysis. In the course of the study, the current curricula of courses in logistics, career paths available to graduates and the impact of the quality of education on success in this field were also analysed.

3. Results

The objective of the master's degree programmes in logistics is to develop the potential of students by providing them with the necessary knowledge and skills to be successful in their future career development. The data collected by filling out the questionnaires are presented in Table 2, which contains the main statistical indicators, such as the minimum and maximum value, the mean value and the standard deviation, for seven variables related to the programme.

Table 2. Summary statistics

Variables	Minimum	Maximum	Mean	Std. deviation
V1 (Effectiveness of the programme with respect to career)	3	5	4.76	0.625
V2 (Contribution of the programme as a factor for employment)	2	5	3.56	1.013
V3 Impact of the skills and knowledge obtained on salary)	3	5	3.96	0.903
V4 (Sufficiency of practical experience in the programme)	3	5	3.80	0.857
V5 (Programme's relevance to the business)	3	5	4.36	0.525
V6 (Satisfaction with the existing programme)	2	5	4.22	0.887
V7 (Intensity of the programme updating)	2	5	4.38	0.945

Table 3 presents a correlation matrix (Pearson (n)) between the seven variables (V1-V7) used in the study of the effectiveness of master's degree programmes in logistics, with indicated Pearson correlation coefficients between them and the values different from 0 with a significance level of alpha = 0.05.

Table 3. Correlation matrix (Pearson (n))

Variable	V1	V2	V3	V4	V5	V6	V7
V1	1	0.539	0.417	-0.130	0.331	0.760	0.849
V2	0.539	1	0.873	0.742	0.879	0.836	0.689
V3	0.417	0.873	1	0.675	0.892	0.699	0.712
V4	-0.130	0.742	0.675	1	0.752	0.435	0.196
V5	0.331	0.879	0.892	0.752	1	0.615	0.541
V6	0.760	0.836	0.699	0.435	0.615	1	0.847
V7	0.849	0.689	0.712	0.196	0.541	0.847	1

Based on the correlation matrix, we can conclude that there are significant positive correlations between several variables. It is clear, for example, that the effectiveness of the programme with respect to career development is positively correlated with satisfaction with the existing programme (**r = 0.760**) and the intensity of programme updating (**r = 0.849**). Based on the same reasoning, the contribution of the programme as a factor for employment is positively correlated with the programme's relevance to business (r = 0.879) and satisfaction with the existing programme (**r = 0.836**). Furthermore, the influence of teaching skills and knowledge on salary is positively correlated with the programme's relevance to business (**r = 0.892**) and satisfaction with the existing programme (**r = 0.699**). The results obtained from the analysis also confirm the negative correlation between the adequacy of practical experience in the programme and the effectiveness of the programme with respect to career development (**r = -0.130**). The presence of correlation does not mean that there is a causal relationship; therefore, it is necessary to perform additional analysis and build a reproduced correlation matrix to determine the causal relationship and the direction of these relationships. The ***reproduced correlation matrix*** shows a somewhat different correlation coefficient compared to the original ***correlation matrix (Pearson (n)) presented in Table 4.***

Table 4. Reproduced correlation matrix.

Variable	V1	V2	V3	V4	V5	V6	V7
V1	0.996	0.521	0.446	-0.127	0.316	0.762	0.853
V2	0.521	0.972	0.891	0.739	0.875	0.819	0.725
V3	0.446	0.891	0.818	0.701	0.809	0.737	0.645
V4	-0.127	0.739	0.701	0.945	0.777	0.387	0.213
V5	0.316	0.875	0.809	0.777	0.820	0.669	0.554
V6	0.762	0.819	0.737	0.387	0.669	0.836	0.820
V7	0.853	0.725	0.645	0.213	0.554	0.820	0.841

Based on the analysis of the data in the reproduced correlation matrix, we can conclude that there are significant positive correlations between several factors. The effectiveness of the programme with respect to career development has a strong positive correlation with satisfaction with the existing programme (r = 0.762) and the intensity of programme updating (r = 0.853). Based on the same reasoning, the contribution of the programme as a factor for employment has a strong positive correlation with the programme's relevance to business (r = 0.875) and satisfaction with the existing programme (r = 0.819). On the other hand, there is a negative correlation between the adequacy of practical experience in the programme and the effectiveness of the programme with respect to career development (r = -0.127).

In the course of the study, the goodness of fit test was performed to check whether two common factors were sufficient and adequate to make a conclusion about and explain the main trends and correlations between the variables in the data and to explain whether additional factors were necessary to obtain a more precise illustration of the situation. The goodness of fit test showed that the model used for deriving the factors was statistically significant. The value of the chi-square (observed value) was 90.275, and the critical value of the chi-square (critical value) was 15.507. The test had 8 degrees of freedom, and the p value was lower than 0.0001, which shows that there is a statistically significant relationship between the variables within the model. The null hypothesis (H0) states that two common factors are sufficient, whereas the alternative hypothesis (Ha) assumes that more factors are necessary. The results show that the calculated p value (< 0.0001) is lower than the significance level of alpha = 0.05 (alpha = 0.05), which means that we should reject H0 and accept Ha; more factors are necessary for a more precise description of the dataset. The analysis of the main components of the factor analysis is presented in Figure 1.

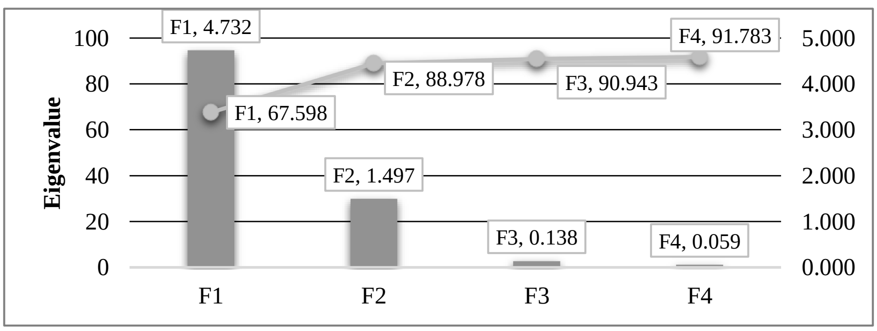

Figure 1. Factor analysis.

The percentage of variance is the percentage of total variance in the data explained by each factor. In this case, F1 explains 67.598% of the total variance, F2 explains 21.380%, and F3 and F4 explain only 1.965% and 0.840%, respectively. The cumulative percentage is the cumulative amount of variance in the data explained by each factor. In this case, F1 and F2 combined explain 88.978% of the total variance, whereas F1 through F4 combined explain 91.783% of the total variance. As a whole, the results show that the first two factors (F1 and F2) are the most important and represent the larger amount of variance in the data, whereas the third and fourth factors (F3 and F4) only explain a small part of the variance.

The analysis of the results from the survey of recent graduates of master's degree programmes in logistics confirms that the majority of them believe that education in Nikola Vaptsarov Naval Academy has prepared them adequately for the rapid changes in the environment and the requirements of logistics operators. The results from the survey show a strong relationship between the intensity of programme updating and the practical orientation of the programme for the career results of the graduates. It was concluded that employers value and prioritise hiring university graduates who have not only in-depth knowledge but also practical experience and specific skills for solving problems related to the latest management methods in logistics. This means that master's degree programmes need to be reviewed and updated in a timely manner with a higher frequency so that future logistics experts can more successfully realise the rapidly changing business environment. The survey shows that providing students with more opportunities for practical experience and application in the real world of the theories learned during their studies is of crucial importance for their rapid career growth.

The results from the interviews with experts from the industry and employers in the field of logistics supported the results from the survey. Many of them emphasised the importance of practical experience and acquiring problem-solving skills that are adequate to the changing context in preparing students for a career in logistics. These experts also stressed the need for closer cooperation between the academic field and logistics companies to guarantee that the master's degree programmes will be relevant and effective when preparing students to enter the work force. Moreover, the experts stated that the logistics business should be the actual initiator for increasing the qualification of their employees through master's degree programmes. Their concerns were primarily related to the fact that employees who have already been hired and who graduated at an earlier stage are not sufficiently prepared for changes; they need to continuously update and upgrade their knowledge to be competitive in the context of the changing market conditions and development of logistics. The timely updating of master's degree programmes can be a factor in acquiring new knowledge and skills even by hired employees who have already finished their studies and can contribute to their career development and higher salaries in the labour market.

4. Conclusion

This study analysed the impact of master's degree programmes in logistics on the career development of graduates. Based on the summarised results of the study, it can be concluded that these programmes are effective in preparing students for a career in the respective industry. Nevertheless, there is still room for improvement of these programmes by putting effort into the timely updating of the curricula to guarantee that they will correspond to the challenges of the rapidly changing business environment. One of the key recommendations of the study is the significance of practical experience and the application of modern methods and theories in the real economy, not only for recent graduates but also for logistics experts who have already been hired and practice the profession. Therefore, it is important for universities to focus on ensuring the updating of master's degree programmes to attract students without such a degree and without practical experience as well as students who already work as logistics experts so that they do not fall out of the labour market. This can be achieved by maintaining updated curricula that focus more closely on modern industry trends and by encouraging the practical application of theories in real-life situations.

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Techniques of Shortening in Maritime English

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Abstract: This study aims to offer a classification of shortened terms and terminological phrases in Maritime English using the lexico-semantic method. It is based on examples excerpted from learning materials designed for cadets and students of Navigation at Varna Naval Academy, all of them compiled in the Learner's English-Bulgarian Maritime Dictionary and forming a large corpus representative of the domain they are used in. Shortening here is chosen as an umbrella term for initialisms, acronyms, clippings and blends. The topic is worth discussing because it reveals techniques of shortening in maritime English thereby raising learners' awareness to a variety of English they are going to face in their future work in a multinational environment.

Keywords: shortening, classification, clipping, blending, abbreviation

1. Theoretical Background

Shortening of terms and terminological phrases as a pattern of term formation has been an object of research of many scholars but the process itself is referred to in different ways by them. The typology offered of short forms also differs to some extent. The purpose of this paper is to offer a classification of shortened terms and terminological phrases in Maritime English (ME) using the lexico-semantic method. The examples discussed are excerpted from learning materials designed for cadets and students of Navigation at Varna Naval Academy, all of them compiled in the Learner's English-Bulgarian Maritime Dictionary (Velikova, Toncheva, 2009) The corpus itself consists of 5370 instances and is therefore authentic and representative of the domain they are used in. The study also focuses on the techniques compressed terms are formed by which will raise learners' awareness to a variety of English they are going to face in their future work in a multinational environment.

It should be noted that the tendency towards shortening and abbreviation is a process characteristic of language as a whole. However, it largely pervades special languages and ME terminology in particular, as well. Shortened forms ensure communication not only through economy of effort but also by condensing information and enhancing the information value of certain linguistic units. Besides, they represent a special category of synonym which assumes a particular importance in special languages (Sager 1990).

There are several factors to be considered when discussing abbreviations and shortenings. Their emergence has been boosted by the large number of multi-word terms. According to Brunt it is the length of names (and terms) and the principle of linguistic economy that has made the use of abbreviations essential both in theory and practice (Brunt, 1999). Moreover, it is through compression in vocabulary that economy in texts is mainly achieved (Sager, 1990). In ME, however, abbreviations are abundant also for economy of time, especially in written communication. For example, in telegram and telex writing there are no clear-cut rules but any short words may be left out – articles or prepositions, while the rest may be blended, altered, abbreviated, which in combination with other abbreviated forms, makes the texts produced unintelligible for landlubbers. Traces of this can still be noticed in today's exchange of information.

Overall, linguists use various hypernyms to group 'initialisms', 'acronyms', 'clippings' and 'blends' together. Danilenko calls the "structure for naming one and the same concept with the same meaning but shortened by means of definite linguistic processes" lexical shortening (Danilenko, 1977). Sager regards them as a form of compression (Sager, 1990). According to Quirk et al. the proper term for shortening of words is abbreviation which is involved in English word-formation through acronymy, clipping and blending (Quirk et al, 1985). McArthur uses the same term to describe what he calls the fastest growing language in the world (McArthur, 1988). Bulgarian linguists have also adopted it to describe "the formation of new words by combining initial sounds or letters or shortened parts of complex phrases" (Simeonova, 2016). I will use the umbrella term 'shortening' for initialisms, acronyms, clippings and blends in this study in order to distinguish it from the large group of abbreviations in the corpus. I will also leave univerbization aside as a subtype of shortening.

2. Techniques of Shortening Used in Maritime English

2.1 Shortening Resulting from Clipping

Clipping is defined as "the reduction of a word to one of its parts" by Marchand (1969). According to Sager (1990) it is a frequent and highly productive method in which syllables or letters are omitted from any part of the word. Fandrych holds that clippings move to different registers or styles as compared to their long equivalents (Fandrych, 2008). This is why most scholars claim that clipped forms are more often met in professional slang than in regular terms. The process occurs after dropping the initial, medial or final part of a word. For example, initial clipping is observed in *copter* < *helicopter; plane* < *airplane* and final clipping – in *gas* < *gasoline; prop* < *prope*ller. Medial clipping is rare as in *fo'c'sle* < *forecastle* and *bosun* < *boatswain*.

The corpus records two classes of clipped forms in terminological phrases as well. The former refers to clipping the final part and preserving and combining the initial parts of the words, e.g. *MAREP < Mariner Reporting System; SATCOM < satellite communications; COLREG < Collision Regulations*, etc. In the latter only one of the words is clipped and the other is preserved, e.g. *NAVAIDS < Navigational Aids; NAVAREA < Navigational Area or Fog Det < Fog Detector Light* where the third component is omitted. However, these are borderline cases and can also serve for illustrating patterns of blending.

2.2 Shortening Resulting from Blending

Together with other forms of compression blending has been pervasive in the English language of the late 20th and early 21st centuries and imparts colour not only to specialized but also to general English.

Plag describes blends as "words that combine two (rarely three or more) words into one, deleting material from one or both of the source words." (Plag, 2003). Consequently blending involves the shortening of two words and then compounding them. Fandrych emphasizes that "blends derive their meanings from the two underlying words from the parts of which they were formed, but, unlike compounds, they show an additional semantic component", therefore very often they are "consciously composed" (Fandrych, 2008).

In order to describe the findings in the corpus we are going to apply the blending rule formulated by Plag (2003) with A, B, C and D, referring to the respective parts of the elements involved. According to it we can identify the following classes of blends in ME terminology:

1. AB + CD → AC – *information request → INREQ; hazardous material → hazmat; casualty evacuation → casevac*

2. AB + CD → AD – *transmitter + receiver → transceiver; boom + hoist → boost; floating hotel → floatel; collapsible container → coltainer*

3. AB + CD → ACD – *merchant ship → mership; radar dome → radome; discharging port → disport*

4. AB + CD → ABC – *self-discharging → selfd; ship position reporting system → shippos*

5. AB + CD → ABD – *bulk container → bulktainer, tank container → tanktainer; sea airplane → seaplane.*

There are two other classes based on three elements such as

6. AB + CD + EF → ACE – *International Maritime Satellite Organization → INMARSAT*

7. AB + CD + EF → AF – *radar transponder beacon → racon*

where at least one of the elements is omitted. Minor spelling, phonetic, morphological, or grammar changes may also be observed in all examples pointed in this study as well as complete deletion of one of the components.

2.3. Shortening Resulting from Abbreviation

Scholars treat abbreviations in two different ways – either as a technique of word-formation, or as "a special category of synonym which assumes a particular importance in special languages" (Sager, 1990). They are similar in nature to blends, because both blends and abbreviations are amalgamations of parts of different words (Plag, 2002). They are numerous in ME and extensively used in practice. Besides, the classifications offered also differ depending on the principle selected.

Starting with the standard ISO 704: 2009, which establishes the basic principles and methods for preparing and compiling terminologies, it points out four basic types of abbreviated forms: clipped terms, abbreviations, initialisms and acronyms (ISO 704, 2009). Medina (2004) distinguishes four main types of abbreviations from a morphological point of view: simple abbreviations, clipped words, blends and complex abbreviations. Simple abbreviations are those formed by taking just the initial or any other letter from a group of words, e.g. *ARCC – Aeronautical Rescue Coordination Centre, ASD – Admiralty Sailing Directions*, etc. Complex abbreviations combine two or more simple abbreviations through several typographic symbols, such as a hyphen, slash, etc., e.g. *B/H – Bill of Health, Bo-Ro – Bulk, Oil and Ro-Ro Carrier, c.i.f. & e. – cost, insurance, freight & exchange*. However, this classification leaves individual terms and their short forms aside.

Plag groups abbreviations depending on orthographic and phonological properties (Plag, 2002). They can be either spelled in capital or in small letters, and they can be either pronounced by naming each individual letter (so-called initialisms), e.g. *CMG – Course Made Good, FSC – Flag State Control*, etc., or by applying regular reading rules (so-called acronyms), for instance *DOC – Document of Compliance, SHEX – Sundays and Holidays Excluded*, etc.

McArthur builds his classification on pronounceability (1988) distinguishing between initialisms, acronyms and clipped forms. Further on, he makes a distinction between unpronounceable and semi-pronounceable types of initialisms. Compare for example *ETD – Estimated Time of Departure [i: ti: di:]* to *DTG – Date Time Group [di: ti: dʒi:]*. Acronyms are grouped into pronounceable, mimicking a word and intentional homonyms as in *SOPEP [sopep] – Shipboard Oil Pollution Emergency Plan, FAST – Fleet Anti-Terrorist Security Team [fa:st}* and *NAIADES [naɪə'diːz] – Navigation and Inland Waterway Action and Development in Europe.* The latter example is probably named after the Naiads – river nymphs in Greek mythology. *NAVTEX – Navigational Telex* can serve as an example of a syllabic acronym.

Although this classification highlights pronunciation which is an essential feature of abbreviations, the distinctions it makes are somewhat fuzzy and it does not include types of abbreviations which are common in ME terminology. The same holds true for the two classifications discussed previously.

I am going to apply a classification based on the corpus which outlines a number of subclasses depending on the techniques of shortening as well as the areas where they are used.

3. Classification of Shortened Forms based on Techniques Used

1. **Initialisms** have already been discussed here. In them only the initial letters of words, or sometimes initial syllables, are "put together and used as words" (Adams, 1973). There are two types of initialisms: acronyms and alphabetisms. Those pronounced as single words are referred to as acronyms, e.g. *LO/LO - Lift-on/Lift-off, EPIRB – Emergency Position Indicating Radio Beacon, ECDIS – Electronic Chart Display and Information System,* etc. Alphabetisms are always pronounced letter by letter, e.g. *DBEATS - Dispatch Payable Both Ends on All Time Saved, ATT – Admiralty Time Tables, BBB – Before Breaking Bulk.* Sometimes a word may be left out but the choice which one it should be is arbitrary, e.g. *STCW – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.*

2. Another group of abbreviated multi-word terms is a **combination of numbers and letters**, e.g. *A1A – Continuous Wave Telegraphy, Morse Code, R3E – Telephony Using Amplitude Modulation: Single Sideband, Reduced Carrier, H+24 – Continuous*, etc.

3. **Single words** may be abbreviated in a number of ways:

a. by leaving vowels out most frequently met in a written form – *cgo – cargo, frt – freight, hdlg – handling, scty – security*, etc.

b. if the initial letter is a vowel, it is included in the short form – *enqry – enquiry, abdnt – abandonment,* *acct – account, obstn – obstruction*, etc.

c. by keeping the first syllable in the word – *road – roadstead, aero – aeronautical, al – algae, alt – altitude,* etc.

d. by keeping the first syllable or part of it and the last letter – *recvd – received, bgd – bagged, shpg – shipping, mld – molded*, etc.

e. by keeping the prefix intact – *unco – uncovers, unexam – unexamined, redely – redelivery; irresp – irrespectiv*e, etc.

This type of shortening does not have its own distinctive pronunciation but is either spelled with capital letters or with lower-case letters. In Bulgarian this process is uncommon – if it occurs, it is occasional and probably a result of previous understanding between users.

A good point to consider is that there may be two or more abbreviations of a term, for instance *vsl, ves, V – vessel, sta, stn – station, pos, psn, posn – position, P & I, PANDI - Protection and Indemnity Club*. Besides, homonymy is pervasive with abbreviations, Thus *ltr* may be interpreted as either a *letter* or *litres*, *OT* may mean *overtime* or *on truck*. Actually sometimes an abbreviation may give rise to various readings, e.g. *m* may stand for *1.medium, 2.metres, 3.minute, 4.mass, 5.midship, 6.month.*

4. **Hybrid abbreviations** which combine two or more ways of shortening may also be considered here. They are usually combinations of abbreviated and blended elements as in *Search and Rescue Satellite Tracking – SARSAT.* The opposite process may also be observed as in *LORAN – Long Range Navigation* where the first elements are clipped while the last one is abbreviated as an initialism. In *INTERTANCO – International Association of Independent Tanker Owners* only three of the terms are subject to shortening, the first and the last but one are clipped, while the last one is reduced to an initial, the other two elements being left out. *BO-RO –- Bulk, Oil and Roll-on/Roll off* is a combination of the two techniques again – abbreviation and a clipped form of another acronym. *DAMFORDET – Damages for Detention* on the other hand is a kind of abbreviation not quite condensed where the first and the last component are clipped but the preposition is kept in full. *SeaBee – Sea Barge Carrying Ship* seems not to belong to any of the classes described above because there is only one element abbreviated to an initial, the last two are omitted resulting in an easy to pronounce word.

4. Classification of Shortened Forms Based on Area of Application

From a thematic point of view abbreviations used in ME belong to different spheres:

a. Electronic communications where the so-called e-abbrev or netcronyms belong (McArthur, 2000)

b. Documentation fulfilment

c. Operations records

d. Graphical representation of routes, passage plans, etc.

e. Legal and contractual matters

f. International commerce

g. Insurance, etc.

Among these here are some of the most typical ones:

1. **Abbreviations and symbols in charts** are usually found in a written form and indicate specific seabed characteristics, dangers to navigation, lights, marks whether on land, at sea or in the air, aids to navigation and so on. Besides, they are displayed on all navigation equipment and systems on board and must be consistent and uniform in accordance with the Admiralty Nautical Publication 5011 – *rk – rock, so – soft, sf – stiff, sh – shell, sh – shoal, si – silt, Mon – Monument, Obs – Obstruction*, etc. (Velikova, 2018).

2. **Technical abbreviations** as units of measurement as well as mathematical symbols also fit in here – *kt - knot(s), nm - nautical miles, fm - fathom, mb – milibar, deg - degree*, etc.

3. **Abbreviations in contracts, shipping documents, certificates and cargo and package types** abound in the ME domain. INCOterms as well as chartering terms belong to this group, too, e.g. *CFR – COST AND FREIGHT, EXW – EX WORKS, B.N. – Booking Note, B/L – Bill of Lading, tcs – tierces, Bar – Barrel,*

ISGOTT – International Safety Guide for Oil Tankers and Terminals, etc. In fact, all shipping documents, conventions and codes tend to have a full and short name form.

The examples given so far prove that the spelling of abbreviations differs: either with capital letters or with small letters, or a combination of both – *EmS – Emergency Schedule*, with superscripted or subscripted symbols - Rem^{ble} *– remarkable;* C_w *– Coefficient of the Waterplane Area,* with or without dots, the trend being not to use them any more.

5. Teaching and Practicing Shortened Forms

It is our duty to make English abbreviations part of our ESP syllabus wherever they logically fit. They shouldn't be connected with the students' level but rather be introduced step by step within the topics taught. Practice has shown that it is better to explain the mechanisms of getting a full form short rather than leave abbreviated forms obscure and unclear. It is obvious that students are already aware of the phenomenon because of their extensive use of electronic communications, so they should be encouraged to guess how words are compressed and why not create their own abbreviations.

Suitable activities in this respect may involve matching, differentiating, choosing a correct answer, combining full and short forms, even expanding the meaning of abbreviated terms or phrases.

6. Conclusions

"Abbrevomania or initialese" as described by McArthur in the end of the 20^{th} century is truly the fastest growing language in the world. This study has explored types of shortening as an umbrella term for initialisms, acronyms, clippings, and blends with a large number of examples. It has proved that all of them are extensively used and not only in a written form. They have moved into the ME domain from different subject fields and are indicative of different communicative situations and genres.

In spite of the trend towards shortened forms very few English abbreviations have an accepted standardized abbreviation in Bulgarian. Usually the majority has an accepted translation equivalent and the abbreviation is either the English one or there is no abbreviated form at all. Since some of the above are still unspecified or non-standardized, the English abbreviation is preferred instead of creating a Bulgarian one.

Last but not least, it is essential for our students to know the techniques of shortening in maritime English because this will familiarize them with a variety of English they are going to cope with in their future work on board ship. It is even more critical for them to know and choose the correct forms – whether full or short, according to the type of communication they are going to be involved in.

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Introducing Maritime Educational Standard for Mitigation of Infectious Diseases Spread on Large Passenger Ships

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Abstract: Infectious diseases on large passenger ships can easily be spread if effective measures for detection and control are not in place. The COVID-19 pandemic revealed the inability of existing policies and protocols of large passenger ships to effectively detect and respond to emerging diseases other than gastrointestinal illness. An integrated approach addressing prevention, mitigation and management (PMM) of infectious diseases is, therefore, essential. One segment in that approach is developing education programs addressing these PMM tasks and aimed at future seafarers, i.e. students of maritime universities. However, to be able to develop such programs, a common educational standard is needed first. This paper presents an effort to introduce educational standard for mitigation of infectious diseases spread on large passenger ships. To establish such standard, a literature review was performed on large passenger ship epidemiology along with an assessment of current medical educational standard for future seafarers. Gaps are detected and, based on this, mandatory knowledge and skills identified with a clear list of learning goals and outcomes.

Keywords: large passenger ships; cruise industry; infectious diseases; educational standard

1. Introduction

The Covid-19 pandemic has had a significant and unprecedented impact on the global cruising industry. Industry has suffered huge financial losses due to the suspension of operations, cancellations of sailings, and the need for refunds (Schabbing 2022). Cruise lines have also faced numerous challenges, including outbreaks onboard ships, changing regulations, and reduced demand for travel. Several high-profile outbreaks on cruise ships resulted in the quarantine of passengers and crew and negative media coverage, further damaging the industry's reputation (Willebrand et al. 2022; Chen et al. 2022). The need to implement new health and safety protocols, such as increased cleaning and disinfecting measures and social distancing, has also added to the costs for cruise lines. With the global easing of travel restrictions, cruise lines have gradually resumed operations. However, it is expected that the industry will take time to fully recover from the Covid-19 crisis (Pan et al. 2021).

According to scientific literature (Wu and Li 2022; Camarero Orive et al. 2022), there are certain measures that cruise industry can take to prevent, mitigate and manage (PMM) infectious diseases. Prevention measures include screening passengers and crew for symptoms of infectious diseases, implementing strict hygiene and cleaning protocols, providing hand sanitizer stations throughout the ship, and requiring vaccination for passengers and crew. Mitigation measures include early detection of infections through onboard testing, contact tracing, isolation of infected individuals, and providing medical care onboard or in port. Cruise lines should also have contingency plans to manage outbreaks, including protocols for disembarking and repatriating affected individuals and their close contacts. Management measures include regular communication with passengers and crew regarding the status of the outbreak, providing clear and accurate information on the measures being taken to manage the situation, and ensuring that all necessary resources are available for the medical staff to contain the outbreak (Sharples et al. 2022).

Cruise ship staff that is designated to conduct PMM measures on board, needs to be trained for such activities (Smith Johnson et al. 2022). Currently, seafarers adhere to The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), which sets out mandatory minimum requirements for medical first aid and medical care on board ships, setting up standards of competence for seafarers designated to provide medical first aid on board ship and for seafarers designated to take charge of medical care on board ship (Chodnik et al. 2013). According to the STCW convention, seafarers designated to take charge of medical care on board ships must meet specific competency requirements in providing medical care to the sick and injured while they remain on board. As far as infectious diseases are concerned, they need to have a general understanding of them and knowledge of disease prevention that includes disinfection and vaccination requirements. Competences are assessed based on evidence obtained from practical instruction and demonstration and, where practicable, based on approved practical experience. The criteria for evaluating competence regarding infectious diseases is complete and effective protection against infection and spread of diseases. International Maritime Organization's (IMO) Medical Care Model Course 1.15 suggests that the general topic of diseases should be covered in 4 hours of lectures, with the topics of disease prevention and hygiene on board to be covered in one hour, respectively.

It has already been evidenced that the maritime education doesn't always reach the goals established by the IMO (Kalnina and Priednieks 2017). Given the complexity of the PMM measures set for infectious diseases, and the lessons learned from Covid-19 pandemic, it is clear that this type of education proves insufficient, especially regarding large passenger ships. This article tries to introduce maritime educational standards for mitigation of infectious diseases spread on large passenger ships, aimed at future seafarers, i.e. students of maritime universities. To establish such standard, a literature review was performed on large passenger ship epidemiology and the needs of key stakeholders in cruise industry (Zagan, S., Chitu, M.G., Manea 2014). Based on this, mandatory knowledge and skills are identified with a clear list of learning goals and outcomes.

2. Developing Educational Standard

Educational standard establishes the essential knowledge and abilities that learners ought to acquire at crucial stages throughout their education. It provides a framework for curriculum development, instruction, and assessment. Educational standard typically includes learning objectives, outcomes, guidelines for competencies of lecturer and expected workload of a student (Stainbank 2022). They serve as a guide for lecturers and curriculum developers in creating learning plans and assessing student progress. Standards can vary in terms of their level of specificity, with some providing general descriptions of learning outcomes and others providing detailed performance indicators that are closely aligned with specific curriculum materials and assessments.

The purpose of educational standards is to ensure that all students have access to education of balanced quality. Standards help to establish clear expectations for what students should know and be able to do. They provide a basis for evaluating the effectiveness of educational programs and services.

Many frameworks and models are available as a help in development of educational standards. The ADDIE model is a framework for instructional design (Saeidnia et al. 2022; Salinas-Navarro et al. 2022) that is commonly used in education and training, Fig. 1 a). ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation, which are the five key stages of the model:

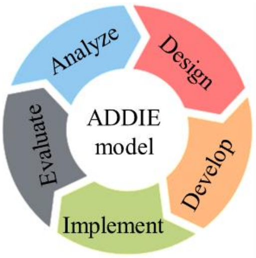
1. Analysis: This stage involves analyzing the needs and goals of students, as well as the constraints and opportunities of the learning environment.

2. Design: In this stage, instructional designers use the information gathered in the analysis stage to design a learning experience that meets the needs of students and achieves the desired learning outcomes. This stage includes developing learning objectives.

3. Development: In this stage, the actual learning materials are developed, such as lesson plans, activities, and multimedia resources. The materials are developed with the instructional design in mind and are typically reviewed and revised several times.

4. Implementation: This stage involves actually delivering the learning experience to students in various format (onsite, online, hybrid, etc.).

5. Evaluation: Here, the effectiveness of the learning experience is evaluated. This includes measuring the achievement of learning outcomes, evaluating the instructional design and delivery methods, and making any necessary revisions.



a) b)

Figure 1. a) Five stages of ADDIE model. b) Bloom's Taxonomy hierarchical model.

Bloom's Taxonomy is used as a most common framework for classifying learning outcomes (Gundić et al. 2020). It is divided into six levels, Fig. 1 b), each of which represents a different type of cognitive skill:

1. Remembering: This level involves recalling previously learned information or knowledge.

2. Understanding: Here, students demonstrate comprehension of the meaning of the acquired knowledge.

3. Applying: Using the knowledge and skills learned to solve problems or complete tasks.

4. Analyzing: Breaking down complex information and examining relationships.

5. Evaluating: Making judgments about the quality of information based on defined criteria.

6. Creating: Generating new ideas or products, or original solutions to problems.

United States' Centers for Disease Control and Prevention (CDC) has established Quality Training Standards (QTS) to ensure quality in developing an educational standard for public health professionals. QTS consist of eight elements that can be successfully transferred to education and training of maritime students:

1. Needs assessment: An assessment should be performed to conclude if the training is needed to close a certain gap among potential learners.

2. Learning objectives: SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) learning objectives should be set for the education or training.

3. Accurate and relevant content: Content should meet the needs of the learners and be based on the needs assessment.

4. Learner engagement: Learner should be engaged in interactive learning process.

5. Usability and accessibility: Materials should be designed for user-friendly experience, and the style and tone of lectures inclusive and clear.

6. Evaluation for improvement: A training evaluation plan should be developed, implemented and used for training improvement.

7. Learner assessment: Learner assessments should be constructed and feedback provided.

8. Follow-up support: Opportunities to learners for continued learning after the training should be provided.

3. Maritime Educational Standard for Mitigation of Infectious Diseases Spread

An educational standard should contain clear and measurable statements that describe the learning outcomes, objectives, competencies of the lecturer and expected workload. These four points are further discussed in this paragraph.

3.1. Learning objectives

Learning objectives are broad statements written from an instructor's perspective that give general content and direction of a learning experience. They describe what an instructor aims to do (Koh et al. 2021).

As for the maritime educational standard for mitigation of infectious diseases spread, learning objective can be set as:

1. Students will be taught the basics of epidemiology and public health, with special emphasis on prevention, mitigation and management of infectious disease spread on large passenger ships.

3.2. Learning outcomes

To establish learning outcomes (Boulougouris et al. 2019), a literature review was performed on large passenger ship epidemiology with Web of Science base taken as a relevant source. Using the search string of "cruising/cruiseindustry/large passenger ships+covid", a total of 319 papers were detected, while using search string of "cruising/cruiseindustry/large passenger ships+infectious disease", a total of 240 papers were detected. Fig. 2 gives the distribution of four main journal categories for published papers.

a) b)

Figure 2. Overview of Web of Science distribution of four main journal categories for published papers with a topic of: a) Covid-19 outbreak on cruise ships, b) infectious diseases on cruise ships.

Based on the reviewed papers and following Bloom's taxonomy, learning outcomes that should be achieved through education of seafarers working on board large passenger ships:

1. Remember the signs and symptoms of infectious diseases and how they are transmitted (Pavli et al. 2016; Willebrand et al. 2022).
2. Apply the rules for personal hygiene (Dahl 2016; Mouchtouri et al. 2020).
3. Apply the rules for cleanliness of the ship (Zheng et al. 2016; Codreanu et al. 2021; van Beest et al. 2022).
4. Understand the necessity of food and water hygiene (Arvanitoyannis et al. 2010).
5. Apply the rules for physical distancing to reduce the risk of transmission of infectious diseases (Rosca et al. 2022).
6. Use personal protective equipment to reduce the risk of transmission of infectious diseases (Zheng et al. 2016; Mouchtouri et al. 2020).
7. Understand and apply health monitoring procedures (Codreanu et al. 2021).
8. Understand the reasons for vaccinations for infectious diseases (Mouchtouri et al. 2019).
9. Use appropriate communication procedures with infected passenger and with medical and port authorities (Li et al. 2021; Anagnostopoulos et al. 2022).

3.3. Lecturer's competencies

Lecturers in the field of prevention of infectious diseases should have a range of competencies to effectively teach students and develop their understanding of the subject matter. Some key competencies include:

1. Knowledge of transmission, prevention, and treatment of infectious diseases (Mouchtouri et al. 2020).

2. Strong teaching skills, including the ability to develop effective lesson plans, create engaging learning activities, and assess student learning (Gundić et al. 2020).

3. Effective communication skills to convey complex scientific concepts in a clear and understandable way (Sharples et al. 2022).

4. Working in maritime sector often requires collaboration with other professionals so lecturers should have the ability to work collaboratively with others (de Água et al. 2020).

5. Given the global nature of maritime industry and infectious diseases, respectively, lecturers should have cultural competency and be able to teach in a way that is sensitive to cultural differences and diverse perspectives (Horck 2010).

3.4. Workload

In total, IMO's Medical Care Course 1.15 should last for 45.5 hours. As mentioned, general topic of all kind of diseases should be covered in 4.5 hours of lectures, while the topics of all diseases prevention to be covered in another one hour, and environmental control on board ship in another hour. To assure quality of knowledge transfer (Rivadeneyra 2022), and understanding the level of knowledge needed, it can be estimated that each of the learning outcomes set in section 3.2 could be covered in one hour, respectively, making that 9 hours. This can complemented with 3 hours of practical work or demonstrations, summing that up to 12 hours in total, which is adequate to 2 day course according to timetables suggested by IMO's Course 1.15.

4. Discussion and Conclusion

There are several aspects that need to be considered before implementing the proposed educational standard. First one is that the development of an educational standard is followed by building an accompanying curriculum. Although related, educational standards and curriculum are two distinct concepts. Curriculum refers to the specific learning materials and activities that lecturers use to teach the content and skills outlined in the educational standards. Standards provide a framework for curriculum development, while curriculum provides the actual content that students receive. So, in order for this type of education to be implemented, and following good practice of maritime education and training, a curriculum must be provided first to institutions and persons conducting it.

Second question would be where to place this type of education, i.e. on which level of education of maritime students. It would serve for crew of large passenger ships, so it wouldn't be necessary for every student at maritime universities, only those planning their careers in cruising industry. It could serve as an elective course on MSc level, possibly in a broader frame of maritime occupational health. Also, it could be placed as a lifelong training program for maritime professionals wishing to expand their knowledge or make a career change.

To sum up, this educational standard serves as a roadmap for creating a competency-based curriculum, identifying instructional methods, establishing evaluation methods and ensuring continuous improvement of mitigation measures of infectious diseases spread on large passenger ships.

Acknowledgements

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Engagement of Students in Maritime Operations – An Exploration into Cultivating Cultural Connection Across Majors at a Maritime University

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Abstract: California State University Maritime Academy is a degree granting institution that serves students of several different disciplines, including license-track, future mariners. There is a cultural disconnect between license-track majors and those who are not pursuing a license. This study evaluates a pilot program developed to increase interdisciplinary engagement and help foster a common maritime identity across all majors as a way of improving student sense of belonging. The program was initially driven by the general perception of faculty in the Marine Transportation department that getting out on small boats would make all students feel a greater level of inclusion on campus. This study was created to formalize the exposure to small boat programming, and create data to validate or invalidate this faculty impression. As it developed, the study expanded beyond small boat operations and into the greater maritime transportation field of study. Eventually, as initial data proves supportive of the faculty impression that this program has value, we look forward to its expansion to include shared learning experiences across all seven campus majors.

Keywords: student engagement, belonging, retention, interdisciplinary education, marine transportation, maritime professionals.

1. Introduction

The California State University Maritime Academy (Cal Maritime) is situated on the Carquinez Strait, in northern San Francisco Bay, California, USA. It is one of seven maritime universities in the United States, and the only one on the U.S. West Coast. Cal Maritime has seven undergraduate degree programs, two of which are ‘license-track,’ where students train for future careers as credentialed, seagoing deck and engine officers. The students of ‘non-license-track’ disciplines, including business, global studies, oceanography, and engineering, will go on to work in a variety of professions - some in the maritime or adjacent industries, others in different fields altogether. Despite having much in common, there is a significant divide between students in different disciplines, particularly between license and non-license track students. This separation exists both socially and physically, with non-license-track students avoiding “maritime” spaces, such as the training ship, boat basin, and simulators. For many students, this manifests itself into a cultural disconnect between themselves and the school’s current and historic maritime identity. This disconnect has consequences for campus cohesion and a negative impact on the collegiate experience for all students, especially those in non-license-track disciplines (some of whom will still go on to work in the maritime industry). With the desire to repair this disconnect and increase retention, we sought to create interdisciplinary activities that would bring all majors together.

Cal Maritime has not been immune to the national trend of declining college enrollment and is constantly seeking to improve student retention. Rates of both enrollment decline and attrition are greater in Cal Maritime’s non-license track programs than in their license-track counterparts. Through several studies spanning the last twenty years (Hoffman et al. 2002, Freeman et al. 2007, O’Keeffe 2013, Whannell et al. 2015, Jaiswal et al. 2022) college attrition can specifically be attributed to students feeling social and academic disconnection, a lack of belongingness, and failing to form an identity within their institution

(Jaiswal et al. 2022). Despite Cal Maritime having five non-license degree programs, its maritime identity still looms large on campus - this presence may inadvertently have an alienating factor for students outside of those disciplines.

Sharing marine operational experiences with students of other disciplines in an effort to improve campus culture stems from our own understanding of how great on-the-water experience can be. License-track students in the Marine Transportation (MT) major (and license-track engineers as well, though to a lesser extent) utilize the campus' scenic waterfront and busy boat basin in a variety of classes throughout their undergraduate education. These classes, which include everything from rowing to shiphandling, are very popular and provide hands-on learning experiences that have a great effect on students. Our goal was to recreate that experience for non-license-track students with a program on the water designed for them. Specifically, we wanted to potentially create a *powerful learning experience* (PLE), defined by Rowland and Kitchen-Meyer (2018) as a learning experience that "stands out in memory because of its high quality, its impact on one's thoughts and actions over time and its transferability to a wide range of contexts and circumstances." Our broader purpose in doing this was the hope that it would help cultivate non-license students' sense of belonging to our maritime community.

In this pilot study, we theorize that exposure to interdisciplinary learning experiences will foster a cultural connection with maritime operations on campus and allow for an increased sense of belonging for all students within the common maritime identity. Our creation of this pilot study is based on literature on increasing sense of belonging as a way of improving retention and positive campus experience.

2. Methods

To begin our pilot program, we reached out to Cal Maritime faculty to ask them to encourage their non-MT major students to participate in this program. Any interested students were asked to complete an online form that focused on area of interest and availability. The first question listed eight specific learning experience offerings relating to navigation, boat handling, and seamanship. The students were provided details on each of the offerings, and they were able to select as many as they were interested in. Students were also given a ninth, 'write-in' option, where they could list any other lesson they were interested in that wasn't listed in the previous eight options. An example of one of the learning experience prompts described above is:

> "Ride-along on the Cub (one of the larger boats in the boat basin) to a planned destination.
> Goal: exposure to charts, electronic charts, RADAR, helm commands, small engines, mooring lines, and more."

The prompt students were given regarding availability was very general, listing day of the week and either morning or afternoon.

With the results from this preliminary interest survey, we organized groups of students who were interested in the same learning experience offering and available at the same time as the instructor who was willing to teach it.

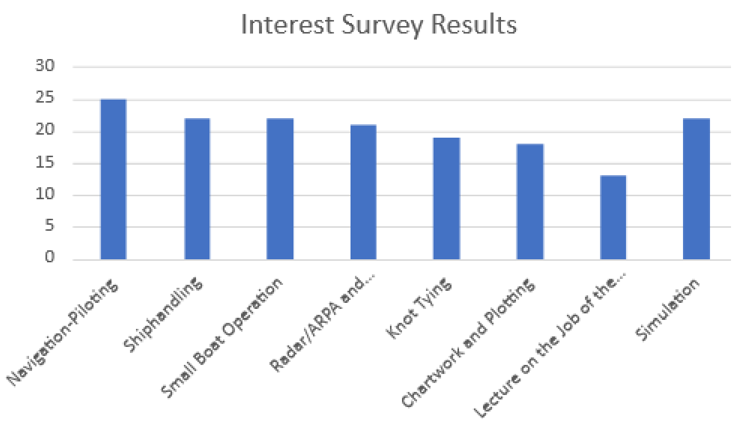
Students met with the instructor on the assigned day and began the program with a seven-question, multiple-choice pretest, which asked if they had ever attended another college, whether they had exposure to maritime concepts prior to attending Cal Maritime, how connected they feel to maritime operations on campus, how connected they feel to the maritime industry and operations, whether they had ever taken classes at Cal Maritime *just* for fun, and why they chose to participate in this program. It also asked their major of study and the number of semesters they had studied at Cal Maritime. This pretest was used to collect some background on the students and to gauge their level of engagement before the session.

Following the program, another seven-question, multiple-choice test was given, which asked again how connected the student felt to maritime operations on campus and to the maritime industry and operations, how satisfied they were with the program, whether they would want to participate in another learning experience program with the MT department, whether they would want to participate in a learning experience program with other departments, and, if so, which departments would interest them. It also asked if they would recommend the program to a friend. This portion of the posttest was used to compare against the pretest and observe any change in engagement following the experience, as well as to see if students were interested in future program participation.

3. Results

Through faculty dissemination and word of mouth alone, we collected 27 student interest responses for program participation, a number that amounts to 6% of Cal Maritime's non-MT major population (CSUM 2023). There were no responses to the ninth, write-in option to request a topic not listed explicitly. See Figure 1 detailing student interest below:

Figure 1. Survey response to learning experience program participation



Survey responses for student availability were mixed, with 21 students available Friday afternoon and 18 students available Saturday.

Results from the program pretest are in tables below:

Table 1a. Pretest Student Data

Q1: Semesters at Cal Maritime	Response %
Two	40.00%
Three	20.00%
Four	20.00%
Five or more	20.00%

Table 1b. Pretest Student Data

Q2: College Attendance Prior to Cal Maritime	Response %
Yes	80.00%
No	20.00%

Table 1c. Pretest Student Data

Q3: Prior Maritime Exposure (pre CMA)	Response %
No exposure	40.00%
Limited exposure	60.00%
Lots of exposure	00.00%

Table 1d. Pretest Student Data

Q6: Have you taken classes for fun	Response %
Yes	60.00%
No	40.00%

Table 1e. Pretest Student Data

Q7: Why did you participate in program	Response %
I love to learn	18.18%
I want to learn more about what MT students are learning	27.27%
I want to learn more about maritime operations for interest	27.27%
I want to learn more about maritime operations as it will assist me in my future career plans	27.27%

Posttest data following the learning experience program indicating perceptions of the program:

Table 2a. Posttest Student Data

Q3: Satisfaction with Program	Response %
Not satisfied	00.00%
Somewhat satisfied	33.33%
Very satisfied	66.67%

Table 2b. Posttest Student Data

Q4: Desire to participate in another program with MT Department	Response %
No, this was enough for me	00.00%
No, I am graduating	00.00%
Yes, if they work out for timing	42.86%
Yes, I am very interested	57.14%

Pretest and Posttest results to question of maritime connection side by side:

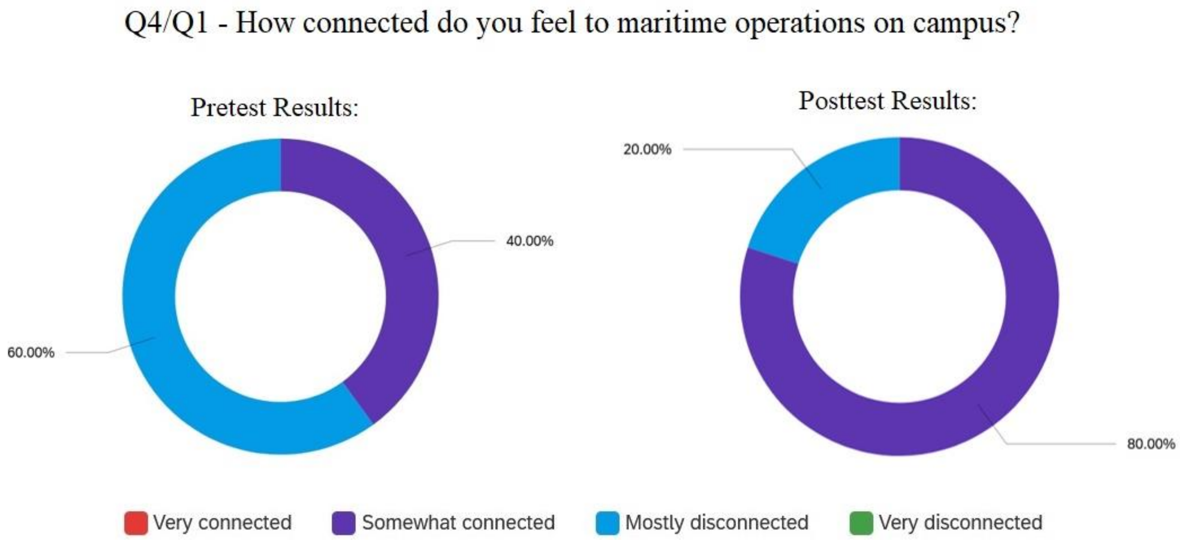
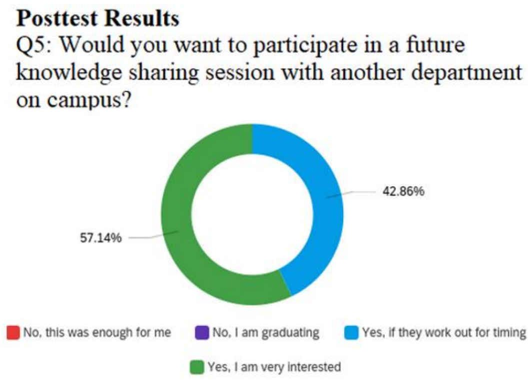


Figure 2. Before & after student responses to Question Q4 & Q1: *"How connected do you feel to maritime operations on campus?"*

Figure 2 shows that prior to the learning experience program, 60% of students felt "mostly disconnected" and 40% felt "somewhat connected" to maritime operations on campus. Following the program, 80% of students felt "somewhat connected" and just 20% felt "mostly disconnected."



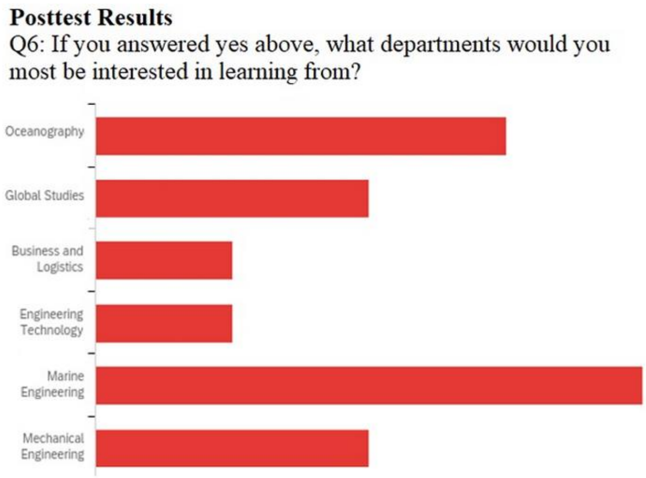


Figure 3. Posttest responses to questions Q5 & Q6

Figure 3 shows posttest results to question 5, *"Would you want to participate in a future knowledge sharing session with another department on campus?"* with 57.14% of students answering "Yes, I am very interested," and 42.86% of students answering "Yes, if they work out for timing" and question 6: *"If you answered yes above, what departments would you be interested in learning from?*" to which 23.1% selected oceanography, 15.4% selected global studies, 7.7% selected business and logistics, 7.7% selected engineering technology, 31% selected marine engineering, and 15.4% selected mechanical engineering.

4. Discussion

As observed in Figure 2, this study demonstrated that through interdisciplinary learning experiences, we have the ability to improve student sense of belonging and connection, both of which correlate with increased retention. Posttest data shown in Tables 2a and 2b indicate students were satisfied with the program and were interested in participating in another program with the MT Department. Further, as shown in Figure 3, students unanimously expressed interest in participating in another shared learning experience with a different department, and their interest wasn't exclusive to any one discipline, but included all. Though the sample size of this pilot study is small, and the results do not therefor guarantee an outcome on a larger scale, we are encouraged by the qualitative results that positively indicate this type of program could improve feelings of belonging and a connection to the campus for all students.

The eight learning experience offerings we proposed had strong interest, as seen in Figure 1, so we plan to continue with those offerings in our next programs through the MT department. We also plan to engage faculty from at least two other departments who received high interest results from students in the post-test, and run a parallel program that includes students from the Marine Transportation major as well.

Shortcomings: The shortcomings of our pilot project were timing and scheduling. It was very difficult to find times, often three-hour blocks of time, where enough students who were interested in the content were available along with the instructor. We were only able to successfully offer one session with usable data collection. A second session was offered in our pilot program, and verbal feedback was positive, but formal pre and posttests were not conducted, so none of the data could be used to contribute to the research.

In future semesters, we will try offering preplanned sessions at the timing that is available for the instructor, and ask students to sign up directly for sessions based on planned content and time. This change may limit participation, so we plan on gauging feedback on why some students chose to participate in a particular offering and not others. A question on this will be added to the post-test. One last adjustment we plan to make is to move pre and posttests to a digital format, to keep all data centralized and accessible to all as soon as it is collected.

Ultimately, we are inspired by the success of the pilot program and look forward to working with faculty across disciplines to expand it. With continuous development of unique shared learning experiences, Cal Maritime students may begin to form greater bonds to each other, leading to increased feelings of belonging to the institution as a whole that transcend maritime identity alone. Perhaps as well, students sharing and promoting their own majors may bolster their identity formation as it relates to their community within Cal

Maritime. Though this is of course speculative, we are confident work aimed at cohesion and shared experiences will enhance the education for all students and result in a positive impact on campus.

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Session
Policy Aspects

BoK- STCW-TRB Triumvirate Course Mapping for Learning Outcome Matrix of BS Marine Engineering Program

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Abstract: The European Maritime Safety Agency (EMSA) has raised several deficiencies regarding the Philippines' maritime education and training over the years since 2006. The most notable of them include the non-spiral, non-holistic, and outdated approach to the curriculum being implemented. This led to the endangerment of the employment of Filipino seafarers aboard European vessels and the potential removal of the Philippines from the IMO whitelist. To address this looming problem, this study has developed a triumvirate mapping that uses the elements of the STCW, the Book of Knowledge (BoK) by IAMU, and the training record book (TRB) of Global Maritime Education and Training Association (GlobalMET). The resulting framework served as a guide in crafting the learning outcomes for a holistic, STCW-compliant, and practical approach. The methodology employed a qualitative design of exploratory nature wherein the STCW Table was cross-referenced and analyzed with the BoK and TRB. This resulted in a new framework containing a triumvirate map that will be essential to the curriculum developers in formulating a program that will be at par with the global standards with a three-pronged approach to cadet development, spiral learning, and competence acquisition as required by the STCW.

Keywords: course mapping; curriculum development; global maritime professional; maritime education and training; book of knowledge

1. Introduction

The European Maritime Safety Agency (EMSA) has already conducted a series of audits on maritime education and training (MET) here in the Philippines starting in 2006 (Andersen & Nielsen, 2013). Throughout the years, non-conformities and observations were listed, and most of the findings in recent years were centered on the delivery of education amongst Maritime Higher Education Institutions (MHEI). In the last meeting with the International Association of Maritime Universities (IAMU) and International Maritime Organization (IMO) delegates, it was pointed out that the major findings when it comes to MHEIs in the Philippines are the non-spiral, non-holistic, and obsolete education, and training (IAMU, 2020). These findings led to the brink of Filipino seafarers being banned from European Union (EU) ships, which will potentially wipe out 28,784 Filipino seafarers from employment (EMSA, 2019).

Currently, the Maritime Industry Authority (MARINA) and the Commission on Higher Education (CHED) are working to address the stated findings. One solution they have crafted is the introduction of the new curriculum under the Joint CHED-MARINA Memorandum Circular 01, series of 2022 (JCMMC 01 s. 2022). The new curriculum should be able to address the spiral learning approach being recommended by EMSA with the injection of emerging technologies. This new curriculum also inculcated the concepts and principles being presented from the Book of Knowledge (BoK) of IAMU, where not only cognitive faculties will be honed but also the psychomotor and affective faculties of the cadet as well. In addition, the competencies under Table III/2 and Table II/2 of the International Convention on Standards, Training, Certification, and Watchkeeping (STCW) were removed to focus more on the competencies of the operational level officers (CHED,2022).

Despite these measures taken by CHED and MARINA, it was later found out during the last meeting with MHEIs all around the Philippines in September 2021 that there are still inadequacies. One, although the spiral education approach was much improved from the last curriculum, there are still flaws that can be observed, especially with the flow of the learning outcomes. Second, the complexity of the assessment of cadets based on cognitive, affective, and psychomotor faculties without the learning outcomes being holistically developed prior. Lastly, compliance with the STCW Code when it comes to the knowledge, understanding, and proficiency (KUP) that can be accomplished in an approved shore facility was not taken into consideration (CHED & MARINA, 2021).

Through the years, the framework being used in the development of the curriculum in maritime higher education is based on the IMO Model Course 7.02 and 7.04. This IMO framework is based on the STCW Code, where learning outcomes are given for each KUP stated in the STCW Table. Then the IAMU released its BoK to guide member institutions in developing learning outcomes for a more holistic approach suitable for the tier of education being delivered. However, the use of the Book of Knowledge in crafting the maritime education curriculum is not yet widely practiced due to the difficulty of adopting the said framework with the IMO Model Course. The training record book (TRB) produced by different organizations also offers a potential framework on which the maritime curriculum can be based on. This way, cadets, as they go through with their program, can be able to attain the knowledge and skills required by the STCW convention while also being able to accomplish the tasks designated in their TRBs (Cunningham, 2015).

Therefore, a framework for the curriculum development of maritime higher education needs to be crafted to merge the matrix of the IMO Model Course, the BoK, and the TRB. This kind of framework will be beneficial to ensure the development of a holistic cadet that attains all the needed KUPs required by the convention. In the process, the training tasks indicated in the training record book that can be accomplished using shore facilities can already be ticked off, thus making the training onboard focused on the tasks that cannot be replicated on shore. This will ensure the compliance of the Philippines' MHEIs to the STCW and put an end to the Philippines' woe with the European Maritime Safety Agency.

This study aims to develop a triumvirate course mapping using the STCW, BoK by IAMU, and the training record book of the Global Maritime Education and Training Association (GlobalMET), which can be used as a matrix in the crafting of learning outcomes of the maritime curriculum under the BS Marine Engineering (BSMARE) program. To attain the overall objective of the study, there are sub-objectives that need to be accomplished along the way, the first is the development of the level of achievements matrix for the three learning domains, learning outcomes matrix, BoK course mapping, TRB course mapping, STCW course mapping and the cross-mapping of the aforementioned course maps.

2. Methods

2.1 Research Design

This research employed a qualitative research design specifically on the aspect of exploratory case-study framework where a new idea is generated from the existing facts, ideas, and frameworks. The data and information were gathered from the STCW Code, the BoK by IAMU, and the TRB developed by GlobalMET. A new framework and matrix were developed based on the analysis and cross-referencing of the different components of the three frameworks.

2.2 Level of Achievement Matrix- Intended Learning Outcome Matrix

The first procedure was the development of the level of achievement matrix for Tier A, which is the undergraduate study for operational-level officers based on the IAMU Book of Knowledge. The focus areas were plotted with the different levels of achievement and the expected outcome per level. This produced three tables, with one each for cognitive, affective, and psychomotor domains. Once the level of achievement has been established, the intended learning outcomes per focus area for that level have been identified from the IAMU BoK (IAMU, 2019). This produced another framework showing the mapping of the different guides in the development of learning outcomes per focus area. Each domain, specifically cognitive, affective, and psychomotor, had one table each.

2.3 BoK Course Mapping, STCW Course Mapping, and TRB Course Mapping

Afterward, the different intended learning outcomes determined were mapped against the courses being implemented by CHED-MARINA for their BSMARE programs. Each intended learning outcome was analyzed if such is relevant to a particular course. This will produce the BoK Course Mapping for each of the learning domains. The next step was the TRB Mapping of the different courses offered by CHED-MARINA. This cross-referenced the different tasks included in the TRB of GlobalMET to the different courses they are related to. This involved a thorough analysis of the different tasks in the TRB. Before the development of the triumvirate mapping, the CHED-MARINA STCW Course Mapping was checked regarding the completeness of all KUPs, alignment, and compliance with the STCW Convention.

2.4 BoK-STCW-TRB Cross-Mapping and Analysis

Once the checking was completed and the lacking KUPs had already been addressed, the triumvirate mapping of the BoK-STCW-TRB was developed per course. This is a detailed and comprehensive table where for each course, the different intended learning outcomes from the BoK are considered together with the KUP stated in the STCW Code. TRB tasks that can be accomplished for that course and KUP are also included.

3. Results

The level of achievement was first determined in line with the latest memorandum released by CHED-MARINA under JCMMC 01 s 2022. This new memorandum aims to produce graduates with the competence listed under the STCW Table A-III/1 and Table A-II/1. In reference to the BoK developed by IAMU, the level of achievement appropriate for the program outcomes stated is Tier A, with some elements of Tier B for the principle of mechanics and thermodynamics. Analyzing the program outcomes and the curriculum released by CHED-MARINA, a tier A-tier B hybrid will be mapped for the level of achievement according to BoK (IAMU, 2019).

3.1. Intended Learning Outcome Matrix Map

The level of achievement needed for the mental aspect of the cadets for Tier A-Tier B hybrid was mapped in accordance with the BoK. The level of learning based on Bloom's Taxonomy is determined by each of the four major scopes of learner's development, namely the foundational elements, academic elements, professional-technical elements, and the professional-soft elements. The BoK aims to develop a holistic approach to the learning of the cadets. Thus, the level of achievement is also determined for the affective and the psychomotor domain. A representative table is only shown, which is only a portion of the extensive table mapped out for the three domains of learning across the four focus areas with 28 sub-focus areas.

Table 1. Representative table of learning outcome matrix for the psychomotor domain.

Focus Areas	**Perception (Awareness)**	**Set**	**Guided Response**
11. Technical Competencies as per International Requirements (STCW)	**Identify** maritime actions that involve complex movement patterns and **choose** correct action(s) among various options to meet operational requirements of efficiency and safety as per international requirements	**Explain** the most professional, efficient, and safe way of performing practical motor tasks. **Prepare** optimally for commencing such tasks	**Respond** to and **follow** instructions regarding specific technical operations that require practical motor-skills

Once the level of achievement was properly and correctly determined, the intended learning outcomes for each domain were mapped out based on the BoK. Each sub-focus area under each of the different levels of learning has its own intended learning outcomes. Table 1 shows the mapped-out intended learning outcomes for the psychomotor domain as a representative sample due to the extensiveness of the original table. The same mapping was carried out for the cognitive and affective domains. Subsequently, a course mapping was performed between the determined intended learning outcomes against the set of courses provided in the JCMMC 01 s 2022. The factors considered in the analysis of the mapping done were based on the course descriptions, program of study, and the program outcomes provided in the memorandum.

3.2. BoK-STCW-TRB Triumvirate Mapping

The next mapping and cross-referencing were the training record book tasks indicated in the GlobalMET TRB against the courses. The task listed in the TRB under each function and competency was compared with the KUP and competency mapping of the course packages. The TRB tasks were mapped against the course under which the KUP was covered, as shown in Table 2. Table 2 again shows a representative table of the original table due to its extensiveness. An STCW-based course mapping was also performed to check the alignment of the course presented by CHED-MARINA to the competencies required by the convention. The course mapping also checked that all the required competencies were acquired by the cadets in compliance with the provisions of the STCW. The course packages of the JCMMC are mapped and cross-referenced with Table A-III/1 of the STCW Code, as shown in Table 3. The TRB tasks course mapping, together with the BoK ILO course mapping and the STCW course mapping, are triumvirated to develop a more comprehensive and holistic framework that will serve as guidelines in formulating the learning outcomes of the courses of the BSMARE program. The three-axis framework will take into consideration the learning outcomes for the three domains stipulated in the BoK in consideration of the practicality of the tasks listed in the TRB in compliance with the STCW Convention. This will formulate a program that encompasses all three major frameworks of international maritime education and training.

Table 2. Representative table of TRB course mapping.

	MAINPROP	**EWK1**	**EWK2**	**MAINT**	**COMPRE**
Function 1: Marine Engineering at the Operation Level					
Competence: Maintain a safe engineering watch					
1.1: Taking over and accepting a watch and handing over a watch					
1.1.1 Demonstrate good understanding of procedure for handing over of engineering watch (a) at sea (b) in port					

Table 3. Representative table of STCW course mapping.

Competence	**Code**	**Knowledge, Understanding, and Proficiency**	**MAINPROP**	**EWK1**	**EWK2**	**MAINT**	**COMPRE**
Function 1: Marine Engineering at the Operational Level							
Maintain a safe engineering watch	**1.1.1**	**Thorough knowledge of principles to be observed in keeping a marine engineering watch inlcuding:**					
	1.1.1.1	Duties associated with taking over and accepting a watch					

Table 4. Triumvirate course mapping for auxiliary machinery.

BoK ILO	Basic Construction and Operation Principles of Various Pumps	Basic Construction and Operation Principles of Air Compressors	Basic Construction and Operation Principles of Heat Exchanger
Cognitive Domain			
Identify key mathematics information and recall equations related to academic and professional skills			
Explain the relevant mathematical principles			
Affective Domain			
Practice simple decision-making within the maritime workspace			
Initiate actions that demonstrate a proactive attitude in maritime professional practice			
Psychomotor Domain			
Explain the most professional, efficient, and safe way of performing practical motor tasks. Prepare optimally for commencing such tasks			
	Make a simple sketch of a centrifugal pump showing various components	Make a simple sketch of various positive displacement pumps onboard, showing various components	Make a simple sketch of an air compressor showing various components

As shown in Table 4, which is the sample triumvirate mapping developed for an auxiliary machinery course, the extensiveness of the table shows the three criteria on the x and y-axis. The intended learning outcomes for the three domains based on the BoK are listed in the leftmost column. The STCW KUPs that need to be attained are listed on the topmost row, with the appropriate TRB tasks in line at the bottom row. This three-axis triumvirate map serves as an effective guide in the formulation of much more effective and holistic learning outcomes for the different courses.

4. Discussion

With this triumvirate course mapping being one of its kind and the foremost comprehensive framework in curriculum development, inculcating the concepts and foundations of the STCW, BoK, and TRB, there are only a few studies that were in correlation with the newly developed framework. To develop a globally competitive marine engineer in the modern world, professional skills are inadequate (Andersen & Nielsen, 2013). Soft skills and technical skills are becoming more and more critical requirements for a marine engineer in the 21st century. This is in line with the aim of the Global Maritime Professional (GMP) under the IAMU initiatives, wherein the two major focus areas are technical skills and soft skills, as indicated in the BoK. As seen in the developed course mapping, these focus areas are emphasized in the leftmost column with the specific learning outcomes for the different courses. This will enable the development of an appropriate program where professional skills are being honed together with technological and soft skills. At the recently held IAMU virtual conference in March 2020, the most important skill in the data revolution is soft skills, with technological skills coming in at number two (IAMU, 2020).

With the rise of cybersecurity in the maritime industry, together with the increasing maritime incidents on the part of the crew despite advancements in technology, a global maritime professional is increasingly in demand across the seven seas (Bauk & Ilcev, 2021). This emphasized the importance of using the BoK as guidelines in the formulation of the MET programs by the different administrations, especially those who are party to the STCW Convention. The TRB is also an essential part of the attainment of the needed competencies by future marine officers, which should also be updated with the changing times (GlobalMET, 2011). To bridge the gap between inadequate sea time and the limitations of opportunities encountered onboard ships, some of the tasks indicated in the TRB can be administered by institutions. This can fuel the development of maritime instruction and assessment considering the performance of some of the TRB tasks.

The Philippines' MET has made strides, but there is still a lot of room to grow (Cunningham, 2015). First is the upgrading of the level of learning from mostly remembering to analyzing and possibly creating, which can be boosted by using the framework as guidance. There are also issues regarding the alignment with the STCW Convention, with some of the KUPs left unaddressed. The approach in the delivery and the sequence of the courses are also not following the spiral approach, with some of the programs tackling advanced competence and topics prior to the fundamental ones. Lastly, the balance and the holistic approach in the determination of the psychomotor, affective, and cognitive development in each of the KUPs are also not well planned and implemented. The Philippines' MET also lags in the current technological trends and development with the introduction of emerging technologies and green shipping. With the three-pronged approach being used by the triumvirate, the learning outcomes and the program will become more updated, holistic, practical, and, most importantly, in compliance with the STCW Convention.

Assessing and ensuring the proficiency of the cadets after undergoing their respective maritime programs needs a lot to be desired as the current program is honing the development of professional skills only based on the STCW (Kalnina & Priedniks, 2016). In the age of information, this is insufficient to meet the demands of modern shipping. Soft skills and technological skills are additional skills and competencies that need to be inculcated in maritime students. The STCW 2010 Manila Convention needs to be updated to accommodate the major changes that have happened over the last decade. Thus, to augment the gap posed by the outdated STCW, certain elements of the GMP and the BoK need to be assimilated into the current curriculum.

The current issue facing the MET is its evolution towards the information age (Manuel, 2017). With the advent of emerging technologies, it is recommended to upgrade and update the program. The triumvirate mapping exactly fits the framework they are seeking, where the three domains of learning are being honed across the critical focus areas. This is coupled with the strict adherence to the competencies stipulated in the STCW while offering flexibility in the delivery of the shipboard training program by allowing the maritime institutions to fill the gap for the TRB tasks that can be replicated onshore. This STCW-BoK-TRB mapping is a revolutionary guide, especially in the Philippines, to meet the standards set forth by the shipping companies and agencies such as EMSA. The comprehensive parameters to consider in crafting the learning outcomes leading to the revision of the curriculum are one step further in developing an updated, holistic, and effective maritime program that will ready future marine officers for the upcoming revolution in the shipping industry. This will make the curriculum development of the administration and the schools much easier and more effective.

5. Conclusion

Based on the data gathered, it is concluded that the process for the development of the triumvirate mapping starts with the determination of the level of achievements based on the BoK, followed by the mapping of the learning outcome matrix leading to the course mapping of the BoK, TRB and the STCW. Combining the three maps with careful analysis leads to the development of a new framework for the design and development of the program for BSMARE, which is the BoK-STCW-TRB triumvirate map. The completeness of the KUPs acquired was checked together with the appropriateness of the designation of the KUP. Careful analysis and interpretation of the guidelines of the BoK, together with the STCW Code and the TRB, is essential for the effectiveness of the developed framework.

For the next step of this research, verification of the developed framework and matrix should be done through an alpha test that will be conducted in the proponent's institution, which will be then verified by evaluation and audit of third parties. The result of the alpha test will then be compared with the result of the beta test that should be conducted in other institutions to ascertain the effectiveness of the newly developed framework and whether it is applicable to the Philippines' MET and to the international setting as well.

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Exploring possible content and structure of a quality maritime master programme in Denmark

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Abstract: The growing need for highly educated individuals in the maritime sector in Denmark is contrasted by the fact that maritime education in Denmark is mostly represented by programmes at the professional bachelor level and lower. Denmark is historically a seafaring nation with a large maritime sector consisting of shipping companies, repair yards, ports, brokers, and the support industry. Comparable countries all provide maritime educational programmes at a higher academic level. This study uses interview data from experts in the maritime sector to construct a theory explicating the influential elements when creating higher academic maritime education programmes. The methodology used is constructivist grounded theory, which results in a theory which includes seven aspects: barriers, broad and deep duality, maritime domain awareness, motivating circumstances, networking, non-maritime knowledge, and theory and praxis balance. While the study has been made in a Danish context, the results are likely to transfer well in a global context because of the focus on an in-depth understanding of the elements of the theory and their connections.

Keywords: maritime education; master programme; grounded theory; lifelong learning

1. Introduction

The maritime sector is an important part of the Danish economy and culture. Denmark's maritime cluster is often called “The Blue Denmark”. The Blue Denmark employed more than 100,000 persons in 2020 and was responsible for 24.6 % of the total Danish exports of goods and services this year (COWI, 2022).

With a strong maritime history and tradition, one would expect the maritime field to be strongly represented in the educational system. While this might be true for Maritime Education and Training (MET), which is the more vocational part of the maritime education system. It is not the case for higher academic education. Limited possibilities for further education in the maritime field are affecting individuals and the maritime sector. The industry needs qualified employees, and maritime professionals need options to engage in further education. There is a need for more knowledge regarding the creation of maritime master programmes other than the usual mapping of competency needs in the industry.

This study aims to explore how maritime education in Denmark could be expanded to provide an option for those wishing further education in this field while meeting the workforce needs of The Blue Denmark. Further education should be a step up from the current MET level and become European Qualifications Framework (EQF) level 7. This need leads to the following research question:

How do experts envision a Maritime Master programme that could accommodate industry demand, academic standards, individual candidates’ ambitions regarding content and structure, and the underlying principles for constructing such a programme?

The paper is structured as follows: In Section 2, a preliminary literature review is undertaken. The methodology is described in Section 3. Section 4 explains the analysis before the findings are presented in Section 5. A post-analysis literature review is then developed in Section 6 to qualify the discussion and conclusions drawn in Section 7.

2. Literature Review Section

The literature review for this study has been divided into a preliminary literature review and a post-analysis literature review. These two literature reviews serve distinct roles in the grounded theory method (GTM). Often it is recommended by classic grounded theorists (Glaser & Strauss, 1967) to delay the literature review until after the analysis, but in this study, a preliminary literature review was completed to provide the researcher with heightened theoretical sensitivity, as suggested by Charmaz (2014, pp. 306–309). Careful consideration was taken not to let the views of the existing literature to overshadow the theory emerging from the data. After the analysis and theory construction, the post-analysis literature review was completed to qualify the results and discuss them in light of existing research.

In the following, a brief summation of the pre-literature review is provided. The definition of "maritime" in the context of this paper is: "associated with the sea or waterways to the sea in relation to navigation, shipping, etc." (Dictionary.com, n.d.), which is close to the definition used by The Blue Denmark. The literature, however, offers many ambiguous definitions, which makes it important to consider the respondents' understanding of the concept.

Maritime education and training (MET) are often narrowly defined as the education and training of seafarers. Often, the emphasis is on meeting the global standard of competence provided by the International Maritime Organization (IMO) in the Standards of Training, Certification and Watchkeeping for Seafarers (STCW). In Denmark, MET is carried out by maritime education institutions, which are independent of universities and university colleges.

MET has undergone a transformation from being mostly vocational to become increasingly academic, thus awarding other degrees in addition to STCW certificates. The increased academisation of MET in Denmark has occurred parallel to the global trend in MET (Manuel, 2017). This trend is also found in the Danish education associated with other professions and semi-professions such as nursing, teaching, and pedagogy. The trend is closely related to the relationship between theory and praxis (Johansen & Frederiksen, 2013).

Acquiring competencies is a key outcome of education. The decision regarding which competencies graduates need is crucial and one with several stakeholders. Competency is a complex construct, Salman et al. (2020) suggest that competencies can be classified into sixteen distinct types, broadly divided into two aspects: visible or hard aspects of competence and hidden or soft aspects of competence.

3. Methodology

GTM was the main methodology for this study. GTM is a qualitative approach that constructs theory from empirical data while setting existing theories and discourse aside. This line of thinking fits very well with the scope of exploring how to construct a maritime master programme. Several scholars, such as Creswell & Poth (2018, p. 83) and Charmaz (2014, p. 344), recommend GTM for exploring processes. Creswell & Poth specifically mention developing an educational programme as a prime example of a suitable process.

The data was collected by interviewing experts from the field using a semi-structured interview guide. Additional data was gathered from selected maritime master programme information websites using web archiving. Interviews were recorded and transcribed verbatim using NVivo 20. Interview respondents were selected from the following criteria: (1) being part of the maritime industry or education, (2) having at least ten years professional or academic experience, (3) being an associate professor or part of management.

Table 1. Credentials of interview respondents

Respondent	Title	Field	Experience
A	Professor	Maritime education	1 year maritime, 10 years educational
B	Vice president	Maritime shore based	15 years maritime
C	Head of education	Maritime sea-based	4 years maritime, 12 years educational
D	Manager	Maritime shore based	12 years maritime
E	Professor	Maritime education	10 years maritime, 5 years educational
F	Project engineer	Industry	Unique*
G	Professor	Maritime education	3 years maritime, 18 years educational

*This respondent was snowball sampled as a part of the theoretical sampling process because of his unique insights into the concepts emerging in the analysis.

The respondents should also together represent a broad view of the maritime field, i.e., industry, education, shore-based, sea-based etc. Seven respondents were selected, and their key credentials are presented in (Table 1.) Programmes for web archiving were selected for their theoretical value to the concepts that emerged in the interview data and their geographical and cultural closeness to Denmark. The sampled programmes are listed in (Table 2.).

Table 2. Maritime programmes sampled.

Programme name	Institution(s)	Nationality
Maritime Management (MSc)	University of South-Eastern Norway (USN)	Norway
Maritime Management (MSc)	Chalmers University of Technology	Sweden
Maritime Engineering (MSc)	Nordic Five Tech*	Scandinavian
Maritime Affairs (MSc)	World Maritime University (WMU)	Sweden

*Alliance of the Nordic technical universities: Aalto University, Chalmers University of Technology, Technical University of Denmark, KTH Royal Institute of Technology and Norwegian University of Science and Technology

The sampling method of grounded theory is theoretical sampling. Theoretical sampling starts with a small sample that is analysed and then guides further sampling in an iterative process until theoretical saturation is achieved (Charmaz, 2014, Chapter 8). Theoretical saturation is achieved when no new properties or theoretical insights emerge from new samples.

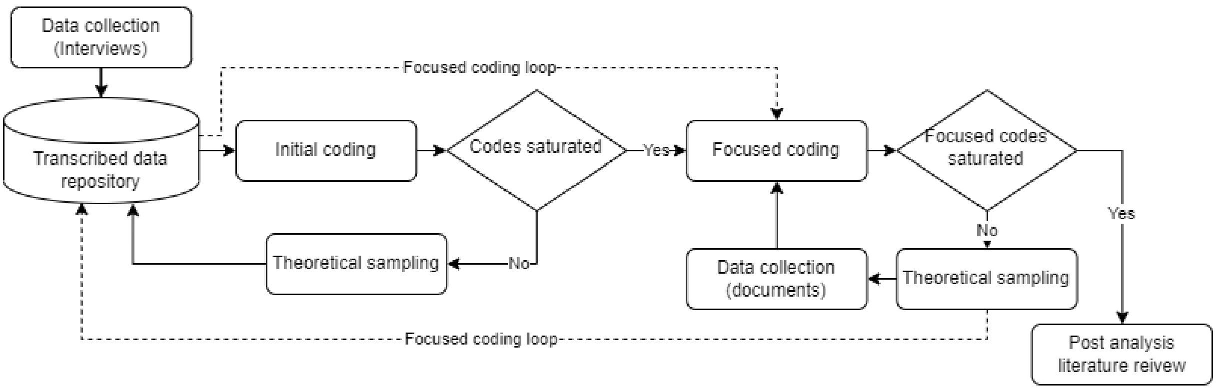


Figure 4. Phase 2 of Three Phase Research Framework

The data was collected and analysed using a modified version of the Three-Phase Research Framework (Yu & Smith, 2021) which systematically organises the process of theoretical sampling and helps determine when theoretical saturation is achieved. The framework was modified in Phase 2 (Figure 1.) because of practical considerations. Instead of doing a full analysis of each interview before conducting the next, a preliminary analysis was made to guide the process. All interview data were considered a repository that could be accessed during the full analysis to reach theoretical saturation.

All coding and memo writing was done using the computer-assisted qualitative data analysis software NVivo 20. The initial coding of interview transcripts was completed using a line-by-line approach to deconstruct the data sufficiently for the ideas to emerge that could escape in a more conventional thematic text condensation (Charmaz, 2014, p. 125). After the initial coding, focused coding was performed on the interview data. The focused codes were then enhanced using the data from the web-archived master programmes. The coding was completed using constant comparison method. The method can be broken into four steps "(1) comparing incidents applicable to each category, (2) integrating categories and their properties, (3) delimiting theory, and (4) writing theory." (Glaser & Strauss, 1967, p. 105).

4. Analysis

The first round of open coding resulted in 38 codes which were mainly descriptive and coded for topics and themes. This result did not contain codes with sufficient theoretical depth because of their more descriptive nature. A second round of open coding was performed on three transcripts, producing 75 codes with much higher analytic quality. Coding a few transcripts meticulously improves the understanding of the relevant material (Juul Kristensen & Hussain, 2019, p. 112).

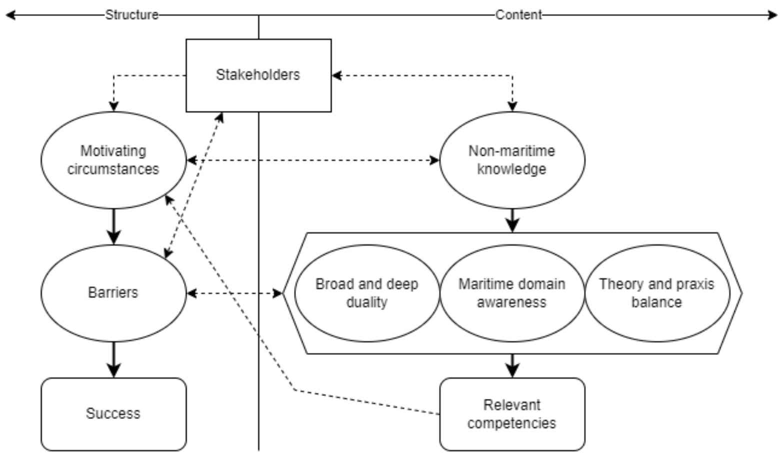
The codes from the second round of open coding were examined to see if any were suitable to become focused codes. The codes with a high appearance frequency in all tree transcripts were selected. Seven codes met this criterion, and two more were selected because of their explanatory value. The focused codes were formulated to include gerunds, emphasising the action or process. Each code was created by reviewing all coded text and the memos associated with each focused code using constant comparison on all levels. This process revealed that two of the codes were properties of other codes, ultimately resulting in a list of seven focused codes.

5. Findings

The focused codes found in the analysis were: Barriers, broad and deep duality, maritime domain awareness, motivating circumstances, networking, non-maritime knowledge and theory and praxis balance.

Barriers are circumstances that block the pursuit of a goal that, without the barrier, would be pursued. Broad and deep duality is the dialectic relationship between general and specialised competencies and the mastery level. Maritime domain awareness is the ability to apply non-maritime knowledge in a maritime context. Motivating circumstances are specific reasons for engaging in further education. Networking is creating and using interpersonal relations in the maritime field and becoming part of this practice. Non-maritime knowledge is knowledge from other disciplines that can become maritime by applying maritime domain awareness. The theory and praxis balance is the relationship between academic and explicit knowledge and vocational and tacit knowledge from both competency and epistemological perspectives.

The theory was constructed using the focused codes and their relations in the data. The theory is described in the following and illustrated in (Figure 2.).



Note. Solid arrows indicate a sequential move in the process. Punctured arrows indicate influence in either one or both directions. The bold black horizontal line indicates the border between the two core categories.

Figure 2. The Theoretical model

The contents of a master programme must contribute to the motivating circumstances. The contribution will be from the content offered (non-maritime knowledge) and from what the result is (relevant competencies). The content will be motivating because of economic value or personal interest. For all stakeholders to be motivated by content, it must strike several balances, most importantly the balance between a broad selection of subject matter while offering deep understandings in some areas. The balance must also be kept between theory and praxis to ensure a programme that meets all stakeholder expectations in a maritime context and the academic level of a master programme. Lastly, elusive maritime domain awareness must be systematically integrated into the program for every non-maritime knowledge subject.

The structure of a master programme revolves around removing barriers for stakeholders. If stakeholders are motivated by the content, only the barriers stand in the way of success. If the motivation is high, not all barriers must be removed. Removing some barriers can be costly, which may create new economic barriers. This problem calls for careful structure planning and stakeholder characteristics exploration.

Above these two dimensions the aspect of networking is hovering, which enables the program but is also a desired outcome of it and a valued competency or asset.

6. Post-analysis Literature Review

The motivations for seafarers to move from a seagoing career to one ashore can be psychosocial or structural (Haka et al., 2011). Haka argues that the psychosocial aspects are the main influence for staying at sea and going ashore. One of the largest motivations for leaving a seafaring career is the work/home balance (Caesar et al., 2021). It is also found that the salary plateau after four to six years of seafaring can contribute to the wish to leave. A major motivation for students and a major selling point for a maritime programme is the possibility of growing a network in the field. Interpersonal networks are very important to succeed in making a career. They are listed by Lau and Ng (2015) as one of the most important motivational factors for students attending maritime undergraduate and postgraduate programmes in Hong Kong.

The barriers for seafarers moving ashore can be summarised as four concepts (Barnett et al., 2006). Learned helplessness, progression from rating to officer, lack of appropriate qualifications and lack of opportunity. Of these concepts, the lack of appropriate qualifications is interesting in relation to a master's programme. Barnett et al. (2006) also list some reasons seafarers stay at sea. These reasons can easily be translated into barriers to moving ashore or engaging in education ashore. A seafarer's lifestyle and a high salary are mentioned as top factors.

The competence profile that satisfies students, industry and universities take is difficult to establish. Using industry-perceived needs as a guide leads to competencies related to operations and projects. The competence profile needed can be expressed as a T where the horizontal line represents general knowledge and the vertical line specialised competencies (Akademiet for de tekniske uddannelser, 2011). The competence profile tie into the theory and praxis balance which by some are seen as a vocational and academic division. Several studies describe this divide in upper secondary education (Halliday, 2000; Jaik, 2020; Nylund et al., 2017, 2018). The conflict also exists in higher education because of the pressure exerted by policymakers and neo-liberal market economy thinking (Rasmussen, 2020). However, some scholars argue that the tension in such a division can be harnessed and turned into a resource (Bartunek & Rynes, 2014).

7. Discussion and Conclusion

In the following the elements of the theory is discussed. The main motivating factor is the content of the programme, making it imperative to get right. This result aligns with other studies (Haka et al., 2011; Ng et al., 2009, 2011). Three factors play a role in transforming non-maritime knowledge into relevant competencies. Of these, maritime domain awareness is critical for resulting competencies to be relevant. Theory and Praxis must be both a motivator and a barrier depending on the balance struck. Broad and deep duality carries the same dialectic dynamic. It is striking the right balance in these areas that is imperative for success. The range of the specific content is wide, emphasising more on keeping content on a level that can foster deep understanding and ensure the vertical line in the T-profile. The horizontal line in the T is the knowledge for developing maritime domain awareness Content should be balanced carefully between theory and praxis, harnessing the strength of the tension between these.

Barriers are also a central element in the theory due to the weight of this topic in the data. Often the interview respondents spoke at length about specific barriers and their possible removal, often aligning with the concepts discussed by Barnett et al. (2006).

Some principles can be established. The first principle is to realise that a series of balances must be satisfied to create a successful programme. One must see these balances from the perspective of all stakeholders to get them right. Motivational circumstances must be created, and barriers removed for all stakeholders by adjusting content and structure. This theory and the focused codes should be regarded as the language for describing and explaining maritime education's creation process and help spark creative thinking. The complexity of the education field makes it beneficial to have such language to put the topic into perspective to the vast number of quantitative studies mapping industry competency needs.

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Factors Impacting Curricula in Maritime Simulator-based Education

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Abstract: The nature of the competencies that maritime students require to work successfully in the industry has undergone significant changes, which require higher education providers to adapt. The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) was adopted by the International Maritime Organization. The STCW Code includes both guidance and constraints for the maritime education and training (MET) curriculum, which may lead to wide variability in implementation. However, a curriculum is influenced by many factors, including regulatory, social and cultural factors. This study examines the impact of such factors on curricula in MET using a concept map based on relevant literature that illustrates the relationships between these factors. The findings highlight significant concepts and ideas for developing an effective, comprehensive and coherent MET curriculum to ensure that students acquire the necessary skills for this safety-critical industry.

Keywords: Maritime education and training; simulator education; curriculum.

1. Introduction

The evolution of technology and automation has a significant impact on maritime education. Numerous studies in maritime higher education have aimed to understand how educational practices can be improved to facilitate effective learning (De Oliveira et al., 2022; Nazir & Hjelmervik, 2017; Scanlan et al., 2022; Sellberg, 2016; Sharma et al., 2018).

There is a significant amount of ongoing debate surrounding what teaching should look like, what should be emphasised, what the curriculum is and how it can be better structured to meet students' needs (Behar-Horenstein & Niu, 2011; Biggs, 1996; Light, Calkins, & Cox, 2009; Moore, 2005; O'Connor, 2022; Oliver & Hyun, 2011; Ramsden, 2003). In terms of what is taught, the curriculum is frequently taken for granted and thought to be easily transferable into new forms (O'Connor, 2022). In most domains, higher education curricula transform in response to changing technologies, policies and economies. Therefore, there is a need for further studies to explore the curriculum in maritime simulator-based education.

This study presents a curriculum concept map to provide a broader understanding of a curriculum to facilitate its sustainable, comprehensive, engaging and effective. . The following section provides information about maritime education and training (MET) as well as curricula definitions to unpack factors that impact maritime simulator-based education.

2. Background

MET offers career opportunities at sea and on land in the maritime sector. After fulfilling their required sailing time, graduates may start employment as deck officers on various types of vessels. Teaching at the university level ensures seafarers' competency and qualifications in accordance with the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), which was adopted by the International Maritime Organization (IMO) in 1978 and entered into force in 1984 (IMO, 1978). The STCW Convention stipulates standards for seafarers' training, certification and watchkeeping. In addition, the Code includes specific recommendations on the training and certification requirements for different types of seafarers (e.g., deck officers, engineering officers) and ratings, which provide guidance whilst also placing restrictions on the MET curriculum.

'Curriculum' is a term that is used with several meanings and different definitions. The *curriculum* is classically defined as the foundation for the teaching-learning process, including instructional strategies, teaching methods, learning resources, lesson plans, evaluation and assessment, staff development and the reconstruction of the human experience within and outside of the school (Duncan & Frymier, 1967; Johnson Jr, 1967; Krug, 1957). Others incorrectly understand a curriculum as simply a basic lesson plan, despite it being more complex and multifaceted than a mere list or series of lessons. Many other factors affect student learning within and outside of the classroom. Therefore, understanding how these factors interact is crucial for any educator.

Table 1 provides relevant selected curricula definitions from the literature to provide a comprehensive understanding of curricula and their impacting factors.

Table 3 Curricula definitions.

Curricula	Definitions
Assessed	Measured through formal and informal assessments, which provide information on student learning and achievement, as well as feedback to teachers on the effectiveness of their instructional strategies (Kelly, 2009).
Co-curricular	Activities aligned with the curriculum and learning objectives that are designed to enhance the student experience (Kuh, 2001).
Extracurricular	Activities that are conducted under the auspices of the school but occur outside of classroom time and are not part of the curriculum. These activities do not involve a grade or academic credit, and student participation is optional (Bartkus et al., 2012).
Prescribed	At a system level, the competent authority prescribes the curriculum, which lays down what has to be learned at each stage of education (Barrett, 2020).
Received	Learned by students based on their experiences, backgrounds and interpretations of classroom instruction (Wiles & Bondi, 1984).
Self-directed	The process of taking control of and responsibility for one's own learning, which can occur in various contexts, including formal education, workplace training and personal development (Caffarella & Daffron, 2013).
Societal curricula	The knowledge and values that individuals acquire from various socialising agents, such as family, peer groups, neighbourhoods and mass media(Cortes, 1979).
Supplemental	Resources that support the curriculum textbooks, software and other media (Glatthorn & Jailall, 2000).
Taught	What is taught in the classroom, including the teacher's interpretation of the written curriculum, the teaching methods used and the learning experiences provided to students (Wiles & Bondi, 1984).
Programme curricula	Embodied in approved state and district guides. Explicitly documented, including syllabi, textbooks and other instructional materials. These guide what teachers teach in the classroom (Glatthorn, Boschee, & Whitehead, 2016).

3. Methodology

Guiding curriculum development is crucial because some curricula may not accurately capture the nuances and complexities of the subject matter, thereby leading to the oversimplification or exclusion of important concepts. A concept map is designed to depict significant connections between concepts in the shape of propositions (Novak & Gowin, 1984). Novak and Cañas (2008) defined concept maps as graphical tools for organising and representing knowledge. It aligns with the cognitive constructivist perpective, emphasizing how learners actively construct knowledge by connecting new information to existing frameworks. Concept mapping also embodies Ausubel's theory of meaningful learning, wherein interpreting, connecting and integrating new knowledge into existing frameworks enhances comprehension (Sexton, 2020). A concept map can structure a research project, reduce qualitative data, analyse the themes and interrelationships within a study, and present findings. Relationships are depicted by unidirectional or bidirectional arrows between concepts, with connecting words or phrases that form a meaningful statement (Moon et al., 2011). Creating a concept map requires generating, organising and refining ideas and concepts to produce a comprehensible and meaningful representation of the subject matter.

In the present study, we embarked on a systematic journey to construct a concept map that would aid us in the curriculum development process. Therefore, the key concepts were first identified through a literature review and engaging in in-depth discussions with experts within the maritime education domain. This helped to determine areas of overlap, knowledge gaps, and potential areas for additional exploration. These concepts were then connected with lines and arrows to illustrate their relationships. A box represents each concept, and the links between the boxes indicate the nature of the concepts' relationship. In this case, the curricula concept map was created to identify the key concepts and ideas that can be considered for use in curriculum development. Furthermore, this concept map align with Biggs' pedagogical principle of constructive alignment, a framework that ensures teaching methods, activities, and assessments are in harmony with the intended learning outcomes (Biggs, 1996). Integrating concept mapping into our study aligns with established educational theories and provides a pedagogically robust method for curriculum development, fostering improved knowledge organization. This map can be used to ensure that the curriculum development is comprehensive, coherent and centred on the most essential concepts.

4. Results and Discussion

It is essential to have a well-structured and comprehensive curriculum that directs teaching and learning processes. Curriculum development should consider some essential distinctions, such as inside-outside, subject-object, nature-culture, human-non-human, theory-practice and changes in time (Edwards, 2011). In this study, the concept map was divided into two parts, which are represented by the background being two shades of grey in Fig. 1. The top half focuses on factors outside of a student's control (university- or education system-related), whilst the lower half emphasises factors within a student's control. Since this study focuses on student-centred learning, it is essential to note that the received curricula are displayed at the centre of the concept map. Student-centred learning is an instructional method that places the student at the centre of the learning process. As such, the teacher serves as a facilitator rather than a mere transmitter of knowledge.

Additionally, the concept boxes have a dotted background pattern to indicate the rate of their evolution over time. Fewer dotted boxes indicate more extended development periods, whilst more concentrated dotted boxes indicate more frequent or rapid changes over time. Additionally, the connecting arrows and lines are labelled to demonstrate the relationships between the concepts.

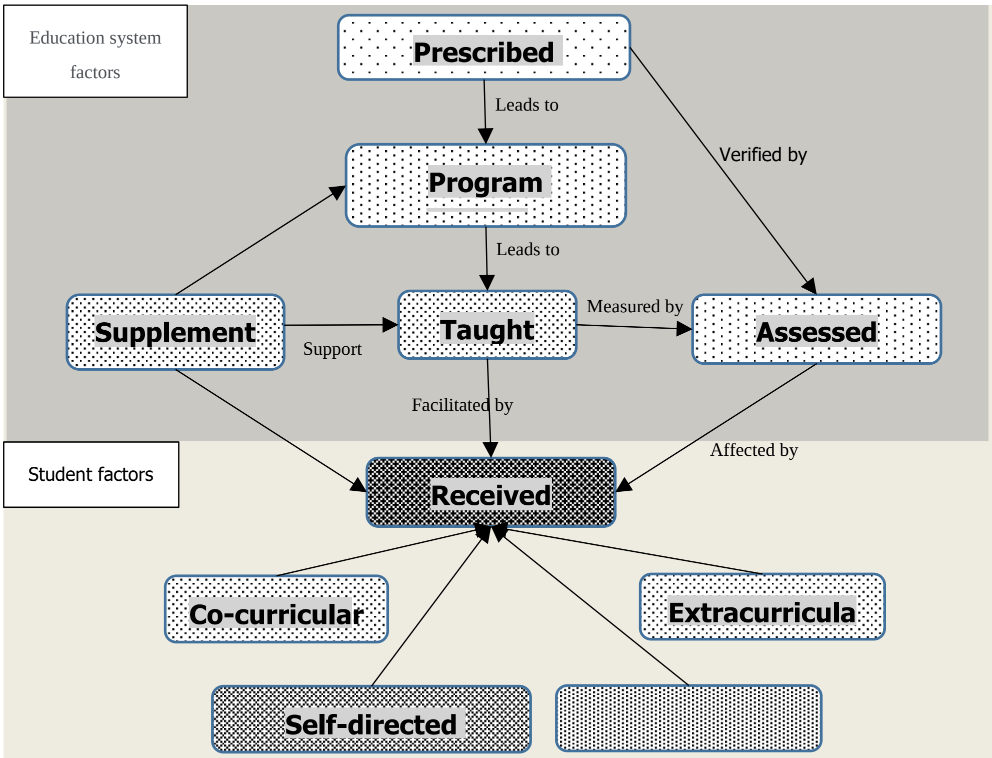

Fig. 1 Student-centred maritime simulator-based education curriculum concept map.

Prescribed curriculum refers to the subjects, knowledge and competencies mandated or suggested by regulatory bodies. The IMO is the regulatory body for MET since the STCW Convention specifies the minimum criteria for seafarers' training, certification and watchkeeping. In addition, the STCW Code provides a complete framework for institutions and teachers to build lesson plans, design assessments and apply teaching practices. Furthermore, national regulatory authorities in both the maritime and education also have influence on the MET.

Programme curriculum refers to a programme that institutions design following the requirements and standards established by the IMO, the state's relevant authorities and the needs of the industry. It is a set of educational objectives, content and instructional resources formed and documented by educational institutions or authorities and mandated to direct classroom instruction. It typically includes study plans, materials and guides. Additionally, incorporating simulator-based training within the program curriculum is closely related to the institutional approaches. Key determinants include the which simulator types to use, the allocated hours in simulators, and the number of simulator instructors. Overall, a programme's curriculum offers a structure for the delivery of maritime education and guarantees that students obtain a thorough and consistent education that fulfils the criteria of the industry and its regulatory authorities. Therefore, it is essential to regularly examine the curriculum and identify parts that may no longer be relevant or need to be updated. The quality and effectiveness of maritime education programs depend on students receiving a well-rounded, practical, and industry-relevant learning experience.

Taught curriculum is delivered to students by the instructor in a classroom environment. It is strongly affected by the programme curriculum but may differ due to factors such as the teacher's interpretation and instruction (teaching style), students' needs, and available materials. These are interdependent and essential components for taught curricula. The process of translating the prescribed curriculum into the taught curriculum is crucial. Moreover, the reasons why there may be a difference between the prescribed and taught curricula should be well understood. To bridge the gap between the prescribed and taught curricula, teacher training, enhanced collaboration amongst educational stakeholders and the adoption of new learning techniques should be considered. Additionally, the focus of instruction should be shifted from the teacher to the student, with the teacher providing guidance and support to help students take responsibility for their own learning, set their own learning goals and actively participate in the learning process.

Supplemental curriculum is an additional set of educational materials or programmes and can include intangible concepts such as a learning environment's culture, values and norms. In this case, the maritime culture may not be expressly included but influences teaching. Likewise, the maritime culture and community influence students' attitudes, values and behaviours.

Received curriculum is closely related to the implementation of student-centred learning. Adopting student-centred learning in higher education will likely increase the alignment between the taught and received curricula, thereby resulting in a more effective learning environment for students. This strategy empowers students to take responsibility for their education and acquire the skills and self-assurance necessary to become lifelong learners in a complex, ever-changing world (O'Connor, 2022). In MET, received curriculum refers to the knowledge, skills and competencies that students actually learn and internalise through their own experiences, interactions and interpretations of classroom instruction, which may differ from the taught curriculum due to students' varied learning styles, prior knowledge, personal perspectives, motivations, engagements with classroom instruction, practical training, real-world situations and societal factors.

Several concepts that occur outside of the school environment but are within students' control are presented in the second part of the concept map.

Co-curricular refers to activities designed to supplement a school's programme curriculum. These activities are outside of the regular programme curriculum but remain an integral part of the educational experience. Co-curricular activities in maritime education aim to improve students' personal and social development and academic abilities. In addition, they provide practical experiences that enable students to apply what they have learned in the classroom.

Extracurricular refers to activities that are organised outside of the regular programme curriculum and aim to develop students' maritime skills and knowledge. These activities aim to enhance students' personal and social development, as well as their academic skills, by providing hands-on experiences that complement the programme curriculum. Examples of such activities include participating in a maritime club or joining a sailing or rowing team. Students can develop leadership, teamwork and personal growth skills whilst gaining practical maritime knowledge through these activities.

Self-directed learning entails the learner assuming responsibility for their own learning process. This emphasises the role of the learner in establishing their own learning objectives, selecting appropriate learning activities and evaluating their own progress. However, biases can arise when students encounter information that is misleading, outdated or influenced by personal beliefs. To avoid this, students should consider the accuracy and reliability of the information they meet with scepticism. This may involve examining multiple sources, consulting with professionals and utilising credible training programmes and resources.

Societal curricula shape students' attitudes, values and beliefs, which can significantly impact their academic and personal development. This type of learning occurs due to students' interactions with their environment and people, both within and outside of the university environment. Societal curricula are frequently unconscious or implicit and may be influenced by university culture, social norms, educators and other adults' personal beliefs and biases. In this case, interactions involve maritime industry workers, regulators, maritime forums, shipping companies and even students from other maritime institutions.

Simulator education is foundational to MET institutions achieving many of the goals set out within the STCW Code, with multiple concepts within the map containing simulator usage. Since the IMO prescribes the use of simulators, METs design simulator use into their curricula and actively teach with them. Furthermore, simulators are used for assessments and supplementary material delivery. From the student perspective, simulators provide an engaging student experience and enable co-curricular activities.

The concept map illustrated in Fig. 1 is a valuable tool that can be used to enhance maritime simulator-based education. It can help educators organise and structure their knowledge, identify gaps in their understanding and establish connections between different concepts. By using the concept map as a reference, MET institutions can ensure that their curricula are comprehensive, coherent and aligned with the requirements of the STCW Code and the maritime industry. Utilising the concept map can also facilitate collaboration among the stakeholders involved in curriculum development, such as faculty members, industry experts and regulatory bodies. By sharing a collective understanding of the key concepts and objectives, these parties can work together to develop curricula that meet the needs of all stakeholders.

In conclusion, the concept map illustrated in Fig. 1 is a useful tool for enhancing maritime simulator-based education. Thus, it would be worthwhile to continue developing this concept map as a guide and educational development resource. The Centre of Excellence in Maritime Simulator Training and Assessment (COAST) consortium aims to develop a guidance document on curriculum synergies, which can later be disseminated at the international level to other professions using simulator training. It is planned to use the concept map as a tool to identify commonalities and differences in maritime institutions in Norway and develop strategies to address any gaps and best practices in the curriculum. It can facilitate collaboration among stakeholders and help identify areas where simulation-based training can be particularly effective.

5. Conclusions

To prepare students for the challenges of the 21st century, educators must accept the need for flexibility and adaptability in educational systems. This requires changes to curriculum and traditional pedagogical approaches with an emphasis on success in today's rapidly changing world. It is critical to define factors, stakeholders and objectives in detail when making decisions about curriculum development.

This study proposed a curricula concept map to identify the key concepts and provide valuable insights and recommendations that can be used to enhance the quality of not only to MET simulation education but also as a model that can be compared and used by other industries.

Future studies should aim to evaluate the effectiveness of the curricula concept map in guiding the development of maritime simulator-based education curricula. Exploring the impacts of curricula developed through the use of this concept map can provide valuable insights into the effectiveness of this approach. Furthermore, by continuing to build upon this study's findings, educators can better guide curriculum development to ensure comprehensive, coherent and effective learning experiences for students. This can ensure that students acquire the knowledge, skills and competence necessary to succeed in their careers.

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Assessing the Challenges to the International Convention of Standards of Training, Certification and Watchkeeping in the Era of Digitalization and Automation

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Abstract: Society is undergoing socio-technical disruptions. The shipping domain is not immune to these revolutions. To address these challenges, the maritime industry, including stakeholders such as shipping companies, regulatory authorities, classification societies, and education providers cannot afford to be reactive to digitalisation and automation advances. These end users must confront these wicked problems to ensure that safety, environmental protection issues and relevant business case(s) allow the shipping domain to thrive into the next century.

Keywords: digitalization; automation; STCW

1. Introduction

Industry is now understanding better the operational and technical disruptions implicit to the emergence of digitalisation and automation in future shipping operations. The International Maritime Organisation (IMO) has had a lens on these developments, promoting its e-Navigation [1] and MASS [2] concepts regarding future challenges and needs of the shipping industry. To date, most of the attention has been directed at technology readiness levels and system integrations. More practically, consideration of how to integrate with the human factor, emerging vocational roles and operator competencies has largely been ignored.

A holistic, comprehensive visioning needs to consider both technical and non-technical aspects within this new complex socio-technical landscape. While there are IMO working groups focused on regulatory considerations, less foresight and attention has been placed on the recruitment and retention of persons employed in the future Shipping 4.0 reality. This includes those entering the profession (i.e., Nautical Studies students), existing seafarers (i.e., continuing professional education) and the pedagogical professionals (i.e., instructors) where the impacts upon these stakeholder gaps have been identified [3, 4].

These education-based objectives can only be achieved if there is alignment between standards such as the International Convention of Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and the context of the environment (i.e, system technologies) typically delivered through third party vendors. A relevant example of poor human integration within a system is the design of the Electronic Chart Display and Information System (ECDIS) for navigation support [5]. Mismatches between the operator and the technology create conflict in the ¨*work as imagined*¨ (by the technology developers) and the ¨*work as performed*¨ (by maritime operators). While it might be thought that this is a fault of the technology developers, complicit are regulators, educators, and service providers in the perpetuation of these problems. These outcomes have created a situation that can ultimately increase the cognitive workload, create deviations in workflow/best practices and cause performance error escalation towards incidents and accidents.

There are many assumptions that the introduction of AI-driven technologies will ease the decision-making burdens of command, control, and communications in complex systems [6]. Specific to navigation and traffic safety, it has been proposed that the introduction of automation and artificial intelligence technologies could:

1. increase performance through automation intervention;
2. decrease operator workload;
3. require less operator knowledge;
4. create more flexibility in task procedures;
5. reduce operator error.

These *supposed* putative benefits must be considered through technological, regulatory, and educational lens so that potential punitive costs to navigation safety do not become the reality.

This paper aims to elucidate the socio-technical paradigm shift that should inform a rescoping of the educational and training outcomes related to the introduction of digitalisation and (low level) automation. The paper will advocate an appropriate human-centred/end-user approach to assess stakeholder needs and education development. This work will build upon activities related to the review of the STCW Convention and Code (IMO 2023, Sub-Committee on Human Element, Training and Watchkeeping, 9th Session (Item 7) and will consider the following recommendations to::

I. address the impact and possibilities of digitalization and emerging technologies on ships and ship operations;
II. address the impact and possibilities from the implementation and use of digitalization and emerging technologies in seafarers' education, training and certification;
III. ensure that the Convention and Code are fully aligned with the IMO standards on ship's operation, construction and equipment;
IV. take into account different approaches to organizing and structuring education, training and certification, including formats of delivery of training.

2. Ironies of Automation

Digitalization, (levels of) automation, artificial intelligence and machine learning continues to create significant disruptions in the maritime domain, particularly for the safe and efficient operations of vessels. One would think that moving cognitive challenging functions from humans to ¨machines¨ would result in positive impacts. This has repeatedly been proven an incorrect assumption [6].

In 2006, MSC 82/15/2 [7] identified issues regarding the proliferation of digitalization and automation within the maritime domain and are still pertinent today. MSC 82/15/2 (xii) recognized the inconsistencies in the display formats between manufacturers and called for a higher degree of standardization. While not the only example of the disruptions from digitalization and automation, the evolution of the Electronic Chart Display and Information System (ECDIS) serves as an example. Largely recognized in the seafaring vocation, the design of ECDIS for navigation support suffers from a typical operational paradox: it can create conflict in the ¨*work as imagined*¨ (by the technology developers) and the ¨*work as performed*¨ (by the end user group). While it might be thought that this is a fault of the technology developers, complicit are regulators, educators and service providers in the perpetuation of these problems. These outcomes have created a situation that can become precursors to increases in the workload required by the ECDIS users, deviations in workflow/best practices and performance errors that could escalate into incidents and accidents. These observations build upon a 2021 report [5] regarding the application and usability of ECDIS. Upon reviewing accident reports citing ECDIS as part of the accident chain and interviewing over 100 Subject Matter Experts (SMEs), the report concludes that *"ECDIS requires significant cognitive resources to use its functions, which has contributed to a minimalist approach by its users.* ¨, pointing towards challenges associated with ECDIS system design, practices and training. While ECDIS serves as an example of how technology may be friend or foe, it is not the only example(s). With increasing digitalization and automation, big data/AI/Machine Learning technologies related to alarm management and cyber security (for example) are suffering from similar poor design outcomes, lack of data transparency and inadequate training and education.

MSC 82/15/2 (ix) refers to systems that may not adequately support how operator(s) situation awareness (SA) is obtained and maintained. Simply described, SA is rooted in operator(s)' cognitive capacity to make accurate and timely decisions. In the navigation vernacular, this process can be generically described as an operator being *in*, *on* and *out* of the loop. But as the levels of automation becomes more embedded in real-time operations, operator SA may become more difficult to achieve.

3. Pedagogy, Regulations and Continuous Professional Education

Nautical academies have a responsibility not only to adhere to requirements prescribed by international shipping regulations and conventions, but to maintain a level of academic scrutiny whilst delivering credible academic programs. This trust includes educating beyond minimum prescribed standards but recognizing higher standards of best practices.

Technology and its applications to support the end-user(s) is not always straightforward and intuitive. In fact, using the ECDIS example above [5], often cite mode error as a contributing factor to the loss of situation awareness. In spite of model courses for ECDIS training, type-specific training and International Standard for equipment and systems (e.g. [8]) accidents and incidents occur and, anecdotally, many functions are difficult for the user to locate and deploy properly. Technology integration is often not user driven; human centered design is often ignored in the development process. Consequently, education providers are automatically one step behind. Technology developers view design through a *work as imagined* lens rather from the end user needs, who solves problems through a *work as done* heuristic. The training required to keep people, environments and assets safe in complex socio-technical systems cannot by prescriptive in design but must consider a more goal-based approach.

The environment for training and education is critical to allow sound learning to occur. Given the ubiquitous usage of complex technologies, integrated workstation, and teams, then learning platforms such as real-time, full mission simulators, virtual and augmented reality technologies need to be considered. While this might pose some economic and technical challenges for some education training providers, it seems likely that these platforms are the foundation for delivery solutions.

Current and near-future technologies in safe navigation will not be transparent and intuitive. It will create disruptions in the delivery of sound education. Theoretical ¨lectures¨ will only provide the basics and a general understanding of a technology. To really understand the technology, students will need time to use it in practice. To address these problems, one may argue that the curriculum requirements may be stripped of "old school items" no longer necessary to know. However, which items are we to remove? What will be the impact of removing a subject on general understanding on navigation and ability to navigate when technology fails?

Moving forward, educators, regulators and research must ensure that the Convention and Code are fully aligned with the IMO standards on ship's operations, construction and equipment (if not promote performance standards well above these minimum prescriptive proposals. HTW9/7/4, item 7.8 (the base document used at IMO for the work with the revision of STCW) states that a *¨significant number of inconsistencies were identified in the text of the annex to the STCW Convention and Code. Many of those are a consequence of amendments that were adopted in different periods of time. In addition, provisions having similar aims should be harmonized, especially but not limited to those in chapters II and III. The above may lead to ineffective implementation of the Convention. Thus, the Parties to the Convention and those involved in implementing, applying or enforcing its measures may not always give to the Convention full and complete effect in a uniform manner."*

Recognizing the importance of both technical and non-technical competencies/skills in the reliable, efficient and safe navigation of vessels in an increasingly evolving complex socio-technical system must inform regulatory and training standards. In document HTW9/7/4 (the following text is cited:

HTW9/7/4, item 7.3 E-learning : With the experience already gained in using new technologies in education and training, it is envisaged that further use of those technologies will continue. Therefore, a review of the STCW Convention and Code would allow for the development of teaching and teaching aids to supplement and support shore-based training, methods for assessment of competence, and approval and monitoring of courses including those outside the jurisdiction of the Party.

HTW9/7/4, item 7.4 Onboard training and use of simulators: It is important to focus on improving the quality of onboard and workshop skills training and seagoing service required in different chapters of the Convention, taking also into account up-to-date learning technologies, including simulators. The work already done at the IMO level and the new output on the "Development of measures to ensure quality of onboard training as part of the mandatory seagoing service required by the STCW Convention" can serve as the basis for the initial review.

Continued development and exploitation of training technologies and e-learning platforms may seem to be a ¨quick fix¨. However, our experiences of e-learning are not always been positive. It is easy to ¨click from one section to the next without learning in depth¨, but these technologies could be useful in the lifelong learning education paradigm. There has been a migration towards virtual training and perhaps it suits the people (i.e. millennials) we need to recruit and retain into the industry. However, technology ¨fixes¨ are not the near-term solution. Leaders in the domain must abandon band aid approaches.

4. Conclusions

The discourse of this paper are the collective thoughts of the authors. These thoughts have their foundations in both the academic and research literature, but most importantly the ¨coalface¨ experiences of technical lecturers with many years at sea, in the classroom and as valued subject matter experts informing the research strategy and program at our university. That being said, the future facing maritime education and training are challenging and difficult to operationalize from a pedagogical perspective.

Given the challenges and opportunities through digitalization and an increase of automated functions striving towards fully automated and autonomous operation of ships, the training requirements and vocational competencies must be revisioned [3, 4]. Recent research has made attempts to identify future training needs for seafarers by comparing the shipping industry to other domains such as aviation, rail, nuclear and mining [9]. Three key areas within these domains' training needs were identified; (a) Cognitive: the skill to think faster and learn easier through exercise, (b) Communicative: in addition to reading and writing, nonverbal communication through observing to infer the meaning and (c) Operational: the skill that includes analytical thinking, effective communication and taking efficient action. The top seven important skills listed were (i) emergency response (ii) communication (iii) well trained and multi skilled (iv) safety awareness, (v) seamanship (vi) tool handling and (vii) IT and cybersecurity [10]. These skills were related to the need for the ability of future operators´ to learn and relearn and to adapt and manage new situations, such as those resulting from emergent AI based technologies and resultant operational procedures. Scanlan et.al. [11] identified cyber security as a skill gap and suggest a revision of the existing Bridge and Engine Resource Management courses to provide necessary skills and awareness to address these challenges. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (IMO, 2011) focuses mainly on technical and operational skills although the Manila amendments to the STCW Convention and Code added changes in the training requirements concerning among other things leadership and teamwork together with modern training methodology including distance learning and web-based training. However, given the above-mentioned research results mainly focusing on "soft skill" development, one might argue the necessity to revisit the SCTW Convention to be able to meet the anticipated future training need for seafarers operating in a digital and highly automated environment.

In the near future Seafarers will remain on the bridge and in control; the education, training, and "core navigational knowledge" will remain both essential and required. It was further identified that the potential dangers associated with the use of any automated system including complacency and over-reliance should be taken seriously. These risks are also present with existing navigational aids, including ECDIS and radar which were clearly noted in IMO MSC 82/15/2. The participants in a research project investigating the influence of algorithm-based software to solve traffic solutions were clear that the technology manufacturers should not market these systems towards inexperienced, fatigued or poorly educated officers. Instead, at early adoption stages of automation and operational integration, decision support should be advisory in nature and provide well trained officers' rule-based information (COLREG) to make and execute a final decision for safe navigation [12]. Paradoxically, even with the risks described eloquently as the ¨ironies of automation¨ [13] in mind, most participants argue that knowledge of the COLREGs might be even more critically considered when using similar support tools. As such, the core knowledge of navigation in education may be improved because of these types of supportive technologies.

In many respects, navigation is social in nature. Is this because a navigator projects him/herself into the "shoes of a navigator on another vessel's bridge¨? Is the human operator trying to use past data or experience from the other vessel to try and understand the future intentions for both bridges?

What about the next vessel to be encountered? Does a navigator necessarily allow the ship to be put in a vulnerable position, which relies on the ¨common sense¨ of other agents within the traffic situation to remain safe? Tacit knowledge, critical thinking and other non-technical skills are clearly required to answer these questions. Current regulations and training tend to me more explicit and prescriptive in nature. It seems that a more constructivist approach to the education of future seafarers and other maritime stakeholders (*e.g.* shore control systems, intermodal logistics) will be in demand.

Will ships and the shipping system become fully autonomous in the near future? Given today's state of technology development and training paradigms, the answer is a considered ¨NO¨! It would likely be too dangerous to create an environment in which humans may be barriered against making safety critical decisions. Decision support systems will have some utility in the near future, but not without considerable reflection of the current regulatory, environment and the training standards. Continuing professional education will also be critical to solving these issues, to identify how the continuous disruptions brought about by new technologies will be managed.

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A Delphi Study to Formalize Domain Knowledge on Maritime Collision Avoidance and Inform Training.

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Abstract:
Maintaining effective situation awareness (SA) is a key facet that experienced Officers of the Watch (OOWs) build to practice safe collision avoidance and sound Bridge Resource Management (BRM). Novice OOWs lack the experience to efficiently use sources of information on the bridge to build and maintain SA. This research takes a human centred approach though a Delphi study to answer the following question: Can consensus be reached between domain experts to create a training tool to increase SA for collision avoidance amongst new watchkeeping officers? The study is founded in Endsley's model of SA and the COLREGs. The researchers will take a mixed methods approach and use a series of surveys administered through Qualtrics to elicit opinions from experienced seafarers as they relate to collision avoidance, SA information requirements, sources of information from bridge equipment, and BRM. The goal is to create a generalizable sequence for efficiently collecting information, supported by a consensus from the experts. In this paper the preliminary insights from the first round of the survey are discussed and the details for how subsequent survey rounds will be designed and administered is explained. If consensus is reached the resulting procedural training tool will be member checked for validation. It is anticipated that this research could improve OOW training programs by reducing the time required for novice OOWs to gain experience in SA for collision avoidance.

Keywords: Collision Avoidance; Maritime Educational Training, Bridge Resource Management, Situation Awareness.

1. Introduction

As the world rebounds from the COVID-19 pandemic, the demand is expected to climb for maritime shipping and subsequently trained seafarers, despite the already strained number of trained Officers of the Watch (OOWs) (UNCTAD, 2021; WMU, 2019). Compounding this problem, training a new OOW can take between 12 and 36 months (Canadian Coast Guard, 2022). Further, research has shown that novice OOWs when compared to experienced OOWs lack the same ability to exercise effective Bridge Resource Management (BRM) and skill to build and maintain good situation awareness (SA) (Atik, 2019; Chauvin et al., 2008). This distinction in experience is important as effective BRM and SA are key to maritime safety; poor SA can lead to an increase in human error and maritime accidents (Atik, 2019). The objective of the research is to gather domain knowledge from maritime subject matter experts (SMEs) on how they establish good SA for collision avoidance with the purpose of formalizing these mental models into procedural training tools such as a checklist.

Central to this research is Endsley's (1995) model of SA which is comprised of three levels: "perception of elements in the current situation, comprehension of those elements in the current situation, and projection of those elements into future states" (Endsley, 1995, p 36). This model designates the perception of the situation as level 1 SA, the comprehension of the situation as level 2 SA, and the projection into a future state as level 3 SA. To illustrate this model using a practical maritime example, consider the International Regulations for the Prevention of Collisions at Sea (COLREGs) rule 15 where two vessels that find themselves in a crossing situation (COLREGs, 2003). In this illustration, the OOWs in each vessel would have to perceive the elements in the current situation (level 1 SA) e.g., pay attention to their own position, course, and speed, as well as the relative location of the other vessel. The OOWs would also need to comprehend the elements in the current situation (level 2 SA) e.g., understand how their own position, course, and speed relate to the other vessel's position course and speed and the COLREGs rule that governs their interaction. The OOWs would finally need to project those elements into a future state (level 3 SA) e.g., recognize the expected actions of the stand-on vessel and the give way vessel and anticipate the approximate ranges where their decision/action is expected to take place. Although the example provides a linear sequence this is not necessarily the case in how SMEs establish good SA. Further, Endsley's model is non-linear, and the OOWs in the above situation may only need select pieces of information from levels 1, 2, and 3 to act in this situation.

2. Research Objectives and Methods

In this research we used a Delphi study to understand maritime operations and report the findings to answer the question: Can consensus be reached between domain experts to create a procedure to increase situational awareness for collision avoidance amongst new watchkeeping officers? To inform this research question, we are conducting a series of surveys. The surveys are designed to ask maritime domain experts their opinions on collision avoidance, best practices in use of bridge equipment, and bridge resource management. The surveys are administered through the Qualtrics™ web application and analyzed through NVivo™ software. Consensus will be measured quantitatively through statistical analysis while the respondents' goals and opinions will be elicited and recorded qualitatively to identify recurring themes related to safe maritime navigation through effective collision avoidance.

2.1 Intended Population

The population sought as participants are Canadian maritime SMEs with at least 5 years' experience as an OOW or Deck Watch Officer. The inclusion criteria included Master Mariners, harbour pilots, and maritime course instructors at nautical institutes, as well as other mariners from industry. We restricted the population to Canadian seafarers for ease of recruitment and commonality of practice; however, the results may be relevant to the broader maritime community as the basis of collision avoidance is in the COLREGs.

2.2 Delphi Methods

A flow chart of the anticipated sequence of the Delphi survey rounds is depicted below in Figure 1. The participants' responses will be tracked through the rounds to link changes in their opinions when presented with other participants' aggregated opinions from round to round.

It is anticipated that the study may involve upwards of four rounds of surveys, however the objective of a Delphi study is to assess consensus or stability in the responses, not to complete a certain number of rounds. It is possible that consensus could be generated in three rounds, or it may require five rounds. If consensus cannot be achieved, then emphasis will be on the stability of responses between the rounds (von der Gracht, 2012). The lack of consensus on a topic can be as profound as consensus.

2.3 Survey Question Design

The initial round of the survey will collect demographic information and gather the SMEs opinions of goals, factors, and information requirements related to SA for collision avoidance. Sample questions from the first round include "What does risk of collision mean to you?", "How do you determine if a risk of collision exists?", "What factors influence the methods in determining a risk of collision?", "What does BRM mean to you?" and "What advice would impart to a new watchkeeping officer?" The survey will also ask questions on the utility and reliability of bridge equipment, specifically Electronic Chart Display Information System (ECDIS), Automatic Identification System (AIS), radar and Automatic Radar Plotting Aid (ARPA), and radio-telephone information, including Vessel Traffic Management Systems (VTMS).

As part of the Delphi process, the results of each round will inform the development of later rounds (e.g., each round of questions will build off the participants' responses). The second round will refine the respondents' opinions of specific collision avoidance goals by presenting aggregated thematic responses from round one to the participants. Participants will be asked if they have a preferred mental model or sequence for collecting information on the bridge to support SA and collision avoidance. Round three is dependent on the results of round two and is planned present a sequence for information collection to support collision avoidance for the group's feedback. Consequently, round four will likely be a confirmation of consensus in the responses.

Participants' responses will be tracked throughout the rounds of surveys to monitor for changing opinions through the process. Once a list of key goals and processes is generated and agreed upon by consensus, the list will then be member checked by a separate panel of SMEs. Member checking is a tested method of validating qualitative research and is used in other research on SA in the maritime sector (Braun and Clark, 2013; Creswell, 2014; Morse, 2015; Sharma et al, 2019).

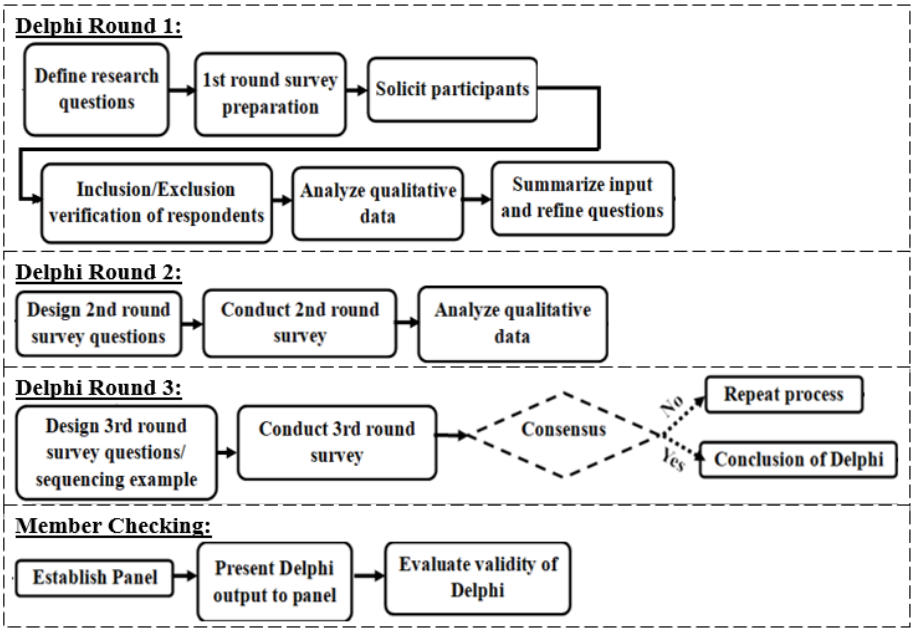


Figure 5 - Flowchart of Delphi method for study (adapted from Kim and Mallam, 2020).

3. Preliminary Findings

3.1 Participants

Recruitment for participants commenced in March 2023. Solicitation took place by word of mouth within the Canadian seafarer community and was aided by social media announcements by the Master Mariners Association of Canada and the Center for Marine Simulation at the Marine Institute of Memorial University of Newfoundland. The recruitment information was also shared peer-to-peer within the Shipping Federation of Canada and the Canadian Pilotage Association. The first round of the survey was closed in April 2023 and resulted in 17 respondents who met the inclusion criteria of the study. These respondents will be invited to participate in subsequent rounds of the Delphi process. A summary of the demographic statistics is included in Table 1. In total,137 initial responses were recorded however 120 were excluded for not meeting the inclusion criteria or based on fraud/bot detection.

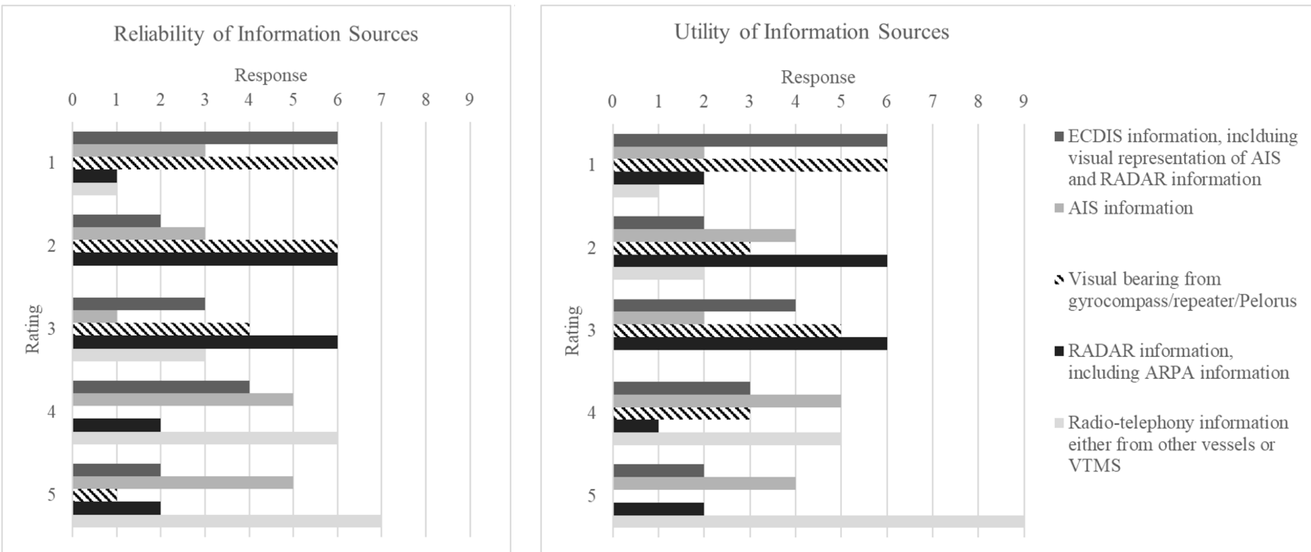
3.2 Initial Responses from First Round

Participants were asked to describe what 'Risk of Collision' meant to them and if there was a specific Closest Point of Approach (CPA) that they considered to have inherent risk of collision. Then, the subsequent questions used a storyboard to describe a scenario at sea where the participant would be encouraged to elaborate on their process for collecting information and describe factors affecting their process and their information requirements to decide to act to avoid collision. These questions were developed to link the language of the COLREGs and their interpretation with the industry standard *A Guide to the Collision Avoidance Rules* (Cockroft and Lameijer, 2011). Additionally, the survey asked participants what BRM meant to them and asked them what advice they would impart to a new watchkeeping officer. These questions were designed to draw out any more information on their interpretation of BRM and collision avoidance practices while considering their interpretation of important knowledge to help a new watchkeeper succeed at sea. For this round of the survey, qualitative analysis is still underway through NVivo software.

Table 1 - Demographic statistics of the participants in the study

Criteria of classification	**Statistics**	**Frequency**	**Percentage (%)**
Age	20-30	3	17.6
	31-40	7	41.2
	41-50	5	29.4
	>50	2	11.8
Certificate of Competency (CoC)	Master Mariner	6	35.3
	Master 3000t (Near Coastal and Domestic)	3	17.6
	Master 500t (Near Coastal and Domestic)	3	17.6
	Chief Mate (Unlimited and Near Coastal)	2	11.8
	Watchkeeping Mate (Unlimited and Near Coastal)	1	5.9
	Fishing Master	2	11.8
Years experience at sea	5-10yrs	7	41.2
	11-15yrs	6	35.3
	>15yrs	4	23.5
Gender expression	Male	15	88.2
	Female	2	11.8

The survey also asked questions related to utility and reliability of bridge equipment, specifically ECDIS, AIS, radar and ARPA, and radio-telephone information, including VTMS. The quantitative responses regarding perceived utility and reliability of bridge equipment as potential sources of information were available for reporting. Figure 2 shows the participants ranking of the sources of information related to their overall reliability (Figure 2.a) and utility (Figure 2.b), while table 2 shows the descriptive statistics of the responses for reliability (Table 2) and utility (Table 3).



(a) (b)

Figure 2. Ranking of information sources for (a) reliability and (b) utility.

Table 2. Descriptive statistics of ranking of reliability of information sources.

Ranking of Reliability	Mean	Median	Mode
Visual bearing from gyrocompass/ repeater/ Pelorus	2.00	2	2
ECDIS information, incl. visual representation of AIS and/or RADAR	2.56	2.5	1
RADAR information, including ARPA information	2.81	3	2
AIS information	3.50	4	5
Radio-telephony information from other vessels or from VTMS	4.13	4	4

Table 3. Descriptive Statistics of ranking of utility of information sources.

Ranking of Utility	Mean	Median	Mode
Visual bearing from gyrocompass/ repeater/ Pelorus	2.25	2	1
RADAR information, including ARPA information	2.56	2	2
ECDIS information, incl. visual representation of AIS and/or RADAR	2.63	3	1
AIS information	3.50	4	4
Radio-telephony information either from other vessels or from VTMS	4.06	4.5	5

Early results indicate that compared to the sources listed, the participants ranked ECDIS information to be the most reliable and visual bearings or observation being the most useful source of information. Radio-telephony information was considered to be the least reliable and least useful.

4. Future Surveys

As shown in flow chart of the Delphi process in Figure 1, results from initial round will inform subsequent rounds of surveys. Conceptually, the goal of the second round of the survey is to narrow the focus in on the processes and information requirements for collision avoidance to produce a sequence for information gathering to be evaluated in subsequent rounds. To support this goal, the intention is to ask the participants how they cross reference their sources of information. For example, participants listed ECDIS as the most useful and reliable source of information, but frequently discussed visual assessment or RADAR assessment. Follow-up questions would ask participants 1) how they compare information between the sources, 2) if they have instances where they would trust one over the other, and 3) if there are methods for optimizing cross-referencing. These questions will help to understand if SMEs employ redundancies in their information gathering. For example, do SMEs take advantage in the designed latency of ARPA plotting to check a visual bearing or ECDIS information. Further, the intention is to pose elaborative or probing questions to understand the generalizability of information gathering processes and how participants support the development of all three levels of SA in Endsley's model.

Consequently, the information collected in the second round of the survey will be used to hypothesize a sequence of gathering information for collision avoidance that is generalizable and useful. The sequence will be presented to the participants in round three to get their opinions on sequencing and on the benefits and drawbacks of that sequence. It is in this round and the next rounds where the measurement of consensus will take place. Since the participants in this round will have been with the study from the beginning, we believe that there will be sufficient context provided to the participants to have them comment and work towards consensus on the sequence.

If consensus can be achieved, or if the responses from the participants have been stabilized, the Delphi portion of the study will be concluded. The resulting product of the Delphi process in the way of a procedural training tool will then be member checked against a separate panel of SMEs who will provide validation and additional insight into the product (Braun and Clark, 2013; Creswell, 2014; Morse, 2015; Sharma et al, 2019). As the participants will be included in each round of the survey, potentially becoming a niche community of practice, their responses may become skewed. The purpose of the member checking SMEs is to confirm that the output of reality matches. Ideally, the SMEs will be checking a consensus-generated sequence for collecting information and establishing situation awareness in the context of collision avoidance. If consensus cannot be achieved, the areas of disagreement and stability will be presented to the panel for their comment.

5. Conclusion

This paper reports the preliminary results of a Delphi study. The participants consider ECDIS to be the most useful, but visual assessment to be the most reliable sources of information on the bridge. Conceptually, this makes sense. ECDIS provides a collated picture of many sources of information. Before ECDIS, the OOW had to create a mental model from a paper chart, radar, and other sources to get the same picture. It is important to also see that the participants still greatly value visual observation. Maintaining a lookout by sight, hearing, and all available means is still a tenant of collision avoidance (COLREGs, 2003). In subsequent rounds, we will work to see the why behind their initial responses. This knowledge will be important to the development of a potential sequenced checklist for gathering information and building SA.

The resulting formalized processes from this research have the potential to assist trainee OOWs in developing BRM schema for the efficient use of bridge equipment and lead to improved situation awareness. Consequently, the formalized processes could shortcut the time to expertise (Endsley, 2018) and be used to change OOW training programs to address the growing demand for seafarers.

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Enhancing e-learning in Maritime Education and Training: Action research in Vietnam context

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Abstract: In the recent decade, e-learning has gained momentum as a potential educational modality in the maritime field, especially after the effect of the COVID-19 pandemic. Yet, the dominant classroom teaching approaches in some maritime educational institutions seem to constrain the effectiveness of e-learning. Therefore, the paper aims to investigate the current status of e-learning implementation in one Vietnam maritime educational institution and deliberate the change regarding the teaching methods, inspired by constructivist approach. To reach the aim, the authors employed a three-phase action research cycle: 1. Understand the context, 2. Deliberate change, 3. Evaluate the results. The study generated the picture of challenges, benefits, and opportunities of e-learning in the context of the Vietnam institution and yield implications of constructivist approach in the online learning environment.

Keywords: e-learning; teaching and learning methods; constructivist approach, action research, maritime education and training

1. Introduction

Maritime industry has witnessed dramatic development of technologies, disrupting numerous areas within the domain. For instance, the emergence of autonomous ships accelerates the change in international regulations to govern them (International Maritime Organization, 2021). Further, the blooming of artificial intelligence and big data has aided the decision-making processes on ships (Ziaul et al., 2020). Besides, many shipping companies have experimented the new environmentally friendly fuel, such as biodiesel, to cope with the stringent emission regulations (Noor et al., 2018).

The advancement of technology has also impacted the educational aspect of the maritime industry. Some maritime education and training institutions (METIs) are using simulation, augmented reality, and virtual reality to complement their classes (Mallam et al., 2019). Besides these tools, e-learning appears as a notable education modality which is widely applied by METIs. Although some scholars still question the appropriateness and the applicability of e-learning in maritime field (Galić et al., 2020), its benefits and popularity are undeniable, especially during the COVID-19 pandemic. In 2020, over 40% of METIs reported using e-learning to a medium or high extent (Maritime Training Insight Database – MarTID, 2020). Further, in the same survey, more than 80% of METIs expressed their belief that e-learning will be more prevalent in the training of seafarers.

However, the dominant education modality in METIs is classroom-based learning (MarTID, 2020). Therefore, when lecturers or instructors deliver their lessons in an online environment, they tend to use the same teaching methods, which may limit the potential of the e-learning platform (Bhandari, 2017). Thus, the paper seeks to explore the current status of e-learning implementation in METIs and deliberate innovative teaching approaches to enhance e-learning lessons. To achieve this purpose, the authors chose action research methodology.

2. Methodology

Action research (AR) is a branch of qualitative research methodology (MacDonald, 2012). AR encompasses a series of research activities and methods such as observations, interviews, experiments to investigate the phenomenon of a specific community. The noteworthy thing in this approach is the collaboration between researchers and practitioners directly affected or involved in the phenomenon. This collaboration will then generate actionable knowledge, aiming to improve the situation of the community. Kurt Lewin (1946), who is said to be the father of this approach, once said, “You cannot understand the system until you try to change it” .

In this study, the authors will work together with the METI’s lecturers and students to understand the current status of e-learning, discuss possible changes in teaching methods, apply and evaluate them. To conduct these research activities rigorously, the academics established a three-phase action research cycle based on a systematic framework proposed by Dittrich et al. (2008) (see Figure 1).

In the first phase, the researchers joined current e-learning classes and observed. After that, we conducted a semi-structure with students and lecturers. These data give us a more comprehensive understanding of the e-learning implementation in the institution. Then, we moved to the next phase, where we worked with lecturers based on the students' needs to generate innovative teaching approaches. We played the role as lecturers to deliver a subject-related matter with the new methods. Finally, in the last phase, interviews are conducted with lecturers and students to evaluate the effectiveness of the teaching approaches.

Action research takes form of a cycle due to the nature of change. As mentioned, the approach will strive to deliberate positive change. However, opposition to change is typically challenging, especially with long-lasting practices. Therefore, the idea is to make a small incremental positive impact with each cycle and repeat the process. This reduces the change resistance and increases the beneficial impact of the study on the chosen community.

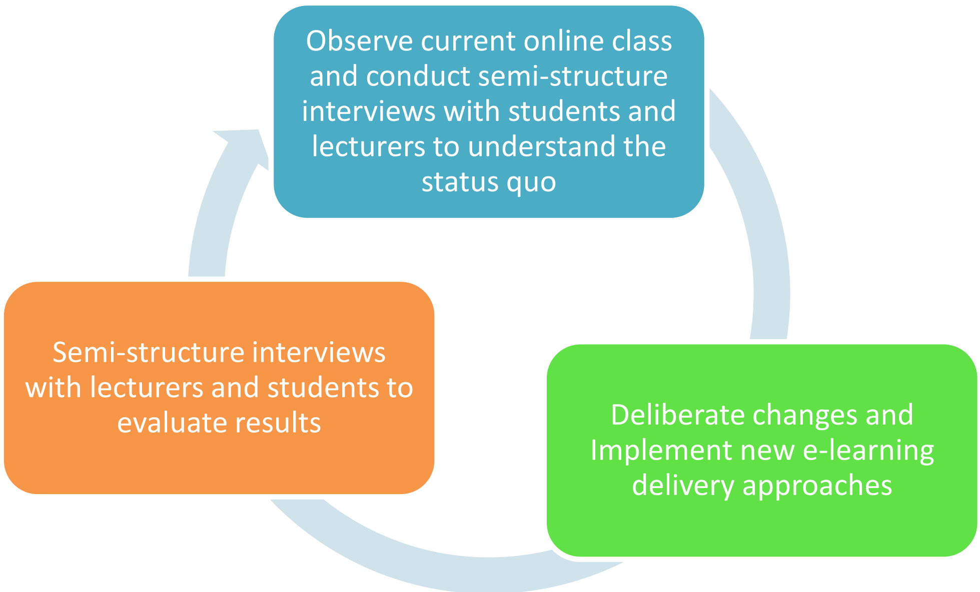

Figure 1. Action research cycle

3. AR phases and Findings

The authors employed a thematic analysis approach to process the data of the observations and interview activities. This technique focuses on identifying common patterns in the data and codifying them into basic themes. Then, we connect these basic themes to form overarching themes for a clear picture of the results. Nvivo software was used to aid this process.

3.1 Phase 1: Understand the status quo of e-learning implementation in the METI

In phase 1, we identified three overarching themes: Opportunities, Challenges, and Needs. For Opportunities, there are two basic themes: perceived advantages and acceptability. The authors discovered that both lecturers and students appreciate the benefits of e-learning, such as flexibility, time and cost saving. Further, they also believe that e-learning could be a part of a blended learning system in the future.

The theme Challenges covers numerous difficulties confronting lecturers and students in online classes, including interaction, distraction, information technology skills, health issues, equipment, university support and internet connection. Many students and lecturers reported a lack of interaction in e-learning classes. This is understandable due to the nature of e-learning where we can only see the voice and the "talking head" of the participants with the current technology. In the actual class in the study, it is even worse because both lecturers and students did not open their cameras, leaving only voice as a means of communication.

Students are usually distracted in an online class as they join it at home, where they can be bothered by family members. Another challenge is the lack of information technology skills; some students are not familiar with the e-learning platform, thus, cannot use its function. This negatively impacted the quality of the lesson. Health issues are also mentioned when participants stare at the screen for a long time, leading to many eye problems. Besides, lecturers stated that they lack the necessary equipment like smart interactive boards and pens to improve the quality of their lessons while the university support is limited. Some students must borrow their friends or family's electronic equipment to participate in the online class. Last but not least, internet connection is a notable challenge. Both lecturers and students sometimes encountered poor internet connection, making it challenging to follow the class.

Another important theme is Needs, which is formed by two basic themes: knowledge and skills, teaching methods. Lecturers believed they needed to be equipped with more knowledge and skills regarding student psychology, voice training, and body language to improve online classes. For students, they emphasized the importance of information technology skills, which help them to engage to the class. Both lecturers and students highlighted the need for new teaching methods to make e-learning more engaging and effective.

These opportunities, challenges and needs are interrelated with each other. One basic theme can affect another and vice versa. For example, a poor internet connection may affect the interaction between lecturers and students and distract participants. The result of phase 1 is summarized by figure 2.

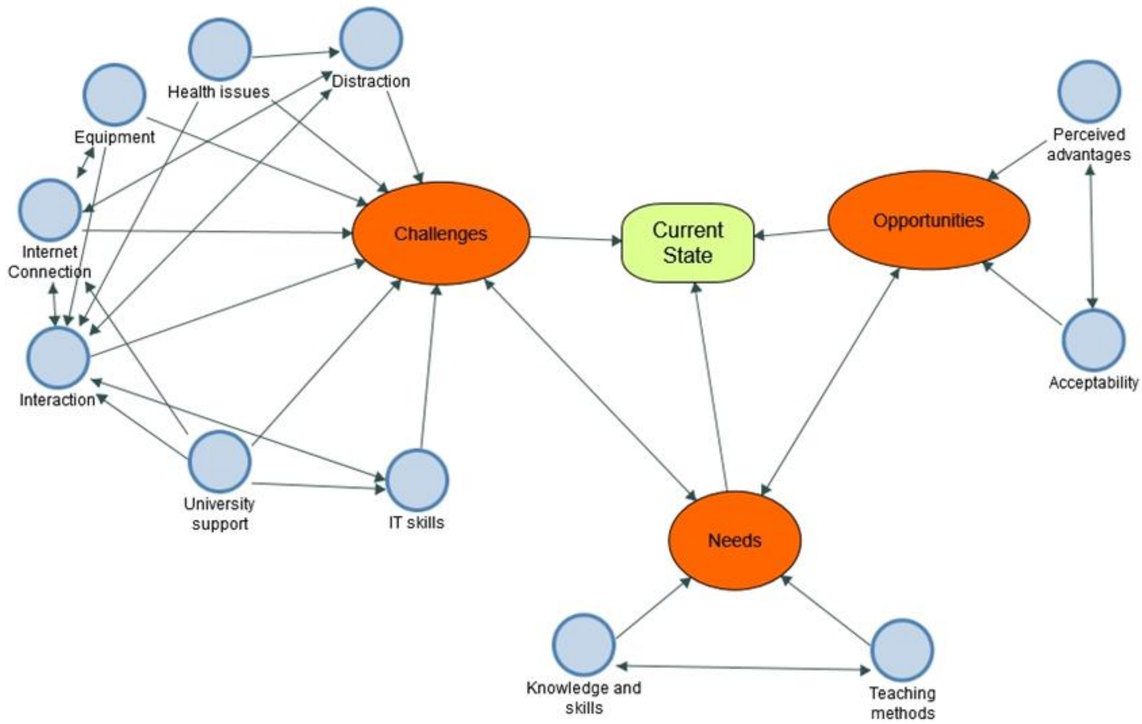

Figure 2. Phase 1's findings

3.2 Phase 2: Generate new teaching approaches, and implement them

Based on the findings of phase 1, we discuss with lecturers and students to generate innovative teaching approaches, aiming to enhance the interaction in the online class. Inspired by constructivism, cognitivism and connectivism theories, we created a set of teaching methods (see Figure 3). Then we played a role as lecturers to deliver subject matter, employing these new methods in online classes. First, we familiarize students with warm-up and ice-breaking activities, making them more comfortable. Second, we encouraged students to open their cameras. Interestingly, two-thirds of classes let us see their faces, which would enhance the interaction during the class. We begin the class with the diagnosis test, including some questions to test their prior knowledge about the teaching topic. After that, we conducted student-centered activities such as group discussion, problem-based learning, and role-modeling situation. With our guidance through the lesson, the engagement level of students increased significantly. Finally, we ended the class with a summarized mindmap to consolidate the fundamental knowledge for students about the topic.

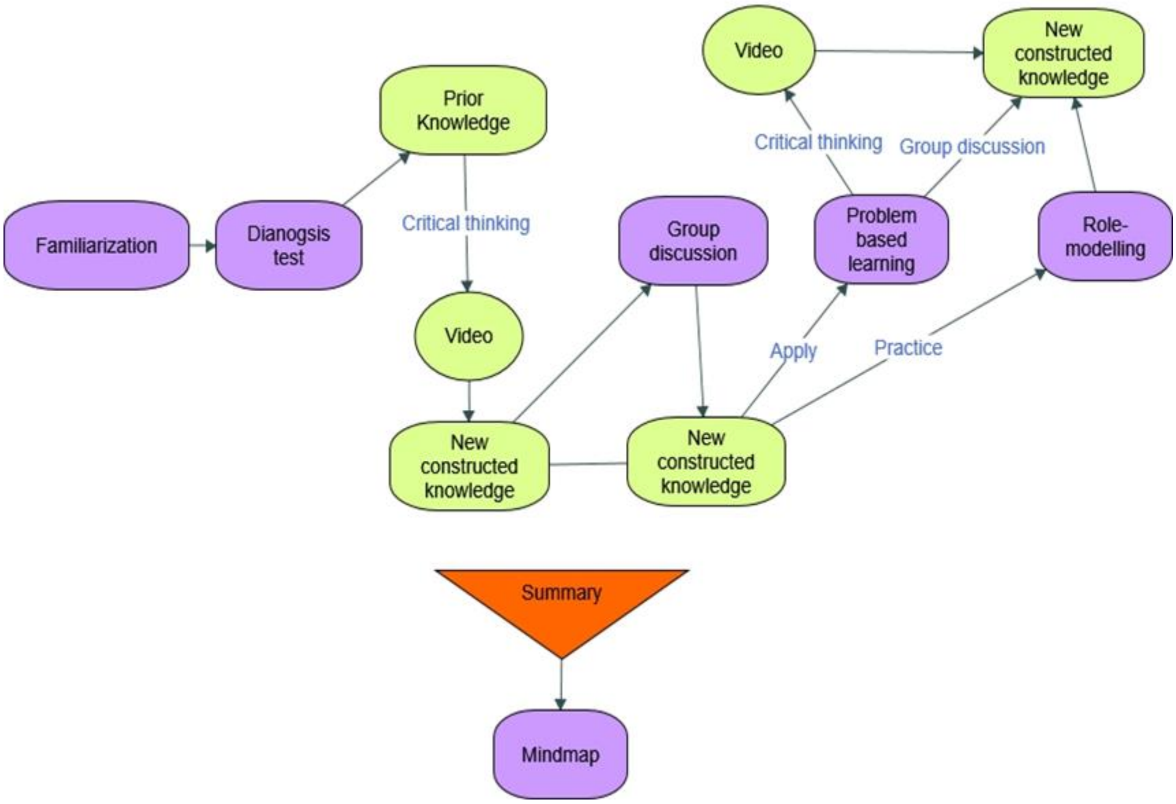

Figure 3. Set of innovative teaching approaches

3.3 Phase 3: Evaluate the results

Immediately following the experimental classes, we conducted the interview with lecturers – who served as an observer during the class – and students to capture their thoughts and reactions. After analyzing the interview data, we explore some implications of the new teaching approaches and some noteworthy things when applying these methods:

Interaction is key

The enhanced interaction during the classes improves the concentration and engagement of students, thus, increasing the quality of the online lessons. The communication between participants helps students acquire a deeper understanding of the problems.

Actively constructing knowledge enhances its retention

In student-centered activities such as group discussion, problem-based learning and role modeling, students are the ones who actively find new knowledge following the guidance of researchers (as lecturers). At the end of the classes, some students can confidently summarize the lessons' content. And they also realized that they could capture the knowledge easier during the interview.

Intended learning outcomes, and assessments are associated with teaching methods

Although participants appreciate the benefits of the new teaching approaches. The concern of choosing the right content and harmonizing with intended learning outcomes and assessments is noticeable. For a teaching method to be effective, it needs to go in harmony with the intended learning outcomes and the assessment methods.

Students' background is a concern

Students' background reflects their habits, personalities and behaviors. During the online classes, some students still remained inactive because they are used to receive the knowledge passively from lecturers. Therefore, lecturers should pay more attention to these students and have incentives (e.g bonus grades) to encourage them to participate in teaching activities. Further, diversifying the teaching methods is also a good solution.

4. Discussion and Conclusion

The study has yielded implications for all the participants of the research, including the authors. For lecturers, they will have more ideas for designing engaging and interactive online classes. They will be able to reiterate the action cycle in their own way. Students will be more active when constructing their own knowledge, thus, making their study more interesting and effective. The researchers also gain a deeper understanding of the e-learning situation in a Vietnam METI context.

One limitation of the research is its small scope (i.e, within a Vietnam METI). Hence, the generalizability is questionable. However, the paper provides the framework for other researchers, lecturers to adapt to their own context. Although the outcomes of the research are small steps to improve e-learning in MET, significant change may start from modest initiatives. The authors hope that the study will pave the way for future research endeavors to investigate this potential learning modality in the maritime context.

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