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Preface

The IAMU Conference (IAMUC) is the part of the 22nd Annual General Assembly (AGA 22) 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 researches.

Travel restrictions, imposed by the COVID-19 pandemic, shifted scheduled hosting of the IAMU AGA at Batumi State Maritime Academy from 2020 to 2022.

The pandemic period is over and IAMUC 22 invites the international experts to disseminate their latest research results. As the hosting university, Batumi State Maritime Academy provides both face-to-face and online participation in the Assembly activities.

"Best Practice: MET and Research for Sustainable Development" is the theme of the AGA 22 IAMUC.

The IAMUC program covers the whole range of Maritime Domain incorporating Environmental, Technology, Economic, Social and Policy sections. The Conference topics deal with Prospective Technologies in Shipping and Offshore Industries, Strengthening Life Long Learning in MET through Innovative Methodologies Application, Enhancing Maritime Safety and Security and Save Our Seas – Environmental Protection Provision.

IAMUC 22 participants are offered to take part in technical workshops and to discuss a wide range of scientific researches with keynote and invited speakers.

"Proceedings of the International Association of Maritime Universities (IAMU) Conference" contain the papers, presented at the technical sessions. Ninety-four high-level abstracts from 22 countries and 35 IAMU universities were submitted to IAMUC in 2022. The double peer-review process of submitted full papers resulted in inclusion of 47 papers to the Proceedings.

All submitted papers, approved by blind reviewer, are included in the Book of Proceedings. The papers are accepted for publication in accordance with their innovation and relevance to the aspects of the Maritime Domain. We hope that papers, presented in the Proceedings, will support teaching, learning and researches of maritime education and training.

The oral presentations at the sessions are followed with the poster presentations held during coffee/tea breaks, although all posters are displayed within the whole conference.

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 BSMA 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 22, will promote the future success of Maritime education, training and research.

Associate Professor Nino Kurshubadze IAMUC 22 Program Editor

Professor Boris Svilicic IAMUC Chief Program Editor

Theme

Best Practice: MET and Research for Sustainable Development

- *Prospective Technologies in Shipping and Offshore Industries*
- *Strengthening Life Long Learning in MET Through Innovative Methodologies Application*
- *Enhancing Maritime Safety and Security*
- *Save Our Seas – Environmental Protection Provision*

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IAMUC 22

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IAMUC 2022

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Session

Environmental Aspect

Preventing pollution of Adriatic Sea: Oil spill trajectory model using Pisces II scenarios and effects of incident on marine environment using multiple regression

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Abstract: Oil spill is the release of a liquid petroleum hydrocarbon such as crude oil, refined petroleum such as gasoline or diesel fuel into the environment due to human activity, which can cause devastating impact to marine ecosystem. According to International Maritime Organization (IMO), oil tankers transport approximately 2900 million tons of crude oil and oil products per year. The quantity of oil spilled annually into oceans exceeds one million metric tons and oil spills have large impact on wildlife and economy as well. This paper presents the simulation of oil spill trajectory on water surface in the Kaštela Bay (in the Adriatic Sea) created by PISCES II simulator. The Kaštela Bay is semi-enclosed basin with cargo port and terminal for petroleum products distribution. The scenarios determinate processes with oil spill in marine environment: the trajectory of oil spill, chemical changes of oil and persistence of oils in the air, water column and sediment. The result of two different scenarios are shown in order to give an insight into potential oil spills impact on marine environment in this sensitive location. Furthermore, observing through whole linear multiple regression model (F=2.734; R=0.517; p=0.097) variable height of wave was identified as significant predictor of speed at which oils spread in (b=1.965; p=0.047). The paper presents different scenarios of oil spill from ships incident scenarios in particular sensitive area and gives the as well as correlation between relevant predictors and speed at which oil spreads. It can also serve as starting point for risk assessment analyses of the incidents in order to minimize the negative impact of oil spills on marine environment.

Keywords: oil spill, marine environment, scenario, PISCES II, the Kaštela Bay

1. Introduction

Oil spill is the release of a liquid petroleum hydrocarbon such as crude oil, refined petroleum such as gasoline or diesel fuel into the environment due to human activity, which can cause devastating impact to marine ecosystem.

According to International Maritime Organization (IMO), oil tankers transport approximately 2900 million tons of crude oil and oil products per year. The quantity of oil spilled annually into oceans exceeds one million metric tons and oil spills have large impact on wildlife and economy as well.

This paper presents the simulation of oil spill trajectory on water surface in the Kaštela Bay (in the Adriatic Sea) created by PISCES II (Potential Incident Simulation, Control and Evaluation System) simulator.

Pisces II has been used for spill trajectory in this research. In this paper, multiple regression is used to determinate how predictors such as currents speed, salinity, air temperature, height of wave, water temperature, and wind speed impact on the speed of oil spreading.

2. Literature review

Spreading of oil layer is dominant process in spillage process. According to Fay (1971), it is possible to examine spread motion in three stages. The beginning one covers effects of gravity and inertia forces. The second stage involves gravity and viscosity as dominant forces, and the third stage occurs when slick disperse and is expressed by the balance between surface tension and layer. While spreading, spill undergoes chemical as well as physical changes. Processes is termed 'weathering'. Some of these processes, like the natural dispersion of oil into water, lead to the removal of the oil from the sea surface and facilitate its natural breakdown in the marine environment. Spilled oil is usually eliminated from the marine environment through the long-term process of biodegradation (Saadoun, 2015). Time interval needed for the biodegradation depends on numerous factors, such as weather and sea conditions at the time of incident, volume of spilled chemicals, and the type of ecosystem (Farrington, 2014). The numerical modeling technique calculating weathering processes of oil with mathematical methods has proven its validity with outputs that have a high degree of accuracy provided in real cases. Estimation reliability of such models is highly subject to the data quality of accident and the model performance (Hodges et al. 2015). To minimize pollution effects, there are numerous conventions. The most important convention for preventing marine environment pollution from ships oil spills is the International Convention for the Prevention of Pollution from Ships (MARPOL), The aims to eliminate intentional and accidental pollution of marine environment.The International Convention Relating to Intervention on the Hight Seas in Cases of Oil Pollution Casualities (INTERVENTION) confirms the right of coastal states to take measures on high sea aimed at preventiong, reducing or eliminating the threat for the coast as a result of oil pollution caused my marine incident, and International Convention on Oil Prepardeness, Response and Cooperation (OPRC). (G. Jelić et al., 2020) This Convention calls Parties to establish national system for responding promptly to oil pollution and to establish oil response equipment (IMO, 2010).

3. Methodology

In the paper, multiple regression method was used for studying the relationship between a single dependent variable and one or more independent variables. Multiple regression provides possibility to combine many variables to produce optimal predictions of the dependent variable. For causal analysis, it separates the effects of independent variables on the dependent variable so it is possible to examine the contribution of each variable (Alison, 1999). Multiple regression is used to determinate how predictors such as currents speed, salinity, air temperature, height of wave, water temperature, and wind speed impact on the speed of oil spreading. Additionally, to reduce non-significant variables from regression model, forward stepwise variable selection algorithm is applied.

Other method used in this paper is Pisces II simulation, to determinate the worst-case scenario for possible oil leakage, and to get input for further risk assessment. The PISCES II is an incident response simulator designed to simulate processes in an oil spill on the water surface. The application is developed in order to enhance oil spill response. Program provides information based on mathematical modeling of oil spill. The Pisces II spill model simulates processes in oil spill on the water surface: transport by currents and wind, spreading, evaporation, dispersion, emulsification, viscosity, variation, burning, and interaction with coastline. In the mathematical model, factors such as environmental parameters, physical properties of spilled oil, and human response actions were taken into consideration. Environmental parameters included coastline, field of currents, weather, wave height and water density. Physical properties of spilled oil included observing specific gravity, surface tension, viscosity, distillation curve and emulsification characteristic. Human response actions include booming, on – water recovery ND application of chemical dispersants (Gucma et al., 2011)

3.1. Pisces II trajectory simulation

Simulations were created for 18 different scenarios. Oil spill is positioned in the Adriatic Sea (Kaštela Bay, 43˚31.983'N, 016˚27.555'E) in August, when the density of tanker traffic is the highest in this semi-closed water body. The Kaštela Bay is semi-enclosed basin with cargo port and terminal for petroleum products distribution.

Data was obtained by Croatian Meteorological and Hydrological Service, for period from 2002 to 2022. Absolute maximum and minimum and mean value were observed. Data included; air temperature, sea temperature and wind force. Current speed simulations were created using this data in order to determinate, which scenario presents the highest risk in the case of oil spill pollution. Data was also used as predictors in linear multiple regression model to determinate significant predictor of speed at which oils spread (Table 1).

Table 1. Pisces II parameters used as predictors in multiple regression model

PREDICTORS	CURRENTS SPEED	SALINITY	AIR TEMPERATURE	HEIGHT OF WAVE (m)	WATER TEMPERATURE	WIND DIRECTION	WIND SPEED
SCENARIO 1	0,5	37,2	26,2	0,3	24,4	135°	2,1
SCENARIO 2	0,5	37,2	26,2	0,3	24,4	45°	2,1
SCENARIO 3	0,2c	37,21	28,3	0,2	22,1	135°	1,8
SCENARIO 4	0,2	37,21	28,3	0,2	22,1	45°	1,8
SCENARIO 5	1	37,23	23,3	0,4	26,9	135°	2,6
SCENARIO 6	1	37,23	23,3	0,4	26,9	45°	2,6
SCENARIO 7	0,5	37,24	36,8	0,3	22,1	135°	2,1
SCENARIO 8	0,5	37,24	36,8	0,3	22,1	45°	2,1
SCENARIO 9	1	37,25	42,2	0,4	26,9	135°	2,6
SCENARIO 10	1	37,25	42,2	0,4	26,9	45°	2,6
SCENARIO 11	0,2	37,26	32,6	0,2	22,1	135°	1,8
SCENARIO 12	0,2	37,26	32,6	0,2	22,1	45°	1,8
SCENARIO 13	0,5	37,27	16	0,3	24,4	135°	2,1
SCENARIO 14	0,5	37,27	16	0,3	24,4	45°	2,1
SCENARIO 15	1	37,28	18,6	0,4	26,9	135°	2,6
SCENARIO 16	1	37,28	18,6	0,4	26,9	45°	2,6
SCENARIO 17	0,2	37,29	13	0,2	22,1	135°	1,8
SCENARIO 18	0,2	37,29	13	0,2	22,1	45°	1,8

4. Results

In eighteen simulations run through PISCES II, the worst-case scenario was scenario 13 (Table 1) when the longest coastal part was polluted. Incident occurred at 12:46, and oil spill reached the coast at 14:26. Oil spill volume was 1440 tonnes, wind direction 135° and wind speed 2.1 bofors. The length of coastline polluted by oil spill was 5683 m, slick area 105712 m^2 and maximum thickness of slick 212 mm (Figure 1).

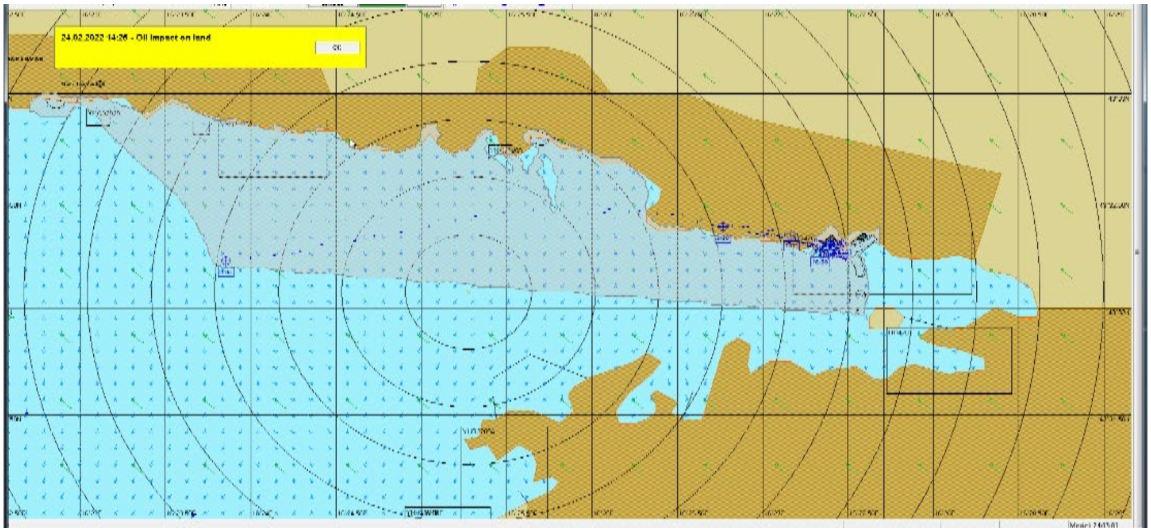

Figure 1. Scenario 13 oil footprint

In scenario 18, incident occurred at 12:46, and oil spill reached the coast at 23:12. Oil spill volume was 1440 tonnes, wind direction was 45° and wind speed 1.8 bofors. The length of coastline polluted by oil spill was 637 m, slick area 567911 m2 and maximum thickness of oil slick was 45.5 mm. Of 1440 tonnes of spilled oil, 82.2 tonnes of oil evaporated. Maximum slick area 567911 m^2 and viscosity 3.2 cSt.

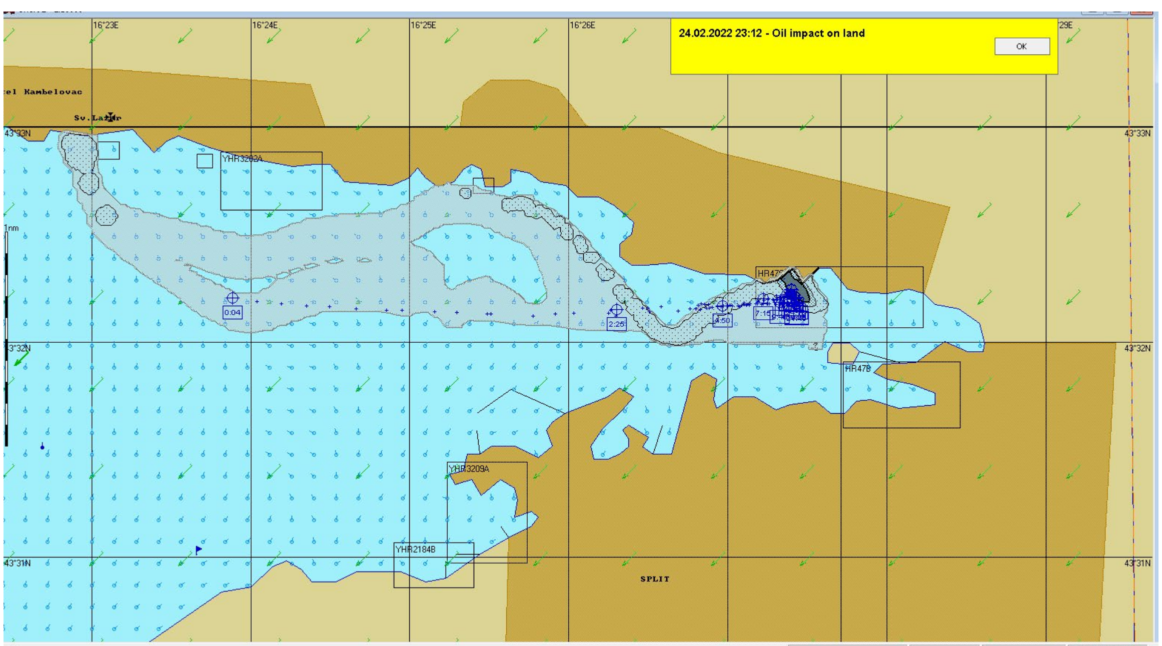

Figure 2. Scenario 18 oil footprint

Spill statistics included data on coastline pollution, slick area, amount of oil evaporated, maximum thickness, volume of dispersed oil and oil viscosity for Scenario 13 and Scenario 18, after 24 hours of running simulation (Table 2).

Table 2. Spill statistic

SPILL STATISTIC	COASTLINE POLLUTION (m)	SLICK AREA (m^2)	AMOUNT EVAPORETED (t)	MAX THICKNESS (mm)	AMOUNT DISPERSED (t)	VISCOSITY (cSt)
SCENARIO 13	5683	105 712	23,0	212	32.4	1.7
SCENARIO 18	637	567 911	82,2	45.5	63.5	3.2

One of scenarios shows large coastline pollution, and another one demonstrates large slick area in this sensitive location. Since bay is semi-closed, and in vicinity of terminal for petroleum products distribution, it is necessary to prevent incidents, and to make further simulations of worst case scenarios, to ensure equipment which would be required to prevent or minimize damage in case of oil leak, collision or some other incident in this area. There is option of providing necessary number of different skimmers and tanks that can float on water and tanks that are placed on land, thus ensuring all the pollution that may come. Pisces II incident response simulator provides possibility of running different scenarios with different kind of equipment necessary to minimize pollution, to determinate which solution would be optimal for different possible outcomes. Parameters currents speed, salinity, air temperature, height of wave, water temperature, and wind speed were used as variables in the analysis (Table 3).

Table 3. Descriptive analysis parameters of all observed variables

Variable	AS±SD	Confidence ±95%	Min - Max	Coef.Var.
Cureents speed	0.57±0.34	0.40-0.74	0.20-1.00	59.92
Salinity	37.25±0.03	37.23-37.26	37.20-37.29	0.08
Air temperature	26.33±9.44	21.64-31.03	13.00-42.20	35.86
Height of wave (m)	0.30±0.08	0.26-0.34	0.20-0.40	28.01
Water temperature	24.21±2.16	23.14-25.28	22.10-26.90	8.91
Wind speed	2.17±0.34	2.00-2.34	1.80-2.60	15.67
Speed	0.29±0.12	0.23-0.35	0.11-0.54	42.80

Table 4 shows that regression analysis identified Height of Wave as significant predictor of speed of oil spread. Forward stepwise algorithm removed all variables from regression model, except Height of the Wave and Water temperature**.**

Table 4. Results of multiple regression analysis with forward stepwise algorithm (β – regression coefficient if variables are standardised, Se(β) – standard error of β coefficient, b – regression coefficient if variables are not standardised, Se(b) – standard error of b coefficient, t(15) –t-test value; p – level of statistical significance)

	β	Se(β)	b	Se(b)	t(15)	p
Intercept			1.16	0.61	1.90	0.08
Height of Wave (m)	1.34	0.62	1.97	0.91	2.16	0.049
Water Temperature (ºC)	-1.06	0.62	-0.06	0.04	-1.71	0.11
R=0.52; R2=027; F2,15=2.73; p=0.097						

Conclusion

The scenarios determinate processes with oil spill in marine environment: the trajectory of oil spill, chemical changes of oil and persistence of oils in the air, water column and sediment. The result of two different scenarios are shown in order to give an insight into potential oil spills impact on marine environment in this sensitive location: the worst-case scenario for both coastal and sea pollution.

In eighteen simulations run through PISCES II, the worst-case scenario was Scenario 13 when the longest coastal part was polluted. Incident occurred at 12:46, and oil spill reached the coast at 14:26. Oil spill volume was 1440 tonnes, wind direction 135° and wind speed 2.1 bofors.

The length of coastline polluted by oil spill was 5683 m, slick area 105712 m^2 and maximum thickness of slick 212 mm. Of 1440 tonnes of spilled oil, 23 tonnes evaporated and viscosity was 1.7 cSt.

In scenario 18, 82.2 tonnes of oil evaporated. Maximum thickness of oil slick was 45.6 mm, slick area 567911 m^2 and viscosity 3.2 cSt. Wind direction was 45°. Polluted part length (m) is 637. (Figure 2).Although one of them showed substantially better results for coastline pollution, slick area was significantly larger than in other case. Therefore, both cases are extreme.

Furthermore, observing through whole linear multiple regression model (F=2.734; R=0.517; p=0.097) variable height of wave was identified as significant predictor of speed at which oils spread in (b=1.965; p=0.047). The obtained results can also serve as starting point for risk assessment analyses of the incidents in order to minimize the negative impact of oil spills on marine environment.

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Cost Effect of EU's Carbon Levy by Container Ship Capacities

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Abstract: The increase in global GHG emissions has revealed the concept of sustainability in transportation and to prevent this increase worldwide, regulations or laws are required. In the literature, the use of fossil fuels is shown as the primary cause of GHG emissions, and it is stated that the share of the transportation industry in this use is quite high. Aiming to reduce GHG emissions, IMO has committed to reducing carbon emissions from the shipping industry by at least 50 percent below 2008 levels by 2050. The levy to be charged for international marine fuel has emerged as an important component of this strategy. This study aims to determine the cost effect of EU carbon levy for container ship owners and freights. Within the scope of the study, the data on the X shipping line's container ships that called at EU ports between April 2021 and April 2022, obtained from the ShipsGo Global Container Shipping Platform have been analyzed. Results demonstrate that The X shipping line should pay 336.784 €, 757.765 €, 1.178.745 €, 1.683.922 € consecutively in 2023, 2024, 2025 and 2026 as carbon levy.

Keywords: carbon levy, GHG emissions, container ships

1. Introduction

Although maritime transport is the greenest type of transport, causing the lowest carbon dioxide emissions per unit load carried within the scope of economies of scale, it accounts for 3.3% of global (CO2) carbon dioxide emissions, 2% of nitrogen oxide (NOx) emissions, %11 of sulfur oxide (SOx) emissions and 4% of global greenhouse gas emissions (Tokuşlu and Burak, 2021). Considering that nearly 3% of the world's annual carbon emissions are generated by the global shipping industry, the pressure to reach the international goal of zero carbon level by 2050 is increasing day by day. Since, IMO has committed to reducing carbon emissions from the shipping industry by at least 50 percent below 2008 levels by 2050, the levy to be charged for international marine GHG emissions has emerged as an important component of IMO's this strategy (Parry, et al., 2022). Since approximately 90% of the world's tradable cargo is transported by sea, it is estimated that the global tax of approximately US$ 40 per ton of CO2 will reduce CO2 emissions by 7.65% (Mundaca, et. al., 2021). In this line with the aim to determine the cost effect of EU carbon levy for container ship owners and freights, levy calculations have been made with the datum gathered from ShipsGo Global Container Shipping Platform, EMSA (European Maritime Safety Agency) and EMBER (EU Carbon Permit Index).

2. Shipping Emissions

As the dominant mode of transport for international cargo, maritime transportation plays and will continue to play an essential role in global trade and economy. Considering that almost 90% of world merchandise trade is transported by ocean going vessels, in general sense maritime transport is responsible for almost one-tenth of CO2 (carbon dioxide) emissions and is an important source of air pollution (Stevenson, 2022:41). As in all other modes of transport that burn hydrocarbon fuels for energy use, ships also create air pollution, which deteriorates air quality, negatively affects human health and climate change. While merchant ships consume fuel for energy, on the other hand they emit particles creating air pollution. Ship sourced pollutants that adversely affect climate change and public health include carbon dioxide (CO2), nitrogen oxides (NOx), sulfur oxides (SOx) and particulate matter (World Health Organization, 2018). Globally, the marine shipping industry's annual emission contribution from human sources is calculated as 2.2% CO2, 15 % NOx and 13 % SOx (IMO, 2015: 1 – 2). Pollution types from the shipping industry are classified and defined in Table 1.

Table 1. Pollution types from marine shipping.

Pollution Types	**Definitions**
Carbon Dioxide (CO2)	A major greenhouse gas (GHG) contributing to climate change and ocean acidification (WHO, 2018)
Nitrogen Oxides (NOx)	A collection of gases of various combinations of nitrogen and oxygen (United States Environmental Protection Agency, 1999).
Sulphur Oxides (SOx)	A collection of gases of various combinations of sulphur and oxygen (Landrigan et al., 2018)
Methane (CH4)	A colorless, odorless gas is the atmosphere that is considered to play a major role in what is called the ''greenhouse effect'' (European Maritime Transport Environmental Report, 2021)
Particulate Matter	A collection of solid and liquid particles formed during fuel combustion (Cho, 2016)

Source: Adopted by author

When it is compared with the other modes of transportation, shipping can be considered as one of the modes of transport with the lowest carbon dioxide (CO2) emissions per distance and weight carried. However, pollution from shipping activities has serious adverse effects on air and water quality, as well as on marine and estuarine biodiversity. Ships are quite complex systems with various features such as having different types, operational profiles, control systems, types of cargo carried, fuels consumed, and materials used. To ensure sustainability, it is necessary to consider the effects of ships on both water and air as they move on the surface (Comer et. al, 2020: 15; EEA, 2020: 30).

When the emission rates from ships on a global and regional basis are evaluated based on numbers, 2018 data presents those ships calling at EU and European Economic Area have released 140 million tons of CO2. This constitutes 18% of the total global CO2 emissions from international shipping activities. The ships that are thought to be responsible for 90% of the emissions are those that are over 5000 gross tons and carry out commercial activities (European Maritime Transport Environmental Report, 202: 37). On the global scale, it has been observed that CO2 emission rates in international maritime transport increased by 4.9% in 2021 compared to 2020, despite the slowing effect of the pandemic. Figure 1 summarizes global maritime transport emission rates relative to 2019 by ship types.

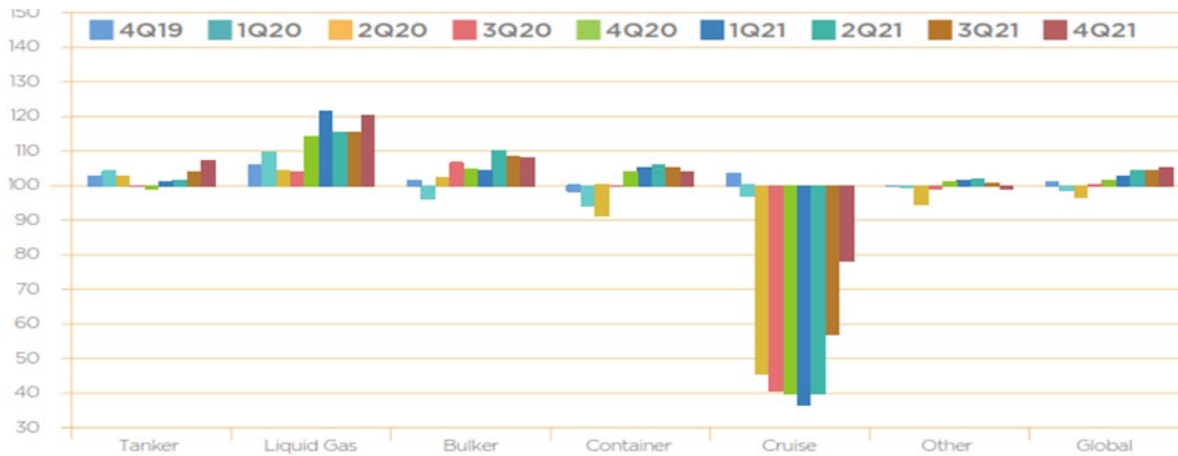

Figure 1. Quarterly international shipping CO2 emissions trends (index: 2019=100).

Source: Stevenson, 2022: 44.

The most striking point in the figure is the emission reductions in cruise ships, whose operations have slowed down due to the global lockdowns. Liquid bulk carriers, on the other hand, are among the parties that dominate emission consumption due to reasons such as additional gas capacities, strong demand structure and longer routes with high volumes. Due to the stable demand for durable goods, longer routes requirements and congestion at ports, the emission rates of container and bulk carriers, which constitute the two largest segments, continued to increase. Lastly, tanker ships started to mobilize in second the half of 2021 as the quarantine process begin to improve, contributing again to emissions consumption (Stevenson, 2022: 44 - 45).

3. Regulations Related GHG Emissions in Maritime Industry

As reducing emissions from ships is a complex issue that falls under the responsibility of different institutions and covers different policy areas (e.g. maritime transport, marine environment, climate change, air pollution, energy, transport, trade, infrastructure and human health), (Miola, et al., 2010), to date, the international shipping sector within the International Maritime Organization (IMO) appears to lag behind other sectors in reducing overall emissions.

The main regulations regarding air pollution from ships can be classified as; International Convention for the Prevention of Pollution from Ships (MARPOL) (International Maritime Organization, 2022a), United Nations Convention on the Law of the Sea (UNCLOS) (International Union for Conservation of Nature, 2022) and Kyoto Protocol (United Nations Framework Convention on Climate Change, 2022).

The main international convention, MARPOL, covering the prevention of operational or accidental pollution of the marine environment by ships, accepted by the International Maritime Organization (IMO) in 1973 and later amended by the 1978 and 1997 protocols (International Maritime Organization, 2022b). With the Air Pollution Conference held in 1997, IMO brought the issue of air pollution from ships to the agenda and added a protocol to MARPOL 73/78 and adopted the regulations on "ANNEX VI: Prevention of Air Pollution from Ships". MARPOL Annex VI, which entered into force in 2005, revised in 2008 with significantly tightened emission limits and entered into force in 2010 (IMO, 2022c). A part of MARPOL Annex VI, which consists of 33 regulations, adopted in 2011, also covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships. Applicable to approximately 99% of world trade tonnage, MARPOL has contributed greatly to the significant reduction of pollution from international shipping (International Maritime Organization, 2022b).

The United Nations Convention on the Law of the Sea (UNCLOS), (1982) defines the rights and responsibilities of nations regarding their use of the world's oceans and provides the legal framework for the conservation and sustainable use of the oceans and their resources (Miola, et al., 2010). In addition, the Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, and the parties set and commit to internationally binding emission reduction targets for GHGs. The protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005 (Poulopoulos, 2016).

While the whole world strives to ensure fair welfare for all living things on the planet, another step that is expected to have permanent and sustainable results was announced in 2019 as the European Union's climate action plan, as the “Green Deal”. The European Union aims to zero its greenhouse gas emissions by 2050 with the changes and regulations it will implement in many sectors with the European Green Deal (Ecer, et. al., 2021). Under the Green Deal, the shipping sector will have to play a central role in tackling climate change by easing the multiple demands on the EU's land resources and improving the use of water and marine resources (Adamczak-Retecka, 2021). Within the scope of the Green Deal, the EU has created the “Fit for 55” package, which revises the climate, energy and transport legislation, in order to reach the target of reducing emissions by at least 55 percent by 2030. The reforms proposed by the "Fit for 55" package include a range of maritime measures, from a sustainable fuel mandate within the EU to the inclusion of marine emissions in the bloc's emissions trading scheme (ETS) (Council of the European Union, 2022). Suggestions that will directly affect the maritime industry are classified as follows.

- EU Emissions Trading System (ETS): Extended to include maritime transport.
- Fuel EU Maritime Initiative: It includes the maximum limit on the greenhouse gas intensity of the energy used on board and certain obligations for using land power source or zero emission technology.
- Energy Taxation Directive (ETD): It includes the introduction of a minimum tax rate for certain fuels / ships (Council of the European Union, 2022).

The current Energy Taxation Directive (ETD) sets the structural rules and minimum consumption tax rates for the taxation of energy products and electricity used as motor fuel and heating fuel. The updates introduce a new tax rate structure based on the energy content and environmental performance of fuels and electricity, and broaden the tax base by including more products in coverage and removing some of the existing exemptions and deductions. The proposal, introduced on 14 July 2021, introduces a minimum tax rate on the relevant fuels used for intra-EU ferries, fishing and cargo vessels. Sustainable and alternative fuels, on the other hand, will be subject to a minimum zero tax rate for a transitional period of 10 years when used for maritime transportation (Business and Human Rights, 2021).

4. Methodology

This study aims to determine the cost effect of EU carbon levy for container ship owners. To reach this aim the 356 voyages of X shipping line between 22.04.2021-17.04.2022 gathered from ShipsGo Global Container Shipping Platform used as a sample. EU Carbon permit index datum has been used as CO_2 price in calculations which is obtained from ember-climate.org website. And the EMSA (European Maritime Safety Agency) website is used as the main source to obtain the amount of CO_2 emitted by each ship. The port time of ships has been neglected as CO_2 emissions amount in berths cannot be reached by the authors.

5. Findings

Within the scope of the Green Deal, the Maritime Emissions Trading System is examined under three headings. According to this;

a. 50% of the CO_2 emissions on the voyages of the ships to/from the ports of the European Economic Area (EEA),
b. 100% of CO_2 emissions from voyages between European Economic Area ports

c. 100% of CO_2 emissions in European Economic Area ports must be subject to carbon levy.

A 4-year plan has been made to pay the taxes calculated as specified, and 20% of CO_2 emissions in 2023, 45% in 2024, 70% in 2025 and 100% in 2026 will be priced by the EU. The levy responsibilities arising from the voyages of the ships between 22.04.2021 and 17.04.2022 belonging to the company examined within the scope of the study are shown in Table 2.

Table 2. Annual carbon levy of X shipping line

Year	Levy amount of voyages to/from EEA	Levy amount of voyages between EEA	Total
2023	186.760 €	336.784 €	523.544 €
2024	420.210 €	757.765 €	1.177.975 €
2025	653.661 €	1.178.745 €	1.832.406 €
2026	933.802 €	1.683.922 €	2.617.724 €

Accordingly, the amount of carbon levy that X shipping line has to pay in 2023 for a total of 16 ships has been calculated as approximately (the value is considered to be approximate because the calculations were made using the voyages between April 2021 and April 2022, the CO_2 emissions of those voyages and the carbon prices of the dates of those voyages) 523.544 € plus the amount due to the time spent in the port.

Table 3. Carbon levy cost of ships per unit mile

Vessel	Capacity (TEU)	kg/CO2 nm	Levy per unit mile (€)			
			2026	**2025**	**2024**	**2023**
M/V 1	1122	199,01	8,87	6,21	3,99	1,77
M/V 2	1139	301,9	7,79	5,45	3,50	1,55
M/V 3	1157	208,16	9,25	6,47	4,16	1,85
M/V 4	1199	241,3	5,70	3,99	2,56	1,14
M/V 5	1208	296,54	7,93	5,55	3,57	1,58
M/V 6	1221	321,13	22,84	15,98	10,27	4,56
M/V 7	1445	232,44	9,70	6,79	4,36	1,94
M/V 8	1445	232,94	9,08	6,35	4,08	1,81
M/V 9	1604	239,15	9,1	6,4	4,1	1,8
M/V 10	1604	390,61	16,91	11,84	7,61	3,38
M/V 11	1604	326,23	18,74	13,12	8,43	3,74
M/V 12	1604	274,6	11,10	7,77	4,99	2,22
M/V 13	2474	363,81	13,12	9,18	5,92	2,62
M/V 14	2478	392,85	19,90	13,93	8,95	3,98
M/V 15	2478	364,72	17,97	12,58	8,09	3,59
M/V 16	2837	354,08	23,4	16,4	10,5	4,7

Table 3 shows that some sister ships produce different amounts of CO2 emissions and levy paid per unit mile varies. The deviation of CO2 emission amongst sister ships may be explained by many reasons including some tolerances in AIS data, redundant capacity on board, performance of main engine, hull fouling or some energy saving applications such as derating of main engine, optimization of propeller, etc.

6. Conclusion

In this study the total amount of carbon levy which should be paid by X shipping line is calculated on a yearly basis, annual levy for each ship of fleet as well. Also the cost as per unit mile for each ship is determined. The X shipping line should pay 336.784 €, 757.765 €, 1.178.745 €, 1.683.922 € consecutively in 2023, 2024, 2025 and 2026. This will cause an additional cost on the freight. The additional cost may be fixed per each container or simply can be calculated as per mile/teu for each single voyage which will be a more fair assessment to the authors' suggestion. To decrease the levy and CO2 emitted as well, all shipping lines should apply new technologies suggested by IMO for energy efficient management which is cost effective and environmentally friendly.

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Enhancing Green Skills in Maritime English Course

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Abstract: The aim of MET has always been to equip graduates with a set of professional skills necessary for their successful performance in the industry. In order to provide sustainable development and face challenges of the current environmental situation in the world, the educational system shall focus much attention on green skills development at MET institutions. The present paper is aimed at specifying most effective ways of enhancing green skills in Maritime English course.

To explore the attitude to green skills development and the ways to embed green skills into Maritime English course, an online questionnaire survey was undertaken for students and educators of Kherson State Maritime Academy (KSMA). Maritime professionals were also interviewed concerning their experiences of green skills related to the workplace. The survey identified that in spite of their importance for the industry there is a gap between the green skills needed aboard ship and the skills actually being developed at MET institutions. The majority of maritime professionals do not consider that students always possess the relevant skills to provide safety and increase efficiency of this sector. In addition, the survey revealed that there is no clear concept of green skills.

Keywords: green skills, maritime education and training (MET), Maritime English course.

1. Introduction

Global changes connected with climate threats, environmental degradation, possible food shortage, technological innovations, high carbon emissions, wide spread of viral diseases demand new approaches to the organization of our lives. As stated in a report (Maritime Skills Commission Annual Report 2021), “the maritime sector has a unique role to play in the decarbonisation process. Whilst there is a huge focus on technology, there is often less discussion on the skills required to enable the transition”.

Maritime industry provides the largest scope of the world transportation services, so that’s quite clear why green skills issues concerning this sphere attract attention of researchers. Reducing the amount of carbon dioxide emitted from ships, energy-sufficient use of ships, and seafarers’ awareness of these issues are the dominating research topics in current articles. Among them, enhancing green skills of future seafarers is of paramount importance for the future of seafaring and the civilization survival in general.

Maritime training institutions should be ready to adapt their curricula and activities content to the challenges awaiting their students in future job roles. MET institutions offering education and training at all levels are in general able to respond to the industry needs and to fill the skill gaps (Current Skills Needs 2020). The aim is to ensure that maritime professionals possess key digital, green and soft management skills for the rapidly changing maritime labour market.

2. Literature Review

Realizing the need to introduce green skills content into the educational process at MET institutions, researchers of environmental issues focus on various aspects concerning the educators' role in the process. Green skills are understood as skills related to reducing environmental impact and supporting economic restructuring with the purpose of attaining cleaner, more climate resilient and efficient economies that preserve environmental sustainability and provide decent work condition (Pavlova 2018). The structure of green skills is considered to consist of three dimensions: knowledge, skills, and attitude (Ibrahim et al. 2020). Green skills support sustainable economy, society and the environment through activities performed in the industries, businesses and the community.

A group of academics (Beşikçi et al. 2021) based their research on the assumption that awareness and knowledge of seafarers about the energy efficiency should be enough for practicing low carbon-energy efficiency operations. It was observed that the basic knowledge levels of the seafarers concerning energy efficiency were lower than expected. According to the results of the study, one of the main problems here relates to inadequate education and training of seafarers on energy efficiency. The researchers conclude that management level courses at Maritime Faculties can make a great contribution to the awareness and knowledge of seafarers.

Another research moves closer to issues concerning pro-environmental education of future seafarers. The authors (Čulin et al. 2019) state truly that lack of environmental knowledge is identified as a barrier to environmental concern and behaviour and that eliminating knowledge gaps does not necessarily translate to behavior change. The strong point of the study is in reviewing determinants of pro-environmental behaviour and in provision of practical suggestions for educators to plan and execute educational activities to increase the willingness of seafarers to adopt environmentally-friendly practices. Emphasis on evoking students' emotional reactions by alternative knowledge transfer (fiction films, open discussions, field trips, success stories etc.) is viewed as an effective way for educators at maritime universities to form students' protective behaviour towards the environment.

In one more study (Hamid et al. 2019), the idea above that generic green skills can be shaped through teaching and learning, designed by lecturers using diverse teaching methods, but they are not proven methods of developing practical green skills among students, is refrained.

The approach suggested as a result of implementing an innovative programme is not the least important (Santos 2016); it is not always necessary to change attitudes in order to change behavior. In fact, a focus-designed local programme encouraged behaviour change first, which resulted in subsequent normative support for green institutional decisions (i.e. changing norms by changing behavior). In other words, maritime institutions and individual educators should set behavioural examples in addition to transferring knowledge: education activities should be performed in an environmentally-friendly manner (reduction of paper consumption, division of solid waste, no-smoking policy and the like).

Dayue Fan (2016) continued their discussion by asserting that green skills can be instilled in students through various teaching and learning activities. Academics, though, should be clearly and accurately aware that green skills are relevant to green practices, and green practices are exposition of one's self-awareness.

Focusing on the problem of developing the future maritime industry professional, a group of educators (Água et al. 2020) set the aim of filling the existing gap between education and training programmes, while integrating the 21st century professional skills. Besides raising awareness of the educational and training challenges ahead, more effective teaching methods are suggested in order to meet the needs, particularly supporting double loop learning, together with a pragmatic proposal for a realistic programme at master's level.

Presenting their perception of how to incorporate green skills ideas into lectures, a group of academics (Hamid et al. 2019) specify that all undergraduate programmes in public higher learning institutions should incorporate generic green skills in the curricula.

The current absence of scientific articles on enhancing students' green mindset in the process of learning Maritime English indicates the necessity to develop transitional environmental content as additions to training modules.

3. Methodology

The purpose of the paper is to specify most effective ways of enhancing green skills in Maritime English course.

New training content is needed to keep up with the new skills that are emerging. Three possible options are outlined (Harris and Sunley 2021): to add modules to the existing maritime courses; to introduce entirely new courses that explore the application of new technologies, and to add maritime modules into advanced courses.

Nearly all the ideas about maritime institutions activities concerning enhancement of green skills may be applied in teaching and learning Maritime English with certain alterations due to the specificity of the discipline. Regretfully, researches on green skills development in the Maritime English course are rare. Instead, practical elaborations provide some insights for adopting them in teaching and learning Maritime English.

As there is no specially developed Maritime English language syllabus on green skills promotion, training materials for teaching adult students are basically about including issues of sustainability and ways of reducing greenhouse gas emissions in the English lessons at which students are involved in reading texts on different energy sources and reporting on these to each other. This type of planning helps combine environmental education and language instruction. By including 'green touches' into each module, teachers make students feel drastically important effect of green skills on our future lives.

Students may be streamed (GreenHeart Education) to become more environmentally-friendly by: learning about and comparing environmental/sustainability issues of various locations: global warning and climate change, air and water pollution, garbage, overconsumption of natural resources; exploring carbon footprint and energy audits; creating environmentally related blogs/websites; learning cultural concepts such as needs versus wants, facts versus beliefs versus opinions, rights versus responsibilities; writing essays/emails on environmental issues concerning maritime industry.

Seafarers' perception of the significance of environmental issues for their work is distinctly seen in the diagram (Čampara et al. 2017) of the courses that should be included in the seafarers' education programme, among them *Marine Environment Protection* and *Marine Ecology*.

In order to enhance green skills training, the entire educational approach at MET institutions shall move to "greening" course syllabi. After a series of our successful interdisciplinary cooperation with instructors and lecturers engaged in teaching specialized disciplines like *Geography of Shipping* and *Meteorology*, there came a decision of continuing it with a complementing action of embedding green skills into Maritime English course. Such initiatives can be realized only through joint efforts of the instructors of Maritime English and specialized disciplines (e.g. *Marine Ecology*, *Maritime Law*, *Economics*, *Innovative Technologies and Technical Means of Navigation*). Together they shall impair the value of green skills to maritime students of today. In future, such skills can be a key to professional success. The joint actions of instructors and lecturers should help students acquire green knowledge and skills and apply them in maritime industry environment. The focus of our research lies within the content of Maritime English course and specialized disciplines listed in the curriculum of the Navigation Department.

The analysis of syllabi of the abovementioned disciplines for maritime cadets narrowed the "green" content to three areas – "Environmental Concerns", "Oil Pollution Prevention" and "Operational Pollution Prevention". It was decided that by adding "green" module "Marine Pollution Prevention" into Maritime English course the students will be able to: 1) explain causes of marine pollution; 2) describe shipboard response to oil spills; 3) comment on the MARPOL Annex I-VI regulations. The essential competency was formulated as the following: summarize regulations for marine pollution prevention according to MARPOL. The duration of the module is about three weeks. The detailed content of the module is presented in the table below (*Table 1*).

Table 1. Content of the “green” module

Environmental Concerns	Oil Pollution Prevention	Operational Pollution Prevention
Pollution Sources	Annex I	Annex II
MARPOL	SOPEP	Annex III
Special Areas	SOPEP Locker	Annex IV
	Environmental Protection Communications	Annex V
	Oil Spill Cleanup	Garbage Disposal
		Annex VI
		Ballast Water Management

The instructors of Maritime English shall demonstrate their readiness to effective interdisciplinary cooperation with instructors and lecturers of specialized disciplines. Moreover, they can involve the maritime experts (e.g. graduates from MET institutions, maritime officers) into the training process itself.

Another important aspect to consider is a need of adequate learning resources to embed green skills into Maritime English course – cases for analysis, job-oriented projects for students, authentic documentation. The primary task is to select and adapt the learning resources and exploit opportunities for language learning. Being language instructors, we usually focus on language mastering. A learning content is used by us as a resource for communicative skills development. Whereas, a variety of job-oriented tasks are aimed at provoking students to apply the language learnt into practice.

In our opinion, the most reliable learning resources for enhancing green skills are cases, sea stories, maritime accident reports, extracts from books written by seafarers. The accompanying tasks shall be thoughtfully elaborated; they serve as effective tools for arousing students’ interest and motivation to participate in discussions. As a result, the sea stories, cases, etc. help the maritime students understand what is happening beyond the classroom besides acquiring “green” knowledge from the technical texts in the course books, conventions, codes and manuals (Kudryavtseva et al. 2021).

4. Data Analysis

To explore the attitude to green skills development and discuss the ways to embed them into training process, four online surveys were conducted for different groups of target audience – students (undergraduates and senior), maritime specialists of management level and the educators of KSMA. The participants were interviewed with the purpose to gain information on the concept of green skills, their values for the industry, experience of implementation of green skills in the workplace.

The questionnaires were designed using Google Form online service; the invitations to participate with the links to follow were spread among the KSMA students, educators and partners. With 90 total participants, the respondents were 35 second-year students, 23 fourth-year students, 25 educators of different faculties and 7 sea-going maritime specialists in positions from the Second Officer to Chief Mate. The survey comprises 5-9 questions (multiple choice and open-ended types), and, taking into consideration a dual nature of green skills (knowledge and behavior), the questions were designed to integrate both cognitive and affective domains. The obtained data have been analyzed to determine parties liable to contribute to and methods to incorporate green skills into Maritime English course, in particular.

To get information on green skills perception, all groups were asked to determine and underline the most important aspect of green skills. The respondents were provided with some options to choose from – knowledge of international and national regulations, green technologies usage, environmental awareness, practical involvement in protecting ecosystems, responsibility for environmental management) or add their own answer. All the participants prioritized practical involvement in protecting ecosystems, such as saving resources and recycling as well as providing energy efficiency, managing garbage and ballast water as the key components of professional skills for seafarers. It is worth to notice that the junior students and educators (respondents without sea-going experience) highlighted environmental awareness as an important aspect of green skills as well. While the maritime specialist and senior students (respondents with sea-going experience) did not consider it such as significant and called attention to responsibility for environmental management. Such discrepancy can be explained by the needs to measure and assess skills and abilities in the workplace rather than behavior.

To determine the area of green skills implementation the interviewees were asked to specify green skills used at sea. As maritime specialists recognize the potential hazards the shipping industry exposes to the marine environment, so they consider the crew need green skills actually being used on everyday basis to provide proper ship operation. As for the students' answers they were more detailed and specified such areas for green skills implementation as garbage treatment onboard and MARPOL regulations (junior students), and, in addition, ballast water operations (senior students).

To analyze the current situation, the students were invited to list green skills they have already obtained. Both junior and senior students mentioned their knowledge of MARPOL regulations, ability to sort, recycle and dispose garbage onboard (junior students), and, in addition, usage of alternative energy sources, willingness to keep the planet clean and safe for humanity (senior students). The students' answers have shown some progress in moving from cognition into sphere of values.

Answering the question what subjects contribute more into green skills development, from the list provided, the students put *Maritime English* on the first position (82% of junior, and 52% of senior students), *Economics* and *Maritime Law* (43% of junior, and 39% of senior students), *Innovative Technologies and Technical Means of Navigation* (35% of senior students). The special place of Maritime English course could be explained by its interdisciplinary nature.

The students were also asked how they plan to develop green skills in future. The majority of the respondents showed their concern for the environment and intention to improve their practical skills at sea with further transferring them ashore, to study more on that topic by themselves and at the lessons, share and discuss new information with their peers and family. Some of them demonstrate their readiness to take responsibility and do proper work as maritime officers, keep marine environment as safe as possible. The students' answers demonstrate conscientious environmental behaviour in daily working activities and mature attitude in terms of self-development and duties.

To investigate the contribution of education into green skills enhancing, the educators and maritime specialists were suggested to think of the specific opportunities or facilities MET institution needs to enhance green skills. In addition to financial support the maritime specialists pointed out the role of human factor. The policy of MET institutions needs to be focused on student-centered approach and employment of experts from occupational field. The educators' responses also emphasized the necessity of upgrading the entire educational approach and move to "greening" course syllabi. Among the ideas suggested, the institution has to use environmentally friendly technologies, segregate garbage, use solar batteries, promote education on green skills and instruct the personnel to develop them. The respondents stated that there is no need of specific facilities for that purpose, educators should be aware of the concept of environmental education, learning resources, and projects to arouse students' interest in pollution prevention.

To identify the areas for improvement and the ways to enhance green skills training, the educators were asked to share the challenges they encountered in their everyday practice. In spite of the fact the educators teach green skills, the majority (56%) complain about absence of clear concept on such teaching, some of them (28%) experience lack of specific knowledge to embed green skills in their courses. In addition, they are in high need of adequate learning resources – cases for analysis, job-oriented projects for students, authentic documentation, and interdisciplinary cooperation in developing green skills at their courses.

5. Conclusion and Recommendations

The survey identified that, in spite of the importance of green skills for the industry there is a gap between the skills needed aboard and the skills actually trained at MET institutions. Taking into account the importance of Maritime English course as the one that significantly contributes to enhancing green skills, English instructors make efforts to design a "green" course and incorporate knowledge from different subjects, improve communication skills, and build proper attitude to living and working at sea. Though all the participants consider green skills to be an essential part of professional skills, there is a need to design "greening" course syllabus, develop learning resources and apply active learning approaches to promote green skills honing and meet the industry requirements.

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Creating an Industrial Symbiosis with Ship-Generated Waste

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Abstract: Sustainable practices are becoming more important in many industries as demand grows and resources become limited. Since one answer for establishing sustainable industries is to shift from a linear economy to a circular economy, examples of industrial symbiosis have become more prominent. Industrial symbiosis, a circular economic model that can help decarbonize industries, is one viable remedy for the negative effects on the environment. The maritime industry can have a significant role to play in this approach with all the waste generated on ships. The aim of this study is to theoretically design a model that will evaluate the suitability of the ships participating in an industrial symbiosis with the waste they generate. First, it was determined which of the wastes generated onboard ships could be included in an industrial symbiosis, and then it was calculated how much of these wastes could be supplied in a given time frame. Finally, the areas in which these wastes can be used as raw materials are specified.

Keywords: Industrial symbiosis, Ship-generated waste, Sustainability, Green transition, Decarbonizing

1. Introduction

As widely known that the World must learn new ways of working together in order to solve the challenges of 21st century like water consumption, waste management and use of resources. By 2050, it is estimated that the world will consume three times more resources and produce twice as much waste than today (Kaza et. al., 2018). This will result in intensified climate change effects, ecosystems overload and an increased landfill. Following the same path, and failing to make resources and energy consumption more sustainable could put the world in a vulnerable position. Therefore, more strategies to "close the loop" on resource use and extraction, especially in sectors with high energy intensity and environmental impacts like the process manufacturing need to be implemented.

In The 2030 Agenda for Sustainable Development, the United Nations set 17 global goals for sustainable development which are urgent call for all member countries to act. One of the main goals of this global agenda is Responsible Consumption and Production and with the specified targets of this goal, UN aimed to substantially reduce waste generation by prevention, reduction, recycling, and reuse. Encouraging companies to adopt sustainable practices and achieving environmentally management of wastes in their life cycles to reduce their release to air, water, and soil to minimize their adverse effects to the human and environment were other targets of the UN [URL1].

A possible solution for this problem is industrial symbiosis, a circular business model that can play an important role in decarbonizing of industry (Chertow, 2000). Maritime industry can play an important role in this model. The waste generated on ships can be collected on ports and be used by the industrial symbiosis created in those areas including the ports. The challenging part and the first thing to be sorted out should be identifying which waste can be used again as a resource and then which industries to be included in this symbiosis in an optimized way considering the infrastructures. It is necessary to determine the places that can use each other's waste at close distances and its adequacy should be investigated. Also, it may be necessary to establish new centers for the recycling and reuse of these wastes.

In this study, firstly waste generated on board ships will be defined and classified according to their potential to be a raw material in process manufacturing in different industries. Then, a calculation for a selected port and time period will be done to determine the amount of waste that can be collected. To provide an uninterrupted supply chain and to avoid any shortages, liner ships that call certain ports at certain times will be the focus of this study. It will be followed by determining the suitable industries which can be included in this symbiosis to benefit from using waste generated on board ships.

This partnership will ensure that resources can be shared and reused, thus saving money, and minimizing waste. In this way, the symbiosis created will support the green transition and provide mutual benefits both economically and environmentally (Neves et. al., 2020). Also, this maritime industry-based symbiosis is expected to be a driving force for the green transition of all ports around the world. In addition to the positive effects of the investments made in this field on the environment, the long-term economic positive effects will also convince the industries to take a step in this area. Drawing a roadmap to determine how sustainable cooperation can be developed in this regard will be one of the vital steps to achieve a green future.

2. Examples of Industrial Symbiosis

As demand increases and resources decrease globally, sustainable approaches are gaining importance in many industries. Since the transition from linear economy to circular economy is one solution for creating sustainable industries, examples of industrial symbiosis started to become more visible. The most important of these is the symbiosis in Kalundborg, which has a power station in its center and includes many companies such as factories, farms, production facilities etc. that exchange waste energy or materials (Ehrenfeld and Gertler, 1997). A symbiosis in Barceloneta involves wastewater and chemicals among firms in several industries (Chertow et. al., 2008). Symbiosis in Landskrona consists of organic waste, chemicals, energy, storage places, wastewater and even employees exchange (Mirata and Emtairah, 2005). A large symbiosis in China consists of 31 exchanges of energy and materials between companies (Yu et. al., 2015). Similar examples of symbiosis can be seen at large and small scales. Although a symbiosis involving ships is not seen in the literature, there are symbiosis involving ports. Rotterdam Port was part of a symbiosis program which focused on exchange of waste heat among firms and through households (Baas, 2008). It is seen that there are also smaller-scale symbiosis in some ports of Europe.

3. Regulations Related to Waste Generated on Ships

The International Convention for the Prevention of Pollution from Ships (MARPOL) and Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) are the main international regulations aimed at preventing ship-borne wastes from polluting the marine environment. There are also international regulations such as the Helsinki Convention, which have a narrower geographical scope, deal with waste sources other than ships and aim to protect the marine environment. However, these regulations do not deal with the specifications of port reception facilities or the processes after the ship generated wastes are delivered to those facilities. MARPOL only requires member states to ensure the provision of adequate reception facilities in ports.

Although the process of delivering the wastes from ships to these organizations is controlled by official documents such as the Garbage Management Record Book, the wastes are only subject to local regulations after they handed over to the land facility. To fill this gap, European Union detailed the requirements of port facilities with the Directive for Port Reception Facilities (2019) and stipulated that there should be predefined plans for waste collection and handling (EU, 2019). In the directive, separate collecting of waste from ships is highlighted not to prevent possible recycling and reuse opportunities by combining the wastes on land which are stored separately on the ships according to MARPOL. However, recycling, reuse and recovery operations must follow the Waste Framework Directive and other relevant EU waste legislation for EU countries and domestic laws of other countries (Arguello, 2020).

4. Management of Waste Onboard Ships

When the handling of wastes produced on land is ordered from the most environmentally friendly to the most harmful, it can be defined as long-term landfilling, recycling, reprocessing, and reusing (Deja and Kaup, 2019) Since most of the waste generated onboard ships are delivered to port facilities, they become part of the waste generated and handled on land. The nature of the operation, which requires ships to be remote from land, makes it difficult to store and handle the garbage and other waste generated on the ship. Moreover, even if ships make frequent port calls, the cost of this process increases as there are no other options other than port facilities to dispose of wastes.

According to MARPOL Annex V, waste generated on ships can be classified as all kinds of food, domestic and operational waste, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically. There are currently 3 options for the handling of these wastes. Disposal into the sea is one of these options under strict obligations. Comminuted food waste can be disposed into the sea if the distance of the ship from the nearest land is more than 3 nm outside the special areas and more than 12 nm in special areas. Discharge of cargo residues, cleaning agents and additives, animal carcasses can be permitted in some special circumstances. However, discharge of waste such as plastic, synthetic material, cooking oil, paper, glass, metal and similar is prohibited in all waters due to their potential environmental hazard [URL-2]. Especially plastic garbage is very resistant to degradation and generates a variety of environmental hazards linked with waste buildup in nature, since it has hazardous impacts on living beings, soils, and water supplies over time (Meneses et. al., 2022). For these kind of waste, other options must be followed.

Incineration onboard can be an option except for wastes such as garbage containing more than traces of heavy metals, refined petroleum products, and polyvinyl chlorides but it is prohibited to discharge incinerator ashes into the sea in all waters.

Even if the incinerator method is used, ashes must be delivered to a port reception facility which is the third and most common option for handling ship waste. IMO has recognized that provision of reception facilities is essential for effective MARPOL implementation. Marine Environment Protection Committee (MEPC) emphasized the importance of reception facilities and recommended member states to provide reception facilities (PRF) which are sufficient in quantity and quality. PRFs provide services for collecting wastes that cannot disposed into the sea from ships and handling the waste in compliance with related national regulations for a fee. PRFs can play a critical role in a symbiosis because they would be the link between ships and manufacturers on shore. Accurate segregation of the waste and suitable transportation for uninterrupted supply chain are crucial factors for an efficient symbiosis.

5. Case Scenario Calculations for Industrial Symbiosis Involving Ships

To achieve an efficient symbiosis, regular supply of raw materials plays a vital role. Bass (2011) highlighted several symbiosis projects which were rejected because of unpredictable supply of raw materials. Leigh and Li (2015) pointed out the importance of effective supply chain for a sustainable symbiosis. It can be said that it is difficult to include a sector such as shipping into such a symbiosis, where waste is delivered from ships at regular intervals, not continuously, into such a symbiosis. Therefore, the ships that would be most appropriate to include in such a symbiosis are those that operate as liners such as Ro-Ro or container ships. In this study, two major ports in İstanbul region were selected as Step 1 for estimation calculations.

Port 1 is the home port of a Ro-Ro company engaged in international voyages and Port 2 is the most frequented port of a shipping company engaged in liner container shipping. Besides hosting suitable ship types, another reason for choosing these two ports is their proximity to various industries, which is an important criterion for symbiosis.

Step 2 is to determine the number of ships visiting these ports for a period of time. Sailing schedule of the Ro-Ro company in Port 1 indicates that 9 different ships make port calls in a 10-day period and there is always a ship at port [URL-3]. Sailing schedule of container shipping company in Port 2 indicates that 28 different ships dock at the selected port within a one-month period and there is no time when there is no ship in the port [URL-4].

Third step is to determine the amount of each type of waste generated by selected ships. Regardless of how the ships manage the waste they produce; it is mandatory to record the produced and handled quantities in the garbage record book according to MARPOL and present it to the authorities when necessary [URL-5]. However, it can be predicted that these records are questionable since it is impossible to carry out any inspection during the production of wastes. In the report of EMSA, the amount of waste generated onboard different types of ships and different types of waste, amount of waste delivered to port facilities and amount of waste handled onboard the ship has been determined as close to reality with empirical studies [URL-6]. Hence, amounts determined in report were used for the calculations in this study. In addition, the main waste types in this study were determined as plastic, food waste and cooking oil since they are more likely to be used as raw materials in the industry and their intermediate processing requirements are relatively less. Table 1 shows the estimated amount of waste for selected type of ships for one ship in one-month period.

Table 1. Estimated amounts of waste generated onboard selected ships [URL-5]

	Ro-Ro Ship (Port 1)	Container Ship (Port 2)
Plastic	21,75 m^3	2,7 m^3
Food waste	0,95 m^3	0,95 m^3
Cooking oil	30 liters	30 liters

As a result of the calculation made by considering the estimated quantities in Table 1 and the number of ships mentioned before, the amount of waste that can be collected from the ships in a month at the two selected ports is given in Table 2.

Table 2. Estimated amount of collectible waste

	Number of Ships at Port 1	Waste Amount at Port 1	Number of Ships at Port 2	Waste Amount at Port 2
Plastic	27	609 m^3	28	75,6 m^3
Food waste	27	25,65 m^3	28	26,6 m^3
Cooking oil	27	810 liters	28	840 liters

Step 4 is the determination of usage areas of selected wastes. The most common practice in utilization of waste cooking oil is producing biofuels. The perception of waste cooking oil is shifting from harmful waste to viable raw material for industrial use. Especially in developed countries, the use of fuel produced from waste cooking oil collected from land facilities is becoming widespread. In 2021, a transoceanic flight of Air France was powered by a fuel mixture including 16% sustainable aviation fuel produced from waste cooking oil [URL-7]. Also, EU aimed to reach 5% sustainable aviation fuel in jet fuel mixtures by 2030 [URL-8]. According to Zhang et. al. (2003) despite requiring a very complex process, the use of waste cooking oil to produce biodiesel is feasible and it may reduce the cost of raw material. On the other hand, recent studies aim to use waste cooking oil for purposes other than biofuel production. Mannu et. al. (2019) proposed use of waste cooking oil to produce bioplasticizers, chemicals as energy vectors and solvent for pollutant agents. Chemical composition of waste cooking oil makes them valuable in the creation of lubricants but the viability of such applications is linked to effective recycling techniques. Mannu et. al., 2020 and Panadere (2015) pointed out that waste cooking oil can be treated to produce pyrolytic oil, hydrogen gas, power by direct combustion, or as a carbon source if it is purified and sterilized properly.

Food waste is more difficult to handle than other types of waste due to its structure containing many different components and requiring certain storage conditions. However, food waste contains a variety of organic substances and nutrients. In this respect, food waste can be used as raw material in the production of bioethanol, biogas, organic fertilizers (Dong, 2020), various chemicals and fuel if it is supplied at right amounts (Lin et. al., 2013). In particular, vegetable wastes can be used for producing animal feed (San Martin, 2016). After removal of undesired components such as carbon, glass or ceramic production can be possible (Cornejo et. al., 2104).

Plastics are being used widely because of their durable and lightweight structure and have an advantage that can be turned into refurbished and reusable same material after becoming waste. However, the disadvantage is that too much fossil fuel is used for its production and if it is not used in the circular economy, it decomposes very slowly in nature. Hahladakis et. al. (2020) emphasized that plastic is a sustainable alternative over other materials due to its easier recycling requirements and can be considered to have an important role in circular economy. For using as raw material, plastics can be treated mechanical or chemical. Mechanical recycling of plastic trash involves remelting the material to create granules or final commercial goods. Chemical recycling of plastic can be made using a chemical technique such as pyrolisis or catalysis to extract monomers or directly transform it into other valuable materials (Payne and Jones, 2019). Plastic wastes such as polyethylene and polypropylene are utilized as feed to create syngas by steam gasification (Saebea et. al. 2020). Chemical recycling processes are used to transform plastic trash into fuel and other useful items (Salaudeen et. al., 2019). Plastics can also be used as materials to be burned in incineration process and energy recovery can be accomplished by utilizing a boiler to create either thermal or electrical energy (Gu et. al., 2017).

6. Conclusion

The increase in consumption in the world and the decrease in resources require sustainable approaches in many industries and the derivation of new resources. A global transition from linear economy to circular economy that focuses on reusing waste as raw materials is a concept to achieve a more sustainable world. As a subset of the circular economy, the concept of industrial symbiosis allows one firm's waste energy and materials to be used by other firms as raw materials for production or heating.

Management of the waste generated by the ships is done by conventional processes that are disposing into sea under strict regulation, incineration and delivering to port reception facilities. However, waste delivered to port reception facilities are landfilled and generally not included in the recycling process.

In this study, a case scenario was designed to include ship generated wastes in industrial symbiosis. Since uninterrupted and predictable supply of raw material is essential for production, container and Ro-Ro lines which are operated as liner were selected. Because of wider potential use, food waste, cooking oil, and plastic wastes were designated for calculations. Considering the schedules of ship operators, amounts of wastes that can be collected from ships were calculated and are of usage as raw material were identified from literature. It can be considered that certain types of ship generated waste can be used in industrial symbiosis. For the implementation of this concept, it can be advised that usage area of other types of ship wastes, economic feasibility, and role of port reception facilities in this process should be studied in further studies.

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Integration of Renewable Energy Sources and Smart Technologies in On-board Ships

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Abstract:

Renewable energy use is a viable approach for reducing fuel usage and greenhouse gas emissions in on-board ship. Solar power is becoming a cost-effective fuel reduction with the development of photovoltaic (PV) module technologies. Wind energy is a pollution-free, renewable source of electricity that is abundant at sea. To ensure that zero-emission oceangoing vessels are commercially available by the mid-2030s, it is required to combine hybrid renewable energy resources and vital technologies such as Artificial Intelligence in the maritime industry. This study looks into the viability of deploying renewable energy resources in the maritime industry using current technologies.

Is integration of renewable energy resources with Artificial Intelligence towards Zero-carbon fuels possible to decarbonize maritime shipping?

Is employing renewable energy resources to reduce shipping emissions in on board cost effective?

Renewable energy resources availability and its real-time forecasting is becoming increasingly important for utilities and grid balancing with large renewable energy capacity as wind and solar deployment grows. Predicting and estimating the variables such as wind speed, solar irradiance and the resulted power output, are required for various horizons of time, tend to range from a few minutes to an hour beforehand wherein for stabilizing the grid and scheduling the resources obtained to next-day for optimizing the unit to several days ahead. To generate forecasts over such a wide range of sizes, it is necessary to combine a number of methodologies, each with its own set of capabilities, into a single forecasting system. To maximize the predictive capacity of both, Physical and dynamical prediction methodologies are combined with statistical learning and artificial intelligence (AI) technology in best-practice systems. High-quality narrow projections on the order of a few minutes out to roughly six hours are crucial to aid grid operators in optimizing renewable energy.

In the case of marine solar power, the amount of fuel saved by using solar power alone on large ships is quite tiny due to the uncontrollable weather conditions. Renewable energy sources such as wind turbines and solar panels have a basic deficiency in terms of controlling the electrical generation besides expensive. As a result, if they are not adequately controlled, Grid Instability may occur due to the issues in the utility controls and in the worst scenario it may cause breakdown [Julián Ascencio-Vásquez, et.al in 2020]. Furthermore, the criteria for interfacing these systems to the utility are becoming increasingly stringent, requiring DG systems to deliver specific services, including grid frequency and voltage regulation. They are unable to provide any services due to the inconsistent and fluctuating wind speed due to which it could not give dedicated support to the system in micro grid and on board ship, where the generators will be responsible for stable active- and reactive-power requirements.

1) The discrepancy between the generated wind power and the demanded grid power is compensated or absorbed

using energy storage technologies.

2) Power distribution solutions are used to regulate the flow of electricity between diverse sources and to deliver some grid services.

Distributed renewable technologies may transfer any surplus energy produced to the grid with the help of AI software, and utilities can distribute that power to where essential as it is shown in the figure 1. When the requirement is less, offshore energy storing can hold surplus power while deploying AI could be a solution for directing the energy [Branko Koovic, et.al in 2020 and Sue Ellen Haupt, et.al in 2020]. The proposed system with the deployment of AI to the Renewable energy source will provide a promising solution in onboard ships. It will lead to increased challenges in requiring synchronization, forecasting and optimization to keep the grid in balance.

Keywords: Renewable Energy resources, PV system, CO_2 Emission, MPPT, Deep Neural Network

Introduction

Extensive usage of fossil fuels for electricity generation and transportation leads to the climatic changes and the uncontrollable challenge exist in the globe is global warming. Developed countries across the globe are focusing on generating alternative solution for the power generation. Consequently, significant investment in research and development for creating the carbon free solution [M. Nurunnabi, et.al in 2019 and R. Singh, et.al in 2018]. Power generation by the solar energy and the wind energy are the renewable energy resources which plays a significant role and is eco-friendly. Integrating Renewable energy resources with the electric grid paved way for the emergence of the smart grid. Smart grid technologies include Distributive Power Network, Flexible loads, Active transmission and in other concepts [J. Ke and X. Liu in 2008, M. Xu, et.al in 2019 and A. Elgammal in 2018]. The primary purpose of making carbon free emission and cost effective solution leads to the utilization of fast growing Renewable energy resources with the enhanced Wind turbine and the Photovoltaic technologies. The size, features, and qualities of the wind turbine and photovoltaic technologies have a significant impact on strength efficacy while implementing in onboard ships.

Hybrid renewable energy technologies are becoming conventional technology for power generation since it involves the process of combining the alternating energy resources such as wind and solar because of its potential availability. Out of other renewable energy resources solar is potential one due to its cost effective nature [X. Li in 2013, U. Akram in 2017 and A. Benali in 2018]. The unpredictable nature of the renewable sources, and its uncontrolled, probabilistic, and highly fluctuating nature of the integration of the solar and wind system as hybrid system will exhibit challenges, such as operational issues and stability. Some of the other possible challenges such as Grid to load variance, voltage inconsistency, poor load following, poor power quality, frequency variation, and reliability [Z. Ullah in 2019, A. A. Z. Diab in 2019 and A. A. Z. Diab in 2019]. Due to the transient energy characteristics, the complexity of High power flow appears while integrating the wind turbine and the photovoltaic resource. Multiple nonlinearity and transformation problem will appear during the integration. A framework to characterize and address the occurrence of the High power flow during the integration of the Wind turbine and Photovoltaic technologies with the following consideration

- (i) The background and the significance of the challenge
- (ii) Output power estimation from the Wind turbine and the Photovoltaic is from the datasets available with the wind speed and solar radiation
- (iii) Selecting objective operations
- (iv) Defining technical difficulties, optimization techniques, and reliable and consistent variability
- (v) Resolving High power flow challenges

Several academicians have recently addressed the OPF issue, focusing on several of the above tasks [T. Adefarati N.

T. et.al in 2017, Mbungu, et.al in 2019 and M. Venkateshkumar et.al in 2020]. Power system domain got extended due to the application of the renewable resources with the recent technological advancements.

Optimization of the hybrid power system in the smart grid system, in combination with Model Predictive Control (MPC) architecture, is another key research topic. To minimize the utilization of the utility grid and to maximize the renewable resources usages, MPC design creates a strategy. Applications adopting the combination of Renewable energy resources and grid are explicated under various scenarios [N. Mbungu, et.al in 2017, N. T. Mbungu, et.al in 2019 and 2020, D. H. Tungadio, et.al in 2018]. A technological application of microgrid context with the coordination of energy aims to develop stability in the power flow between the generation of power and consumption. Consequently, balancing the power between the generated and the demand of the system will be carried out by controlling the power flow in tie lines and the frequency deviations in the microgrid using Model Predictive Control.

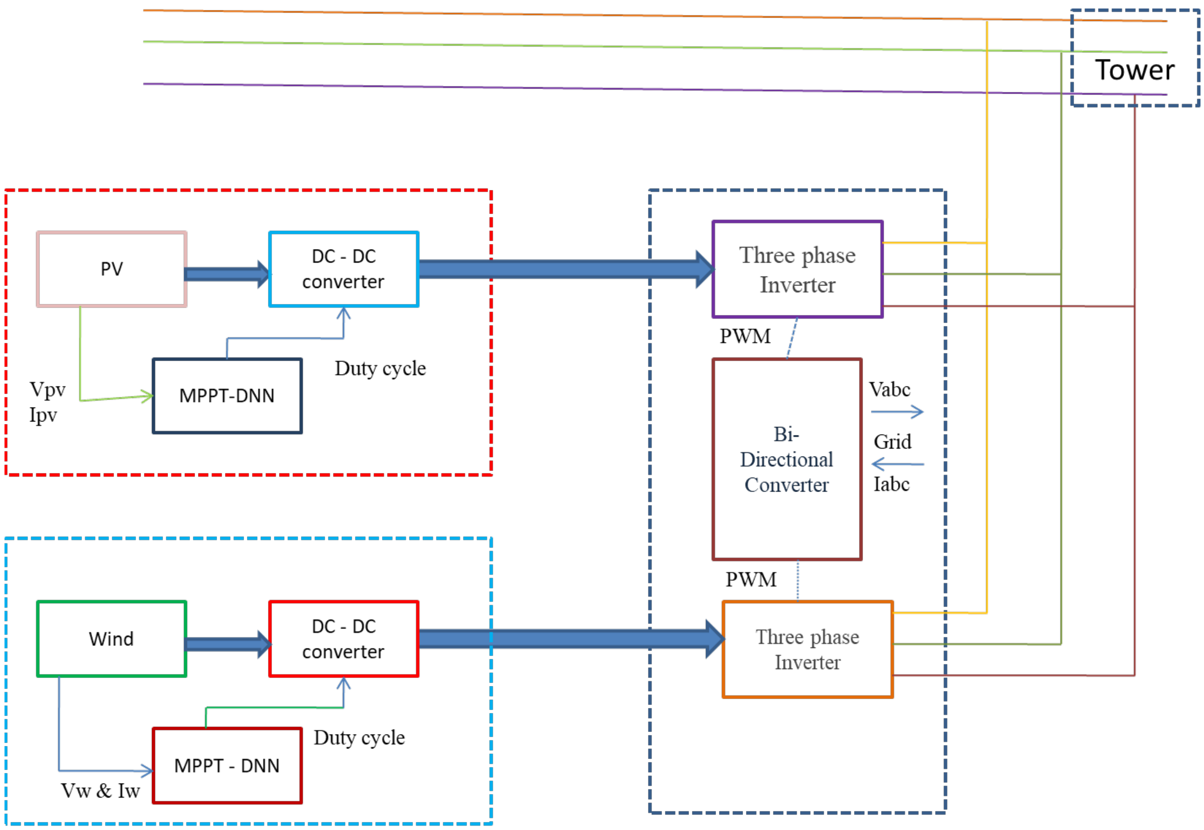


Figure 1 Block Diagram of DNN based MPPT controller for the Hybrid System

This paper concentrates on the development of novel Deep Neural Network based Maximum Power Point Tracking (MPPT) algorithm for providing solution to the challenges in integrating the Photovoltaic and Wind generators as shown in Figure 1. This article mainly contributes on the following

(i) DNN based MPPT controller design and modeling for the Photovoltaic system and analysis of performance under various weather conditions

(ii) DNN based MPPT controller design and modeling for the Wind system and analysis of performance under different wind speed and its context

(iii) DNN based MPPT controller design and modeling for the integration of grid with the Hybrid system and analysis of performance under various context

The rest of the paper is dissected as follows. Section 2 discusses about the DNN based MPPT controller design and model for PV system under various weather conditions. Section 3 discusses about the DNN based MPPT controller design and model for wind system under different wind speeds. Section 4 discusses about the DNN based MPPT controller design and model for the integration of grid with the Hybrid system. Section 5 elaborates the performance of all systems and addresses the cost effectiveness of the hybrid system. Section 6 discusses about the concluding remarks for the hybrid system and its effectiveness.

DNN based MPPT for PV system

The MPPT algorithm is to extract energy maximally under different weather contexts. Advancements have been achieved by developing new MPPT algorithm with the integration of different controllers; some of the controllers are ANFIS, ANN, Fuzzy, Perturb and Observe (P&O) and others [S. B. Santra, et.al in 2018, J. S. Ojo, et.al in 2019, S. Messalti, et.al in 2015 and R. Divyasharon, et.al in 2019]. Deep Neural Network based MPPT algorithm is developed for the Photovoltaic system by considering the dataset of different solar radiation and also observed radiation with the experimental setup at Academy of Maritime Education and Training, Deemed to be University funded by All India Council for Technical Education (AICTE), New Delhi, Government of India. The simulation is simulated with the MATLAB environment. The PV array of 1KW is considered for the proposed simulation. The proposed block diagram uses DNN based MPPT algorithm of Photovoltaic system is shown in the figure 2. The model is fed with the collected dataset from kaggle and the observed real time data at the prime location of the experiment, where it was taken. Flow model of the DNN based MPPT controller is shown in the figure 3(a) and the model representation is shown in figure 3(b). The DNN layer has two input layers such as Irradiance and the temperature from the Photovoltaic system; 500 hidden layers and an output layer. The DNN based MPPT controller is trained to predict the accurate voltage and current across the photovoltaic system.

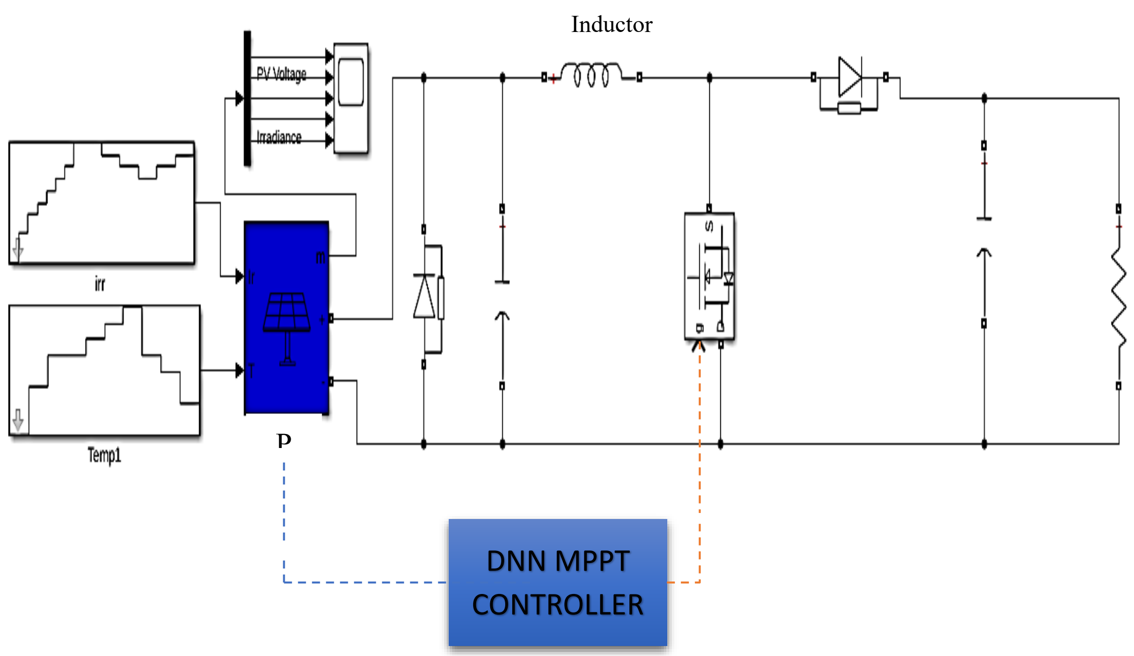
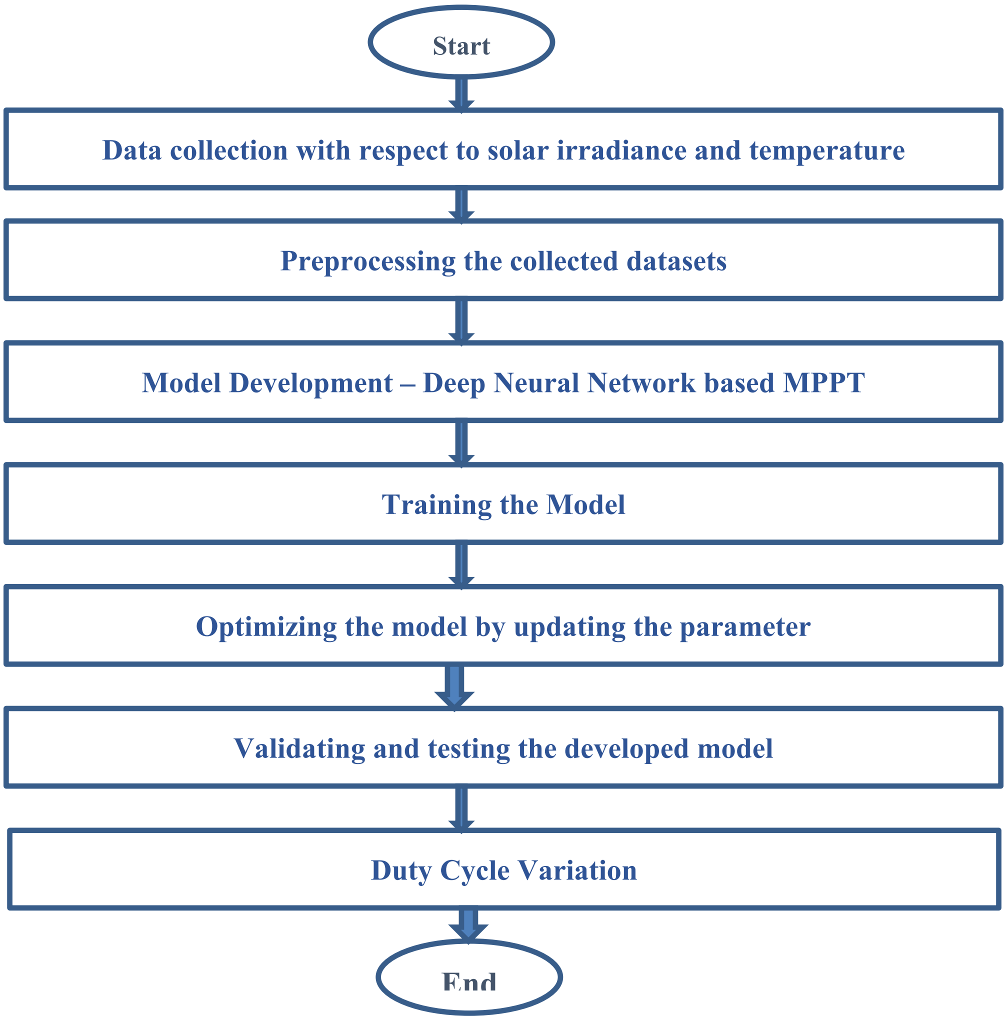
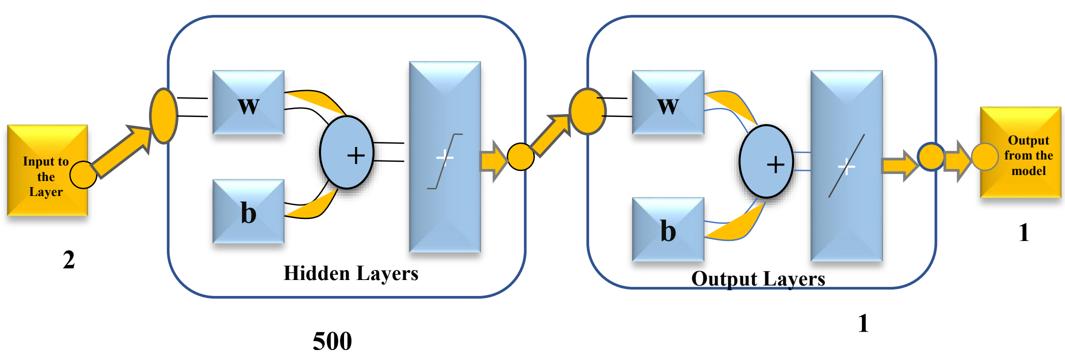


Figure 2 Block diagram of the DNN based MPPT controller



(a)



(b)

Figure 3 Deep Neural Network Model of PV system (a) Flow Model (b) Model representation

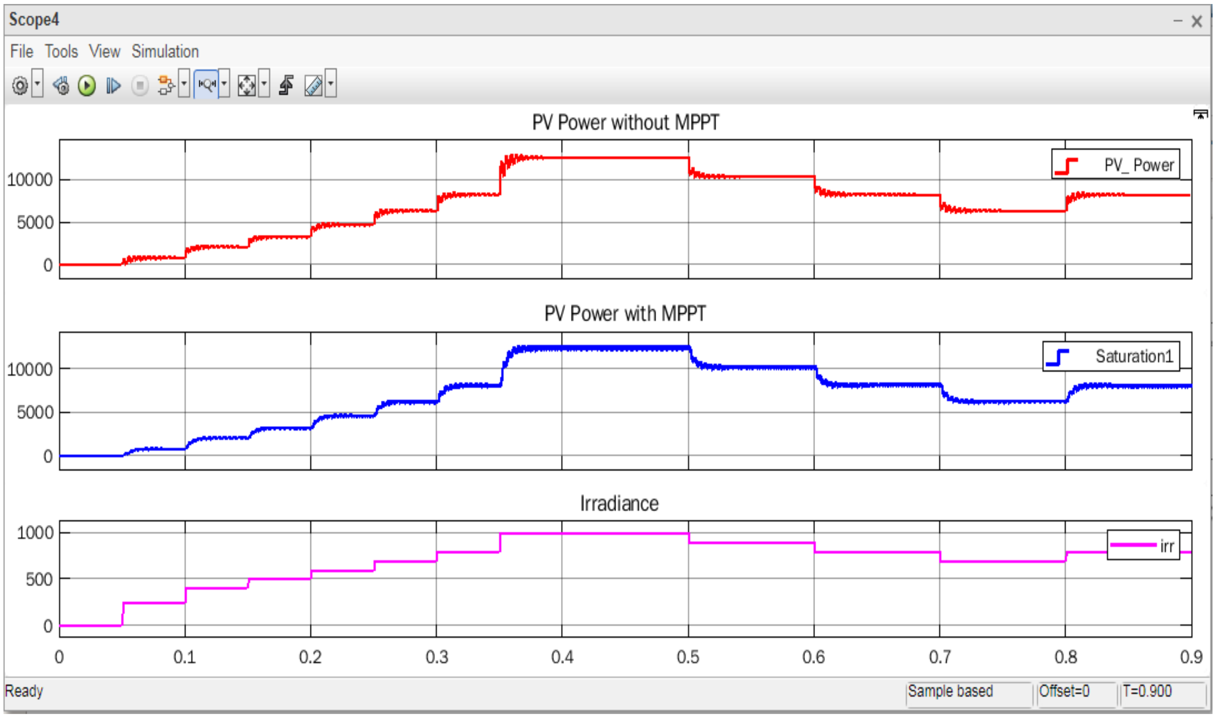


Figure 4 DNN based MPPT controller output for PV system with respect to radiance and temperature

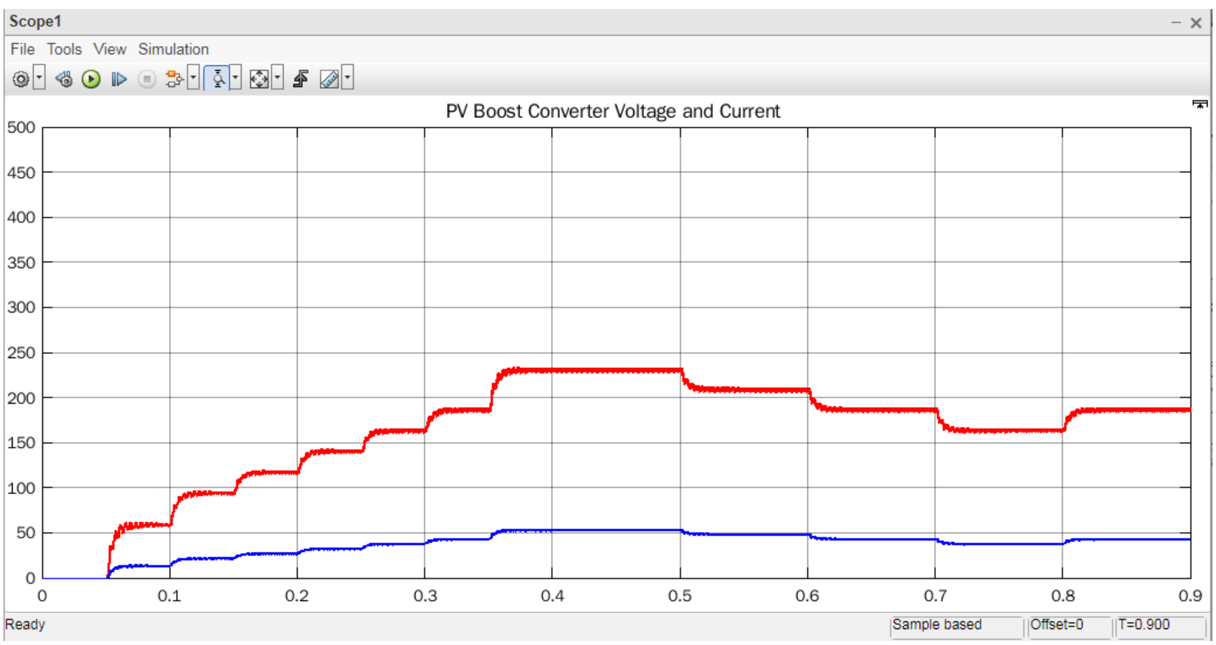


Figure 5 Photovoltaic Boost converter voltage and current

The simulated output for the DNN based MPPT controller output for PV system with respect to radiance and temperature is shown in figure 4. The proposed DNN based MPPT controller is developed in the MATLAB environment with the applied voltage of 1KW for the Photovoltaic system and observed the results under various solar radiations. Consequently, Buck-Boost converter is used in the experimental setup to boost the voltage from the solar radiation and the simulated results are shown in the figure 5.

DNN based MPPT for Wind system

Deep Neural Network based MPPT algorithm is developed for the experimental setup available in AMET University, by considering the dataset of different wind speed [S. Yushu, et.al in 2019 and T. Adefarati, et.al in 2019]. The simulation is simulated with the MATLAB environment. The 1KW wind energy system is considered for the proposed simulation. Figure 6 shows the proposed block diagram of DNN based MPPT algorithm. The model is fed with the collected dataset from kaggle and the observed real time data at the prime location of the experiment, where it was taken. Flow model of the DNN based MPPT controller is shown in the figure 7(a) and the model representation is shown in figure 7(b). The DNN layer has two input layers such as wind speed and otheres from the wind system; 500 hidden layers and an output layer. The DNN based MPPT controller is trained to predict the accurate voltage and current across the wind energy system.

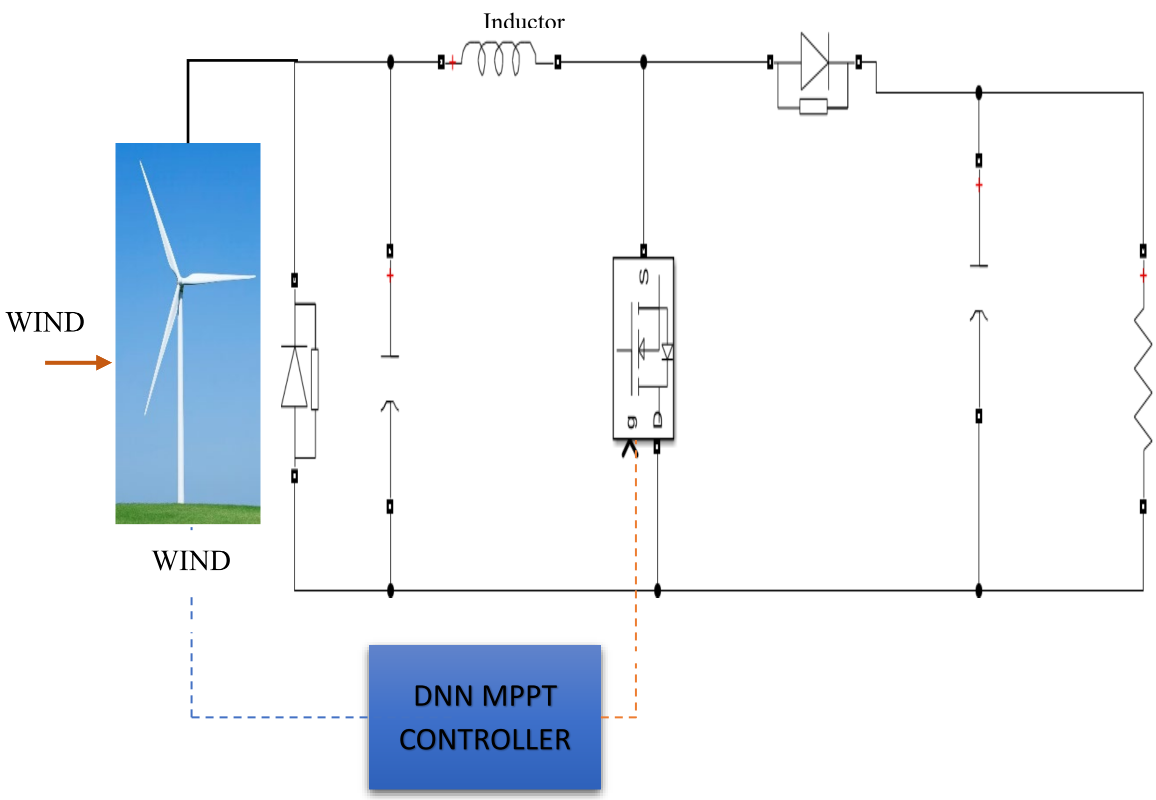
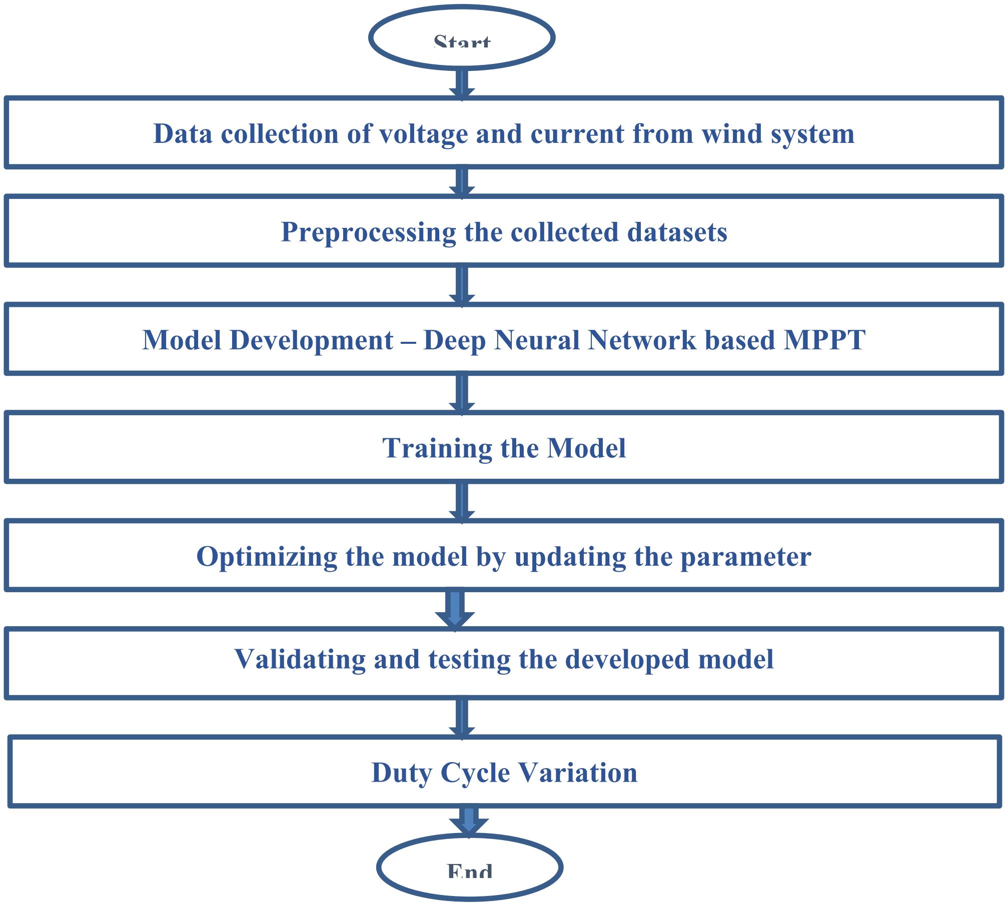
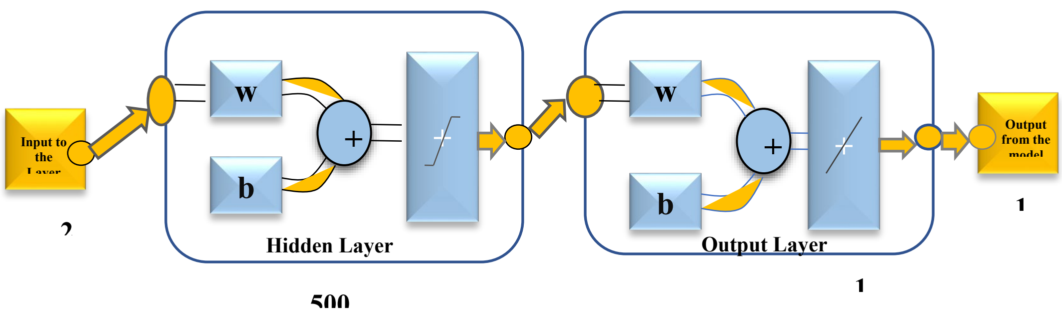


Figure 6 Block diagram of DNN based MPPT controller for Wind system

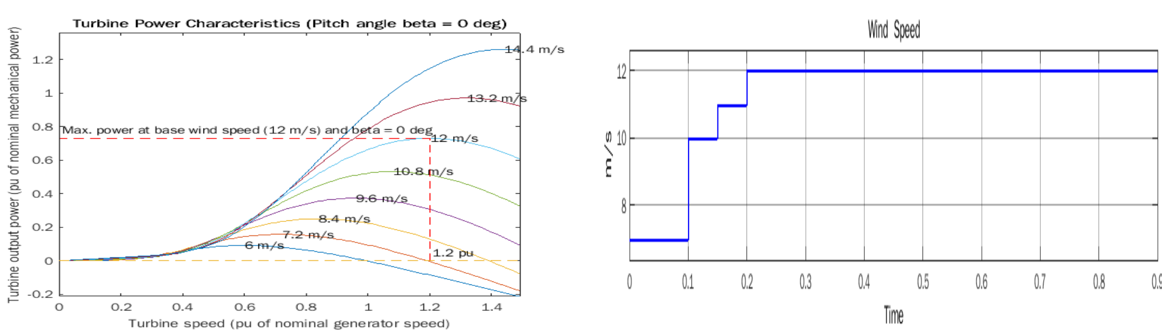


(a)



(b)

Figure 7 Deep Neural Network Model of Wind system (a) Flow Model (b) Model representation



(a) (b)

Figure 8 Wind Characteristics (a) Wind Generator Turbine Speed (b) Wind speed

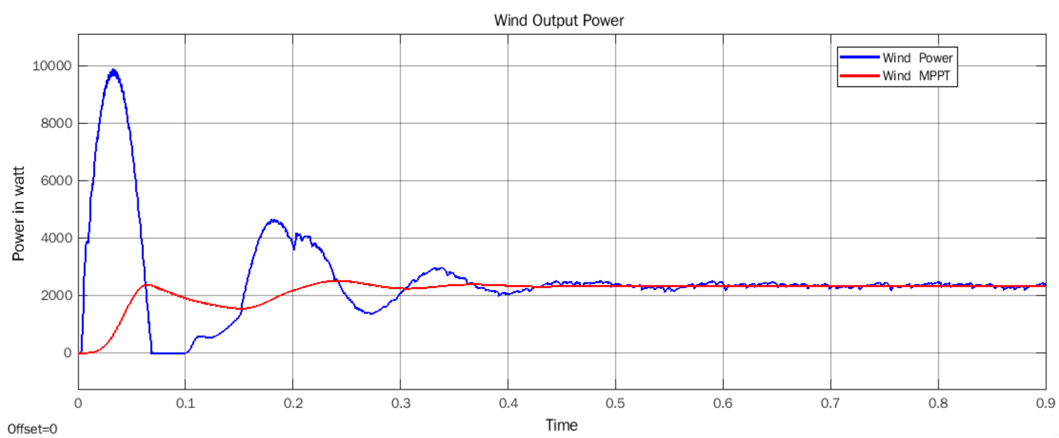


Figure 9 DNN - Wind Power with and without MPPT

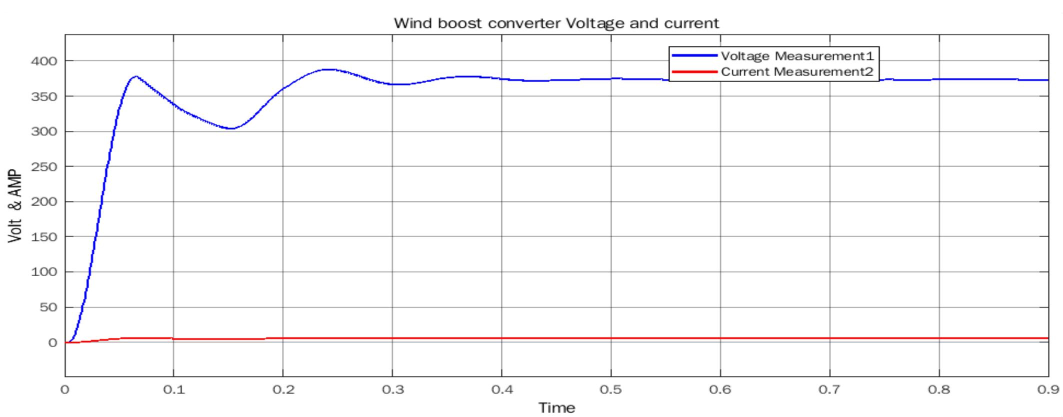


Figure 10 Wind boost converter Voltage and Current

The wind's turbine generated speed and the wind speed is shown in the figure 8. The simulated output for the DNN based MPPT controller output for Wind system with and without MPPT wind power is shown in figure 9. The proposed DNN based MPPT controller is developed in the MATLAB environment with the applied voltage of 1KW for the wind system and observed the results under different wind speeds. Consequently, Buck-Boost converter is used in the experimental setup to boost the voltage from the wind energy system and the simulated results are shown in the figure 10.

DNN based MPPT for Hybrid system

Deep Neural Network based MPPT algorithm is developed for an experimental setup at Academy of Maritime Education and Training, Deemed to be University funded by All India Council for Technical Education (AICTE), New Delhi, Government of India. The Hybrid system is developed by considering the dataset of both solar and wind under different weather conditions. The simulation results are developed using MATLAB environment. Both the 1KW Photovoltaic energy system and wind energy system is considered. The model representation is shown in figure 11. 1000 hidden layers are considered in the Hybrid system. The DNN based MPPT controller is trained to predict the accurate voltage and current across the hybrid system using the input voltage and current.

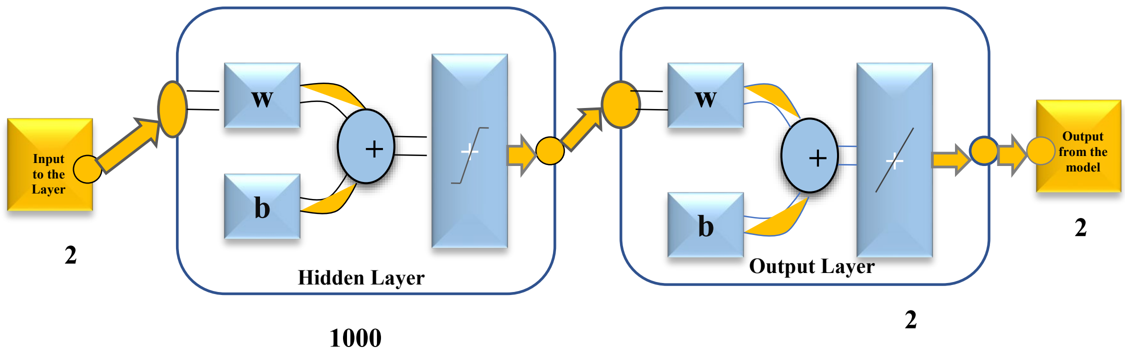


Figure 11 Deep Neural Network Model of Hybrid system

Figure 12 and 13 shows the Load real power and reactive power consumed by the load in terms of kilo watts. The simulated output of the total power generated by the Hybrid system is shown in figure 14.

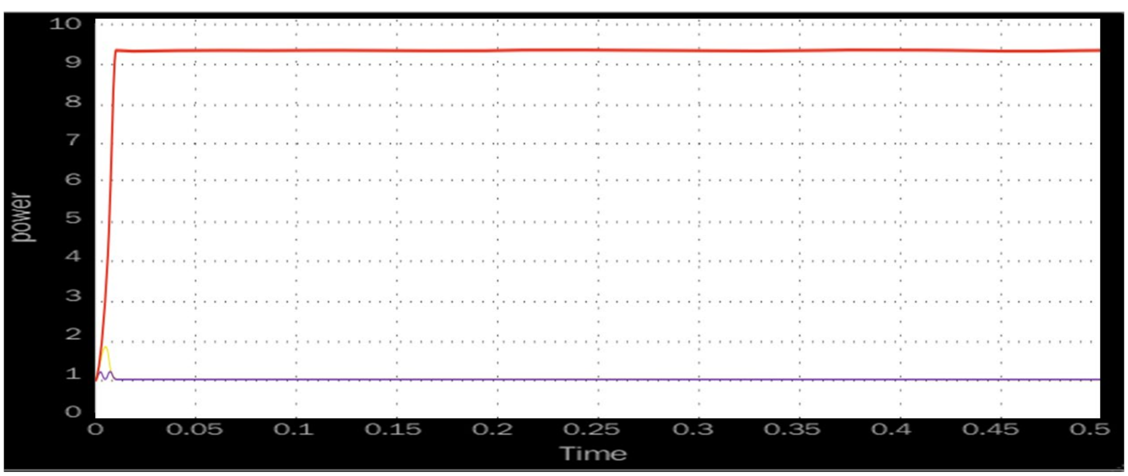


Figure 12 Real power consumed (KW)

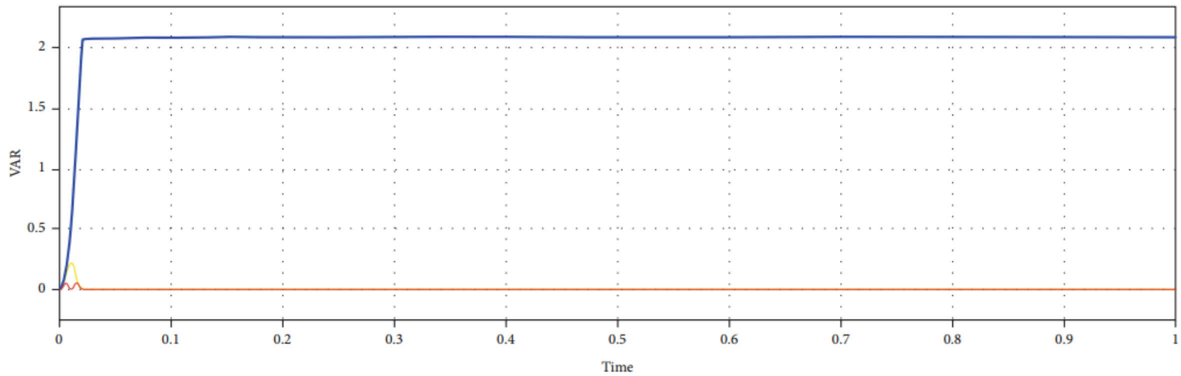


Figure 13 Reactive Power consumed (KW)

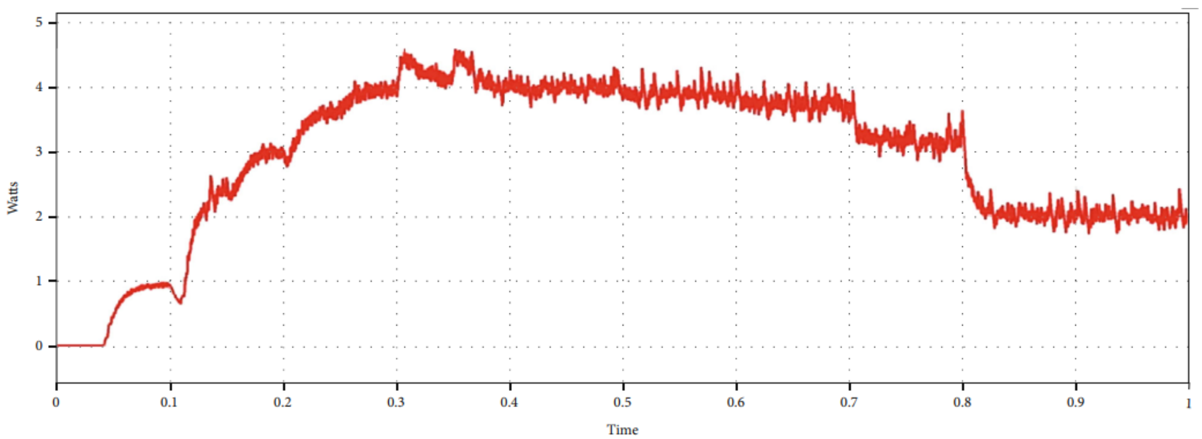


Figure 14 Total Power generated by the Hybrid System (Photovoltaic and Wind System)

Results and Discussion

The Simulation results of the Photovoltaic, Wind, and the Hybrid system under various weather influences are discussed in the paper. The simulations are carried out in the MATLAB environment. The performance of the Photovoltaic, Wind and the Hybrid system for the Total Harmonic Distortion with the proposed DNN-MPPT controller and the PI controller in terms of voltage and current values is tabulated in the table 1. It clearly depicts the effectiveness of the system which will be used for carbon free environment.

Table 1 Total Harmonic Distortion

System	DNN-MPPT Controller		PI Controller	
	Voltage (V)	Current (A)	Voltage (V)	Current (A)
Hybrid	0.11	0.10	0.16	3.60
PV	0.11	0.015	0.16	0.33
Wind	0.11	2.25	0.16	29.5

From the Proposed system, the hybrid power is about 2KW, which is a combination of Photovoltaic and wind system. The Photovoltaic array could be mounted on the deck areas of the vessel or on the sails or on both areas. The installation area should be subjected to the weather influences and the marine environmental conditions such as humidity, corrosion and other limitations in the area. The wind system can also be mounted on the deck area of the vessel subjected to the wind characteristics. The Hybrid system with the grid in onboard ships will provide considerable cost effective solution.

Conclusion

The proposed research dealt with the viability of implementing the renewable energy resources such as Solar and Wind in on-board ships; Integration of the Hybrid system and the Smart Technology have the possibility of reducing ship's emission and to progress towards zero carbon emission. The technological, environmental, and economic implications of a hybrid energy system are highlighted in this research by incorporating hybrid energy systems into On-board ships. Integration of renewable energy resources into existing fleets or into the new shipbuilding and design, with a limited number of new ships aiming for 100 percent zero-emissions technology implementation in on-board ships as a cost-effective solution in the long run. The research work analyzes the Deep Neural Network integration with the Maximum Power Point Tracker controller and is employed with the Photovoltaic system, Wind System and the Hybrid system. The level of challenges encountered depends on the appropriate energy availability in the sea route, and the primary cost in implementation. This research work also concentrates on the generation of renewable energy resources and the challenges in maintaining the stability of the system. The Deep Neural Network based MPPT controller would be a viable solution to maintain the grid stability. It concludes that the Smart technology integrated renewable energy resources utilization as a Hybrid system in on-board ships will be a promising solution for upgrading the Maritime Industry towards Industry 4.0.

Acknowledgement

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Study of Water Treatment Technologies

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Abstract: Purification of sea water is difficult because the amount and diversity of microorganisms it contains are much higher than in fresh water, however scientists are creating new and improved cleaning and desalinization methods. We have examined purification methods that make no changes in general in the water: Mechanical – reservoir pollution: suspended solids, acidity (pH); Chemical - chlorination and ionization; and the process of osmosis. Samples included the Batumi Dolphinarium, the Batumi Aquarium, the training pool of the Georgian Maritime Academy, Lake Nurigel, the vessel Cadet (BSMA) training vessel and the Batumi Yacht Club waters. Using a bathometer, we took samples of water at various depths to analyze their chemical composition, physical properties and the amount of inorganic or organic impurities. Measurements were made by photometer. In previous studies we addressed the issues of water pollution near the coastal zone of Adjara. Present research will contribute to the improvement of our training course “Marine Pollution Prevention and Control Methods” at the Georgian Maritime Academy. The participation of students in the study will contribute to their research skills and allow us to establish information on the key sources of pollution and apply appropriate pollution prevention policy.

Keywords: water purification, pollution prevention training and policies, comparative pollution analysis.

1. Introduction

Salt water makes up 97% of our planet's water resources. Transforming this resource into potable water has been one of mankind’s great achievements, yet one in ten people still suffers from a lack of drinking water. In dry regions it is difficult to get the required amount of water, while in other areas large amounts of water are available but unsuitable for drinking. Water purification is crucial where no other source is available than salt water, for example in the Middle East and Africa. The transformation of seawater is also needed for long-distance navigation vessels (Figure 1), space stations, polar stations, and other particular cases [3].

River confluences and salt marshes near the ocean can also be transformed into drinking water. Sea water is analyzed for the following chemical and physical properties and characteristics: salinity, density, compressibility, the speed sound is carried, the light absorption coefficient, electrical conductivity, specific heat capacity and other factors. Technology to convert brackish sea water, or other brackish water into clean, drinkable water could change the lives of millions of people, and research technologies are improving. However, installing the tools and equipment is often a lengthy process and costly, although progress is being made to simplify and shorten the installation time, creating technologies that are more accessible to regions that need them most.

A key issue is keeping treatment methods and means both suitable and safe to use [4]. From a technological point of view for water treatment, these resources can be divided into two types: 1) brackish water (containing 30 to 45 grams of salt per liter) such as ocean waters and most sea waters; and 2) saline water (0,5 to 30 grams of salt per liter, which includes some continental bodies of water, for example, the Black Sea and the Sea of Azov. Both types of water contain many components, but the main one is sodium chloride (which is the same as table salt).

Considering the results of studies on water treatment works (there are up to 20,000 water treatment plants worldwide) we can conclude that ≈50% of consumable water is produced in North Africa and the Middle East; up to 20% in East Asia; 13% in North America; and 10% in Europe, of which 6% is produced in Spain. As for the consumption of distilled water, up to 65% is used for urban areas; 35% in industry; 6% in the energy sector and 4% in agriculture.

Technologies for obtaining clean water include condensation (obtaining water from the air), transforming salt water to freshwater, and other methods such as using purification microchips that can be used at home. Billions of gallons of clean water are produced through these methods today.

Figure 1. Water treatment plant on seagoing vessel

Figure 2. Carnegie Perth's Wave Energy Project

For example - especially interesting projects include the use of water waves. The "Carnegie Perth's Wave Energy Project" (Figure 2) has a dual function: 1) generating energy through waves and 2) purifying sea water using the generated energy, thus making it suitable for drinking. After water treatment, the remaining electricity is sent to a shore control station and stored. Similar types of installations are currently operating off the coast of Western Australia.

2. Study Methodology

The working environment of our graduates is the sea and the waters of the world ocean, where there is knowledge about water treatment technologies and their application are important for the job. We decided to find out the level of knowledge of students in this area using a qualitative research method (a survey of students). The first step was a short online survey, with 5 questions:

1. Suppose you are on an excursion. What should you do if you run out of drinking water on the way?

2. Suppose you encounter a swamp, a lake, a river, a river confluence or the sea. Which reservoir water is unsuitable for drinking?

3. Why is it necessary to clean river / sea water?

4. What method / methods of sea water purification do you know?

5. Name the types of sea water pollution and the main sources of pollution?

Three hundred, mostly third-year students, answered the survey. After processing and analyzing the data, we realized that 75% of the interviewees did not understand the importance of water purification, 85% were not familiar with water purification methods and 55% could not name sources of water pollution. The results of the survey were alarming.

In the second stage of the study we formed student work groups to explore types of pollution in different settings, the sources of pollution and the means for treatment. The following sites were selected: I - The Batumi Dolphinarium (Figure 1-1, 1-2, 1-3), the Batumi Aquarium (Figure 2), the Marine Academy Training Pool [6] (Figure 3-1, 3-2). II - Nuri Lake (also Pioneer Lake**,** natural lake in Adjara, Batumi **(F**igure 4), Ballast Waters from the Training ship Cadet ship (Figure 5) and Batumi Yacht Club Water Area (Figure 6).

Figure 1-1. Dolphinarium

Figure 1-2. Ozon treatment plant

Figure 1-3. Seal pool

Figure 2. Aquarium

Figure 3 - 1. Marine Academy Pool

Figure 3 - 2. Marine Academy Pool

Then we made a schedule – we started take water analyses at the first three facilities (Table 1) on 15.12.2021, we finished on 25.12.2021. We planned to take water analysis at the second three facilities (Table 2) in the period 5.01.22.-25.01.22. We inspected each facility, got acquainted with the water treatment facilities, took samples, checked the water quality on various parameters by express-analysis and laboratory methods, analyzed the results and made the appropriate conclusions.

Sample taken in the above reservoirs were studied in the laboratory. The results of the study are given in table 1. Appropriate cleaning methods were applied for each object.

Table 1. Water analysis of the first three facilities

№	Type of sample	Temp	suspended solids	Ph	ozone O_3	NO_2	NO_3	NH_3
		°C	mg/l		mg/l	mg/l	mg/l	mg/l
1	**Dolphinarium**							
	Sample before cleaning							
	Seal Pool	18	< 2	< 5,1	0	0,01	0,05	0,03
	Dolphin Pool	18	0,02	6,5	0	0,01	0,02	0,02
	Sample after cleansing (osmosis, ozonation)							
	Seal Pool	18	0	< 5,1	< 0,02	0,37	0	0
	Dolphin Pool	18	0	< 5,1	< 0,01	0,39	0	0
2	**Aquarium**							
		Sample before cleaning						
		19	< 4	< 5, 5	0	0	-	-
		Sample after cleaning (filtering)						
		19	< 1	< 5,1	0	0	-	-
3	**MaritimeAcademy Pool**							
		Sample before cleaning						
		0	-	6,5	-	-	-	-
		Sample after cleaning (chlorination)						
		17	-	7,2	-	-	-	-

Figure 4. Nurigel Lake

Figure 5. Cadet ballast sample

Figure 6. Yacht Club water area

Sample taken in the above reservoirs were studied in the laboratory. The results of the study are given in table 2. Appropriate cleaning methods were applied for each object.

Table 2. Water analysis at the second three facilities								
№	**Type of sample**	**Temp.**	**suspended solids**	***Ph***	***Cont. Fe***	**COD**	**BOD**	**Dissolve oxygen**
		℃	mg/l		mg/l	mg/l	mg/l	mg/l
1	**Lake Nurigel**	Water sample (near the shore)						
		12	34	-	0,001	25	4,3	6.0
		Water near artificial aeration (fountain)						
		12	19	6			6	6,5
2	**Training ship Cadet**	16 °C	109,5	7	8,5	-	-	3,8
3	**Yacht Club water area**	13 °C	2	5	0,9	-	-	-

3. Final Conclusions and Recommendations

As a result of the research, various types of water treatment facilities were studied, including the latest, most modern and most effective means – ozonation which is used in the Batumi Dolphinarium. Water purification in the Batumi Aquarium is carried out by a mechanical method (filtration). The chlorination method is used to purify the water in the Maritime Academy training pool. Oxygen saturation is used to improve the water quality of Lake Nurigel (aeration method) [1].

Analysis of the results of laboratory studies (Table1- light-colored, slightly turbid, with a small amount of precipitation. Table 2 – Sample was muddy, with precipitation. There were floating compounds, sometimes with a specific odor, that appeared before treatment. These disappeared after treatment showing how water quality improved as a result of treatment.

The Black Sea and its basin are important parts of the Georgian ecosystem and play a major role in the country's economy. Georgia's Black Sea coastline is 320 km long, and more than 75% of the country's rivers flow in the Black Sea basin. Thus, it is highly important to ensure that untreated water does not pollute key reservoirs [3] which can cause contamination from impurities and chemicals, thus affecting the flora and fauna of the reservoirs. Pollution would seriously harm tourism, which is a major economic factor for the region. This is why awareness of the populations living in these areas is important [5].

Our project is a methodology "to identify types of pollution in the Black Sea region of Georgia, using a collaborative research method with Maritime Academy students, and to select the most adapted solutions to different types of water pollution. To raise public awareness of specific types of water pollution and provide information within the local education system that will impact behavior of the populations living along the Black Sea coastal areas [2].

The program will develop adapted presentation materials based on our findings, for information on the protection of the region's unique environment. Local administrations should take a greater responsibility for the prevention of coastal pollution, to avoid tragic consequences [7]. Our study revealed the need for more local awareness, and the importance of including these subjects in the education curricula.

Acknowledgements.

We thank the administration of the Batumi State Maritime Academy for their support in purchasing measuring equipment, which helped in carrying out laboratory studies.

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IAMUC 22

Session

Technological Aspect

THE SEAWORTHINESS OF A TRAINING SHIP "NAŠE MORE" IN HEAVY SEAS

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Abstract: Safe navigation depends on many factors, such as the maneuverability and stability of the ship, the nature of the waterway, the sea state and other external factors and, above all, the seamanship of the mariner. Therefore, it is necessary to analyze the movement of the ship in different conditions. The seakeeping analysis is usually done by model tests and/or calculations during the design stage, while full-scale measurements in real conditions are very rare. This paper presents the full-scale measurement of a training ship motion in heavy seas as part of a research project entitled "Modelling Uncertainty of Ship Wave-Induced Response in the Adriatic Sea (MODUS)", fully supported by the Croatian Science Foundation. The experiment was performed on the training ship "Naše more" in the port of Dubrovnik. The wave height ranged from 4ft to 6ft with SE wind. The waves came from the direction of 180 ° to 183°. The wave buoy SPOTTER was used to collect the data on the movement and height of the waves. The ELLIPSE2-N-G4A2-B1 sensor recorded the ship's behavior and was placed on the bridge.

Keywords: ship motion experiment; six motion components; Spotter buoy; Ellipse2

1. Introduction

Safe navigation through channels, straits, the open sea, and oceans and the avoidance of dangerous situations at sea depend on many factors, such as the maneuverability and stability of the ship, the nature of the waterway, the sea state, and other external factors and, above all, the seamanship of the mariner. The collision risk assessment and the decision-making process to prevent collisions at sea are based on the criteria of maritime rules and the experience and knowledge of the officers (Vujičić et al. 2018, Vujičić et al. 2017). The technological advances made the forecast charts and data quite reliable, but some elements important for the safety of navigation may deviate, though. Such elements are the current height of the wave in foul weather and the ship's motion, which even the most experienced officer cannot predict. The interaction between currents and waves must be taken into consideration as it leads to change in wave height and period. Analysis and prediction of environmental conditions should be performed to calculate the environmental loads acting on ships to increase the ship's operability (DNV GL 2017). It is, therefore, necessary to collect all the information available on-board the ship and analyze it for future modelling. Various data collected and stored on board ships could be used for scientific purposes (Vujičić et al. 2020). The simulation of a ship's motion is a fundamental task for ship simulators used as training or studying tools (Varela 2011). The conditions in the simulator should be as real as possible as compared to those at sea. Thus, this is an excellent tool that can improve the simulator software. For all these reasons, it is crucial to know the actual ship motion in each sea area and weather condition. For a more reliable knowledge of the ship's motion at certain wave heights and in a specific area, it is necessary to collect all relevant data and information in real time. Ships must be able to withstand the loads at sea. Thus, it is important to analyze the degrees of freedom and a ship's response to rough seas. In general, uncertainties in modelling a ship's response to rough seas and the uncertainties in numerical calculations can be eliminated by processing the data collected from ships and drawing new conclusions. Furthermore, artificial intelligence can increase the operability of the ship, optimize waterways, help decide how to maneuver the ship in adverse weather conditions, be useful in the design for any shipbuilding project based on reliability methods, and contribute to greater safety of navigation. The paper is part of the research project "Modelling Uncertainty of Ship Wave-Induced Response in the Adriatic Sea - MODUS" and is a dimensional measurement of the research ship motion in rough seas. The purpose of this particular test was to see how ships with similar characteristics to the one used in this trial would react to rough seas. This test is especially useful for the ships that operate on the route between Croatia and Italy. The trial showed how the ship would react to heavy weather, particularly applicable to the route between Croatia and Italy and along the Croatian coast. This data facilitates voyage planning, i.e. helps to the captain to decide whether it is possible to reach the destination safely. In addition, the data obtained is useful for ship simulator providers as the direct implementation of these findings improves the simulator software used for training, practice and voyage planning in a virtual reality environment. The main equipment used for this experiment is the solar-powered floating buoy SPOTTER and Inertial Measurement Unit - ELLIPSE2. The Spotter is a solar powered wave buoy used to explore wave-driven dynamics and can be used as a moored or a free drifting configuration (Raghukumar et al. 2019). The correlation analysis performed by Houghton et al. showed that the Spotter buoy provides data with very low errors (Houghton et al. 2021). ELLIPSE2 is a sensor that records the roll, pitch, and heave movements as well as GNSS position. The investigation carried out by Lüer (2020) showed that it is a very accurate system. This study is a follow-up to previous research carried out by Katalinić et al. (2022), and Matić and Katalinić (2020). They focused on measuring the wave-induced motion of a sailboat in small to moderate waves in relation to its size. The present study is motivated by current efforts in industry and the research community to quantify and reduce the uncertainties in modelling the waves and wave-induced responses (Bitner-Gregersen, E.M. (2022)). The intention is to facilitate many risk-based seakeeping applications, such as ship operability analysis and extreme wave load calculation (Petranović, T. et al. (2021)), heavy weather manoeuvring (Papanikolaou, A. et al. (2014) and Bitner-Gregersen, E.M. & Skjong, R. (2008)), and weather routing (Dong, Y., Frangopol, D. M. & Sabatino, S. (2016) and Prpić-Oršić, J. (2016).

The article is structured as follows: after the introduction, the description of the methodology and equipment used for the experiment are presented in Section 2. The results of the measurements are presented in Section 3 together with the statistical analysis using the STATREL software. Finally, the last section provides conclusions and plans for future research.

2. Methodology

Full-scale measurements of the wave-induced responses of the training ship "Naše more" (LOA 31.35m, beam 7.4m, drafts 2.180m F and 3.485m A) were carried out in the Dubrovnik Pilot station area from 09:30 to 13:28 hours. A free drifting half submerged buoy SPOTTER with a weight of 5.5 kg and a diameter of 38 cm was used to record waves in real-time every 0.4 seconds and reported its GPS location to the user every hour via satellite. The ELLIPSE2 sensor was used to measure the wave-induced ship motion. The Spotter buoy transmitted the real-time data to a laptop and alerted the team to buoy movement. IMU ship sensor provides roll, pitch, heading, heave, and centimetric GNSS position. The experiments were conducted on 05 November 2021. Measurements of ship response were made for 4 different heading angles (with respect to the main wave direction of 180°, 183°) 000°, 180°, 325°, 135° in the area where the Pilot boarding ground is located. The angles of approach 000°, 180°, 35°, and 225° were determined, whereby 35° corresponds to 325° due to the symmetry, while 225° corresponds to 135°. Each measurement trial lasted 30 minutes, and the sailing speed was 5±0.2kn in the first, third, and fourth measurement trials, while it was 4±0.2kn in the second trial. While the ship response measurements were taken, a floating buoy simultaneously measured the waves in the same area where the ship was sailing.

3. Results

The heave and pitch time series were measured at four different heading angles (Euler angle). For illustration and because of the highest ship responses, only the measurements at a heading angle of 180° are shown (Figures 2-3). Simultaneously with the measurement of heave and pitch, a floating buoy was used in the same sea region to record the wave elevation shown in Figure 1, and it can be seen that the largest amplitude of the wave was 1.27 m. Figures 2 and 3 show that at the end of the measurement trial, the highest heave amplitude was 1.72 m, and the largest pitch amplitude was 7.05°.

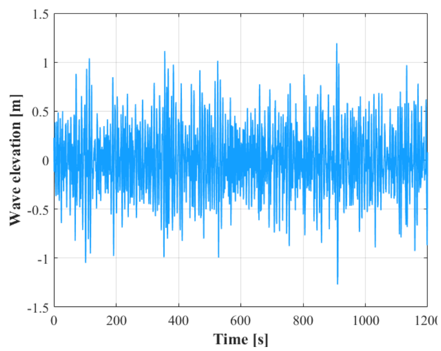

Figure 1. Wave elevation

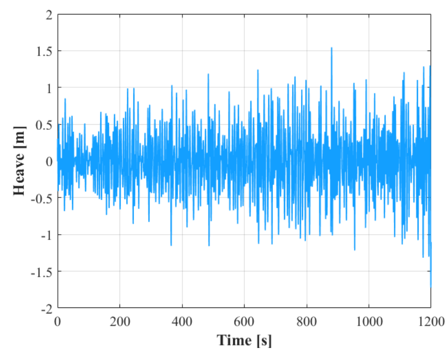

Figure 2. Heave measurements at heading angle of 180°

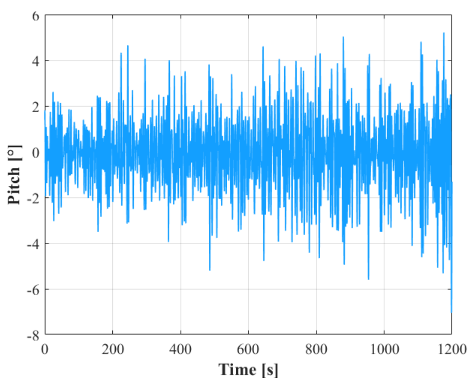

Figure 3. Pitch measurements at heading angle of 180°

The statistical analysis of the heave, pitch, and wave time series is performed using the STATREL software, an auxiliary program in the STRUREL system (STRUREL 2007). STATREL is a tool that allows basic analyses of statistical data and their graphical representation. The time series analysis application in STATREL includes several tools for data manipulation and a set of estimation methods. In addition, STATREL allows some basic transformations of the original time series to perform the relevant spectrum analysis.

Basic statistical descriptors of three time-domain signals are provided in Table 1.

Table 1. Basic statistical descriptors of the measured time series

Statistical property	Wave el., m	Heave, m	Pitch, °
St. deviation	0.342	0.391	1.463
Min.	-1.270	-1.723	-7.051
Max.	1.240	1.546	5.212
Skewness	0.041	0.066	0.022
Kurtosis	3.184	2.996	3.256

From Table 1 it can be seen that the pitch and heave motions, as well as the wave surface elevation, are nearly Gaussian processes since the skewness is approximately zero and the kurtosis is around 3, which corresponds to the values of the normal probability distribution.

In STATREL, the Husid function can be used to determine whether a random process is stationary (Katalinić 2021). The Husid Function is defined as the integral over the square of the process, which represents the energy development of the fluctuating process X(t) with a mean value of zero:

$$Husid(t) = \int_0^t X^2(\tau) d\tau, 0 \leq t \leq T_d \quad (1)$$

where Td is the duration of the observation (STRUREL 2007).

For a stationary process, the Husid function is a curve that slightly oscillates around a straight line. Figures 4 and 5 show the Husid function of wave amplitudes and heave. The Husid function of wave amplitudes tends more toward a straight line than the Husid function of pitch. The reason for this lies in the fact that the waves were measured by a free-floating buoy, and the pitch was measured on-board ship advancing at a forward speed. Consequently, the process of the wave elevation satisfies a condition of the statistical stationarity better than the ship's motion.

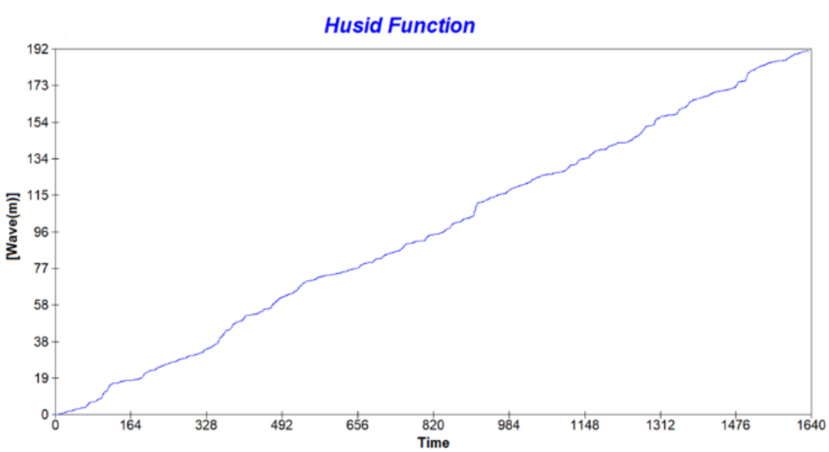

Figure 4. Husid function of wave elevation

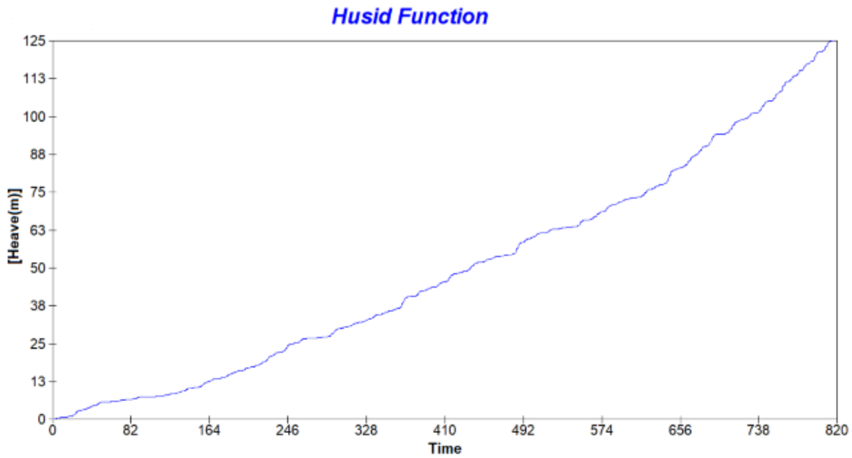

Figure 5. Husid function of heave

The energy spectrum in STATREL is calculated as the Fast Fourier transform (FFT) of the auto-correlation function. The energy spectra obtained for the time series of wave elevation, heave and pitch are shown in Figures 6 - 8. The wave spectrum presented in Figure 6 is measured by the freely floating buoy, and response spectra presented in Figures 7 and 8 were measured on-board ship progressing with forward speed.

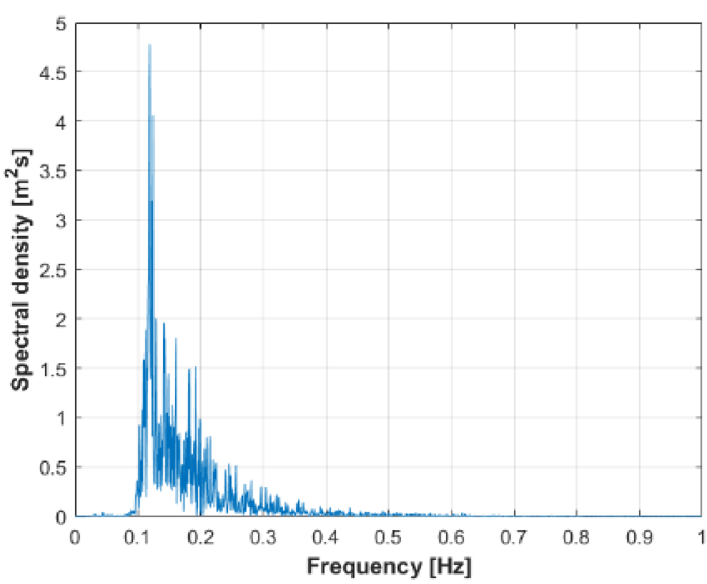

Figure 6. Wave energy spectrum for time series presented in Fig. 1

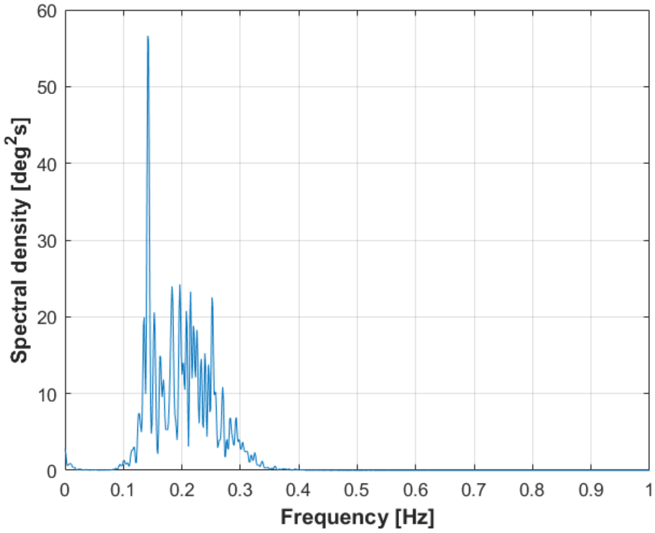

Figure 7. Energy spectrum of pitch for time series presented in Fig. 3

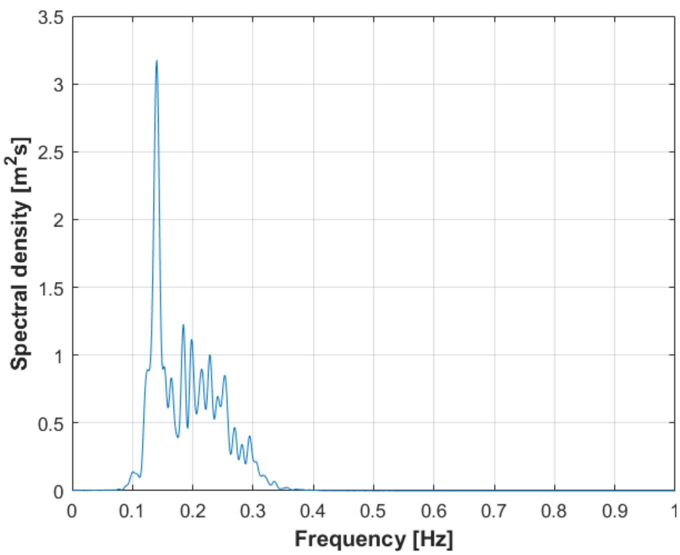

Figure 8. Energy spectrum of heave for time series presented in Fig. 2

The integrals of the energy spectra in Figures 6-8 can be used to derive the spectral characteristics of the random wave process. Table 2 shows a comparison of the standard deviations and mean zero-crossing frequency of three random processes based on measurements and spectral analysis. Table 2 shows that the compatibility of the standard deviations is excellent, despite minor variations in the mean zero up-crossing frequency. These inconsistencies appear as a result of the "smoothing" of the wave energy spectrum and the resulting integration error of the second spectral moment, as explained in the STATREL theoretical manual (STRUREL 2007). These small differences in the mean zero up-crossing frequency have no practical significance.

Table 2. Comparison of statistically and spectrally defined characteristics of random process

Statistical property	Wave elevation		Heave		Pitch	
	measured	spectral	measured	spectral	measured	spectral
Standard deviation, m	0.342	0.342	0.391	0.391	1.463	1.461
Mean zero up-crossing frequency, Hz	0.201	0.207	0.195	0.201	0.203	0.209

4. Conclusion

This paper presents the full-scale measurement of the wave-induced ship response of the training ship "Naše more" in the Adriatic Sea, namely in the port of Dubrovnik approach area. The advantage of this method is that the testing was conducted in real sea waves. It lasted four hours and during this time the ship was on different courses and wave heights. The 4-hour voyage proved that the SPOTTER buoy and the ELLIPSE2 sensor were reliable in rough seas and met the requirements of this experiment. The movements of the ship, i.e. the heave and pitch motions, were observed with the direction and wind speed as well as wave height at four different heading angles. The pitch and heave motions, and the wave surface elevation are almost Gaussian processes as the range of skewness and kurtosis indicate the normal probability distribution. The STATREL software was used for the statistical analysis of the heave, pitch, and wave time series as well as for their energy spectra. Based on this experiment, the wave-induced ship motions in the port-approach channel can be predicted with reasonable accuracy. Standard seakeeping theories assume a linear relation between varying wave spectrum and the respective ship response spectrum. This relation, the square of the transfer function between wave and ship response at different frequencies usually referred to as RAO (response amplitude operator), that is deducted from the presented full-scale experiment can thus be applied also for different sea states that the ship will sail in. Moreover, the measured results can be used to validate the results obtained by standard seakeeping calculations and to estimate their accuracy for the vessel at hand.

Future research should focus on the comparison between the measured wave spectra in sheltered and deep-sea waters. The measurements of coastal waves should be compared with the ship response in deep seas and obtain the results that would help reduce the seakeeping uncertainties.

Acknowledgements

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Applying CFD Simulation To Analyze Turbocharger's Impeller of Marine Diesel Engines

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Abstract: Marine diesel engines use centrifugal compressors as the impeller to supercharger for diesel engines and directly driven by exhaust gas turbines. The working process of the impeller is a combination of changing parameters and thermodynamic process inside the impeller. The technical and environmental conditions of the impeller will affect to working characteristics of engine. The technology to simulate and calculate the effect of quality and gas flow learning (CFD) is developing strongly and widely applied in different fields such as: aviation, marine and industrial. Research and application of CFD simulation techniques to analyze and simulate the working process of impeller is a necessary requirement to serve the problem of operation and design of turbocharger impellers for marine ship diesel engines. In this article, the using the experimental results of the turbocharger Mitsubishi MET42SC with the DA3G impeller of the ship VTB BRAVE ship to verify the results of the impeller CFD program simulation.

Keywords: CFD, Simulation, Turbocharger, Impeller.

1. Introduction

1.1 Turbocharger's impellers for marine diesel engine.

Today's modern marine diesel engines are all equipped with turbochargers to increase the engine's power [8], [9]. Turbochargers integrated by exhaust gas turbine, air compressor, lubrication system and auxiliary equipment. It uses the exhaust gas energy of the engine to rotate the turbine that drives the impeller Figure 1a. The impeller used in turbocharger is usually a centrifugal compressor. Brands of turbochargers: MITSUBISHI, ABB, MAN, KPP, IHI, GARRET, HOLSET … usually use centrifugal compressors (Figure 1b). The advantage of this type of compressor is its compact size, suitable for the rotational speed of the turbine.

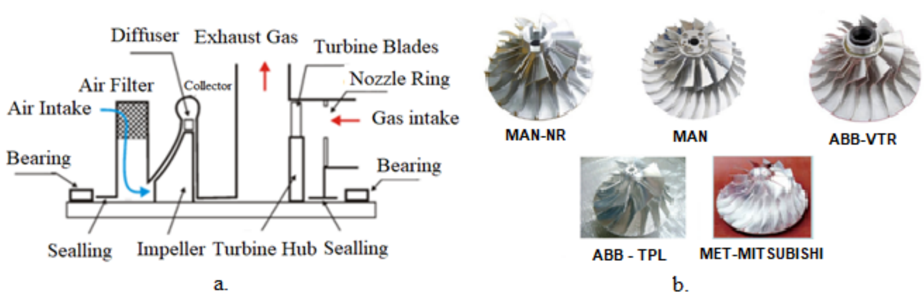


Figure 1. Centrifugal compressor construction

1.2 Increasing pressure process in turbocharger's impeller

The pressure of the pressurized air in an impeller depends on the blade profile, the ratio of the inlet diameter (Dh) and the outlet diameter (Dt) of the compressor blade [7]. For understand the operation and increase air pressure of impeller, in turn consider the principles of the processes of increasing air flow pressure in impeller described in Figure 2a.

The process of increase air pressure of impellers divided into three stages [6] as follows:

- Stage 1: The pressure of the air increased by centrifugal force or by the square of the enthalpy:

$$\Delta p_1 = u_2^2 - u_1^2 \quad (1)$$

- Stage 2: The air flow pressure increases due to a decrease in the velocity w in the impeller due to an increase in the airflow cross section:

$$\Delta p_2 = \omega_2^2 - \omega_1^2 \quad (2)$$

- Stage 3: Air pressure flow increased by the diffuser on the compressor outlet:

$$\Delta p_3 = c_2^2 - c_3^2 \quad (3)$$

The total pressure increases in an impeller can described as the following equation (4):

$$\Delta p_{tot} = (u_2^2 - u_1^2) + (w_1^2 - w_2^2) + (c_2^2 - c_3^2) \quad (4)$$

Concerning the additional pressure increase in the centrifugal field, impeller predetermined for a high-pressure ratio in an impeller frequency corresponding to a low flow ratio. It is very convenient to design exhaust turbochargers for diesel engines with only one impeller.

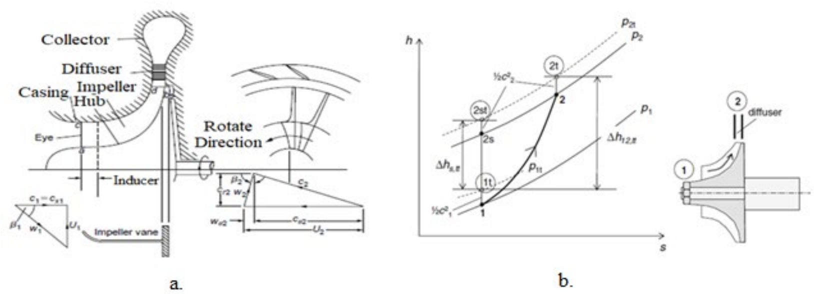


Figure 2. Increasing air flow pressure in impeller.

The process of pressurizing on the impeller is described on the h-s graph [3] in Figure 2b, in which the pressure increase stage in the compressor impeller is stage 1 - 2, here will sum up both stage 1 and 2, stage 3 is performed on the diffuser in the compressor housing, applied CFD to analyses the processes as well as the changes in the working parameters of the turbocharger according to the three processes above.

1.3 Determination actual air mass flow supplied to diesel engine

According to ship diesel engine theory, to determine the actual amount of air to ignite the amount of fuel injected into the engine cylinder [5] is determined by the following formula:

$$G_{kktt} = \frac{\pi D^2 S \eta_n \rho_k \varphi_a}{4} \quad (5)$$

Where: D cylinder diameter, S piston stroke, η_n intake coefficient of air; φ_a is the sweep coefficient, ρ_{kk} the density of the intake air and the engine.

Otherwise, to determine the actual amount of air supplied to the engine according to the air residue factor α, according to the formula:

$$G_{kktt} = \alpha . G_{lt} \quad (6)$$

The theoretical, amount of air [kg/ct] to ignite the amount of fuel injected into the cylinder during a g_{ct} cycle is determined:

$G_{lt} = g_{ct.} G_o$ (7)

With G_o theoretical amount of air to burn 1 kilogram of fuel [kg]; g_{ct} the amount of fuel injected into the engine cylinder in one cycle:

$$g_{ct} = \frac{G_{nl}}{60.i.\tau.n} \quad (8)$$

With G_{nl}: Fuel consumption for the engine in 1 hour [Kg/h], i: is the number of cylinders, τ number of strokes, n: engine revolutions [RPM].

According to (6), (7), (8) and engine parameters, choosing a suitable air residue coefficient α for 2-stroke engines, determine G_{kklt}: to burn the amount of fuel supplied to the engine.

Otherwise, according to [4], the actual air consumption to burn 1 kilogram of fuel for diesel engines is determined by the following empirical formulas:

- For diesel engines 4 strokes: G_{kktt} = 3 x 14 = 42 kgkk/ kgnl (9)
- For diesel engines 2 strokes: G_{kktt} = 3 x 16.5 = 51.5 kgkk/ kgnl (10)

2. CFD simulation program of turbocharger's impeller.

2.1 Building program to simulate turbocharger impeller using CFD.

The CFD simulation program in Ansys 2020 R2 academic version [1] for impeller blades used in turbochargers conducted according to the following steps:

- Open the Workbench screen in Ansys, save the program name: "MET42SC DA3G".
- Use the CCD tool to design the compressor according to the basic parameters of the compressor such as: inlet diameter (D_h), outlet diameter (D_t), Pressure ratio (R_p), number of impeller blades (Z), Rotation of impeller N(RPM) etc…
- Then forward the impeller's data to BladesGen tool to edit the blade inlet and outlet angle, blade profile accordingly.
- Use Turbogrid to mesh the compressor blades in accordance with the simulation program,
- Transmit the data after meshing to the CFX window to run the setting of working parameters and then run the simulation program, we will receive impeller output the simulation results.

2.2 CFD Simulation running and results

We will obtain the results of air flow changes such as pressure, temperature, velocity, entropy. The results of the program obtained as follows:

1. The basic parameters describing the operation of the compressor as per Table 1 as below:

Table 1. Impeller performance results table.

Parameters	Value	Unit
Rotation Speed	-2303.83	[radian s^-1]
Inlet Mass Flow Rate	11.0690	[kg s^-1]
Inlet Volume Flow Rate	4.8659	[m^3 s^-1]
Reference Radius	0.2230	[m]
Input Power	119,664	[W]
Total Pressure Ratio	2.6103	
Total Temperature Ratio	1.3470	
Polytropic Head	1,039,460	[J kg^-1]

2. 3D simulation of the shape, size, structure of the compressor (Fig 3a.), the cross-sectional section along the direction of air flow from inlet to out of the compressor impeller (Fig 3b.) and blades mesh (Fig 3c.).

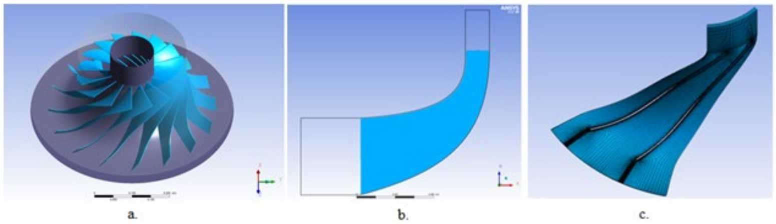


Figure 3. 3D simulation and impeller longitudinal section

3. Evolution of pressure change around impeller vane (Fig. 4a.), static and total pressure in the flow direction on a blade span from inlet to outlet of the impeller blades (Fig. 4b) and temperature change (Fig. 4c.).

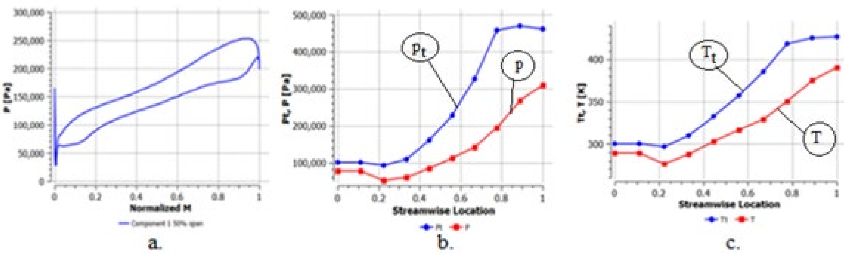


Figure 4. Pressure variation in front and behind and along the blade length.

4. The results of graphical simulation of the change of the velocity vector, the entropy of the gas flow on the blade and changing pressure of the air flow from the inlet to the outlet of the impeller graphically.
5. Graphic description the air pressure at the air inlet and outlet of the impeller vane.
6. The velocity vector represents the direction and intensity of the air flow in the.

3. Simulating impeller of Mitsubishi MET42SC – DA3G.

As analysis of the results obtained in the previous section related to the important parameters is evaluated during the working process of the impeller, in this section, the results obtained from experiment of the impeller MET42SC – DA3G of Mitsubishi will be evaluated air increase rate of impeller by CFD simulating of the impeller.

3.1 Experimental parameters of DA3G impeller.

According to the experimental results recorded on the engine fitted with DA3G impeller when testing with actual engine at the workshop [2], the working parameters related to the recorded impeller including impeller rotation N, air pressure outlet P_{rtd}, air pressure inlet P_{vtd} and fuel consumption of the engine in hour G (kg/h).

To evaluate and verify the simulation results, the tested results of the MET42SC turbocharger with Mitsubishi's DA3G impeller used on the main engine of the VTB BRAVE ship (renamed from M/V SUN FRONTIER), building at the MIURA Shipbuilding Co., Ltd in 1997.

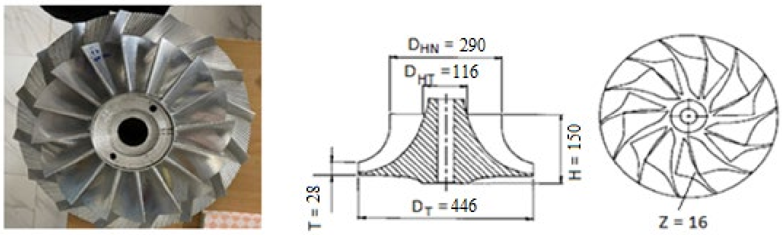


Figure 5. Drawing of DA3G impeller.

The main engine is a 2-stroke diesel engine Mitsubishi model: 6UEC33LSII, continuous power: 3927 PS and maximum power: 4400 PS; Engine Speed: 210 RPM. [2]. Mitsubishi's DA3G impeller (Figure 7) is a single-stage compressor installed on the MET42SC turbocharger. During the maintenance of the turbocharger for M/V VTB Brave, we have been opened and measuring the geometrical dimensions of impeller as shown in Table 2.

Table 2. DA3G Impeller geometry parameters.

Parameters	Value	Unit
Number of Blades Z	16	Pcs
Outlet Diameter D_T	446	mm
Shroud inlet Diameter D_{HN}	290	mm
Hub inlet Diameter D_{HT}	116	mm
High of impeller H	150	mm
Hight of Tip T	28	mm
Average of blades thick T_c	20	mm
Air of Hub inlet angle β_{1H}	40	Degree
Air of shroud inlet angle β_{1T}	65	Degree
Outlet of Hub Angle β_{2H}	22.5	Degree
Outlet of shroud Angle β_{2T}	30	Degree

Besides the geometrical dimensions, the operation environment of the impeller also an important factor that determines the operation characteristics. It is the ambient temperature and pressure of the air.

According to the results obtained in Table 2, the experimental parameters related to the working characteristics of the impeller are evaluated through the following parameters: rotation, pressure, inlet temperature and outlet temperature. The measured values are by ship testing in the condition of newly installed equipment, ensuring the allowable reliability to evaluate the working characteristics of the impeller. Experimental operation Parameters of impeller and diesel engine in M.V VTB Brave as per table 3 below:

Table 3. Experimental working parameters of impeller DA3G.

Parameters	Value			
N [V/P]	12,000	17,300	20,500	21,800
L %	50	75	100	110
P [ps]	1,954	2,931	3,927	4,210
$P_{vtđ}$ [Pa]	101,019	100,804	100,764	100,627
$P_{rtđ}$ [kg/cm^2]	0.5	1.2	1.8	2.1
$P_{rtđ}$ [Pa]	150,358	219,004	277,845	307,264
$T_{vkkđ}$ [^{o}K]	307	308	309	310
$T_{rkkđ}$ [^{o}K]	353	399	431	449
G_{nl} [kg/h]	256.7	375.9	497.6	611.1
G_{kktt} [kg/s]	3.6722	5.3703	7.1184	8.7421

3.2 Simulation with Ansys CFD.

3.2.1 Simulation conditions:

Choosing the simulation model according to the following initial conditions as below:

- The pressure of the air supplied to impeller as atmospheric pressure relative to sea level P_{vt} = 101325 Pa.
- Average ambient temperature of the air entering the impeller in the tropical area T_{vkk} = 310°K (37°C).
- The air consumption with the simulated values at 50%, 75%, 100 % and 110% of the engine load.
- Actual amount of air supplied to the engine [kg/s]. It is needs to determine the actual amount of air supplied through experimental and theoretical values.
- Air mass flow supplied to the engine. Using the experimental formula (10) updated in Table 4.

3.2.2 Ansys CFD simulation results.

According to the actual parameters of the DA3G impeller, Run program according to tested RPM: 12,000; 17,300; 20,500 and 21,800. The input parameters of the impeller, we have P_{vtm} =101,325 Pa; T_{kkm} =310°K, actual amount of air consumed by the engine [kg/s] corresponding to each working mode of the impeller from table 3. The results obtained from the simulation for the values of P_{rtm} and T_{rkkm} record at table 4.

Table 4. Impeller working parameters from CFD simulation program

Parameters	Value			
N (V/P)	12,000	17,300	20,500	21,800
P_{vtm} [Pa]	101,325	101,325	101,325	101,325
T_{vkkm} [°K]	310	310	310	310
G_{kktt} [kg/s]	3.6722	5.3703	7.1184	8.7421
P_{rtm} [Pa]	156,253	226,428	280,354	310,257
T_{rkkm} [°K]				

3.3 Evaluation of simulation results

According to the results in table 3 and table 5, summarizing the pressure change and outlet temperature of the impeller in the experimental state and the simulated state, we obtain the results are compared with Table 5.

Table 5. Evaluation of results

Parameters	Value			
N [RPM]	12,000	17,300	20,500	21,800
P_{rtd} [Pa]	150,358	219,004	277,845	307,264
P_{rtm} [Pa]	156,253	226,428	280,354	310,257
ΔP_r [Pa]	5,895	10,573	2,509	2,993
ΔP_r %	3.92	4.83	0.90	0.96
$T_{rkkđ}$ [°K]	358	410	443	449
T_{rkkm} [°K]	371	426	464	467
ΔT_{rkk} [°K]	13	16	21	18
ΔT_{rkk} %	3.50	3.76	4.53	3.85

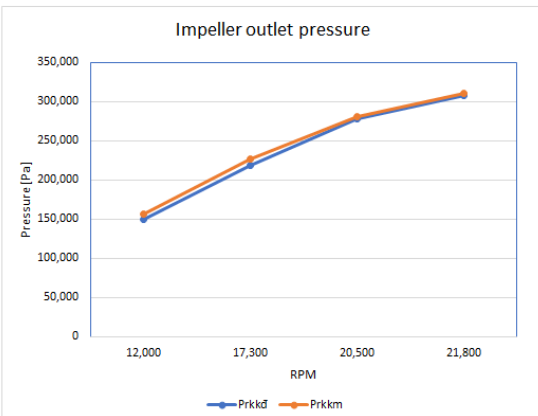
From table 5, We are obtaining a graph comparing experimental and simulation results for temperature and pressure in Figure 6. We will have working characteristics of the impeller as below:

- The law of changing pressure and temperature of the air coming out of the impeller in experimental and simulated modes is the same.

- Output pressure values of the two modes are similar and within the allowable error range ΔP_r and $\Delta P_r\%$. The biggest error lies in the rotation value of 17,300 RPM with $\Delta P_r\% = 4.83\%$

- The temperature value of the air coming out of the impeller in the two states is similar and has the largest error $\Delta t = 4.53\%$ at the rotation value of 20,500 RPM. This error is within the allowable error of the measurement, so the experimental and simulation results are similar.

- The obtained simulation results of the program are consistent with the actual working characteristics of turbocharger impeller on diesel engines.



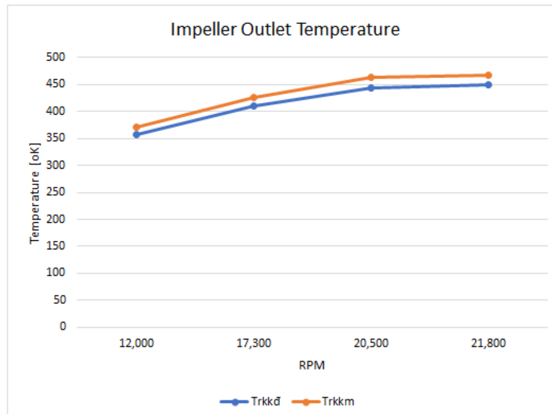


Figure 6. Comparison chart of simulation and experimental pressure and temperature comparison chart.

4. Conclusions.

The turbocharger's impeller CFD simulation program has been realistically testes according to the pressure, temperature, and air flow to evaluate the working characteristics of the impeller for the diesel engine.

This program also used as a tool to analyze the working process and design turbocharger impellers for marine diesel engines and using to develop other research related to air centrifugal compressors and turbochargers of marine diesel engines.

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Optimization of ship electrical power system modes according to reactive power

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Abstract: The use of high quality electricity is essential to ensure optimal modes of the ship's electrical installations. One of the indicators of the quality of electricity is the power factor, which can be increased by reducing the reactive power. One of the ways to solve this problem is the optimal distribution of reactive / inactive power. This paper discusses the determination of reactive source capacities based on the relative increment method with minimal losses.
Keywords: Active power losses; Reactive power losses; Reactive power compensation.

1. Introduction

On the scale of raising automatization quality of modern ship's power plants and propulsion machinery, simultaneously raises the demand on the quality of produced electricity.

The improvement of technical economical indicator of ship's power plants can be carried out by creating ship's electro-energetical system, which can provides with electrical power not only ship's common electro-consumers, but in case of necessity, the ship's propulsive system.

Ship's electro-energetic system is aotonomous system, which includes limited number of generators and large amount of loading, the majority of them consists of asynchronous motors. From the point of view of electro-energetic balance, choosing the generators must be done while designing a ship, in order to meet all energetic requirements, namely, according to active power (W) and reactive power (VAR).

Very often carried out analysis on electric loading includes requirements only about active power (Prousalidis JM 2015 [8]). Accordingly, the problems about the meeting of requirements of reactive power arise. The correct distribution of reactive power defines the load value of the electrical power system and efficiency improvement.

2. Main text

It is possible to provide optimal modes of ship power plants by using power plants control systems. Accordingly, the demand for high quality electricity is increasing. Many factors affect negatively on the electricity quality. Power losses are mainly caused by: active power (I^2R) losses, energy (I^2Rt) losses, cable overheating and voltage drop (IR) losses. All these losses mainly depend on the power circulating in the network. Also, modern power network is unthinkable without semiconductor converters and regulators. This, in turn, leads to distortion of the sinusoidal current (the content of higher harmonics increases), decrease in power factor so increase of inactive powers.

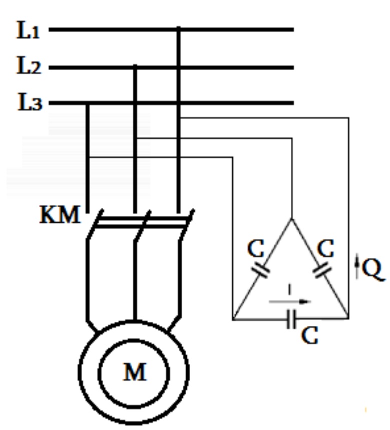
Reducing / eliminating of these negative factors is the most important task of the ship's power system. Nowadays, there are two ways of solving inactive power compensation (Dudko S. 2018 [2], Luong Thu Phong 2009, [4]): reactive power compensation; distortion power compensation. Reactive power compensator (RPC) and active filter (AF) are the basic elements of a compensating device.

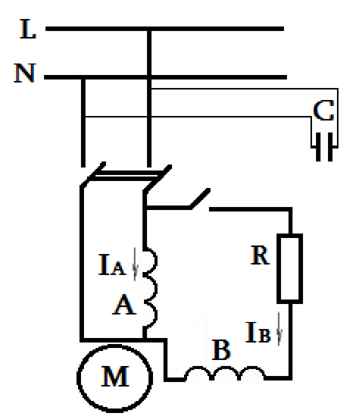
Traditional approaches to inactive power compensation don't meet modern requirements, due to huge mass-size indicators, low efficieny, small frequency regulation range, and other factors. Usually changing any units in the electrical power system in order to improve the quality of electricity causes a number of difficulties. It's better to use compensating devices, which can be located at any point of electrical power system.

It should also be taken into account, that asymmetric loads are frequent in electrical systems in general and on board ships too. In these cases, the use of a three-phase compensating device based on static capacitor batteries is unacceptable. Due to the asymmetry of the reactive load, it is advisable to determine individually the compensation capacity for different phases (Chunashvili B. 2016 [1]).

In ship's electrical power systems, where shaft-generators are in operation, synchronous compensators are used to compensate reactive capacities. A synchronous compensator is a synchronous motor, that is not loaded and is connected in parallel with the electrical power supply system. Like synchronous generators, their reactive power is regulated by excitation connected to an autonomous voltage regulator, which regulates the excitation current of the rotor coil. In this case the compensator acts as a reactive energy source or as an inductor that absorbs the reactive power (Prousalidis JM, 2009 [6]).

Compared to all methods of reactive power compensation, it is considered that the best method is the correct distribution of reactive power in the electrical network (Prousalidis JM, 2011 [7]). The expected changes in the distribution of reactive power in the large loads mode of the electric network is minimal. In case of small loads no significant effect will be obtained. This is caused due to the following factors: in the case of large loads, the reactive power reserve is relatively small; transmission of reactive power in the network is associated with an increase in voltage loss. In addition to the above mentioned, reactive power transmission is connected with the increase of active and reactive power losses. Therefore, the task of transmitting reactive power will be substantially reduced to the use of the nearest compensating device to the consumers, as a result, transmission lines will be protected from overload (Makharadze G, 2000 [5]).





a b

Figure 1. a - 3-phase motor with reactive power compensation capacitor battery;
b - single-phase motor with reactive power compensation capacitor.

The experiments carried out showed the importance of the correct selection of the capacitor battery. It must be selected individually for each induction load. Table 1 shows the experiment results, which clearly shows the effect of a properly selected capacitor battery. The parameters without index correspond to the parameters of the inductive user connected to the network without a compensating device, and the index 1 – parameters of capacitor battery in case of switched on mode. Specifically, if triangly connected capacitors with 10 microfarads capacitance are connected in parallel to a 3-phase motor (Figure 1. a), the reactive power will increase and the power coefficient will decrease - at nominal load (M = 1.57Nm) from 0.77 to 0.37.

When connected capacitors with 2 microfarads capacitance to the same motor, the reactive power significantly reduced and the power factor incread maximally - at nominal load (M = 1,57Nm) from 0,77 to 0,86, the importance of the circulating current value was also reduced from 0,87 A to 0.66 A. It is also effective to connect capacitor battery to a single-phase motor (Figure 1.b), the power factor has been increased from 0.68 to 0.86, the current has been reduced from 0.12 A to 0.1A.

Table 1

Motor type	**1phase motor**	**3 phase motor**			**3 phase motor**		
P (W)	18	470	287	448	470	287	448
Q (VAR)	18	131	402	371	131	402	371
S (VA)	27	491	494	581	491	494	581
cos□	0,68	0,27	0,58	0,77	0,27	0,58	0,77
I (A)	0,12	0,74	0,74	0,87	0,74	0,74	0,873
U (V)	220	387	387	387	387	387	387
M (Nm)	0,123	0	1	1,57	0	1	1,57
n (1/min)	1400	1484	1424	1350	1484	1424	1350
C (□□F)	0,74	3x10	3x10	3x10	3x2	3x2	3x2
I_1 (A)	0,1	1,44	1,63	1,74	0,35	0,47	0,66
P_1 (W)	18	144	303	427	130	293	436
Q_1 (VAR)	8	-958	-1036	-1053	188	112	86
S_1 (VA)	21	987	1099	1158	232	315	445
cos□□	0,86	0,15	0,26	0,37	0,56	0,93	0,96

The optimal distribution of reactive power Q, without taking into account the technical limitations, can be calculated by the relative increment method that is the Lagrange method. Assume reactive power generation is not associated with any costs. In this case, the only aim of the optimal distribution of reactive power should be the reduction of active power losses. Suppose, active powers are given and they are unchanged. Such assumption is approximate, because the changes of losses in network and are caused by changes of active powers in the electrical power plants. The losses due to this assumption will depend on the Q reactive power. It is possible to determine the minimum of a function by using the Lagrange method (Idelchik V.I 1988 [3]):

$$\boldsymbol{F = \Delta P + \lambda W_Q} \quad (1)$$

Where,

$W_Q = Q_{r1} + Q_{r2} + \cdots . + Q_{rk} - Q_{\text{Ø}} - \Delta Q = 0$ – reactive power balance equation;

ΔQ - reactive power loss;

k – the number of reactive power sources;

Q_L - total load value, which in the given case is constant $Q_L = const$

$\boldsymbol{\lambda}$ **–** horozontal vector of the matrix created by appropriate parameters,

$$\boldsymbol{\lambda} = \frac{\partial F}{\partial S} = (\frac{\partial F}{\partial P}, \frac{\partial F}{\partial Q}) \qquad (2)$$

If reactive power generation don's require costs, the optimal condititition will be recorded as follows:

$$\begin{cases} \frac{\partial F}{\partial Q_{r1}} = \frac{\partial \Delta P}{\partial Q_{r1}} + \boldsymbol{\lambda}\left(\mathbf{1} - \frac{\partial \Delta Q}{\partial Q_{r1}}\right) = \mathbf{0}; \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . \\ \frac{\partial F}{\partial Q_{rk}} = \frac{\partial \Delta P}{\partial Q_{rk}} + \boldsymbol{\lambda}\left(\mathbf{1} - \frac{\partial \Delta Q}{\partial Q_{rk}}\right) = \mathbf{0}, \end{cases} \qquad (3)$$

From this,

$$-\boldsymbol{\lambda} = \frac{\frac{\partial \Delta P}{\partial Q_{r1}}}{1 - \frac{\partial \Delta Q}{\partial Q_{r1}}} = \cdots = \frac{\frac{\partial \Delta P}{\partial Q_{rk}}}{1 - \frac{\partial \Delta Q}{\partial Q_{rk}}} = \mathbf{const} \qquad (4)$$

This equation allows us to determine the reactive power of all sources, corresponding to the $\boldsymbol{\Delta P}$ minimum losses of the active power of the network. As a result, energy losses in the network will be reduced. It should be noted that for generating 1 kilowatt of electricity on average, 0.084 litres (0.07 kg) of diesel fuel is used. As a result of its burning, 3 times the mass of CO_2 (approximately 0.21 kg) is produced (Prousalidis JM 2015 [8]). Therefore, the reduction of losses is directly reflected on reduction of emissions.

3. Conclusion

All the measures tend to solve ecological problem are very important today. In this regard, it is important to reduce emissions. The world fleet is very large and consequently the volume of emissions received from the production of electricity on each ship are large. Reducing losses in the electrical system is one of the ways to reduce emissions. This is achieved by optimizing the power system modes according to the reactive power. We can choose two ways:

- Only a small number of vessels are equipped with reactive power compensators. That's why, it is necessary to modernize the ship's electric power systems, which means to install static capacitors in parallel with inductive loads. The selection of the capacitance of the capacitors should be done according to the inductive loads.
- The correct distribution of reactive power at the stage of ship planning is very important. It is possible to determine the reactive power sources with minimal losses using the relative increment method (Lagrange method), followed by the minimum active power loss in the net and the increase of system efficiency.

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Analysis of Hydrometeorological Conditions in the Main Georgian Poti Port, its Impact on the Cargo Turnover and Ways of Solutions

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Abstract: A favorable geographical position Poti port and increase cargo turnover should be provided by maintenance of safety navigation and minimal influence hydro meteorological conditions. The influence of prevailing wind directions – East and West, constant sea currents allows the waves to deposit the sediments in the entrance channel and that the most important unfavorable meteorological conditions contribute to closing the port for navigation for several days. Paper presents the analysis of hydrometeorological conditions for the creation of technical decisions which can be conducted in Port of Poti to provide the safety navigation, decreasing besieger's sediments in the entrance channel and cases of closure of the port for navigation. The presented paper continues the previous three papers - "New Black Sea Terminal of Port Kulevi and it Navigating Features", "Analysis of Hydrometeorological Characteristics in Port of Kulevi Zone" and "Mathematical Modelling of Wave Situation for Creation of Protective Hydrotechnical Constructions in Port Kulevi" where considered the aspects of safety navigation provision Kulevi port. Ports Kulevi and Poti are at close range of each other and for analysis of hydrometeorological conditions in the Poti port possible to use the results of research that are presented in these three papers.

Keywords: Poti Port, Hydrometeorological Conditions, Bulk Cargo.

1. Introduction

Geographical position of Georgia - Asia, the Near East and Europe crossroads and presence of already existed means of communication between Georgia and oil producing regions - Kazakhstan, Turkmenistan and Azerbaijan, also the necessity of search and the creation new alternative ways of safe transportation of oil to Europe and especially container cargos from Europe to Asia grants special responsibility the main Georgia cargo Poti port.

Operator of Poti port is APM Terminals. APM Terminals, along with Maersk Line, DAMCO, Svitzer and Maersk Container Industry combine to form the Maersk Transport and Logistics business unit [9].

In 2018 APM Terminals Poti (APMT) and the Poti New Terminals Consortium (PNTC) signed a Memorandum of Understanding for a USD $100 million-dollar investment in a new bulk cargo terminal. The facility will have an annual capacity 1.5 million tons of dry bulk cargo [9].

In 2020 APMT and PNTC have signed an agreement for the joint development of a new bulk cargo facility on the northern side of the Poti Sea Port,   APMT will invest in constructing a new breakwater, 400 m of quay wall and dredging up to 13.5 meters vessel draft, and PNTC will invest in building a new dry and bulk cargo facility including extensive yard area and rail connection in Poti [13].

2. Analysis of meteorological and hydrological conditions

The hydrometeorological conditions in the ports of Kulevi and Poti do not differ from each other. The results of studies presented in [7], [8], [10], [11] and [12] were used to analyze the hydrometeorological conditions in the port of Poti.

Winds. The collection and analysis of wind conditions (direction, speed, maximum and minimum values) in the port of Poti was carried out using daily data received from the State Hydrographic Service of Georgia from the meteorological station located in Poti. Data on the wind regime (daily, weekly, monthly, semi-annual and annual) were processed, calculated on average and built into special graphs. With the help of graphs, the prevailing direction, maximum and minimum wind speeds were determined in different periods of time.

The collection and processing of data on the wind regime was carried out during the annual period from 2020 to 2021 (See Tab.1.).

Table 1. Time period for collecting and processing data on the wind regime

Half-Year	Half-Year	Annual	Summer	Autumn	Winter	Spring
01.07.2020 – 31.12.2020	01.01.2021 – 31.08.2021	01.07.2020 – 31.08.2021	01.07.2020 – 31.08.2020	01.09.2020 – 01.11.2020	01.12.2020 – 28.02.2021	01.03.2021 – 31.05.2021

Wind directions is distributed in the following way (See Tab. 2, 3, 4, 5, 6, 7).

Table 2. Distributed wind directions

Half-Year – A – 01.07.2020 – 31.12.2020									
Wind Direction	ESE	E	WNW	WSW	SSW	W	SSE	S	ENE
%	30.6	16.8	8.7	6.3	5.1	6.9	8.1	4.0	4.9

Table 3. Distributed wind directions

Half-Year – B – 01.01.2021 – 31.08.2021										
Wind Direction	ESE	E	WNW	WSW	SSW	W	SSE	NNW	S	ENE
%	22.7	15.8	10.5	8.9	8.1	7.7	6.7	5.2	4.2	4.0

Table 4. Distributed wind directions

Annual – C – 01.07.2020 – 31.08.2021										
Wind Direction	ESE	E	WNW	WSW	SSW	W	SSE	NNW	S	ENE
%	26.6	16.3	9.6	7.6	6.6	7.3	7.4	4.6	4.1	4.4

Table 5. Distributed wind directions

Winter – D – 01.12.2020 – 28.02.2021						
Wind Direction	ESE	E	SSE	WNW	W	NNW
%	38.8	24.5	6.4	6.8	4.5	3.8

Table 6. Distributed wind directions

Spring – D – 01.03.2021 – 31.05.2021										
Wind Direction	E	ESE	WNW	WSW	SSW	W	NNW	SSE	ENE	S
%	16.9	16.5	11.8	10.8	9.1	8.3	8.9	4.9	4.7	4.5

Table 7. Distributed wind directions

Summer – D – 01.07.2020 – 31.08.2020									
Wind Direction	ESE	WNW	WSW	W	SSE	E	SSW	S	NNW
%	21.9	11.3	10.9	11.6	9.8	10.5	9.1	5.8	3.9

Prevailing directions of the wind, as it can be seen in the tables of distributed wind directions are the ESE, East, WNW and West.

The average speed of the wind is mainly between min – 2.5 м/s, max – 10.1 м/s and it is acceptable for safe entrance and leaving and quite lower than criteria of safety safe maximal wind speed.

Direction of entrance channel of Poti port and prevailing directions of the winds are the same, allowing the safe entrance and leaving of the ships.

According Poti Port Regulations during the wind strengthening to 17 m/s, and reduction of visibility less than 0,5 miles, as well as, waves exceeding sea force 5 by Douglas scale at the entrance channel the Port access and exit are prohibited.

Observations show that the duration of the maximal indicators of the wind is between from 3 to 8 hours and the change of the wind direction the speed decreases to the average indicators of – 4. 5 м/s – 6.0 м/s. The longer wind is detected from West, ESE, and East. They may blow during 2-3 days, sometimes for 5 days, in the period of June-October.

Storms. The stormiest period is the period from November to March. The least number of the storms is in the summer – July-August. The bigger duration of the storm is in November and December and is 5 days (117 hours). The most often stormy winds are from the East – they repeat in more than 70%. The winds of wave-dangerous direction are the wind of western quarter and South-West. Stormy West and South-West winds repeat in 13-15%; strong stormy winds with the speed more than 18м/s are mostly detected from South-West.

Air's temperature regime. Average annual temperature – 14.2°, the hottest month of the year –is August (average temperature – 23.3°, maximal – 37.3°). The coldest months are January, February (average temperature – 6-7°, minimal temperature -10°, in February).

Precipitation. Maximal amount of precipitation is in August-September (240-250 mm, on average, absolute maximum – 614 mm – in September). Absolute 24-hours maximum – 268 mm. Average annual amount of precipitation – 1661 mm.

Fogs. The fogs are detected in the spring in majority. The biggest average annual amount is detected in March – 3. There are 18 foggy days on average, in some years – up to 37 days.

Water Temperature. The highest temperature is detected in July-August (average temperature 24-25°, maximal – 29.4°), the average temperature in the coldest months – January-March is 7-9°, the lowest – 2.8° (February).

Salinity of water. Regime of water salinity plays an important role in hydrodynamical processes of the shore as well as in navigation in water area. Salinity of water is 14, 25 prm, which increases in the winter, at the lowest cost (the average salinity - more than 15 prm, maximum 19.7 prm). The lowest salinity observed in May and June, during the spring flood river Ronni-discharge (average salinity - the order of 11-13 prm, the minimum 4.85 prm).

Heavy Sea. The analysis of hydrometeorological characteristics shows that the main factor, which influences upon the level of safety of navigation on the approaches to the water area of Port of Poti is heavy sea ([4], [6]). Wave situation determined by the wind waves and swell. The repeatedness of the West and North-West roughness are change only by 2.5% and 9%. The repeatedness of South-West in the spring-summer period increases up to 35-40%. In the cold period of the year on account of active influence of the west winds the wave regime increases. The height of the waves is about 2.0 м which is 2.0% in the winter period of the year. In the warm season, the maximum parameters of the waves are observed, mainly in the South-West of waves, the action of the South-Western, Southern and Western winds. The maximal parameters of the waves as a rule are connected with the wind-caused waves, which parameters are bigger than waves of swell. Average monthly repeat of the wind waves are 36-48%.

Currents. They are two major types of current: sea current, caused with the water circulation in the Black Sea (in the presented case – from South to North) and local shore current. Countervailing currents are connected with the wind surges and directed to the sea. In case of permanent activity of heavy West and South-West (as a rule not less 12-18 hours) wave – along shore currents arise, which direction is constant, and speed reaches 1.0-1.5м/s.

The dynamics of sediments. The dynamics of sediments in Port of Poti is determined by the firm drain of the river Rioni. River Rioni mainly brings the beach-forming solid material to the coastal zone and the channel entering the port. 310.000 m^3 of solid material averagely flows into Poti Sea Port per annum. River Rioni is the biggest river of the West Georgia. It forms the delta, where it joins with Black Sea, near Poti. River Rioni is characterized by large amount of sediment - its overall average annual solid sediment load amounts to 5 million m^3, respectively. 10% of them represent the bottom sediments. Volume of beach-generating 0.1 mm diameter fraction amounts to 1.2-1.4 million m^3. The transportation is made through river flow across the coast, as well as at the cost of the Rioni sediment. The hydrological observations are underway at Rioni northern branch during the recent years ([3], [5] and [14]).

3. Poti sea port

The Poti Sea Port is the largest port in Georgia, handling container, liquids, and dry bulk cargo and passenger ferries. The multi-purpose facility has 15 berths, a total quay length of 2900 meters, more than 20 quay cranes and 17 km of rail track ([9]).

Navigation regime ([1]), in order to prevent collisions at sea, every ship shall observe safe distance from ships entering/leaving Poti port and not impede their movement. Traffic separation system applies between anchorage points in the port of Poti. The aim of the system is to regulate movement of ships in this area, and to prevent opposite movements of ships entering and leaving ports.

The Poti Port ([2]) includes Southern and Northern docks, internal pool, south, west and new north mall, entrance channel and external roadstead. The Poti Port area consists of protected and open parts, where Poti Sea Port Corporation, APM Terminals Poti and New Sea Port of Poti are located (Fig.1.).

The maximum allowable dimensions of the vessels entering the Poti Port: length 240 meters, width 35 meters and draft 10.3 meters and today, after dredging, the maximum draft is 12.5 meters. The entrance/departure of the vessel, more than 180 meters in length and/or with more than 9.0 meters draft, in the Poti Port is allowed only in the light period of the day. The entry/departure from Poti port and tying is allowed day and night for railway, automobile and transport ferry, which is equipped with two main engines and two oar screw, also by front adjoining crafts, the maximum length of the ship shall be 195 meter and the draft 8 meter, in good hydrometeorological conditions and with the ship master’s approval, only in №2 railway ferry wharf.

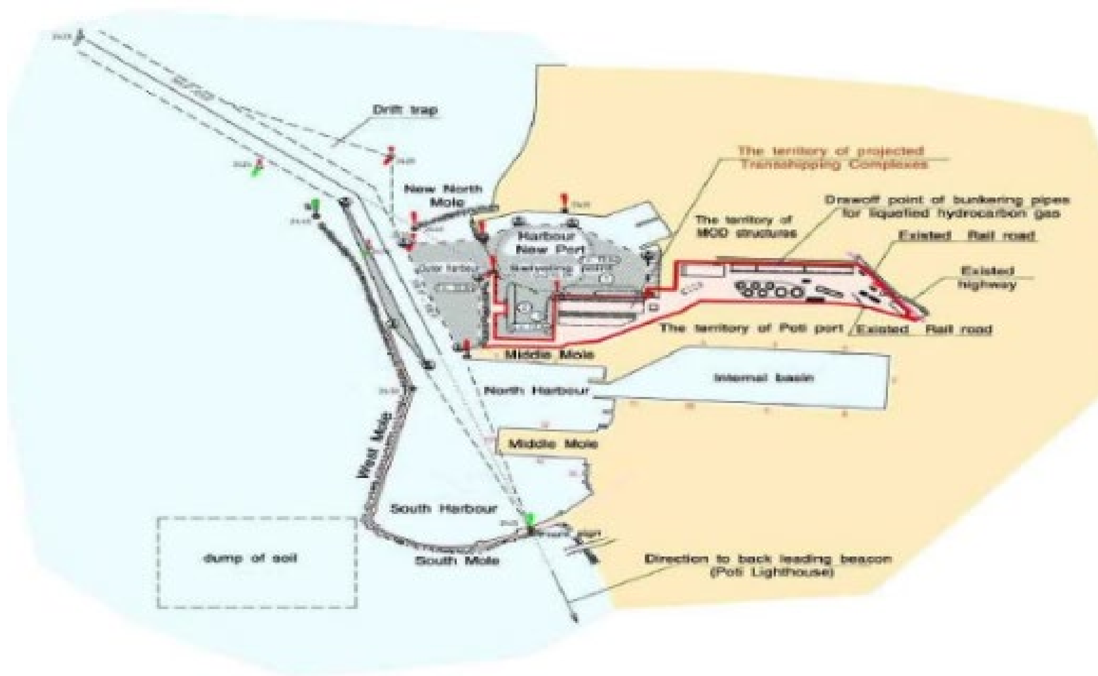

Fig. 1. Layout plan of the Port of Poti and New Sea Port of Poti ([14]).

Container ship with approach equipment, can enter/ leave the port of Poti only at container berth No. 14, During any time of the day-night, The maximum length of the vessel is 190 meters and maximum draft 8.5 meters if wind capacity does not exceed 10-12 m/s, in case of ship's master's consent.

During the wind strengthening 17 m/s access and exit from the Port are prohibited. The departure/entry of ships from the port is decided by the harbour Master considering factual weather conditions and with the agreement pilot. The ferry traffic and mooring operations in the Port, as a rule, are conducted in the wind direction, which shall not exceed 10 m/s.

The maximum safe speed of the vessel in the Poti Port is 5 knot. In the entrance channel of the Poti Port receiving of marine pilot and operations of the ship entry/departure in/out is permitted on the following conditions:

a) There is a Joint Agreement between harbour master, pilot and Ship master;
b) Pilot tugboat has maneuvering characteristics for marine pilot's embarking and disembarking on the vessels;
c) When the wind blows Eastward, the pilot's embarkation aboard and the ship entry/departure in/out operations is permitted, if the wind speed not exceed 17 m/s (wind force 7 by beaufort scale);
d) In case of unfavorable climatic conditions ship's entry in the port is prohibited, if the wave height exceeds 4 meters by Douglas scale.

The water area of Poti Port ([2]) (42°09'N, 041°39'E) is surrounded by the seashore, φ= 42°12' N parallel (outfall of Rioni River), φ=42°08' N parallel (channel of Rioni River), direct line from the sea, which goes to the point, which is aligned from two miles of the coast line of the above mentioned parallels and encompasses:

a) Northern dock – port water area, which is made by the sea area and is set between western mall, northern mall (№1 and №2 wharves and middle mall (№12 and №13 wharves);

Table 8. Profile and Characteristics of Berths Poti Sea Port Corporation, APM Terminals Poti

Berth №	Type of Cargo	Berth Characteristics	
		Length (m)	Depth (m)
1	Oil and product	200	12,5
2	Chemical cargo and ro-ro terminal	183	12,5
3	Bulk cargo	215	8,5
4	Bulk cargo	154	8,5
5	Bulk cargo	173	8,5
6	Bulk cargo	212	9,75
7	Containerized cargo	211	8,25
8	Bulk cargo	215	9,75
9	Bulk cargo	220	8,0
10	Bulk cargo	264	8,0
11	Berth	71	8,0
12	Berth	250	6,1
13	Ro-Ro terminal	97	6,5
14	Containerized cargo	253	8,4
15	Wheat delivered to the mill	155	8,5

b) Southern dock- port sea area, which is surrounded by southern, western and middle mall.

c) Internal bay – part of sea area, which is encompassed in the internal dock.

d) New port dock – sea area, which is surrounded by the northern mall, new northern mall and internal western mall. The New Sea Port of Poti and coast guard base are located in the new port dock. New Sea Port of Poti mostly handles container cargo ships, dry cargo ships and ships with bulk cargo. There is a closed storage depot for 50,000 m³ of cargo on the berth, equipped with appropriate modern systems to supply the ship in bulk (including hazardous bulk) cargoes such as: urea, granulated sulfur, etc.

There is also a train track along the warehouse, and the equipment for emptying the wagons (method of emptying the bottom point) is located directly next to the warehouse, through which the cargo unloaded from the wagon enters the warehouse hangar through a special cargo strip. The New Sea Port of Poti also plans to develop the existing infrastructure and accept ferry vessels in the future.

Table 9. Profile and Characteristics of Berths the New Sea Port of Poti

Berth №	Type of Cargo	Berth Characteristics	
		Length (m)	Depth (m)
1	Containerized cargo	245	12.5
2	ro-ro terminal	210	5.0
3	Bulk cargo	120	2.5
4	Berth	25	6.0
5	Bulk cargo	150	3.5

e) The port entrance channel consists of two legs: the first leg width is 100 meters, depth 10.5 meters, axis direction 129°-309°, length 5 cbl (926 meters), the other leg's width is 50 meters, depth 10.5 meters, axis direction 158.9° -338.9°, length -3.5 meters (648 meters).

Anchorage Areas and Points: ([2]) the north district №200 – is intended for only tankers and/or vessels loaded with dangerous goods; the south district №300 – is intended for the dry cargo vessels.

There are two anchorage points designated for the vessels to conduct a cargo operations while standing on roadstead: point №1 φ = 42°09,'6 N; λ =041°38,'0 E 16 meters in depth and №2 φ = 42°09,'6 N; λ=041°37,'3 E 15 meters in depth. The Pilot performs the vessel disposal in the above-mentioned points by the claim of the Master.

The Poti Port operates during day-night time, without weekend and holidays. The Pilotage and provision of a towed service for the vessel are mandatory.

It is prohibited producing of towed operations in the Poti Port, if the wind speed exceeds 17 m/s. In the cases of a ship helm, anchor and the main engine failures towed operation performance is permitted, if the wind speed does not exceed 10 m/s.

4. Statistics of ship calls and cargo turnover in the port of Poti

As the Port of Poti in the point of view of hydrometeorolgical conditions is a difficult one. Unfavorable meteorological conditions contribute to closing the port for navigation for several days. This leads to a decrease in freight turnover.

Below is the statistics of cargo turnover and duration of unfavorable metrological conditions from July 2020 to September 2021 in the port of Poti.

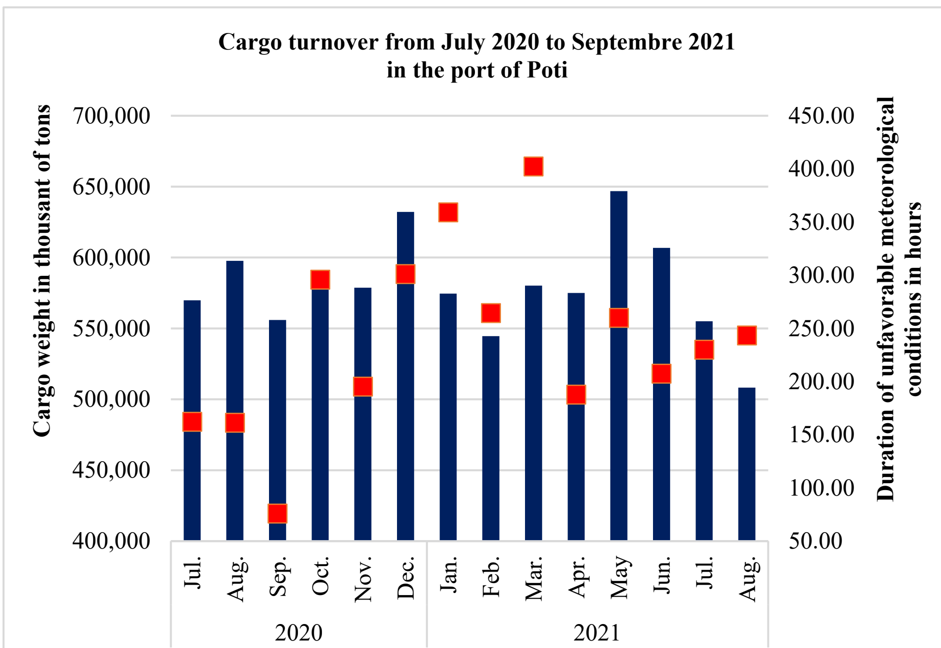

Fig. 2. Statistics of cargo turnover and duration of unfavorable metrological conditions from July 2020 to September 2021 in the port of Poti

An analysis of the observations and statistical indicators of cargo turnover show that in the study period from July 2020 to September 2021, official data on the duration of adverse meteorological conditions should have decreased in cargo turnover in the port of Poti, however, in most cases when they were announced adverse meteorological days, the port of Poti worked on actual weather conditions, due to which we do not observe correlation in statistics of cargo turnover and duration of unfavorable metrological conditions (Fig. 2.).

Conclusion

It is possible conclude, that a favorable geographical position Poti port and increase cargo turnover should be provided by maintenance of safety navigation and minimal influence hydro meteorological and hydro logical conditions:

- The main factor, which influences upon the level of safety of navigation in area of Port of Poti is heavy sea.
- The duration of the maximal indicators of the wind is between from 3 to 8 hours and the change of the wind direction the speed decreases to the average indicators of – 4.5 м/s – 6.0 м/s.
- The configuration of the moles of Poti port and the New Sea Port of Poti, considering into account the reconstruction, secures the approach to the harbor of the waves of N and NW storms of the height of not more than 0.4-0.2 m.
- The sediment near the port of Poti is caused by the solid runoff of the Rioni River. The main settling of sediments occurs in the inner water area, as well as on the inlet channel, therefore it is necessary to measure the depths at the port entrance and in the inlet channel twice a month, and after each storm.

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Simulator Training beyond the boundaries of Engine Room Watch-keeping

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Abstract: Traditionally and historically, engine room simulators are employed by Maritime Education and Training (MET) institutes to educate trainees to face real life machinery space situations commonly known as watch-keeping which enable safe operation of the ship. In addition, the trainees can be prepared to face the emergency situations with suitable exercises. International Maritime Organization (IMO) convention on Standards of Training, Certification and Watch-keeping (STCW) also recommends approved simulators for assessment of competency and demonstration of continued proficiency in certain areas. [1] Essentially, the scope of engine room simulator training was restricted to training engine room watch-keeping and assessment.

The capabilities of modern simulators in maritime training and education are gaining importance in recent times due to its unique features in providing integrated learning to students. Marine engineering, comprising of several facets of engineering such as Mechanical, Electrical and Electronics, Control systems, Heating, Ventilation and Air Conditioning (HVAC), finds simulators playing a vital role that surpasses any other medium of instruction. In the hands of dedicated and creative simulator instructors the engine simulators can provide another dimension of integrated learning. Simulators can be used to provide the theoretical foundation to most of the engineering concepts in various branches of engineering mentioned above. For example, the concept of reactive power in electrical engineering and its effect on the distribution system at various settings can be best demonstrated to students with advanced simulation exercises. This goes beyond the limits of traditional simulator exercise regime.

This paper analyses how the engine room simulator technology can be utilized to teach theoretical engineering concepts with carefully created simulator exercises that display various trends and relevant quizzes. The exercises do not entirely reflect engine room watchkeeping but augment theoretical engineering concepts with practicals, which may not be possible to do in a normal classroom situation or in a training ship scenario without a substantial cost / risk. Further the quizzes inserted in suitable instances within the exercise enable the student an integrated approach to purposeful learning. The quizzes further provide the instructor an authentic assessment scheme of individual student's learning and grasp of the theoretical concepts. The paper also aims to indicate that this methodology will provide a pathway for training future autonomous ship operators.

Keywords: emergency preparedness, autonomous shipping, future maritime training

Introduction

Engine Room Simulators (ERS) are essentially dedicated to train and assess engineers in watch-keeping duties. The manufacturers of simulator algorithms create malfunctions which when injected into scenarios make disturbances in running parameters of the machinery which are identical to the real life situations. The trainees are expected to respond to the situations and rectify the faults or initiate corrective action as specified to reinstate normal running conditions.

The ERS manufacturers like Kongsberg clearly display the intentions of creating these malfunctions in their product brochure under the heading 'Training Philosophy' as follows: "Simulator training has over the last years proved to be an effective training method when training engineers, especially where an error of judgment can endanger life, environment, and property. A dynamic real-time computerised simulator can compress years of experience into a few weeks and give knowledge of the dynamic and interactive processes typical for a real engine room. Proper simulator training will reduce accidents and improve efficiency and give the engineers the necessary experience and confidence in their job-situation." [3]

Although Kongsberg Training Philosophy states: "A simulator will give an easy introduction to background theories through the realistic operation of the simulator" the real exploitation of the simulator for theoretical training lies in the hands of a dedicated ERS instructor. Background theories emphasize and consolidate engineering concepts which is essential for competence training.

Example # 1 - Generator load sharing and governor droop

Comprehending the effect of governor speed droop for diesel engines as prime movers, may be quite challenging even for the final year students in the STCW management level competence training, when it comes to load sharing between two or more generators. To demonstrate that the generator with less governor speed droop take more load in a load sharing situation, two Diesel Generators (DG # 1 and DG # 2) are run to share the total load while maintaining the governor speed droop at 60% (default value) in each generator. During the investigation the students must keep the power management system switched off by changing over all generators to manual mode. Next the Bow thruster is started as the controlling device for the load for the generators and the pitch kept at a low value. The pitch is controlled only when the generator loads need to be varied. It is not considered as a controlling variable in the research.

We use the 'Trend Group Directory' in the simulator to record the variation of the following parameters:

1. Diesel Generator # 1 kW load (Red)
2. Diesel Generator # 2 kW load (Beige)
3. Diesel Generator # 1 droop setting (Green)
4. Diesel Generator # 2 droop setting (Purple) – which is the controlled variable

Both DGs are identical in operational characteristics under same droop. Total load capacity for each generator is 900 kW.

Starting with equal load sharing of a total of approximately 1050 kW of active power we reduced droop in DG # 2 from 60% (default value) to 40% in 5% steps. DG # 2 step reductions are shown in Purple. For each step reduction of droop in DG # 2, DG # 1 dropped its kW load while it was gained by DG # 2. Students can clearly observe that the Generator with less droop, i.e. DG # 2 takes more kW load than the Generator with larger droop; in this instance DG # 1 where we did not change the droop and maintained it at 60%.

The Figure 1 below shows how load is gained by DG # 2 at each step reduction of its droop. The load gained by the DG #2 is the mirror image of the load reduced from the DG # 1

In the second demonstration we do a similar variation of droop for DG # 1 while keeping Turbo Generator (TG) droop constant at 50%. Similar to the first one we start the exercise with the same total load of 1050 kW shared equally between the DG # 1 and TG. The difference from the first exercise is that the TG has a Droop setting of 50%. DG # 1 step reductions are shown in Green. As the DG # 1 Droop is reduced from 60% to 35% its kW load increases as shown by the red curve, while the TG load is dropped (Beige curve). Similar to the first exercise red curve is the mirror image of the beige.

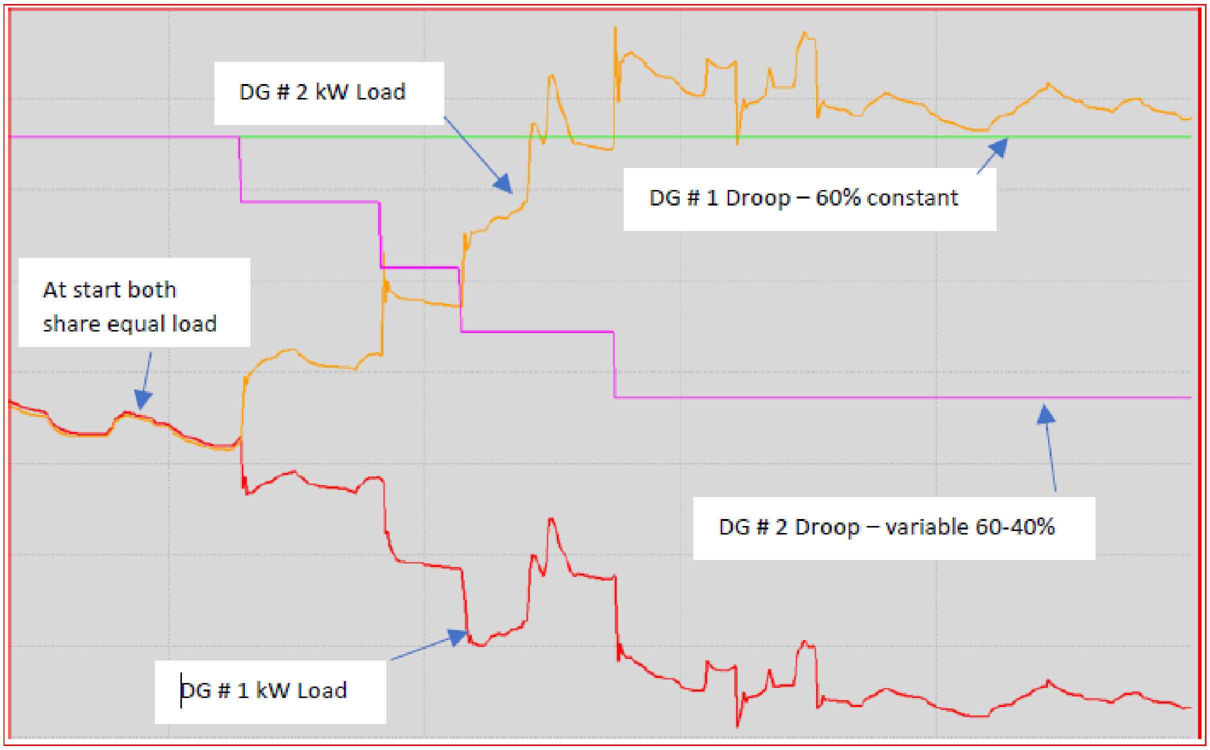

Figure 1. How variation in DG # 2 Droop affects both DG # 1 and DG # 2

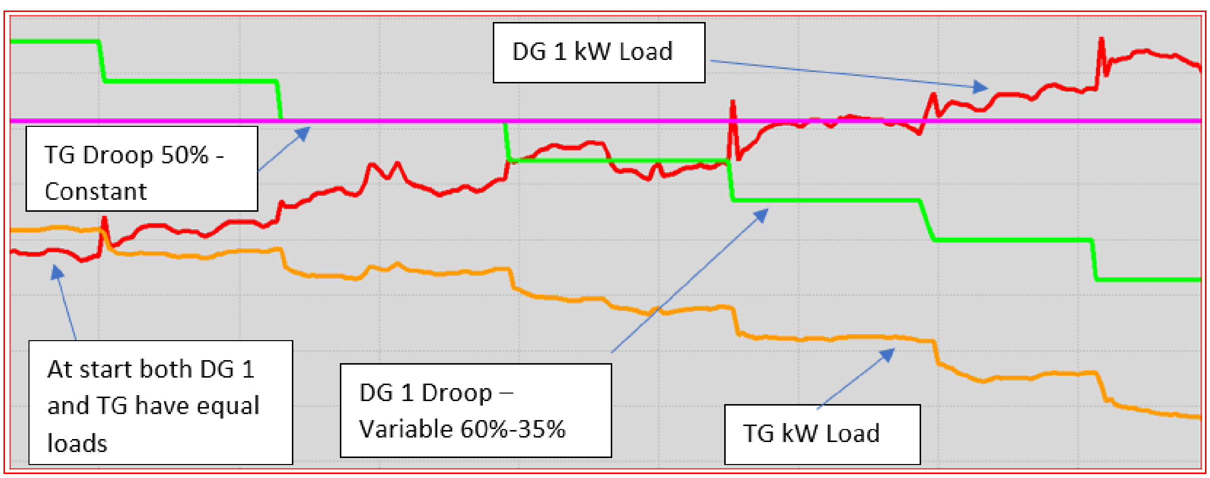

Figure 2. How variation in DG # 1 Droop affects both TG and DG # 1

This demonstration of how two generators running in parallel can further be extended to:

- One generator running with droop and the other with an 'isochronous' (zero droop) governor. In this demonstration we run DG #1 with 60% constant droop and DG # 2 with zero droop or isochronous governor.

- Finally, we run both DGs with isochronous governors. In both above situations we run the total load below 900 kW to prevent a blackout situation.

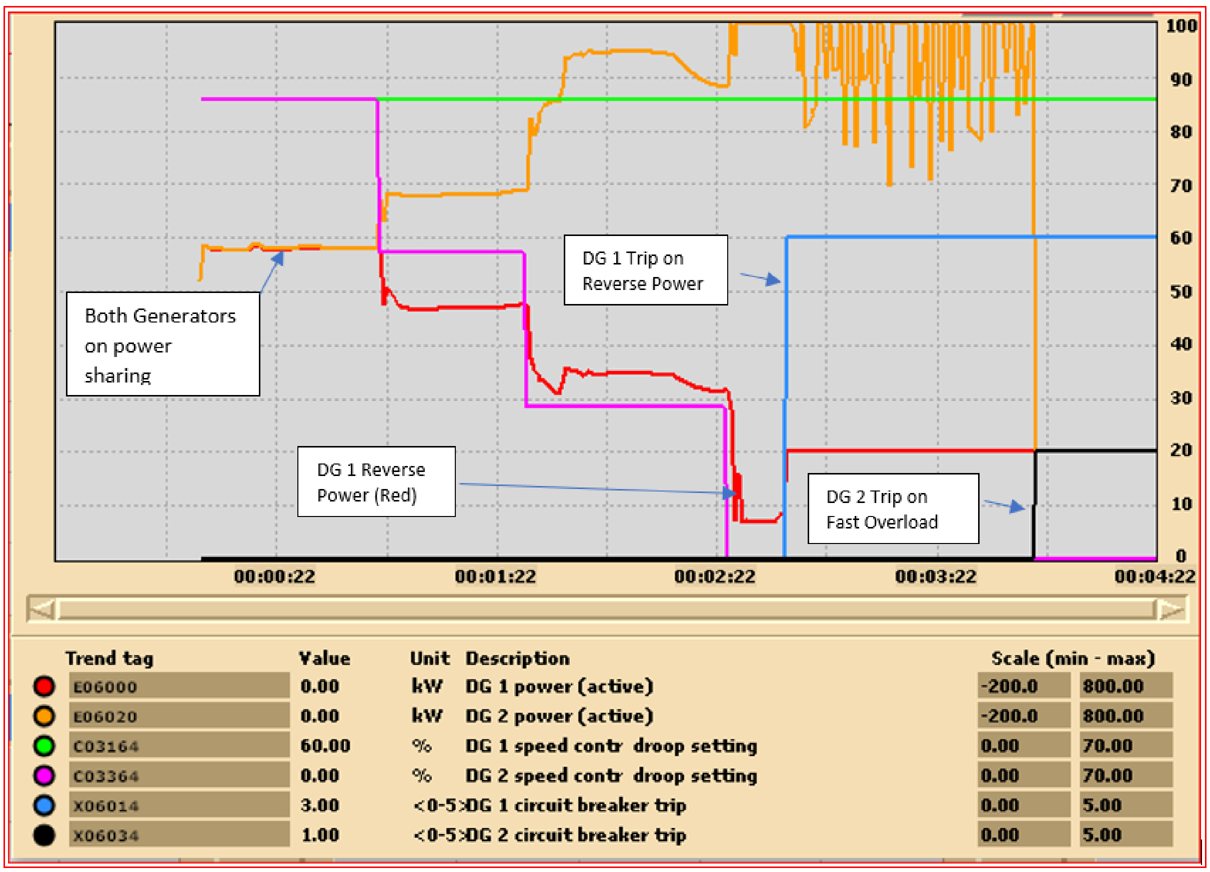

Figure 3. The results of running DG # 2 as Isochronous and DG # 1 as Droop.

Note the reduction in droop setting in DG # 2 from 60% to 0% in three steps of 20% each. When DG # 2 Droop setting (Purple) reaches zero, it behaves as an isochronous governor and takes the total load. As a result, DG # 1 goes into reverse power as it's ACB is still connected. Subsequently DG # 1 trips on 'Reverse Power Protection. Although the total load of the system is less than 900 kW. Soon after DG # 1 is tripped, the isochronous governor of DG # 2 is trying to cope up with load fluctuations and trips after 1 minute 7 seconds on 'Fast Overload', causing an inevitable black out situation.

Finally, it can be demonstrated that if we run both generators with isochronous governors, the system becomes very unstable as both generators are fighting to supply power to the system and eventually trip off one by one as in the previous demonstration. The first generator will trip on Reverse Power while the second will be on Fast Overload.

These simulator demonstrations make some concepts that would be very difficult to explain in a classroom setting quite feasible, eliminating demonstration with very expensive real equipment.

Example # 2 – Powerfactor correction with Synchronous Motor

In an AC distribution system power factor correction can be done by two methods:

a) Capacitor bank
b) Synchronous motor

The theory and practice involved with employing capacitors to correct power factor is quite straight forward. The inductive loads in a distribution system such as motors and transformers create a phase difference between the supply voltage and the current. This phase difference can be eliminated by introducing a suitable capacitor to the circuit that counter acts to make the phase difference to almost zero.

However, the synchronous motor method needs clarification for most students as the underlying principles need demonstration and clarification. The Shaft generator of Kongsberg MC-90-V simulator provides the reverse operation of the Synchronous generator as a synchronous motor, which enables the students to understand the concepts of power factor correction by excitation control of the rotor. In a synchronous motor there are two rotating magnetic fields. The first is the stator rotating magnetic field which starts rotating in the airgap once the 3-phase supply is switched on. Once the rotor reaches the full speed it has no relative cutting by the stator rotating magnetic field and the first magnetic field has no effect on any other components. However, the second rotating magnetic field is due to the rotor coils which are supplied with a DC supply to create the rotor magnets. This second rotating magnetic field cuts the stator of the motor, which is stationary and induces a back e.m.f. in the stator. The magnitude and the phase angle of this. back e.m.f. depends on the excitation of the rotor. This back e.m.f. in turn can either make the Supply voltage and current to lag, lead or stay in-phase.

In the demonstration we start with the Full Ahead Loaded ship. The synchronous motor is now on “Power Take Off” (PTO) or Generator mode. First, we need to record the values of the following:

1. Propellor speed / Ship speed and Fuel economy
2. Generator stator current
3. Power produced by the shaft generator
4. Power factor as the Shaft Generator
5. Power factor of the Turbo Generator

Then we start the DG # 1 and share the load with TG so that we can run the Shaft Generator as a synchronous motor. We follow the steps given below to achieve “Power Take In” (PTI) or Synchronous motor which gives a boost to the shaft to improve the fuel economy of the main engine. By varying the excitation of the synchronous motor rotor, we change the system power factor. At the optimum Power Factor position, (1.000) we again record the values mentioned above to determine the effect of the synchronous motor running in PTI mode.

Item	Parameter	PTO (Generator Mode)	PTI (Motor Mode)
1	Propellor speed	74 RPM	74 RPM
2	Ship speed	15.37 Knots	15.37 Knots
3	Fuel economy	205.73 Kg/Nm	201.97 Kg/Nm
4	Power produced	350.9 kW	-537 kw
5	Power factor	0.783	-0.998
6	Power factor of TG / DG	0.91 / 0.92	0.78 / 0.85

Table 1: Parameters of the Shaft generator showing fuel economy of Main Engine in PTI Mode.

Power Factor correction

We can further vary the Excitation and observe the behavior of the Power factor of the motor along with the stator current to plot the Synchronous motor V-curves and inverted V-curves.

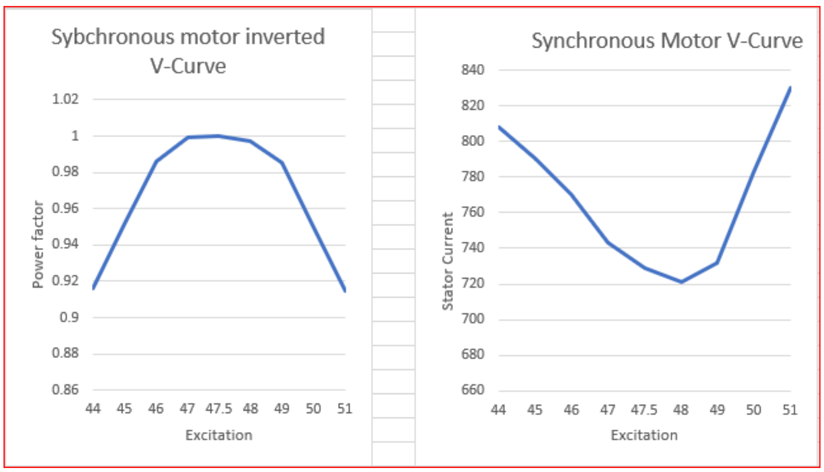

Figure 4: Variation of system power factor and Stator Current by varying Rotor Excitation.

Note that in the Table above fuel economy has improved, confirming that the shaft generator is now running as a motor giving extra power to the main engine.

The controlling of the power factor by varying rotor excitation is clearly observed and analyzed by the students with the evidence provided by the simulator. The evidence in the Table 1 above is to confirm that the motor in PTI mode enables saving of fuel as the synchronous motor delivers additional torque to the propeller shaft.

Further Examples

While the above examples prove that the engine room simulators can be used to augment theoretical training concepts by well prepared exercises, further examples involving tunning of controllers in the engine room can be added to this list. Tunning Proportional+ Integral + Derivative (PID) 3-Term controllers normally involve the following accepted methods:

1. Zeigler Nichols
2. Cohen Coon

Both above methods employ quarter wave damping which can be very explicitly interpreted by the 3-Term controllers in the engine simulator.

Additionally, we use exercises on Refrigeration for demonstration of common problems that cannot be done with real equipment.

Conclusions

Despite the troubles or events that are expressed by the simulator system are the same, the behavior carried out by the trainees are different based on their knowledge and skills. J. Rasmussen explains that the reading of the indicator needle of the flowmeters may be interpreted differently depending on the situation.[2] The difference in the normal condition as "signal", the trigger for the next action is as "sign", the difference under the understanding of the situation is as "symbol". Similarly, Endsley defines the difference in situational awareness as three levels: perception, comprehension, and prediction. [4]

In recent years, the ability of the engine room simulator is not limited to accident reproduction, and it seems that it is possible to acquire higher situational awareness with the intention of the instructor.

Although Engine Simulators are generally accepted as the best tools for operational training for marine engineers a new dimension of its capabilities has been discovered as interpreted by the examples in this paper, where theory is combined with practice to consolidate the learning.
The authors are convinced that further inroads can be made into this domain to explore what other possibilities exist to facilitate learning for marine engineers for future autonomous shipping.

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Automated Lifeboat Manifestation Embarkation System (ALMES): Facilitating Evacuation/Manifestation on Passenger and Cruise Vessels

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ABSTRACT:

A plethora of catastrophic disasters resulting in numerous life-losses at sea can be noted, while searching and studying Maritime History. On a positive notion, through the course of time, the maritime industry has experienced technological innovations and advancements in many areas that truly metamorphosed the conduct of safe navigation, the radio-communications field and shed light to many chronic issues of the industry. In an epoch of various significant advancements in many areas of the operation of a vessel, it is quite surprising to notice that analogous progress has not been made in the manifestation/evacuation procedures followed today on cruise and passenger ships. It is worth mentioning that the mustering and life-boat embarkation procedures followed on many cruise and passenger vessels remain unchanged through the years, resembling the exact methods followed on the early 20th century.

This paper will explore the implementation of Radio Frequency Identification (RFID) and Near Field Communication (NFC) sensors, in the form of irremovable bracelets, as tools of manifestation during an “abandon-ship” scenario with the aim to minimize life-losses by facilitating a more effective/efficient means of evacuation and improve coordination during a ship’s abandonment event. The proposed system will be capable of acquiring and recording passenger and crew information carrying the afore-mentioned bracelets, during their embarkation on their designated lifeboats via the RFID/ NFC readers installed at the entryway. Furthermore, certain past abandonment events that led to numerous casualties are examined, as well as the current evacuation procedures followed in the cruise/ passenger vessel industry. This study presents what currently exists in the market related to the aforementioned technology and examines the viability of creating a technologically developed evacuation system, having as a final target the creation and testing of a prototype.

Keywords: SOLAS (Safety of Life at Sea), LSA (Life Saving Appliance), ALMES (Automated Lifeboat Manifestation Embarkation System), Lifeboat, Evacuation

1. Introduction:

In the course of history, the impact of certain very disastrous ship accidents strongly influenced the safety developments in relation to the wider maritime industry (including the issue of evacuation). Among those accidents, there are certain cases that even opened up the opportunity to create new and/or enhance existing Conventions under the auspices of the International Maritime Organization (IMO) (Joseph & Dalaklis, 2021). For example, the sinking of RMS Titanic is considered as the main driver behind the introduction of one of the most important relevant regulatory interventions, the International Convention for the Safety of Life at Sea (SOLAS) (Dalaklis, 2017) in 1914. Similarly, the tragic loss of MS Estonia in 1994, was able to bring several advancements and alterations on the existing regulations concerning the Life Saving Appliances (LSA) and especially the life-rafts design and specifications, as well as the adoption of further requirements concerning public address systems, escape routes, etc. The relatively recent Costa Concordia accident, calls for special attention in the realms of evacuation and crowd management. Despite the fact that this vessel was sufficiently equipped with state of the art technology and LSA means that were corresponding fully to the Internationally established standards in order to accommodate all the passenger and crew needs in case of an emergency, it can be easily understood that lessons related to evacuation conditions have yet to be learned and effectively implemented (with apparent shortcomings in “soft skills” like leadership and crowd management standing out), despite the progress in technological means recorded in the past decades (Schröder-Hinrichs et al, 2012).

It is undeniable that during the past few decades, significant improvements in the fields of research and technology have been taken, leading to advancements in a wide spectrum of safety features and appliances a modern vessel is equipped with. In a modern Navigational Bridge an abundance of devices that ensure the safe conduct of navigation can be found; the Electronic Chart Display and Information System (ECDIS) which works in conjunction with the Automatic Identification System (AIS) providing real-time information about the position, the course of the vessel and additional information about the surrounding ships, is one of the most distinct examples of the technological progress that have been made. Furthermore, a significant number of satellite navigation systems like the GPS, GLONASS and GALILEO and of course the radars equipped with Automatic Radar Plotting Aid (ARPA), constitute only few of the major technological advancements, that the shipping industry has experienced and have notably contributed to the overall safety of the vessel and the people onboard (Pallikaris et al, 2016).

It shall be mentioned here that apart from the development of equipment and devices that facilitate a safer, more efficient and effective daily operation of a ship, the wider domain of LSAs has also benefitted from numerous innovative developments that have increased the level of safety and the possibilities of locating crew and passengers in case of an emergency. For example, Emergency Position Indicating Radio Beacons (EPIRBs), and the Search and Rescue Transponders have revolutionized the Search and Rescue procedures during the tragic moments of a sinking (LSA Code, 2010). Unfortunately, although numerous improvements have happened in all the aspects of a vessel’s operation -as well as on the emergency preparedness and response- an analogous progress is not observed in the evacuation field, as the techniques and procedures followed during an abandonment seem relatively unchanged over time.

Inarguably, the lifeboats carried on a vessel have been considerably improved over the course of time in terms of construction standards, deploying systems, propulsion mechanisms and means of communication. Moreover, a broad variety of lifeboat davits has been developed in order to facilitate the wider spectrum of operational needs and conditions a vessel might experience during emergency situations (i.e. Gravity Davits, Fixed Davits, Miranda Davits, Free-Fall ones); all these are helping to raise the level of safety and the feasibility of launching lifeboats even in extreme conditions (i.e. excessive list, or trim). The manifestation/evacuation methods though, applied today have not followed the same development path. Especially when it comes to large passenger and cruise vessels, in relation to which is understandable that the management and the manifestation of people is more demanding, time consuming and can result in fatal mistakes. Until today, in the majority of cruise and passenger vessels during an abandonment procedure, a verbal manifestation of crew and passengers is carried out, prior to the lifeboat embarkation; this is making the whole evacuation process immensely time consuming and strenuous.

This paper presents an alternative evacuation method utilizing technologies and equipment which already exist and is used in a considerable number of cruise vessels today. The proposed Automated Lifeboat Manifestation System (ALMES) targets to revise and upgrade the currently followed evacuation methods and the serious deficiencies encompassed in them, that in the past have led to numerous casualties. It is undeniable that the majority of the accidents, incidents, mishaps and misconducts derive from the human error and its consequences. Therefore, the adoption of ALMES on cruise and passenger vessels will be able to reduce to a certain level the human involvement in the organizational process of the evacuation and consequently will restrict the occurrence of potential mistakes. Moreover, the common occurrences of large concentrations of people, elevated anxiety and stress levels, panic and confusion will be severely reduced. The aforementioned can be achieved by the application of RFID technology, which through its wide application and adoption in maritime industry (e.g. asset tracking on ports, personnel tracking on offshore platforms) has proven its reliability and cost-effectiveness (SOLAS II-1/24 and II-2/15). The main asset of the RFID technology is its effective ability to track and record a large number of tags simultaneously, during the creation and testing of ship evacuation models; thus making it the necessary "founding stone" for the creation of ALMES, that will be able to execute, monitor and record the automatic manifestation of crew and passengers during their embarkation on the designated lifeboats.

2. Methodology:

During the write up of this paper, the qualitative research method was mainly utilized. Certain past catastrophic incidents that had devastating effects on crew and passengers, resulting to mass loss of human lives and were able to reshape the balances in the maritime industry and introduce changes and advancements, have provided the triggering point for the wider research effort. Furthermore, a brief sociological research was performed through integrating input from various peer-reviewed articles available in the related literature, attempting to provide a clear insight to the mental and psychological state that the crew and passengers experience during an evacuation. As it has been observed during a ship's abandonment people can exhibit various irrational behaviors, that can impact negatively the established procedures (standard operating procures-SOPs) by causing further confusion and unnecessary delays (Jørgensen & May, 2002). Additional material concerning faults and mishaps in abandonment processes was collected by examining reports and sources focusing on past disastrous incidents and special attention was paid to the sinking of the Costa Concordia and the particular feasibility and conditions under which its evacuation happened (Casareale, 2017). Moreover, in order to acquire a better insight and understanding of the nature of abandon-ship drills and preparations for an emergency situation on cruise and passenger vessels -but also to gain professional opinions and overviews on the problems and deficiencies experienced in mustering and evacuation of people- a small number of interviews with professional of the field were conducted (Andreadakis & Sloane, 2021).

3. Discussion:

3.1: Objectives:

The fundamental objective of ALMES is the streamlining of the ship evacuation procedure, by targeting to minimize as much as feasible the miscommunications, human errors, irrational behaviors and at the same time, improve coordination between relevant people. It has been observed that during an abandon-ship situation a wide range of behavioral patterns emerges, that affect not only passengers but also the crew. The spectrum of the feelings and responses experienced by people is very wide and varies greatly. The most common behaviors presented by individuals under life-threatening situations as an abandonment case are primal human instincts, feeling of self-preservation, ineptitude, immense anxiety and panic for the survival of themselves and their loved ones. Of course, as dictated by SOLAS Regulations (SOLAS Ch. 3, Reg. 19.3), there are certain drills that passengers undergo when they are engaged into lengthy voyages, but it is understandable that the amount of that training cannot compensate and be effectively useful to previously untrained individuals. Freezing and inability to act efficiently has also been observed on crew members frequently, even though they have taken relevant training courses and previously participated to several drills. Because of the surrounding circumstances and the stress experienced by them, they become incapable of performing their duties efficiently and consequently delay the abandonment process.

Behavioral patterns as the aforementioned, were largely observed during the sinking of Costa Concordia, where the Master's poor management and the lack of decision making from him and the fellow officers, led to an extremely lengthy abandonment of more than 6 hours (Giustiniano et al, 2016). This is in sharp contrast with the established maximum 30 minutes that are dictated by SOLAS regulations; to make matters even worse, 32 life-losses were recorded at that event. As people tend to be generally affected and influenced by the reactions and behaviors of others in the same surrounding social environment (Nilsson & Johansson, 2009), and in conjunction with the extreme anxiety and stress loads existing during emergency and life-threatening conditions, an inefficient management and manifestation of crew and passengers becomes quite probable. ALMES, by implementing the currently existing technologies in the cruise/ passenger vessel industry aims to create a pioneering solution, that will foster a safer, more effective, efficient and straightforward lifeboat embarkation in the unfortunate event of evacuation.

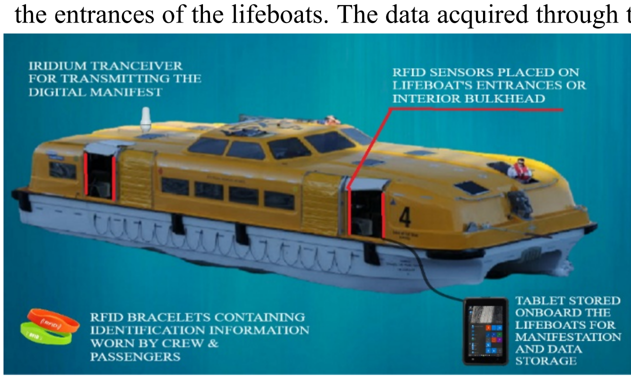
Furthermore, it is interesting to note that although SOLAS has introduced regulations and determined frameworks which provide guidelines and solutions on many operational and emergency issues occurring during the operation of a vessel, it has not created yet a fixed process around the mustering, manifestation and lifeboat embarkation, during an abandonment. Today, there are three mainly used evacuation practices of cruise and passenger vessels. The first and most commonly used practice is the verbal passenger counting, with the muster station leader reading from a paper passenger manifest and relaying these results to the ship's master. Secondly (and more commonly implemented on newer cruise vessels) is the use of portable computers or electronic tablets stored on the bridge under normal circumstances, which must be retrieved first by the station leader/commander during an event of evacuation. These devices communicate with each other via an interconnected onboard network, which displays digital manifests allowing evacuation leaders to relay passenger information and their health condition to the bridge via the on-board network. Although this manifestation system has eased the evacuation process, it is still performed through the use of verbal passenger manifestation, thus allowing for potential errors to occur, in a quite similar manner with the previously explained method. Finally, the most technologically advanced evacuation practice so far, that has been adopted by some major cruise operators, such as the Royal Caribbean and the Celebrity Cruises, is the accounting of passengers and crew via the use of portable handheld scanners handled by designated crew members (Ortega et al, 2020).

3.2: System Implementation Proposal:

RFID technologies over the last decade have dynamically being applied in the cruise and passenger vessel industry, ranging from onboard payments to cabin access. It would be therefore feasible by performing minor additions to the existing RFID infrastructure onboard, to extend these capabilities onto passenger management methods. By implementing the ALMES proposal, bracelets with mounted RFID technology containing all the personal information of the carriers, will be used as the proprietary component of the system. The proposed basic structure and operation of ALMES is summarized below and involves:

1. RFID bracelets containing passenger and crew personal information (i.e. body mass, age, health conditions, cabin number, family members onboard).
2. RFID readers mounted on the entrances of the lifeboats or onto the interior bulkhead.
3. Waterproof IP-67 rated, rigid electronic tablet connected to the sensors, with the necessary software responsible for the data recording of each individual entering the lifeboat.
4. Satellite modem responsible for the transmission of manifest results to the closest MRCC, upon lifeboat's launching.
5. Data connectivity between tablets via onboard wireless network (based upon GSM or WiFi), relaying information between the lifeboats and the Bridge regarding the evacuation status and embarkation conditions onboard lifeboats. The ship's Bridge will be equipped with a monitor displaying in real-time the progress of the evacuation to the ship's Master.
6. This integrated system and relevant data flow shall also be connected to the vessel's VDR, to ensure the storage of the critical evacuation information of passengers and crew.

The aforementioned systems and technologies will be designed according to the requirements and the prerequisites of SOLAS Ch. 3 Reg.4, in order to ensure the system's safety compliance. Bracelets with mounted RFID tags, containing passenger information will be read by UHF-105 readers with reading range 0 to 5 meters, with the ability to read multiple RFID tags at once, to overcome RFID tag collision, while the passengers are going through the entrances of the lifeboats. The data acquired through the mounted sensors will be transmitted to the tablet via



a wired connection, aiming to avoid unexpected errors a cordless system can present, during the operation. The tablet receiving the information will be equipped with a software capable of interpreting the manifest data, displaying lifeboat occupancy, health conditions, missing individuals, and evacuation status and display the information to the lifeboat commanders, as well as to the Master through a central monitor located on Bridge; this approach will allow him/her to personally intervene, whenever needed. Furthermore, the manifestation results will be stored locally to each lifeboat on a solid state drive, along with being stored on the VDR of the vessel. Lastly, upon the launch of lifeboats the whole "digital manifest" of each craft shall be automatically transmitted via satellite communications to the nearest MRCCs.

In the preliminary design and without any commercial bias, the Iridium Satellite System was selected as the appointed transmission means of the manifestation results to the closest MRCC. The choice of Iridium technologies was performed after careful consideration and evaluation of other existing satellite systems in the market, as well as of the nature of the operation of cruise/ passenger vessels. Iridium Satellite Constellation is capable of providing worldwide coverage including the areas of polar regions, providing communication in forms of voice and data transmission. It shall be pointed out that as the operation area of cruise vessels gradually expands and more regions become approachable by the industry, the coverage of all Sea Areas (A1-A4) shall be considered of great importance; especially when it applies to emergency situations where human lives are under threat (e.g. vessel abandonment). Moreover, Iridium, after successfully fulfilling all the mandatory quality checks around the operational and technical requirements established by the International Mobile Satellite Organization (IMSO) (IMSO Website, 2022), is a certified Global Maritime Distress Safety System (GMDSS) provider from December 2019 (Sekiguchi, 2016). Since the aim of ALMES is to be capable of being installed with low cost and minimal modifications on the lifeboats, without requiring later inspection and clearance from the classification societies, the Iridium Roger ITAS Satellite Modem was selected. This particular model is an inexpensive very small, ready-to-use satellite transceiver, that will be able to be retrofitted with minimal or no alterations (e.g. use of a holding magnet) to the lifeboats, thus not requiring any later approval of the classification societies that overcomplicate and make more time consuming the installation procedure. Additionally, it is able to operate in between –40°C and +85°C, and at 75% Relative Humidity, making it ideal for vessels operating on most waterways (Iridium Website, 2022).

4. Summary and Conclusion

It is undeniable that through the years the maritime industry has taken important steps forward towards the further development of equipment and technologies, which aim to improve and reinforce the safety of passengers and crew during the operation of ships. Nevertheless, there is still an important gap to be covered, when it comes to the management of people and the lifeboat embarkation especially for cruise/ passenger vessels. The most important unresolved issue remains the failure to meet the SOLAS requirements towards the evacuation times under realistic conditions (Vassalos et al, 2002). Furthermore, the transmission of the manifestation results after a ship's abandonment remains a thorny issue, as it is frequently problematic with the accounting catalogues being incomplete or wrongly completed. The wide adoption of RFID technologies on cruise vessels in the aspects of the every-day operation (i.e. space access, onboard transactions, could be furtherly introduced to the LSA field, as per the research suggestions (Giustiniano, 2016). It is safe to say that the foreseeable growth of the RFID technologies will give space and prepare the ground for the potential introduction of the ALMES in the cruise/ passenger vessel industry. The probable adoption of ALMES will be able to promote further changes and developments in the field of passenger and personnel management and manifestation in order for the evacuation procedure to comply with the SOLAS requirements to minimize the evacuation times. Furthermore, the application of ALMES would be a contributing tool into reducing extreme behaviors, such as panic, stress, and anxiety, that are being observed during evacuation events, by reducing the human error. Finally, during the next years and after securing the required funding, as part of future related work, it is aimed to build a prototype that will be tested and evaluated in order to prove the value of the concept. This will also allow for the further development of the system under discussion even for commercial purposes and hopefully its successful integration with other relevant systems and technology applications already in use in the cruise/ passenger vessel industry.

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Digital platforms as factor transforming maritime education and industry

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Abstract: During the COVID-19 pandemic, many discussions arose about how digitalization is crucial for maintaining supply chains and ensuring the continuity of transport networks, especially shipping. At this stage, one of the most promising ways to improve efficiency is by introducing digitalization in the maritime industry. After all, the main goals in the information age are the digitalization of information and its proper use. Today, the business world expects faster service, simpler processes, and better efficiency from all companies and individuals. The transition of modern society to the information age challenges one of the main tasks of education to be the formation of the foundations of the information culture of the future specialist. However, all stakeholders are connected through a network, and illustrating the maritime transport process and the roles of its participants can elucidate the special features that are unique to the industry. Advances in information transfer, data analysis, and encryption techniques can reshape the business landscape and allow for managerial innovation, as well as new or complementary forms of learning to achieve it. But the pandemic has also led to a complete reorganization of the provision of education around the world. In practice, the learning process has been continued through a combination of different approaches. One of them is the implementation of web-based software for the shipping industry. Its products help make accurate and efficient business decisions and are designed for brokers, operators, shipowners, research firms, and financial institutions. The purpose of the article is to consider the presented software as a tool that may support maritime education and industry.

Keywords: digitalization, maritime education, maritime industry

1. Introduction

Since the beginning of the pandemic, measures have been taken in shipping to ensure the continuity of operations and thus the security of supply. The difficulties facing the industry are exacerbating the sector's efforts to adapt to a seemingly "new" normal pace of work. Maritime transport and logistics chains are trying to move quickly towards digital technologies. Even the expansion of world's container fleet and capacities of containerships did not happen without the facilitation to shipping industry brought by advanced computer technologies (Velinov, 2013). The companies gradually but completely focus on digitalizing their activities through online platforms and applications. Blockchain technology has gained its fair share of supporters and opponents, but it is still quickly adopted by the maritime industry due to its proven ability to optimize costs. The limitations of traditional business models and the capabilities of business models based on digital platforms and self-organization were revealed (Molodchik, Dimitrakiev, 2018). As the maritime industry gradually embraces digitalization, the use of complex systems such as AI and data monitoring tools will become commonplace. In response, professionals in the field will need to acquire additional skills. They will need to be trained to take advantage of and properly use the data generated by working in tandem with modern systems (Blockchain, 2019).

In the conditions of digitalization, the landmarks in the development of education, business, and the formation of a healthy lifestyle change invariably. Nowadays, with the help of digital technologies, not only the process of acquiring knowledge is being restructured, but also the knowledge itself. A specialist with digital thinking and digital competencies is more in demand in the labor market.

In this regard, the attention of the article is focused on the presentation of web-based software for the shipping industry, complementing the theoretical-abstract aspect with creative educational research and practical use of familiar theoretical concepts.

2. Issues and Challenges

The impact of technology on the nature and pace of the industry has forced companies to create new business models through which they can adapt to change and take full advantage of emerging opportunities. At the same time, universities, their connection to the business environment, and their impact on society have undergone significant changes over the last decade.

According to the traditional view, their role is mainly related to ensuring high-quality education and research in specific fields. At present, they are increasingly looking for different opportunities to influence the sustainable development of society and the environment in which they operate. In addition, they devote time and effort to identifying and putting into practice tools to help clarify the potential and role of technology in effectively addressing the issues in the maritime industry.

In today's globalized world with a rapidly changing environment and constant challenges, competition is not between individuals or organizations, but between systems of interconnected, interacting, and collaborating structures. Also known as the "knowledge triangle", this concept encompasses education, research, and innovation. The ability to think independently based on knowledge, experience, and the ability to apply this knowledge to solve specific problems, is becoming one of the core values of the information society. This is called the competence approach in education, which is most compatible with the concept of modern understanding of education. The main goal is to prepare specialists who have the necessary system of knowledge and large amounts of information. However, in addition to forming harmonious systems of knowledge, the efforts are focused on maximizing their enrichment, memorization, and free operation with them. The desired result is the shaping of a specialist with an orientation towards professional skills with the help of educational information, which provides an opportunity to perform a high-quality professional activity.

The impact of Information and Communications Technology (ICT) on this process is enriched through the use of ICT opportunities (Ostenda, Nestorenko, 2021). They provide teachers with effective aids that enhance pedagogical design during specific maritime practical classes. An example in this direction is AXSMarine - a French company developing web-based software for the shipping industry. The key products and services of the company are AXSDry, AXSTanker and Alphaliner, covering the three main verticals in the industry – the dry bulk, tanker and container market.

The products are designed for brokers, operators, shipowners, research firms, and financial institutions, helping them make accurate and efficient decisions for their business. Each product has a number of modules unique to the business it serves – be it Dry Bulk, Wet Cargo, or Containers.

Figure 1. Commodity flows worldwide, AXSMarine

In the learning process, students have the opportunity to gain access to industry insights on vessel and commodity movements, AIS speeds, Ton-mile analyses, macro- and micro-level congestions and much more. They can also create search through the global fleet in a wide range of technical, commercial, and AIS criteria. They benefit from more than 50,000 proprietary landfills corresponding to advanced terrestrial and satellite tracking sources, including, but not limited to, Spire's state-of-the-art nanosatellites.

Students access a fully organized system of ports, terminals, berths, and anchorages. They quickly compare the voyages of competing vessels, bunker prices, channel costs, and DA. Identify commodity flows and ship trading patterns, making faster-informed decisions. Observe the difference between cargo and ballast travel. In addition, they analyze commodity types, volumes, and charterers' activities. The two main parties, shipowners and the charterers, determine the market (Dimitrakiev, Gunes, 2019). They also have access to macro and micro data of trade flows between zones, countries, ports, or berths. Pre-built graphs allow them to filter, segment, and interact with various parameters. These predefined data visualizations help them tell impactful stories by creating and sharing compelling reports.

Here are some practical examples from AXSMarine's AXSDry platform. The Voyage Calculator is an automated tool allowing its user to get an estimation for the cost of a voyage with minimum input. It can save default values for multiple parameters in each new sheet. This allows setting Terms, Sea Margins, Turn Time, TC or Voyage Commissions, and more, to the most common values of business routines.

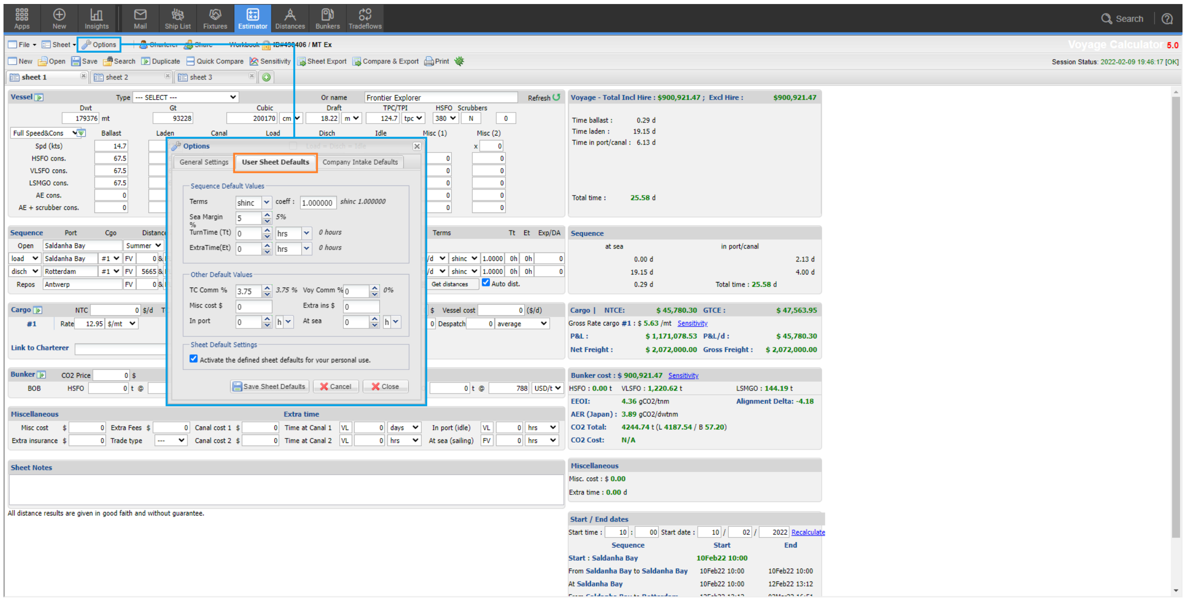

Figure 2. User sheet defaults, AXSMarine

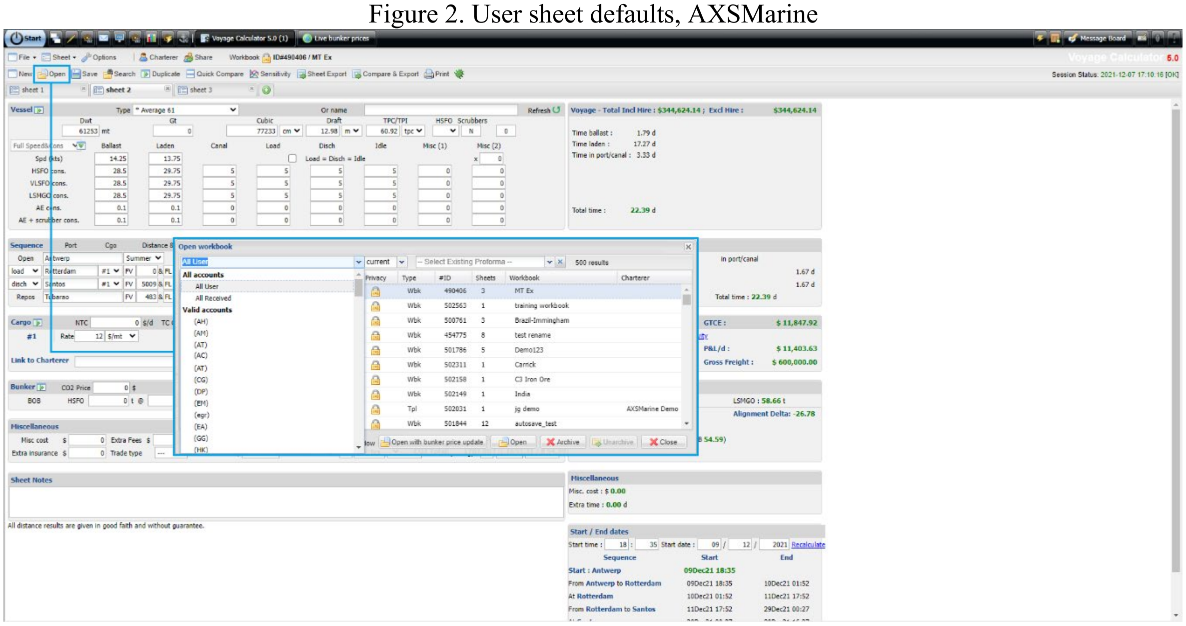

Figure 3. Voyage Calculator, AXSMarine

In addition, the Voyage Calculator is equipped with a powerful tool to help track compliance with the IMO GHG Strategy. The CO2-estimator is a fully automated tool that calculates emissions for each voyage. The results provided are compliant with both the EEOI and the AER methodologies. The calculation gives an Alignment Delta to the EEOI trajectory values, as well as the total CO2 emitted throughout the voyage.

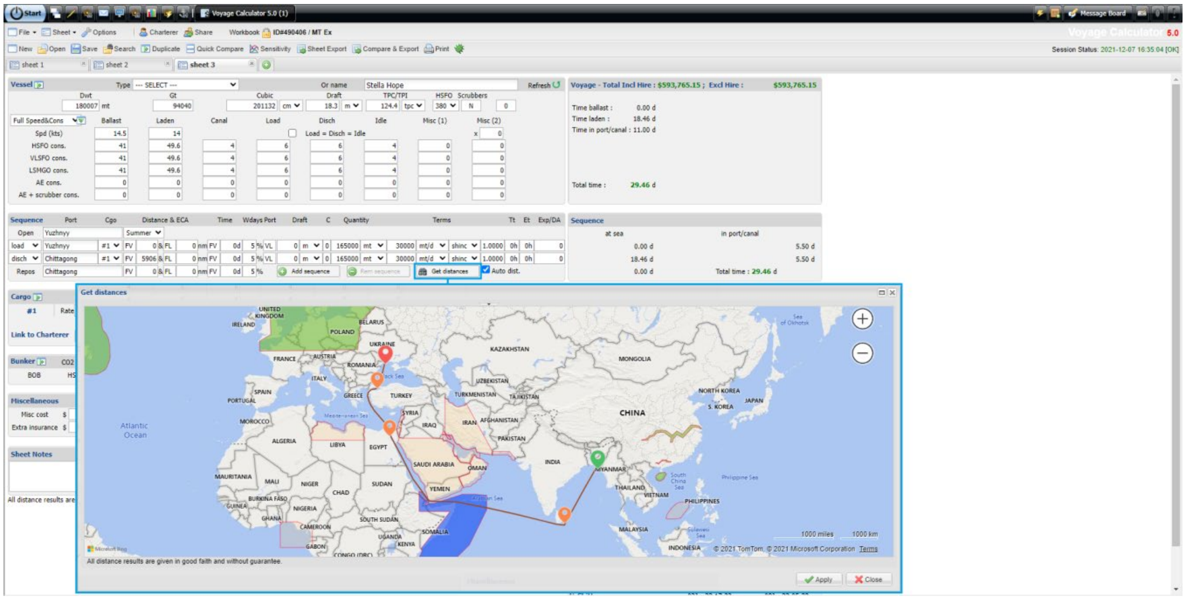

Figure 4. Canal pass, AXSMarine

Calculating whether a vessel could pass through a particular canal is also available. The logic behind the calculation is sophisticated. It takes into account not only the vessel's maximum deadweight and draft as per her technical specifications but also the currently loaded quantity and laden or ballast status of the vessel's voyage. While students can create and save their own calculations, Voyage Calculator also allows access to all of their team members' workbooks. In the "Open" dialogue, there is the option to select each account in the academy. The relevant workbooks saved under that account are then available for opening and editing. There is also the option to open them in new windows or load them with a bunker price update. In a business company, this feature can be used to check and revise calculations before moving forward with a fixture.

Students also have access to the Trade Flows solution which helps users follow fleet performance and trade pattems. Trade Flows is a new-generation software tool providing virtually limitless options when analyzing the global vessel and commodity movements and trends. It allows its user to isolate different fleet segments, trade regions, time periods, types of voyages in a fully customizable grid, which provides details from individual shipments to entire nations' imports.

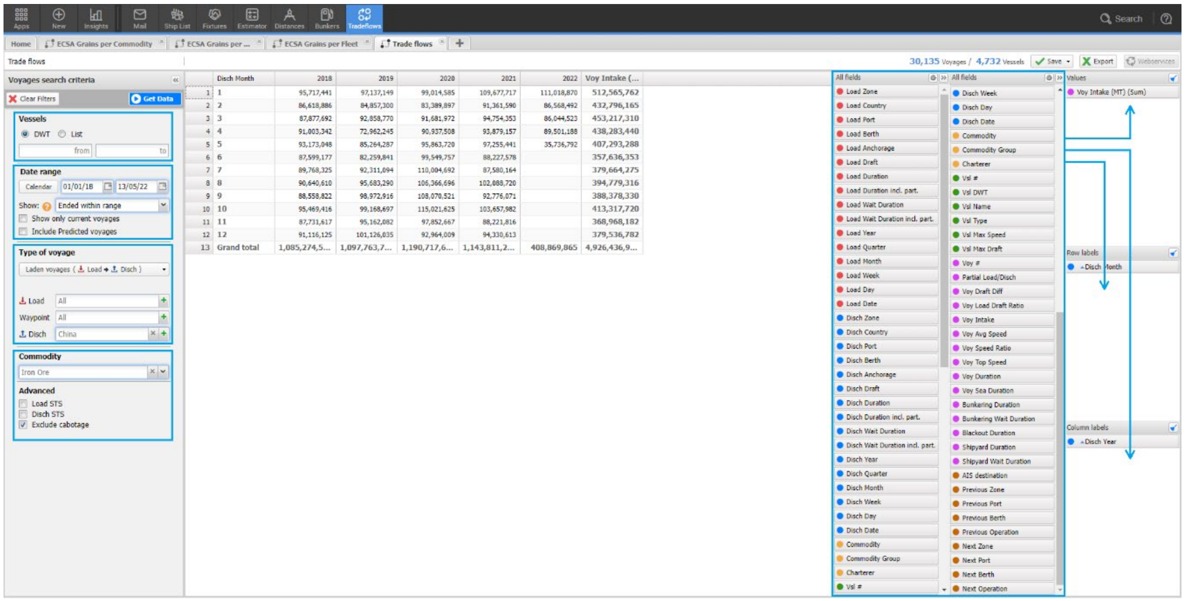

Figure 5. AXSMarine

Trade Flows also has a set of pre-rendered analyses created by AXSMarine to cover the most common maritime trades and routes. These can also be viewed in graphs, instead of data grids. All data is exportable for ease of further analysis by the user.

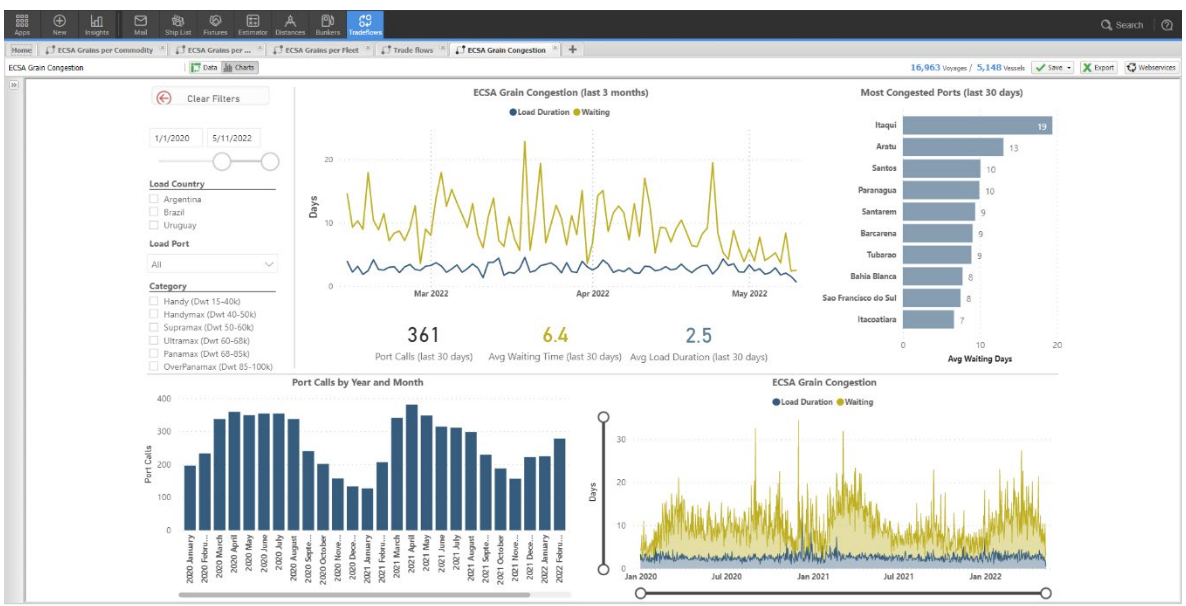

Figure 6. AXSMarine

The Bunkers module provides the latest global pricing data. Apart from giving a fresh picture of the current market, historical fluctuations at each bunker location are also available.

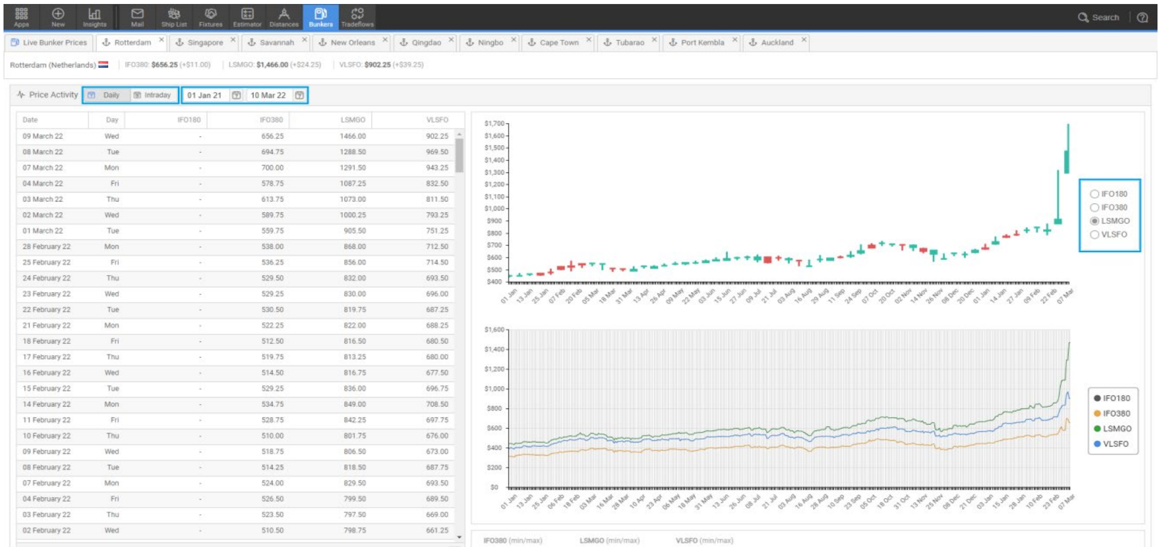

Figure 7. Bunker prices, AXSMarine

The Dry Fleet Disposition Timeseries report gives an overall summary of vessel counts per their laden, ballast or at port status, as well as disposition in the world's oceans. Moreover, AXSMarine is constantly improving its tools. The Dry Fleet Disposition Timeseries report now includes several new features. In the Congestion tab, there are two new categories – Waiting at Anchorage and Waiting Shipyard. While the latter category is self-explanatory, the former includes all vessels waiting at anchorages for reasons unrelated to loading or discharging of cargo, such as bunkering, crew changes, canal passage, etc.

Figure 8. Dry Fleet Disposition Timeseries report, AXSMarine

The Global Congestion Monitor report provides an extensive breakdown of current and historical vessel data following their current operational status at sea or in port. Students can explore individual ship data, cumulative waiting times, and most congested ports, as well as filter by vessel category, commodity transported, points of origin or destination, etc.

Figure 9. Global Congestion Monitor report, AXSMarine

These are just a few of the functionalities AXSMarine's system provides to students in their journey to knowledge and skills in the maritime industry.

However, the main challenge remains to balance the fundamentals with the practical-applied knowledge and skills. It is becoming even more difficult because of the need to be in tune with changes in the maritime industry. That is why the search for answers to managerial and pragmatic tasks, and the extraction of practical postulates, models, and strategies, occupy an increasingly important place in the learning process. Getting acquainted with the state of the freight market presupposes the practical use of theoretical concepts. Academic staff consider the usage of ICT in teaching process has positive impact on the quality of training of maritime specialists as students develop skills of self-organization, hence their performance level increases, they receive positive emotions and motivation and efforts in the area of knowledge acquiring increase (Slyusarenko, Zadorozhnya, 2021).

However, one of the vital advantages of technology is the use of easily accessible and objective information, as well as the achievement of clear interpretive results. Further development and improvement of the study is possible in the direction of development of the use of intelligent and information systems in the field of multimodal transportations (Fedotova et al., 2019).

3. Conclusion

Digitalization and new business opportunities in shipping will increase the demand for qualified professionals, especially in logistics, information technology, and related fields. To reap the full benefits of new business opportunities, the human, institutional and technological capacity must be improved at the same pace as technological advances in the industry. Some international organizations closely monitore all these developments and are actively involved in acceleration programs with start-ups on all fronts in the maritime sector. The future in which growth is activated by technological development is not so far from the horizon (Blockchain, 2019). Undoubtedly, modern technologies are fundamentally changing our lifestyle and work, creating new opportunities and challenges for all of us (Bartusevičienė, Mickienė, 2021). Creating the conditions for specialists to use technology to empower people instead of replacing them is crucial for Maritime Education and Training.

Future port specialists` preparation should include "digital twin" and "virtual reality" technologies (). The focus of learning design and techniques is to facilitate the acquisition of knowledge and skills in the learning environment, which can later be transferred to the work environment. Good practices with applicated theoretical concepts are a guarantee for dealing with the real problems of the maritime industry. And achieving this symbiosis is vital to the success of the idea.

Acknowledgements

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Feasibility study on carbon capture system of LNG-fueled ship-based on comprehensive utilization of heat and cold energy

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Abstract: This study proposed an onboard carbon capture system for a LNG-fueled ship. The design target of the OCCS is to meet the Energy Efficiency Design Index (EEDI) in phase 3. Under this context, an absorption-type OCCS is selected with exhaust gas waste heat and LNG cryogenic cold energy recovery. The CO_2 contained in the exhaust gas is captured and then liquified by the cryogenic cold energy released during LNG regasification. The effects of exhaust gas mass flow rate, the solvent mass flow rate and regeneration temperature on the OCCS performances are investigated. The results demonstrate that the specific heat consumption of the CO_2 capture varies in the range of 10.9~12.2 GJ/tCO_2. The feasibility of the OCCS to satisfy the IMO regulation required EEDI in phase 3 is validated.

Keywords: LNG-fueled bulk carrier; Carbon capture system; EEDI; Waste heat; LNG cold energy

1. Introduction

To be able to achieve the Paris climate agreement goal, the International Maritime Organization (IMO) has called for 50% decarbonization of the shipping industry from 2008 levels by the end of 2050, which means approximately an 85% reduction of CO_2 for each ship. Liquefied Natural Gas (LNG) is regarded as the most potential fuel for international shipping. Compared with heavy oil, LNG can reduce SOx by 90%, NOx by 80%, CO_2 by 20%, and particulate matter by 100%(S Lion et al., 2020). With the improvement of global refueling vessel layout and the development of dual-fuel engines, LNG-fueled ships have developed to large ocean vessels. According to Sharples, the number will be doubled by 2026 and will account for 32% of the total ship demand by 2050(J Sharples, 2019). LNG is stored at a cryogenic temperature of -162°C and needs to be regasified before entering the DF engine, which releases about 830 kJ/kg of cold energy(BB Kanbur et al., 2017).

LNG, to some extent, could be treated as clean fuel except for the CO_2 emission. To overcome this shortage, post combustion carbon capture system (CCS) for dealing with the tail gas is mostly recommended. As for the CCS, the alcohol-amine-based absorption method has become the main decarbonization method because of the characteristics of high absorption load, recyclable absorbent and low cost. Inspired by the cryogenic cold energy and waste heat, the feasibility of the onboard carbon capture system (OCCS) attracts attention. With the OCCS, the CO_2 contained by the exhaust gas would be captured and concentrated. For the convenience of storage and transport, the gaseous CO_2 is liquified and transported to the port for commercial utilization.

The research on the alcohol-amine-based absorption OSSC has been widely studied. Seo et al. (Y Seo et al., 2015) developed several CO_2 liquification processes and evaluated the availability of the ship-based CCS from a life cycle cost perspective. Feenstra et al. (M Feenstra et al., 2019) investigated the feasibility of ship-based CCS on a cargo ship. 30 wt% aqueous monoethanolamine (MEA) and 30 wt% aqueous piperazine (PZ) were used as solvents. The carbon capture cost was in the range of 98 to 389 €/tCO_2. Fang et al. (S Fang et al., 2019) proposed an optimal sizing model to determine the capacity of the shipboard CCS. They pointed out that a 6MW OCCS could reduce124 tons CO_2, which was 55.8% of the total shipping GHG emission. Long et al. (NVD Long et al., 2021) developed a system using MEA/PZ and MDEA/PZ as solvents for CO_2 capture, compression and liquefaction onboard a 3000 kW diesel engine. The results demonstrated that CO_2 removal could be up to 1348 kg/h under the optimum configuration. Ros et al. (JA Ros et al., 2022) designed a ship-based CCS considering solvent selection, heat integration and ship movement. The techno-economic analyses showed that the cost of CO_2 capture for the Sleipnir varied within 119-133 €/tCO_2. Einbu et al. (A Einbu et al., 2022) alleged that the waste heat recovered from the engine exhaust gas was not sufficient for the demand of an absorption-based CCS operating 50% capture rate with 30 wt% MEA as solvent. From the literature review, even though the waste heat from the exhaust gas has been widely applied in OCCS, the utilization of cryogenic cold energy released by the LNG regasification process is seldomly reported.

EEDI is an index representing the CO_2 generated from ships for transporting 1 ton of cargo per nautical mile (nm). The MEPC agreed on intensifying the phase 3 EEDI requirements during the 74th meeting. The decarbonization results of the OCCS should be considered in the EEDI calculation and baseline set. Lee et al. (S Lee et al., 2021) designed a chemical absorption-type OCCS with an ammonia refrigeration system for a container ship. The results demonstrated that the carbon capture amount from the exhaust gas could reach the target line of EEDI in phase 3. The main goal of this paper, which clearly shows the novelty as well, is to introduce the LNG cold energy utilization for OCCS. This study aims to explore the feasibility of MEDA/PZ absorption-based OCCS in satisfying the IMO regulation for EEDI in phase 3 for a LNG-fueled ship.

2. EEDI analysis method

2.1 Reference EEDI and phases

EEDI is not a performance-based but a goal-based technical standard encouraging improvement in the new ship design. From 1 January 2013, an initial 2-year "phase 0" started with the required EEDI. Since then, three phases with more progressive requirements are established to reach 30% reduction between 2025 to 2030. The EEDI reference line represents the average efficiency for ships built between the years 1999 and 2009, which is determined by the ship type and size. The EEDI regression equation for Bulk carrier is described as Eq. (1). The Required EEDI is calculated with the reduction factor X in different phases, as shown in Eq. (2).

$$Reference\ EEDI = 961.79 \times DWT^{-0.477} \text{ for Bulk carrier} \quad (1)$$

$$Requireed\ EEDI = (1 - X/100) \times 961.79 \times DWT^{-0.477} \quad (2)$$

2.2 Attained EEDI calculation for bulk carrier

According to Chapter 4 of Annex 6 in the International Convention for the Prevention of Marine Pollution from Ships (MARPOL) guideline, the attained EEDI of international sailing ships with a gross tonnage of 400 tons should be estimated. The attained EEDI should be calculated with the technical guidelines and verified by the recognized official organizations during the ship building process. The attained EEDI calculation formula provided by IMO is shown in Eq. (3).

$$EEDI\left(gCO_2/ton.nm\right) = \frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\right) + PTI + EFF}{f \cdot Capacity \cdot V_{ref}} \quad (3)$$

2.3 Reference ship

To effectively predict the effect of the EEDI baseline on the design of future bulk carrier, a typical Kamsarmax ship with a dual-fuel main engine (Wärtsilä 12V50DF) is selected as the reference ship. The specifications of the reference ship are listed in Table 1. The compositions of the exhaust gas obtained from the main engine are Nitrogen 75 wt %, Oxygen 16.6wt%, Water 4wt% and CO_2 4.4wt%. Considering the energy balance, only part of the exhaust gas passed through the OCCS, while the rest was discharged to the environment. The LNG fuel is stored in the tank with the cryogenic temperature of -162°C at 100kPa. The required inlet temperature and pressure of the main engine are 60°C and 600kPa. The exhaust gas data and LNG data for the Wärtsilä 12V50DF are given in Table 2.

Table 1 Main specifications of the reference ship

Parameter	Value	Parameter	Value
Type	Bulk	LNG tank	600 m^3
Ship length overall	229 m	Heavy oil tank	1800 m^3
Ship beam	32 m	Marine diesel oil tank	400 m^3
Deadweight	81190 DWT	Main engine type	Wärtsilä 12V50DF
Reference speed	14 knots	MCR rating of main engine	9930 kW

Table 2 Exhaust gas and LNG data for Wärtsilä 12V50DF

Exhaust gas	Engine load			LNG	Engine load		
	100%	75%	50%		100%	75%	50%
Mass flow rate (kgh^{-1})	68400	52560	41040	Mass flow rate (kgh^{-1})	2196	1728	1260
CO_2 concentration (%)	4.8	4.6	4.2	Cold energy (kW)	602.4	474	345.6
CO_2 production (kgh^{-1})	3283.2	2417.8	1723.7	Available cold ($kWhkg^{-1}$)	0.18	0.19	0.20
Inlet temperature (°C)	383	303	285				
Outlet temperature (°C)	120	120	120				
Heat energy (kW)	3106.3	2679.8	1886.6				
Available heat ($kWhkg^{-1}$)	0.95	1.11	1.09				

This study uses Ψ to reflect the captured CO_2 via the OCCS. Thus, ψ could be calculated from Eq. (4). The proposed factor ψ provides suitable criteria for OCCS design. The required EEDI, attained EEDI and the CO_2 captured by OCCS are summarized in Table 3.

$$Required\ EEDI\left(gCO_2/ton.nm\right) = Attained\ EEDI - \frac{\Psi/1000}{f \cdot Capacity \cdot V_{ref}} \tag{4}$$

Table 3 Attained EEDI and required EEDI for the reference ship.

	Phase 0	Phase 1	Phase 2	Phase 3
Attained EEDI ($gCO_2(tn \cdot m)^{-1}$)			3.61	
Required EEDI ($gCO_2(tn \cdot m)^{-1}$)	4.38	3.94	3.51	3.07
Ψ (kgh^{-1})	---	---	113.7	613.8

3. Modelling and simulation

3.1 Overall concept design of the OCCS

The OCCS aims at capturing CO_2 from the engine exhaust gas of the LNG-fueled ship. The captured CO_2 is compressed and liquified before being stored in the tank. The liquified CO_2 would be further transported to a chemical plant for utilization or to an underground injection site for permanent storage. The content of CO_2 in the exhaust gas of diesel or LNG is usually no more than 5 vol%. Therefore, CO_2 separation from the exhaust gas and concentration improvement is the first step for further treatment. CO_2 separation and capture need significant energy input. Ideally, the waste heat from the ship engine exhaust gas should be considered. The electricity consumed by the compressor comes from the ship as well. Compared with the waste heat, the applicable cold energy is much smaller. Therefore, the capacity of OCCS is limited by the cold source conditions. As for the CO_2 liquification process, the cryogenic temperature is required. Considering the temperature range, the LNG cold energy is used for the concentrated CO_2 cooling and liquification. The supplementary cold energy is provided by the seawater. Figure 1 illustrates the block diagram of the overall concept design of the OCCS.

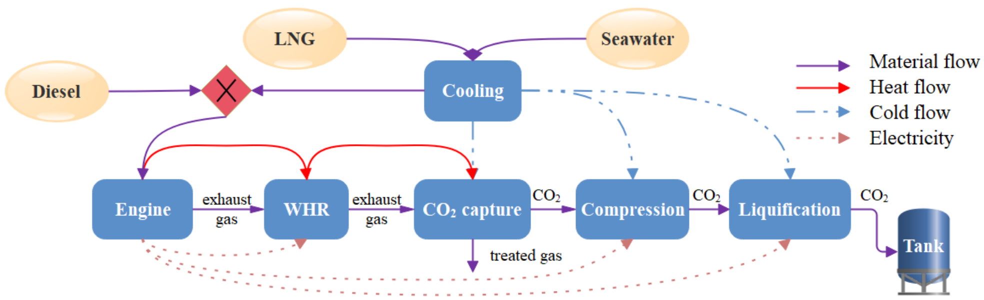

Figure 1 The block diagram of the overall concept design of the OCCS.

3.2 Simulation basis

Aspen HYSYS V12 software is utilized to simulate the carbon capture process. The Acid Gas thermal property package and Peng-Robinson equation are applied for equilibrium calculation and kinetic reactions. The isentropic efficiencies of the compressor and the pump are assumed as 85% and 75%, respectively. The main design and operating parameters for the OCCS are shown in Table 4.

Table 4 Design and operating parameters for the OCCS

Main equipment	Value
Absorber	float valve tower; trays number :10; diameter: 1.372m; tray space: 0.6096m; weir height: 0.05m; calculation method: Murphree's efficiency; lean solvent flow rate: 16000kgh^{-1}; inlet temperature: 30°C; inlet pressure: 450kPa; upper pressure: 190kPa; lower pressure: 200kPa
Stripper	float valve tower; trays number :10; diameter: 1.5m; tray space: 0.6096m; weir height: 0.05m; calculation method: Murphree's efficiency; lean solvent inlet temperature: 80°C; inlet pressure: 300kPa; upper pressure: 150kPa; lower pressure: 200kPa; reflux ratio: 10
Internal heat exchanger	shell-tube type
Pumps	lean pump: from 190 to 300kPa and isentropic efficiency of 75% rich pump: from 200 to 450kPa and isentropic efficiency of 75%
Compressor	from 150 to 1500kPa, isentropic efficiency of 75%, outlet temperature is cooled to 60°C
HEX	shell-tube type; HEX1 hot side: from 60 to 30°C and pressure drop is 0kPa; HEX2 outlet temperature 60°C and pressure drop is 0kPa
Cooler	shell-tube type; coolant: water

The exhaust gas from the main engine passes through the absorption column and only CO_2 is absorbed. The treated gas is vented to the air, and the solvent becomes rich solvent. The rich solvent is pumped to the stripper column for regeneration. Before the stripper column, the rich solvent recovers heat from the lean solvent, which returns from the bottom of the re-boiler. After which, the working medium is supplemented to the original composition. The lean solvent is returned to the absorption column. The CO_2 is discharged in the gaseous state from the column upper. For the convenience of storage and transportation, the separated CO_2 is liquified. Instead of using the complex multi-stage compression process, the cryogenic cold energy released by the LNG regasification process is utilized. The CO_2 storage pressure influences the density and boiling point, which would affect the energy supplied to the OCCS.

The methyldiethanolamine (MDEA) is regarded as the ideal solvent for CCS because of its high CO_2 solubility, acceptable reaction kinetics and friendly cost. After the 1980s, MDEA was widely used in CO_2 absorption process. German BASF company added different activators (such as piperazine, butylamine, imidazole or methyl imidazole, etc.) to the MDEA solvent and successfully developed activation methods for MDEA. MDEA acts as both an electrolyte and a mixed solvent system, so both chemical absorption and physical absorption occur at the same time. MDEA does not react with CO_2 directly but catalyzes the hydrolysis of CO_2. In this study, to improve reaction rate and reduce column height, the MDEA with PZ as the activator is used as the working medium for CO_2 capture. The activated solvent is with the solubility of 22 wt% MDEA and 8 wt% PZ.

3.3 System performance

An important factor is the carbon capture rate that can be attained with the OCCS. The carbon capture rate heavily depends on the available heat provided by the exhaust gas and the cold energy supplied by the LNG regasification process. The OCCS is designed to be able to deal with the full engine load. The heating capacity required for OCCS (GJ/tCO_2) is evaluated via:

$$\varepsilon_{heat} = \frac{3.6 Q_{stripper}}{m_{CO2,ca}} \tag{5}$$

4. Results and discussion

The study of the main parameter influencing the capacity of the OCCS focus on the exhaust gas mass flow rate, the lean solvent inlet temperature and mass flow rate at the absorber inlet. The effect of lean solvent temperature at the absorber inlet on the CO_2 capture and required energy capacity is demonstrated in Figure 2. At the fixed mass flow rate of exhaust gas and solvent, the total required heat amount (Q_{reg}) is decreased from 1916.4 to 1813.9 kW when the lean solvent temperature increases from 20 to 60°C. The captured CO_2 amount ($m_{CO2,ca}$) satisfies the reduction in phase 3 even though it slightly decreases as the column shows. The specific heat consumption (ε_{heat}) decreases from 10.9 to 10.5 GJ/tCO_2. Therefore, the lean solvent temperature at the absorber inlet should be maintained at a relatively higher value. The other limitation of the solvent temperature is the desorb temperature in the stripper. Meanwhile, the higher temperature requires more insulation on the facilities and tubes, which also increases the initial investment and maintenance charge.

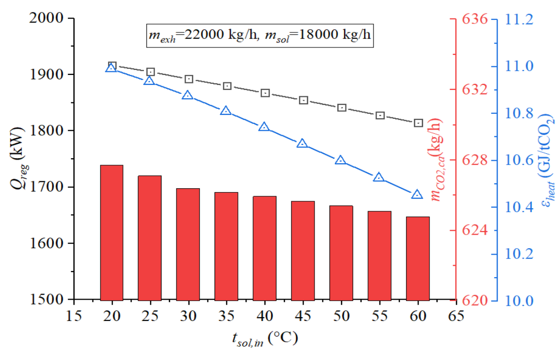

Figure 2 CO_2 capture and required energy capacity

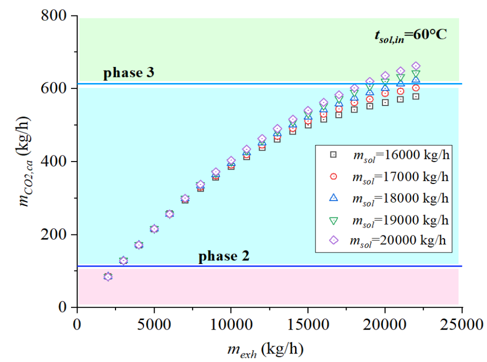

Figure 3 Variation of captured CO_2 mass flow rate

The variation of captured CO_2 mass flow rate with the exhaust gas and solvent mass flow rate is illustrated in Figure 3. The required CO_2 reduction to meet the requirement of phase 2 and phase 3 is also marked. As can be seen, the capture CO_2 obviously increases with the increase of exhaust gas, which proves the capacity of the designed OCCS. However, the increase rate decreases. In addition, increasing the solvent mass flow rate could increase the CO_2 capture amount, and the deviation becomes more pronounced. It concludes that when the solvent mass flow rate is lower than 18000 kg/h, the OCCS could not meet the CO_2 reduction in phase 3.

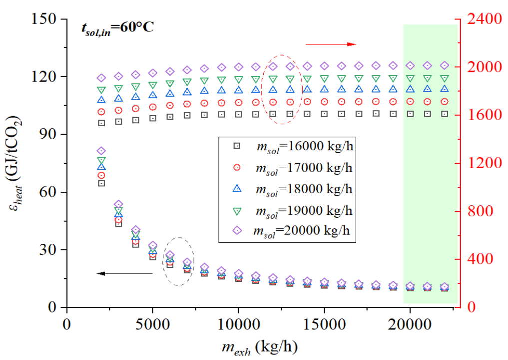

Figure 4 Heat consumption of OCCS

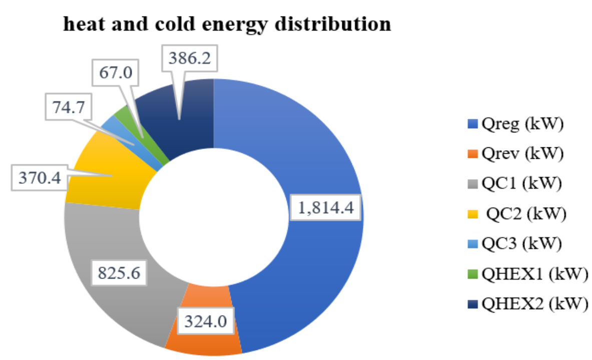

Figure 5 Energy distribution of the optimum condition

The results of heat consumption of OCCS are demonstrated in Figure 4. The total required heat amount (Q_{reg}) varies in the range of 1547.3~2102.7 kW. With the increase of exhaust gas mass flow rate, the amount of CO_2 is accordingly increased, and the total heat consumption by the stripper is slightly increased. At the fixed exhaust mass flow rate, the larger the solvent mass flow rate, the larger the heat amount would be. The total heat consumption determines the facility volume and installation space. At the same time, the specific heat consumption per unit ton CO_2 (ε_{heat}) represents the energy efficiency of the OCCS. The specific heat consumption declines sharply and leveled off gradually with the increasing of exhaust gas mass flow rate. In the region meeting the requirement of CO_2 reduction in phase 3, the specific heat consumption varies in the range of 10.9~12.2 GJ/tCO_2. The smallest specific heat consumption is obtained with the exhaust gas mass flow rate of 22000 kg/h and the solvent mass flow rate of 18000 kg/h. Thus, the optimum working condition is verified. Under the optimum working condition, the mass flow rate of the captured CO_2 is 625.6 kg/h.

Figure 5 shows the heat and cold energy distribution of the optimum condition. The total heat required is 1892.7 kW, which is afforded by the exhaust gas heat recovery. The cooling capacity is supplied by the LNG cold energy and seawater. The recovery cold energy is 453.2 kW and the cooling capacity offered by the seawater is 1853.4 kW. Meanwhile, it is noticed that the cooling capacity for CO_2 capture is 1778.5 kW and that is 528.1 kW for CO_2

liquification. Under the optimum working condition, the MEDA, PZ and water supplement mass flow rates are 1.2, 1.1 and 1140.9 kg/h, respectively.

5. Conclusion

This study proposed an onboard carbon capture system (OCCS) with the integration of exhaust gas waste heat and LNG cryogenic energy recovery for a LNG-fueled bulk carrier. The solvent-based OCCS is designed with the ship constraints and the onboard feasibility is validated. The 22%wt MEAD solvent with 8%wt PZ as the activator is used as the working medium for CO_2 capture. The LNG cryogenic energy is used for CO_2 liquification. The effect of the OCCS on promoting greenhouse gas emission control is evaluated with the energy efficiency design index (EEDI). The effects of exhaust gas mass flow rate, the solvent mass flow rate and the regeneration temperature on the OCCS performances are studied. With the OCCS, the LNG-fueled bulk carrier could satisfy the required EEDI in phase 3 with the specific heat consumption varies in the range of 10.9~12.2 GJ/tCO_2. The possibility of using OCCS to meet the IMO strategy required EEDI is validated for the reference ship. Future studies could be focused on OCCS optimization and economic analysis, which would further promote its practical application. Other types of ships should be taken into consideration as well. The results would provide guidelines for the EEDI reference set.

Acknowledgements

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Towards a Cyber Secure Shipboard ECDIS

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Abstract: A comparative study of cyber security vulnerabilities in ECDIS systems that are implemented on board of three training ships is presented. The cyber security vulnerabilities have been detected by performing computational testing of the ECDIS systems using a widely used vulnerability scanning software tool. The tested ECDIS systems were chosen from different manufacturers and different underlaying operating systems. The results obtained suggest that the selection of the underlying operating system plays an important role in securing the ECDIS systems. In addition, the results point that the cyber security of ECDIS systems could be significantly violated by exploitation of vulnerabilities in the third-party components of ECDIS software.

Keywords: navigation safety, ECDIS, maritime cyber security, cyber-physical system

1. Introduction

The Electronic Chart Display and Information System (ECDIS) has become a major aid for safe navigation of ships. The ECDIS brings the combination of the paper charts workload reduction and real-time navigational information provision, so the ship's navigational officers can focus on the actual traffic situation, improving the safety of ship navigation (Brčić 2019). The International Maritime Organization (IMO) has setup the requirement for the mandatory ECDIS carriage requirement for all SOLAS vessels (IMO 2017a). With the improvement for nearly three decades, mainly by the integration and networking, ECDIS has developed in a complex cyber-physical system.

The security risks rising from the application of cyber technologies in ECDIS systems has been recognized by the IMO, and therefore the general cyber security guidelines for safeguarding the ship navigation are recently published (IMO 2017b). In addition, the cyber security risks must be adequately implemented in the International Safety Management (ISM) code and periodically audited for ISM code from the beginning of the year 2021 (IMO 2017c).

In this work, we present a comparative study of cyber security threats in ECDIS systems that are implemented on board of three ships, Kraljica mora, Aida IV, and Kapitan Gregorio Oca (Figure 1). In order to perform the comparative study, a computational vulnerability scanning of the ECDIS systems was conducted

(a) (b) (c)

Figure 1. The training ships: (a) *Kraljica mora*, (b) *AIDA IV*, and (c) *Kapitan Gregorio Oca*.

using an industry leading software tool (Svilicic 2020, Svilicic 2019a, Svilicic 2019b, Svilicic 2019c) and by applying the same scanning model. The detected cyber security vulnerabilities are studied and solutions for the risks mitigation are discussed.

2. The Shipboard ECDIS systems

The cyber security vulnerabilities in the current deployment of three ECDIS systems have been studied. The ECDIS systems are implemented on the training ships: (i) Kraljica mora (IMO: 9569358), provided by the University of Rijeka Faculty of Maritime Studies (Croatia), (ii) Aida IV (IMO: 9018775) provided by the Arab Academy for Science, Technology and Maritime Transport (Egypt), and (iii) Kapitan Gregorio Oca (IMO: 9859959) provided by the Maritime Academy of Asia and the Pacific (Philippines). The shipboard EDCIS systems are IMO compliant and meets IMO performance standards. The technical specifications of the ECDIS systems are given in Table 1.

Table 1. Technical specification of the tested ECDIS systems.

ECDIS	*Kraljica mora*	*AIDA IV*	*Kapitan Gregorio Oca*
Manufacturer	Wärtsilä Transas	Transas	Furuno
Model	Navi Sailor 4000	Navi Sailor 4000	FMD-3200
Software version	3.02.350	2.00.012	2450074-03.17
Approval date	2016	2009	2017
Installation date	2019	2010	2020

While the ECDIS system of the training ship AIDA IV is implemented in the stand-alone mode, ECDIS systems of the two other ships are internetworked in a local area network together with a sensor switch. Data from the Global Positioning System (GPS) and Automatic Identification System (AIS) are gathered via serial interfaces. The sensor switch is used for gathering data from radar, gyrocompass, Navtex and other sensors.

3. Cyber Security Testing

The testing of the ECDIS systems was performed by computational scanning for cyber vulnerabilities using a software tool that is most widely used in the industry. The testing software tool used is Nessus Professional, version 8.15.2. (Nessus 2022). The ECDIS systems were tested individually, by connecting a laptop with preinstalled testing software tool to the ships' local area network (Fig. 3).

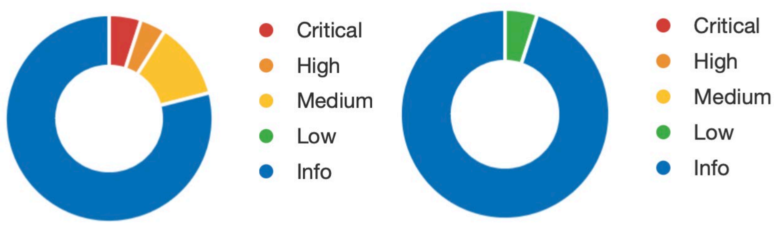
(a) (b) (c)

Figure 2. Cyber security testing of the ECDIS systems implemented on the training ships: (a) *Kraljica mora*, (b) *AIDA IV*, and (c) *Kapitan Gregorio Oca*.

The main objective of the testing is identification of all cyber security vulnerabilities that are known not only to the software developers, but also to potential attackers. The used software tool provides comprehensive database of all known cyber security vulnerabilities, allowing to understand the vulnerability level of the tested ECDIS systems. As the ships are engaged in regular voyage, the tests were conducted is a passive manner, with no disturbance of the ECDIS systems operation, while the ships were docked in a port. The same scanning model was applied for the testing all the ECDIS systems.

4. Results and Discussion

The summary report of the cyber vulnerabilities scanning of the ships Kraljica mora and Kapitan Gregorio Oca are shown on Figure 3. The results obtained indicate high security level of ECDIS systems implemented on the ships Kapitan Gregorio Oca and AIDA IV, while the results show significant vulnerabilities detected on the ECDIS system of the ship Kraljica mora.



(a) (b)

Figure 3. Cyber security vulnerabilities detected: (a) *Kraljica mora*, and (b) *Kapitan Gregorio Oca*.

The ECDIS system on the ship AIDA IV was not tested because the ECDIS software (Table 1) is running on the stan-alone workstation with no hardware for internetworking implemented. However, the ECDIS software is running on the Microsoft Windows XP operating system, which is unsupported by the manufacturer from the year 2014 (Microsoft 2022). The unsupported operating system implies that no new cyber security patches have been released by the manufacturer for about 8 years now. While the ECDIS software is running on the highly vulnerable operating system, the stand-alone implementation with no internetworking ability, provides high level of the cyber security.

The results detected on the ship Kraljica mora (Figure 3a) indicate 3 critical, 2 high and 7 medium cyber vulnerabilities. Exploitation of vulneraries with the critical severity is usually straightforward, meaning that attackers do not need any special knowledge about target systems, and likely results in root-level compromise of target systems. The most critical vulnerability of the ECDIS system is that the ECDIS software is running on the operating system that is unsupported by its manufacturer. In particular, Microsoft Windows 7 Professional operating system has been used, which is not supported by the manufacturer from January 2020 (Microsoft 2022). The remaining critical and high severity cyber security vulnerabilities are related to the vulnerable web server and unsupported version of a system software. In particular, Apache web server version 2.4.49 (Apache 2022) and Python interpreter version 2.7.15 (Python 2022) are running on the ECDIS system. For the both critical vulnerabilities, the support is based on help from members of the communities (Apache and Python communities) who work as enthusiastic volunteers. In addition, the results point out that the significant cyber vulnerabilities exist not only in the software components developed by the manufactures of the ECDIS software (Wärtsilä Transas) or the underlying operating system (Microsoft), but also in the third-party software components (Apache web server and Python interpreter).

The ECDIS system implemented on the training ship Kapitan Gregorio Oca has been shown with low level of cyber security vulnerabilities, having very little impact on the ECDIS operation (Figure 3b). The only vulnerability detected, classified as the low-level, is related to an X11 server running on the ECDIS system. The basis for the excellent cyber security results is in usage of a Linux operating system, which makes the ECDIS system less susceptible to potential cyber security threats. In addition, adequate setup and maintenance of the operating system enhance the level of the ECDIS system cyber security.

5. Conclusions

The cyber security vulnerabilities in the deployment of three shipboard ECDIS systems have been presented. The cyber security testing of the ECDIS system have been done using the industry leading vulnerability scanner. The results obtained show that the highest cyber security level is achieved on the ECDIS system that is based on the Linux operating system, suggesting that the selection of the underlying operating system can play important role to mitigate cyber security risks. In addition, the results point out that the cyber security of ECDIS system could be significantly threaten not only by exploiting vulnerabilities in the unmaintained ECDIS software and the underlying operating systems, but also by exploiting vulnerabilities in the third-party components of ECDIS software.

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Head-worn Display Utilization in Engine Supervisory Work

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Abstract: Smaller formation of onboard teams demands more efficiency in the task allocation, especially for the engine supervisory work where the operators have to undertake monitoring and maintenance jobs. Besides having sufficient non-technical skills, task allocation can be supported by utilizing cognition aids. We examined the utilization of the head-worn display by measuring the human performance factors such as workload, situation awareness, and trust in automation. A human-subject experiment was conducted using a *2 x 2* within-subject experimental design under a multitasking environment in the engine room simulator. The participants were invited to follow two scenarios: either information on the head-worn display is available or absent. The workload measurement shows that the participants perceived a lower workload when information was available on the head-worn display. It also made the participants put more trust in the alarm system and allowed them to finish more maintenance tasks. However, utilizing the head-worn display bring demerits caused by visual complexity and longer response time to the alarm. We see this trade-off is acceptable to achieve suitable response action. Within the limitation of laboratory-scale experiments, human performance factors promise a valuable result as evaluation method before the head-worn display as a cognition aid is implemented onboard.

Keywords: Situation awareness; trust in automation; workload

1. Introduction

Supporting the onboard operators during the work became more important since team formation is smaller, while the remaining workload is similar and even accumulated to the remaining operators. This issue is also raised by the fact that 80% of accidents in maritime operations are caused by human error (Wróbel 2021); and more specifically, 71% include loss of situation awareness (SA) as one of the causal factors (Grech et al. 2002). Unsuitable work environments also have a role. For example, the recently installed alarm system onboard is described as a nuisance and increases the operators' workload because the system is not appropriately installed (Jones et al. 2006). Therefore, in supporting the recent and future onboard operation, one must include the workload, SA, and trust in the automation as they are an essential aspects to construct the human performance factors (Man et al. 2018).

The working situation of the engine department is generally divided between the engine room where the watchkeeping and maintenance are conducted, and the engine control room where monitoring and administration tasks are undertaken. The scheduled maintenance and watchkeeping leave the engine control room mostly unmanned (M0). When the alarms are activated, the operators need to return to the engine control room to acknowledge and undertake the necessary steps to recover the process back to normal. The issue with the alarm system recently, as its number increased since many sensors were installed, is the increased number of false alarms (Maglić and Zec 2020). The situation makes the operators inefficient in allocating the tasks. To counter this issue, the current engine room situation is supported by an indicator column. It functions as the extended alarm display for the operators to quickly know the sources and categories of the alarms. However, because of the limitation of spaces, it only contained few information than the actual alarm display installed in the engine control room.

The study of head-worn display utilization as a cognition aid is getting attention in various working areas (Bal et al. 2021). For instance, its implementation for patient monitoring promises to increase the SA and reduce the workload (Pascale et al. 2019). In general process control, the same objective can be achieved using a handheld mobile device such as personal digital assistant (PDA). However, it seems less practical in the maintenance tasks since the operators often need both hands to undertake the tasks. Thus, the head-worn display seems more applicable as a cognition aid.

Having information on the head-worn display increases the selection attention because the operators can focus on more essential stimuli (McLaughlin and Byrne 2020). For instance, the alarm display on the headworn display gives the advantage of providing the raw information continuously for the operator to confirm; it reduces the workload because the operators can discriminate the false alarms and prioritize the tasks (Pascale et al. 2019). However, its utilization is not without disadvantages. The information from the environment might be missed because the display draws too much visual attention. Therefore, this study examined its utilization in supporting operators and evaluated it using human performance factors such as SA, trust in automation, and workload.

2. Methods

Twelve cadet students from the marine engineering department with an average age of 21.7 (□1.1) were invited to participate in this experiment. They have a range of one month to one year of onboard cadet experience. Based on this background, we assumed the participants had enough capability and understanding to undertake the designated tasks in the experiment. The recruitment and experimental procedure were under the code of ethics approved by the faculty board.

We employed a *2 x 2* within-subject experimental design. The first independent variable is the information condition on the head-worn display: the information is displayed (information-on), and there is no information displayed (information-off). The second independent variable is the task-load level differentiated by the number of alarms that annunciated during the scenario: high-task load with twelve alarms and low-task load with six alarms. To counter the limitation of the data acquisition, all participants experienced all four combinations of scenarios.

The experiment was conducted at the engine plant simulator with a separated engine room and the engine control room. The engine room, shown in Figure 1, consists of three monitors to display the mimic diagram of the engine plant and machinery from an actual model ship. The participants can operate machinery and piping systems similar to the actual activity onboard in the engine room, such as opening and closing valves and running the pumps locally. The engine control room consists of the engine control console, as shown in Figure 2, where the participants can monitor the alarm and observe all parameters of the engine and machinery.

We use the Epson Moverio BT-200 shown in Figure 3 as the head-worn display in this experiment. During both information-on and information-off scenarios, the participants can observe the panel displays, as shown in Figure 4, on the engine control console located in the engine control room. However, the participants only have access to the panel display on the head-worn display when the information-on scenario. The display panel consists of six engine system parameters selected using Subject Matter Expert based on the parameter's importance during the engine supervisory work. Each system parameter has three indicators: online process value, high-alarm threshold, and low-alarm threshold.

During the experiment, we introduce two types of alarms: true alarm that activated when the process value increases (or decreases) based on the real engine or machinery trouble, and false alarm that activated because of sensor failure. The false alarm does not need to be handled by the operators. The ratio between true and false

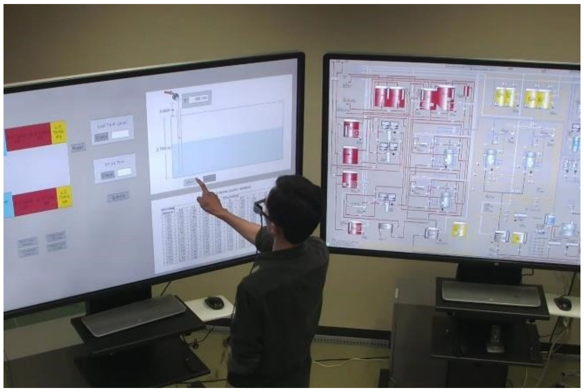

Figure 1 Engine room simulator

Figure 2 Engine control room simulator

Figure 3. Head-worn display device

Figure 4. Display image on the engine control console and head-worn display

alarms in one trial was controlled. There were 12 alarms (4 true alarms, 8 false alarms) in the high-load scenario, and 6 alarms (2 true alarms, 4 false alarms) in the low-load scenario. When a true alarm is activated, the process value will slowly increase (or decrease). In contrast, if a false alarm is activated, the process value will suddenly drop (or climb) to the lowest (or highest) level. All activated alarms were followed by indicator color on the display and audible alarms. Whether the participants acknowledge it, the alarm will go off, and the process value automatically returns to normal after 20 seconds.

In order to replicate the work onboard a ship, the participants need to follow two separate tasks simultaneously. The first task came from the engine control room; the participants had several maintenance tasks such as opening, closing the valve, starting or stopping the pump, and sounding several tanks. Simultaneously, participants needed to conduct a monitoring task by acknowledging the alarms from the engine control room when it was activated. Thus, the participants should prioritize the task: decide when to continue the maintenance tasks in the engine room and when to return to the engine control room to handle the alarms.

Before participating in the measurement session, the participants were asked to join the training session three times to get familiarized with the experiment setup layout, the panel on the head-worn display, and the maintenance tasks on the engine room simulator. The training session was followed by the measurement session, consisting of a two-day visit to the simulator. Each day consisted of two trials with different task-load scenarios but the same information status on the head-worn displays. For instance, a participant will have information-on display status on the first day with a high-task load in the first trial, then a low-task load in the second trial. In the second-day experiment, the same participant will follow some procedures with the information-off display status, begin with the low-task load scenario in the first trial, and proceed with the high-task load scenario.

Using a subjective questionnaire, we measured several human performance assessments for the dependent variables: workload, SA, and trust in automation. We used NASA-TLX (NASA Task Load Index) to measure perceived workload (Hart and Staveland 1988). It consisted of 20 Likert-type scales constructed by six dimensions: mental demand, physical demand, temporal demand, performance, effort, and frustration. The perceived workload was then calculated by summing up the six dimensions after weighing it with factors from the participants. SA is measured with subjective SART (Situation Awareness Rating Technique) (Taylor 1990). It covers ten dimensions grouped into three categories: attentional demand, attentional supply, and situational understanding. The perceived SA is simply defined as the difference between attentional demand and attentional supply that eliminated from the total understanding of the situation. The trust in the alarm system is measured using the TiA (Trust in Automation) questionnaire with 12 dimensions (Jian et al. 2000).

The objective measurement was done by comparing the number of maintenance tasks conducted by the participants in one trial. We also recorded the response time (*RT*) in seconds correction for all activated alarms during the one trial. When participants neglected the alarm, the response time was the maximum since it is automatically deactivated at $RT = 20$ seconds. The measurement also compares the ratio of participants' actions to acknowledge or neglect the alarm.

3. Result

The perceived workload measured using NASA-TLX was tested with two-way ANOVA to see the interference of display status and alarm frequency. The representative of the result is shown in Figure 5. As the result there was no two-way interferences ($F(1,11) = 1.63$, $p = .23$). However, the analysis for each variable bring the result of significance ($F(1,11) = 7.96$, $p < .05$) on the display status effect: participants perceived more workload during the information-off trials ($M = 11.43$, $SD = 2.57$) rather than in the information-on trials ($M =$

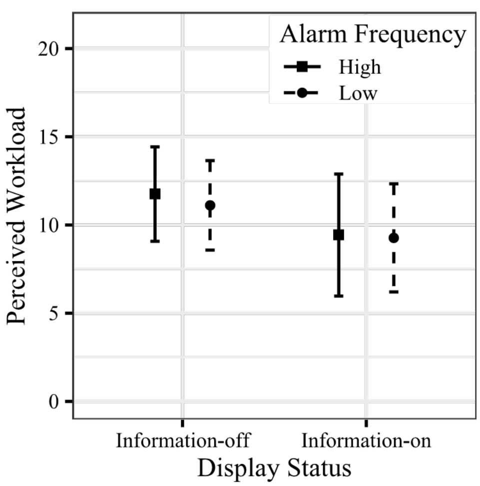

Figure 5 Interference of display status and alarm alarm frequency on perceived workload

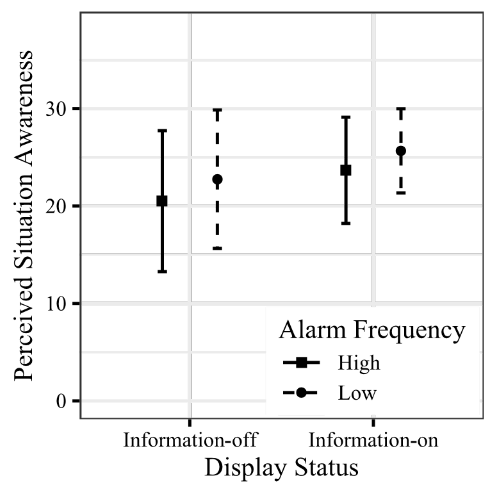

Figure 6 Interference of display status and frequency on perceived situation awareness

9.35, $SD = 3.20$). However, the alarm frequency interference did not give any different for both conditions ($F(1,11) = 1.34$, $p = .27$).

The perceived SA that measured using SART given the result shown in the Figure 6. There was no twoway interaction developed ($F(1,11) = 0.04$, $p = .85$), tested with two-way ANOVA. The display status effect also does not give a significant difference ($F(1,11) = 2.58$, $p = .14$). However, with different alarm frequency, the participants show higher

SA in the low alarm frequency session (*M* = 24.21, *SD* = 5.94) than in the high alarm frequency session (*M* = 22.08, *SD* = 6.47), tested with statistically significant difference ($F(1,11) = 6.97$, $p < .05$).

The subjective questionnaire result from TiA that measured trust in alarm system indicate participants perceived more trust on the alarm system in the trials with the information-on (*M* = 31.21, *SD* = 7.01) than in trials with the information-off (*M* = 27.75, *SD* = 8.39), with statistically significant difference ($F(1,11) = 7.32$, $p < .05$). Meanwhile there was no interference effect of alarm frequency ($F(1,11) = 0.33$, $p = .58$), nor two-way interference include the display status effect ($F(1,11) = 0.55$, $p = .47$) that tested with two-way ANOVA. The interaction between variables on the result is shown in Figure 7.

The objective measurement result of total completed tasks in one trial is shown in Figure 8. Two-way ANOVA was conducted to analyze the result. There was no two-way interaction between the variables ($F(1,11) = 0.38$, $p = .55$). However, the participants finished more task in the information-on trial (*M* = 122.13, *SD* = 27.61) compare when they were under information-off trial (*M* = 109.08, *SD* = 23.11), but with less statistically significant difference ($F(1,11) = 12.97$, $p = .07$).

The objective measurement regarding the alarm response is shown in Figure 9 for the alarm response ratio. There was two-way interaction between the variables of display status and alarm category ($F(1,11) = 41.18$, $p < .01$). The *post hoc* t-test for each variable shows that the participants responded less often to the false alarm

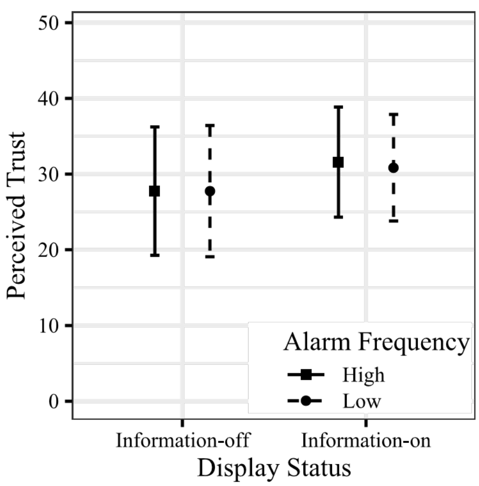

Figure 7 Interference of display status and alarm frequency on perceived trust

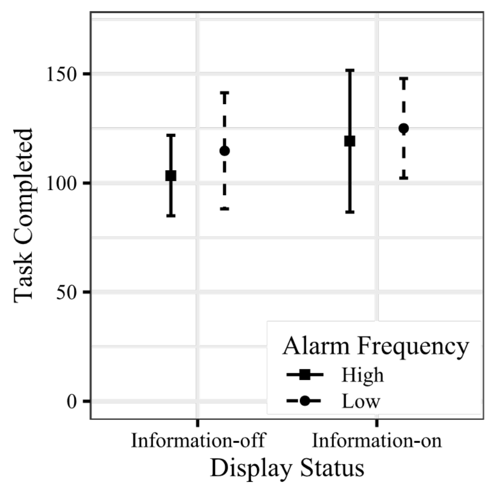

Figure 8 Interference of display status and alarm frequency on the task completed

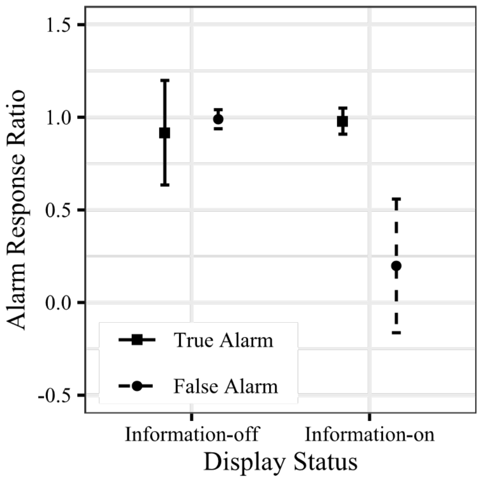

Figure 9 Interference of display status and alarm category on alarm response ration

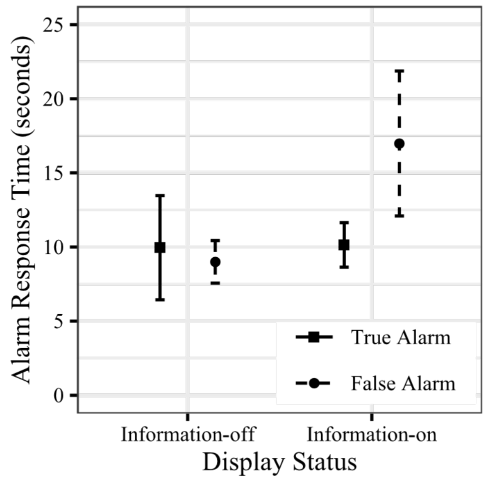

Figure 10 Interference of display status and alarm category on alarm response time

during the trial with the condition of display status information-on (M = 0.97, SD = 0.36) compared to when they were in the trial with information-off status (M = 0.98, SD = 0.51); tested with a statistically significant difference (p < .01).

Another objective measurement came from alarm response time, measured in seconds correction, as shown in Figure 10. There was no two-way interaction between variables, tested with two-way ANOVA ($F(1,11) = 0.51$, $p = .49$). Also, the interference on the single effect of the alarm frequency did not give the significance effect ($F(1,11) = 0.99$, $p = .34$). However, the participant responded to the alarm slower during the trial with the information-on display status (M = 10.27, SD = 1.48) compare when they were conducting the trials with the information-off display status (M = 8.94, SD = 1.27), tested with statistically significant difference ($F(1,11) = 7.69$, $p < .05$).

4. Discussion

An experiment conducted in this paper examined the head-worn display utilization in the engine supervisory control onboard a ship. Using the engine plant simulator, cadets were invited as the participants. During the experiment, they were introduced to the two head-worn display setups (information-on and information-off) and two task-load conditions differentiated by the alarm frequencies (high-task load and lowtask load). The objective measurements such as the number of finished tasks and response time to the alarm are recorded beside the subjective measurements such as workload, SA, and trust in automation questionnaires.

The experiment findings indicate that the participants perceived a lower workload in the information-on trials. It suggests that when the participants have information to confirm an incoming alarm, whether true or false, they can safely neglect to return to ECR. Furthermore, the participants perceived a lower workload by moving between the engine room and engine control room less frequently. However, in this experiment, the alarm frequency did not affect different perceived workloads for the participants. Therefore, it makes us unable to examine the correlation between workload and SA with trust in automation.

The SA, one of the human performance factors that we predicted would increase if participants had information on the head-worn display, did not make any difference. It explains as a trade-off between attention demand and attention supply. While attention supply does increase with the information on the head-worn display, attention demand also increases because the layer of information makes the visual environment more complicated. Therefore, continuously putting information on the visual display is less effective than we thought because it did not improve the SA. Based on this consideration, in practice, information on the head-worn display should be switched off when the engine parameters are in average running condition and automatically switched on when the parameters are developed towards the alarm threshold range.

Perceived trust in the alarm system measured using subjective measurement explains that the participants put more trust in the alarm system when they wear a head-worn display with additional information. Moreover, in the same condition, the response ratio comparison result shows that the participants respond to ECR less often if the false are were activated. Contrary, participants might adopt a "better-safe-than-sorry" approach in the trade-off between maintenance and monitoring tasks when no raw information is available; they took the safe course of action and returned to the ECR every time the alarm sounded.

There is an indication of task allocation improvement since participants finished more maintenance tasks when information was available on the head-worn display. Furthermore, with information available to confirm the false alarms and participants putting more trust in the alarm system, they could safely neglect the false alarms from the ECR and make prioritization between multitasks efficiently. Meanwhile, the response time showed a different tendency: participants with information on their head-worn displays took longer to respond to the alarms. The participants said they only confirmed the information after the alarm sounded, and this confirmation length made the response time longer compare to when there was no information to confirm. Nonetheless, a suitable response action in the engine supervisory control is more important than a quick response time. We suggest that this trade-off between confirmation and response time is acceptable for better task allocation.

There is a limitation in the experimental setup where the information on the head-worn display was continuously present. One must consider including the setup where the participants could activate or deactivate the information presented on the head-worn display. The limitation also comes from the experimental setup where the study was conducted in the simulator using screen displays. It is advisable to conduct the experiment at the environment without screen display to eliminate visual environment complexity when using a head-worn display. However, with the limitation of the laboratory scale experiment, several human performance factors such as workload, SA, and trust in automation show a promising result as an evaluation method before the new cognition aid, such as the head-worn display in this study, is implemented onboard.

Acknowledgments

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A Study of H-Bridge Multilevel Inverter Driven Marine Propulsion System

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Abstract: On account of non-availability of non-renewable resources, Greenhouse gas emissions, CO_2 emissions, environmental aspects increased the utilization of alternative energy resources for marine applications. The current research work fills the need of a typical purpose of social event, tending to clarify the most recent updates, past accomplishments and future focuses of the shipping industry. The main goal is to create a multi-level inverter for a diesel/wind/PV/battery hybrid power system with an induction generator (IG) for a wind-energy conversion system and a synchronous generator (SG) for a diesel-generator (DG) installed in onboard ships. The Maximum Power Point Tracking (MPPT) techniques have been used to get the renewable energies such as solar and wind. Multilevel inverter topologies provide lower THD, lower EMI generation, a better output waveform and higher efficiency for a given output waveform quality. Cascaded H-Bridge topology has been chosen in this research work to design a multilevel inverter. The output of the RES is variable in nature, which is regulated by a hybrid buck boost converter. The regulated DC output is fed to the 13 level H bridge inverter to enhance the performance of the hybrid system. This combination can satisfy the voltage to load in the desired level. H-bridge multilevel inverter improves the voltage profile and simulation results are obtained using Mat lab/Simulink. Results obtained have shown that the system is designed well and the load current and voltage of 9.43% THD rate is maintained in the standard limits for multilevel inverter to get a smooth sinusoidal output.

Keywords: PV system, Wind energy conversion system, Hybrid Buck-Boost Converter, cascade H bridge multilevel inverter, Total harmonic distortion.

1. Introduction

The latest generation system must satisfy increasing demands for electrical energy while expanding usage in industrial and residential applications. Nowadays, the conventional resources have created a major environmental pollution and exhaustion. This problem has significantly emulated the alternative source of energy [1]. Non – conventional resources such as hydro, solar and wind can be used for generation of electrical power to meet the above mentioned power demand issue.

Energy produced from renewable sources can also be used to satisfy the power load demand, and surplus power could be sent to the grid using power electronics conversion system [2]. Renewable energy resources (RES) have fluctuating nature of power flow and the solar photo voltaic (SPV) and wind energy are the most popular and widely used power generation because of its tremendous price reduction over the last decade [3]. The power quality of renewable resources depends on the output voltage and current [4]. PV and Wind energy systems require proper maximum power point tracking to get maximum power from the resources [5]. Thus, the design of system requires suitable converters, proper optimization control and cost by considering all environmental factors. [6]

With the help of modern power electronic converters, the output of RES can be regulated.The primary goal of RES is to generate the real power. Active filter functionality, voltage and reactive energy maintenance can be achieved by utilizing a multi-functional inverter on the RES system. The focus is on developing several new inverter topologies, especially medium voltage converters, which have only recently entered into the industry. In order to get good quality of power, multi-level inverters (MLI) are used for DC-AC conversion. MLI integrates the output voltage by chopping the DC voltage into various levels. Because of the modular structure and requirement for distributed DC sources, the CHBMLI is better adapted in renewable energy sources. In comparing to other MLIs, the effectiveness of CHBMLI is superior due to the enhanced harmonic profile of the stepped output wave and need for reduced number of switches. It also has less electromagnetic interference and dv/dt stress [7,8].

In this research work, the output of RES with MPPT control has given as input to DC-DC/ AC-DC converter. The output of the converter is fed as an input to CHBMLI. The output of MLI is fed to the ship propeller which is shown in Figure 1. The performance of the MLI is made for different levels of configuration and the model is simulated in MATLAB/SIMULINK using power system tool box.

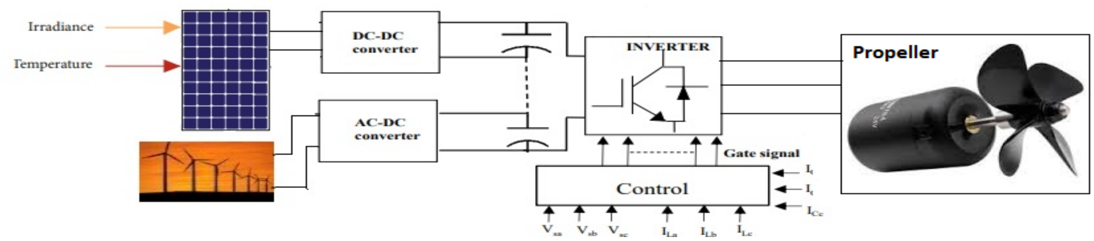

Figure 2 Structure of Hybrid Power System for Marine Applications

2. Hybrid Power Fed H Bridge Inverter Topology

2.*1 PV System:*

Solar PV's primary issue is that its output power varies depending on weather conditions and solar radiation intensity. Due to non-linear PV properties and unexpected panel temperature, research on PV panels and DC-DC converters is progressing. Solar panel arrays equivalent circuit is shown in Figure 2[5].

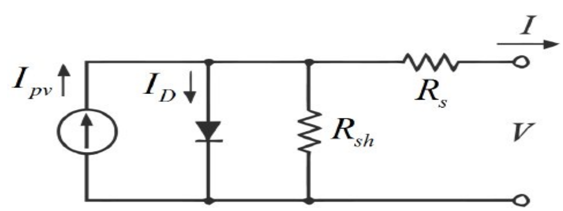

Figure 3 PV Equivalent Circuit

Values of series and parallel resistance and the environmental parameters temperature and irradiation are the deciding factor to get the I-V characteristics. PV cells offers more current, whereas parallel connection of PV cells offers more voltage.

2.2 Wind Energy Conversion System

Wind energy, in particular has a significant benefit in navigation activities since, unlike all the other renewable energies, it is constantly available on the high seas. A wind turbine changes active energy from the wind into mechanical energy.

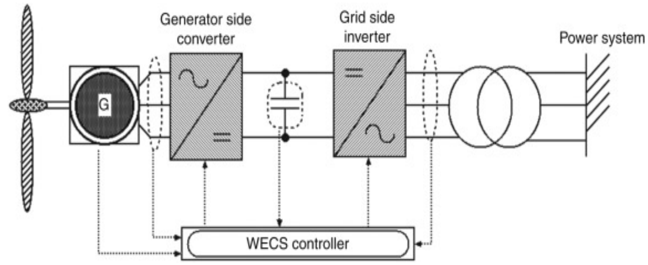

Figure 4 WECS

The structure of wind energy conversion system is shown in Figure 3. The Permanent Magnet DC Generator (PMDCG) is a DC brushed motor with a constant magnetic flux that is separately excited [9,10]. In fact, nearly all permanent magnet direct current (PMDC) brushed motors can be used as a PMDC generator; however, because they were not designed to be generators, they do not make better wind turbine generators so because rotating magnetic field acts as a brake, decelerating the rotor if used as a basic DC generator. The Wind Energy Conversion System (WECS) now has an Optimal Power Control MPPT technique in addition to pitch angle control [11-13].

2.3 Hybrid Buck – Boost Converter:

The structure of buck-boost converter is shown in Figure 4. Variable output of RES is given as an input to Diode Bridge which has an inductor and capacitor across the load. The converter may be used as a step-down or step –up converter and the inductor stores the energy when the switch is ON and discharges when it is OFF. The voltage can be raised or lowered by suitably switching the switching device. Duty cycle determines the output voltage. The rectification process is done by the Diode Bridge circuit; the switching part is carried out by the IGBT switch the finally PWM technique is used for controlling the output voltage [14].

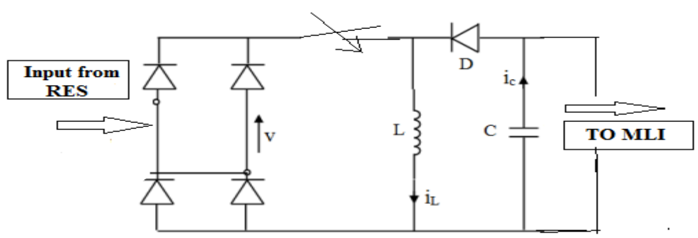

Figure 5 Structure of Buck -Boost Converter

3. **Cascaded H Bridge Multilevel Inverter Topology**

3.1 *Cascaded H Bridge Multilevel Inverter*

The cascaded H bridge inverter is independent of DC sources. For n number of DC source, number of levels must be (2n+1). Depending upon the nature of Dc sources, CHB inverter can be classified as symmetric and asymmetric and the asymmetric topology is considered in this research. Here six unequal DC sources are used to generate thirteen-level output. Number of switches as well as the THD is reduced much in the inverter topology. Figure 5 shows the structure of thirteen level CHB inverter.

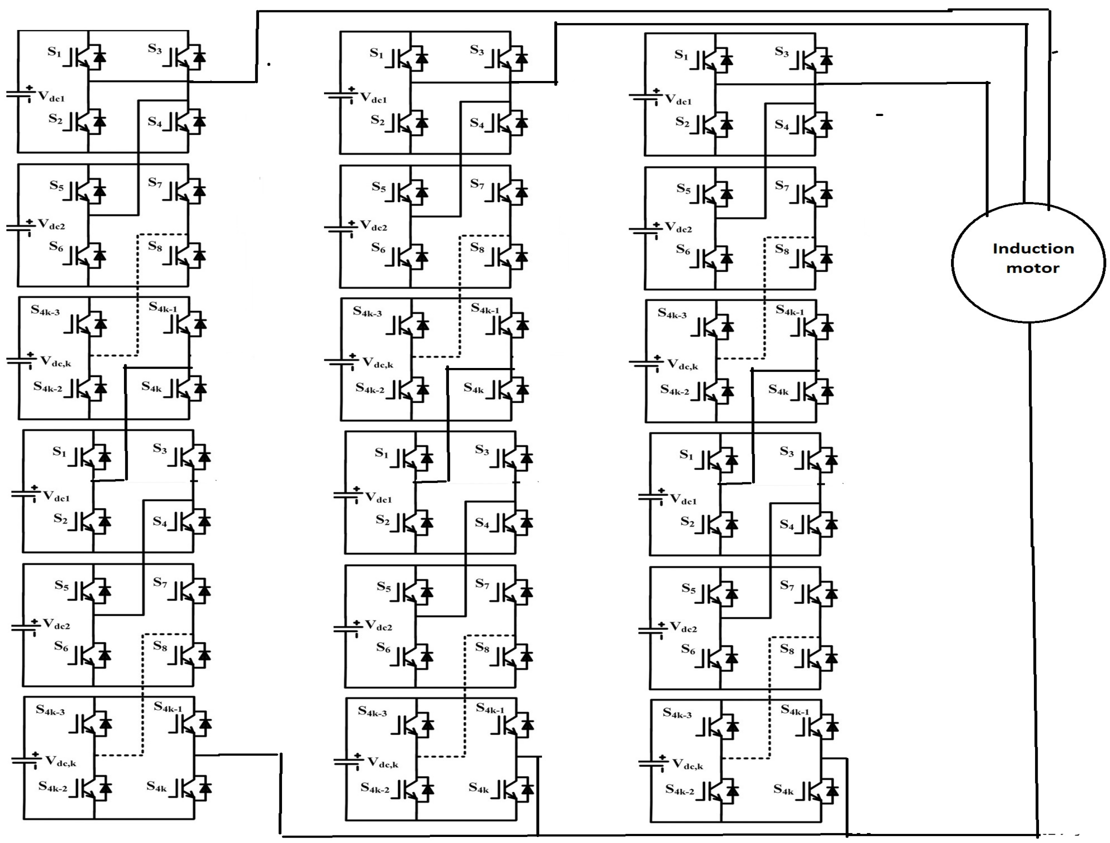

Figure 6 Structure of 13 Level Inverter

3.2 *Modulation Technique*

Pulse width modulation (PWM) is an efficient modulation technique because it has the capacity to minimize harmonics, it does not require additional components. Phase Shift Modulation is used to produce the PWM signals which in reduce the THD also.

4. **Results and Discussion**

The proposed topology of a solar PV and wind energy combination of BUCK BOOST Converter and thirteen level cascaded H-bridge inverter fed induction motor drive propeller was simulated using MATLAB/Simulink R2020a and the simpower system in MATLAB. With the help of a DC/DC Buck Boost converter and an AC/DC Converter, a 1 KW solar and wind energy system is converted to six different 100v outputs. The 600v input to a multilevel inverter with 24 IGBT switches and 6 separate DC sources is converted to 415V, 3 phase with the help of a 13 level inverter using the Level shift modulation technique. A reference wave and a carrier wave are required for the carrier-based Disposition approach. The reference and carrier wave frequencies are 50 Hz and 2500 Hz, respectively is shown in Figure 6. The staircase output voltage and current waveform of 13-level inverter thus obtained is shown in Figure 7 and 8.

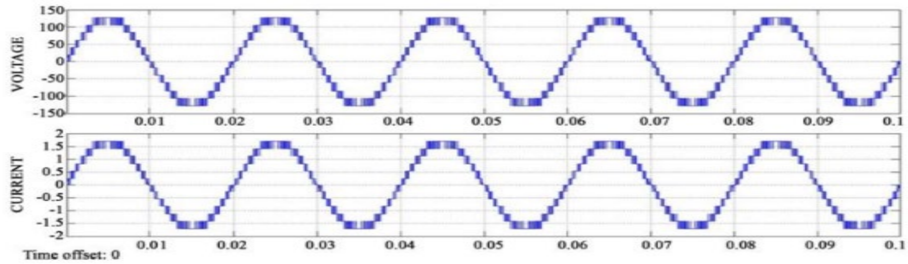

Figure 7 ***Output Voltage and Current Waveform***

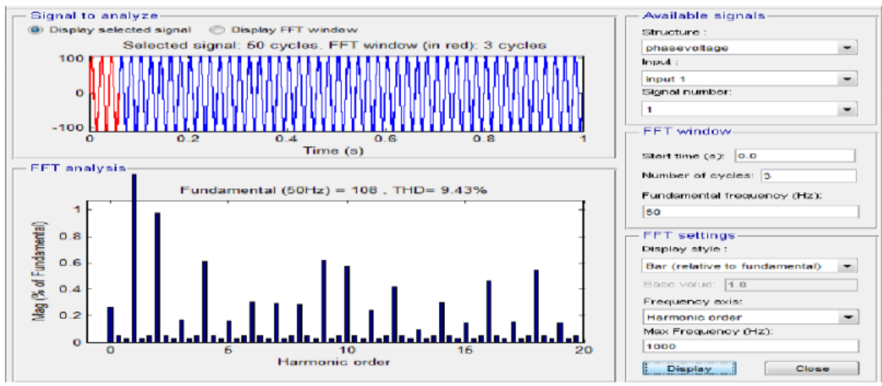

Figure 8 FFT Analysis for 13 Level Inverter (Phase to Neutral Voltage)

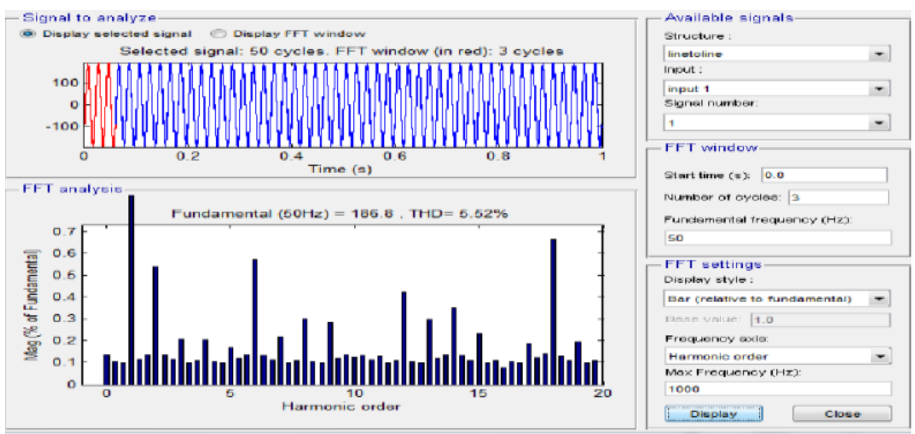

Figure 9 FFT Analysis for 13 Level Inverter (Line to Line Voltage)

The staircase output and the FFT analysis for THD% is shown in Figure 10 and 11 for phase to neutral and line to line. By using PWM technique the odd harmonics are minimized by varying the modulation index (0 to1). For the modulation index value 0.8, the THD obtained is 9.43 for phase to neutral and 5.52 for line to line voltage which is satisfying the IEEE standard for harmonic guidelines. Table 1 shows the comparison of THD of various levels of CHB Inverter, number of H bridges, output levels and number of DC sources.

Table 1 Comparison of THD of various levels of CHB inverter

Sr. No.	Parameters	Three level	Five level	Seven level	Nine level	Eleven level	Thirteen level
1	No. of H bridges	1	2	3	4	5	6
2	No. of switches	4	8	12	16	20	24
3	Output levels	3	5	7	9	11	13
4	No. of DC sources	1	2	3	4	5	6
5	%THD	36.15	26.87	25.66	14.59	11.50	9.43

5. Conclusion

The design and implementation of thirteen level Cascade H bridge inverter with renewable resources (PV and wind) and hybrid buck-boost converter has been discussed in this research work. The proposed system is operated under asymmetric mode with ship propeller/three phase induction motor as the load. The designed system is validated by using MATLAB Simulink tool. Results reveal that this CHBI minimizes the odd harmonics which is very harmful and affects the power quality. The implementation of the modulation index is also visible here when changing the modulation index (varying from 0.3 to 1) to maintain the AC output voltage. It is cost-effective since it uses less number of switches and other components in the design. The proposed model produces lower THD levels, which might fulfill the IEEE 519-1992 standard. This 13 level CHBI inverter enhances the power quality of inverter-based drives by increasing output voltage and lowering THD. The proposed configuration results in a compact and low-cost system with lesser number of switches and switching states which in turn simplifies the inverter control circuitry.

Acknowledgement

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Session

Economic Aspect

South China Sea Contentions and Economic Sustainability of the Shipping Industry

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Abstract: The South China Sea is the most important international maritime passage and carries an estimated 33% of total global shipping annually. For centuries, several neighboring countries have disagreed over assertions of their territorial claims in the area, including China, Vietnam, and the Philippines. Recently, territorial disputes have drawn attention as escalating to potential military conflicts. A military conflict in the South China Sea would force most shipping from Europe, the Middle East, and Africa, which is destined for Asia and the US west coast, to divert around the south of Australia, which greatly increases shipping costs. Military contentions in the area would likely lead to disruption of global supply chains, restructuring of production organization in the involved countries, and be a detriment to national outputs for afflicted countries and consequently the world economy.

Keywords: economic sustainability, shipping efficiency, South China Sea, military conflicts

1. Introduction

As a vital commercial artery connecting Asia to America, Europe, and Africa, the South China Sea is an essential maritime passage for many economies, including the USA, China, and Japan. Each year, the South China Sea claims an estimated one-third of global shipping, with roughly $5.3 trillion worth of goods transiting through this waterway. The dominating principle of international maritime transportation has been "freedom of the seas", emphasizing freedom for all to navigate the oceans and is authored in the United Nation Convention on the Law of Sea (UNCLOS) under Article 87 (1) – "the high seas are open to all states, whether coastal or land-locked."

However, for centuries, the South China Sea has been subject to overlapping territorial disputes, involving China, Vietnam, the Philippines, Taiwan, Malaysia, and Brunei. Over the past two decades, territorial disputes have been escalating in nature, raising concern for potential impending military conflicts. As recently as March 28th, 2022, the Philippines and United States conducted the largest joint military drills in the South China Sea, with nearly nine thousand soldiers participating in the military exercises. China has fully militarized a minimum of three man-made islands it has established in the disputed area. It is well noticeable that the region is arming at an alarming rate. The potential clashes, especially among influential global powers, could lead to disruptions of the South China Sea waterways. Any scale of disruptions has the potential to force trading countries to reduce international trade, divert to alternative sea routes, which will cause cost inefficient for shipping companies, and hinder economic growth on the global scale.

This paper intends to examine the manner in which disputes over the South China Sea would negatively impact short-term and long-term sustainability of the shipping industry. This paper also examines how political instability and military tensions in the South China Sea could lead to changes in productions and supply chains of the relevant countries, as well as affecting their economic growth for the foreseeable future.

The paper is structured as the following: Section I presents an introduction. Section II explains the territorial disputes and military tensions in the South China Sea, followed by Section III, which describes the negative impacts of military contentions on sustainability of the shipping industry. Section IV concludes

2. South China Sea Contentions

2.1 The Disputed Claims on South China Sea

There are seven countries/states that have competing claims for the 1.2 million square miles of the South China Sea, which include China, Vietnam, Taiwan, the Philippines, Malaysia, Indonesia, and Brunei. In addition, the South China Sea is an integral waterway for trade goods, totaling 4-5 trillion USD in goods being transported annually, as well as transporting natural gas. Therefore, the South China Sea has become a crucial financial interest and is of major strategic importance for many countries.

As early as the 1970s, countries began to claim islands and various zones in the South China Sea, such as the Spratly Islands, which possess rich natural resources and fishing areas. More recent territorial disputes began in 2009 with China's announcing of the "Nine–Dashed Line" which were based in their historical sovereign claims to the South China Sea. In 2012, the contention escalated when a Chinese platform was towed into the Vietnam Exclusive Zone. However, in 2016, the Permanent Court of Arbitration ruled against China's claims for the South China Sea and Spratly Island, in favor of Philippines, Indonesia, Malaysia, and Vietnam.

2.2 Military Contentions and Military Competition

Territorial disputes in the South China Sea have been escalated into military confrontations and military completions among the neighboring countries and the international superpowers. According to the Bloomberg report on March 8th, 2022, Vietnam claims that the ongoing military drills conducted by China violates its continental shelf and exclusive economic zone (EEZ), after China carried out a week-long military drill near the Vietnam coast. In addition, China's construction of artificial islands with military installations has made it a focal point of tension with the United States. Analysts fear that China's next move is to create an air defense identification zone (ADIZ) over the disputed waters. In the event of China's threat becoming reality, all aircraft entering the designated airspace would be required to identify themselves, or be subject to interception.

The military conflict in the South China Sea could potentially close the Malacca Strait between Malaysia and Indonesia, and stop all east–west passage between the Pacific and Indian Oceans through the South China Sea. Consequently it would force most ships from the Middle East and Africa, destined for Asia and United States west coast, to be diverted around the South of Australia. This rerouting will certainly increase both consumer and commercial shipping costs, according to studies by Cosar and Thomas.

Escalating tensions in the South China Sea would not only lead to increased military expenditures of adjacently neighboring countries, but also have a heightening effect on militarization levels worldwide. According to the comments of a senior researcher, Nan Tian, at Stockholm International Peace Research Institute (SIPRI), "countries are playing with each other in terms of action-reaction, where when one country increases [purchases], another country [also] increases, procuring more weapons. …That comes as worldwide military spending surpassed $2 trillion for the first time ever in 2021."

3. Impacts on Sustainability of Shipping Industry

So far, the military contentions in the South China Sea has built up momentum at an alarming speed, and yet it has not reached a point of oppressing the waterway to a stalemate. However, it is still of noticeable interest that, according to data collected by Marine Traffic in 2016 and 2017, most ships carrying oil or cargo were choosing to go around the Paracels, instead of electing a more direct route straight through the Paracels, which would reduce fuel costs. It is well understood that if conflict arises and a multi-national crisis shuts down the South China Sea, regardless whether it is only for the short term (such as several days), or long term (e.g. months or longer), the maritime shipping industry would undeniably be one of the first to be hit, and hit hard. The disruption of safe passage routes in the South China Sea would force shipping companies to go through alternative waterways, and rerouting, through either Australia or other even more expensive trade route alternatives. In either case, it would tremendously increase shipping costs, and shipping companies themselves would be forced to pay a spike of other expenses, including premiums for protection operating under war risks, depreciation of currencies, and surges in oil or other fuel costs.

3.1. Cost of Destructions of the Waterways

The tensions and military conflicts in the South China Sea, especially between the two superpowers, China and the United States, is cause for legitimate international concern. The clear and immediate danger of military conflicts would be the disruption to all shipping traffic and endangerment of commercial vessels passing through the Malacca Strait. Though there are other sea lines of communication (SLOC) which offer the entry into the South China Sea, such as the Sunda Strait and Lombok Strait, the Strait of Malacca offers the shortest and thus most economical shipping traffic between the Pacific and Indian Oceans. According to research published by China Power Project, in the event the Strait of Malacca is closed, the added costs of rerouting can be calculated by looking at average daily voyage costs of various vessels. Assuming that tankers and bulk carriers exceeding 100,000 deadweight tonnage (DWT) detour through the deep-water Lombok Strait and smaller ships transiting through the shallower Sunda Strait, a week-long closure of the Strait of Malacca would result in an estimated $64.5 million additional shipping costs. And yet these amount takes only 0.08% to 0.10% of the average weekly value of trade that passes through the South China Sea. If rerouting to Australia, the estimated added shipping costs will be ten times more than that of passing Sunda Strait. The following table illustrates the length of disruption of Malacca Strait, additional cost of retouring other passages and percentage of the South China Sea trade value over the period.

Table 1: Estimated Cost to Reroute All Malacca Traffic (in Million US Dollars)

	Sunda	% of South China Sea trade over period	Lombok	% of South China Sea trade over period	Australia	% of South China Sea trade over period
Daily Weekly Monthly	9.21 64.49 279.46	0.08-0.10	17.00 119.03 515.80	0.15 – 0.18	92.98 650.85 2,820.35	0.80- 1.01

Sources: China Power Project, 2017

3.2. Reorganization of Supply Chains

Tensions in the South China Sea, alongside existing disruptions due COVID, port pileups, and the 2022 Russian-Ukraine War, demand companies to preemptively diversify their supply chains away from the region. It has become a well-accepted notion by now that any degree of trade disruptions could create a critical shortage of components that results in companies lowering productions and losing profits. Additional geopolitical risks will ultimately push more supply chains out of China and cause shifts of production centers to the other low-cost Asian countries, such as

Vietnam, Thailand, and India. “We will definitely see some reshoring and nearshoring,” Peter Sand, chief analyst of ocean-rate data provider Xeneta, told American Shipper. “But the lion’s share of changes I see will involve bringing manufacturing out of China to neighboring Asia countries.”

Some countries on the South China Sea, like Taiwan and Singapore, are export oriented economies and depend heavily upon the South China Sea to transit their products. The conflicts and possible disruptions of the ocean-passage would be devastating to their industrial structure and national economy. In a recently released report, the World Trade Organization (WTO) warned that: “trade could become more fragmented in terms of blocs based on geopolitics.” A worst-case scenario involving the “permanent disintegration of the world economy into two blocs” would reduce long-term global GDP “by 5%”, according to the WTO.

Research performed by Cosar and Thomas predicts that if the military confrontations intensified and blocked the South China Sea waterways, the expected deduction in GDP for a country like Taiwan can be as high as 33%. Table 2 sums up their estimates for related countries (Cosar & Thomas, 2020).

Table 2: For the deduction of GDP of neighboring countries

Countries	Taiwan	Singapore	Vietnam, Philippines, Malaysia, Hong Kong	China	Japan
Predicted deductions in GDP	33%	22%	10 – 15%	0.7%	2-3%

Source: Cosar & Thomas, 2020

4. Conclusion

The South China Sea has become such a contested area among many countries in large part due to its keystone importance to global shipping and the economic advantage from the abundantly available natural resources. High military expenditures and rising geopolitical instability in the South China Sea can lead to higher predicted GDP deductions and lower profitability for the shipping industry, particularly of the countries close to Malacca Strait, the epicenter of the potential conflict. The question of how to keep a sustainable growth of shipping industry has become even more crucial after the outbreak of COVID-19 in early 2020. The subsequent lockdowns of the China and other countries have imposed vastly detrimental consequences on global supply chains. In addition, recent blockages of the Black Sea waterways, as a result of the Ukraine-Russian crisis, could start on global food shortages in the future months, if not years. Therefore, the well-being of the world as well as the sustainability of the shipping industry demand a peaceful solution to the disputes, rather than military confrontations of any kind in the South China Sea.

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Efficient Management of Portfolio Resources

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Abstract: An extended definition of the logistic domain is related to different resources: materials, information, finances, energy, human resources. The management in logistics implies optimal resource allocation which requires the definition and solution of an appropriate optimization problem. Thus, optimal resource allocation is found for transport operations, the establishment of warehouses, financial planning and investment, managing human resources, and the definition of optimal scheduling in working operations. This research addresses a particular topic for optimal financial resource allocation by portfolio optimization. The modern portfolio theory is a tool for formalization and quantification the decision making in investing and financial management of assets. The paper addresses particular issues regarding the definition of portfolio problem. A management policy is developed which makes optimal allocation of financial resources for cash allocation in certificates of deposit with different duration; support of the safe amount of financial resources at the end of each month, taking into consideration the needed payments per month. This optimization problem is solved by using the EXCEL software suit. A particular tool as the Solver function is applied. The paper presents a solution that is practically used for the management of small and medium enterprises. The added value of this research concerns the quantification and optimization of financial resources for logistic management.

Keywords: Decision Support Systems, Portfolio Optimization, Investment Management

1. Introduction

The investment process can be planned and evaluated generally in two environments: deterministic and stochastic. The deterministic case of investments assumes that the majority of components and parameters for the investment conditions are well known. Stochastic and/or random changes in the assets and market environment are predictable and well estimated numerically. The stochastic case of investing cannot rely on fully determined market conditions and asset returns. Thus, for the stochastic case of investments, the decision- maker has to take into consideration the probability that the asset returns can be different according to their currently estimated values. Thus, a new parameter for risk is defined and considered for the investment process. This complicated case of investment is considered by the portfolio theory (Sharpe 1999; Kolm et al 2014). The general goal, in this case, is to maximize the portfolio return and minimize the portfolio risk. The portfolio is regarded as a combination of assets, which participate in the portfolio with different weights. The weights define the relative part of the investment, which has to be allocated for buying the corresponding asset. But the portfolio also deals with risk-free assets. They play an important role in the definition of the market characteristics for return and risk. Explicitly the portfolio theory recommends that if investor targets portfolios return bigger than the market one, he has to undertake a considerable increase in the investment risk (Khan et al 2020; Liu et al 2020). A particular case for the asset characteristics is the duration of their horizon for guaranties for the level of return. Thus, the portfolio can be constituted with a set of activities with different duration of their maturity. Such kinds of portfolios are complicated for evaluations and estimations.

This research develops a particular case for portfolio definition with three types of assets, which have different maturity time. A practical problem is defined as the usage of available free cash of a company to invest in three types of assets. The particular case in this research is the explicit assumption that the assets are risky free. Thus, the portfolio definition targets the maximization of the portfolio return. The risky free assets are chosen as three types of deposits with different maturity. An optimization problem is defined. The added value of this research comprises the demonstration of a solution to the portfolio problem with a generally available software suit. In our case, the defined problem is solved with the support of an Excel environment. The special function Solver is mainly applied for the solution of the problem. The manner of programming this problem is worth it for people, who target investment activities in their general jobs.

2. Portfolio Problem in Deterministic Environments

For this research three types of risky free assets are considered: deposits with maturities of one, three, and six months. The combination of these assets is the content of the portfolio. The investment problem considers how to define the weights of the assets in the portfolio by means to achieve a maximal return for a chosen investment horizon.

The complication of this investment policy comes from the different maturity periods of the assets. Thus, by finishing the shorter maturity period of an asset, its resources can be invested in a new asset with appropriate maturity during the whole investment period. In that manner, an active policy for portfolio management has to be defined. The total goal of such active portfolio management is the maximization of the interests yielded by the risky free assets (Dobrowolski et al 2022).

The investment policy of the company has to be in conjunction with the cash flows, which satisfy the current requirements of the company's operation (Pyka et al 2021; Guo et al 2021). The portfolio policy of cash investments can be defined as:

- Three types of risky free assets are available for investment. They have different maturity horizons.
- The investment horizon for the portfolio is longer than the most maturity duration.
- The company can start active portfolio management with available cash resources.
- At the end of each month, the company has to cover predefined values of active loans and/or receive incomes from their current operations.
- At the end of each month, a safe amount of cash has to be kept, not to be invested for business security reasons.

The unknowns and solution to the portfolio problem are the numbers of the assets, which has to be bought at the beginning of each month. Their number is defined according to the available cash resources for that moment. These resources comprise the available cash from the end of the previous month; the number of assets, which maturity duration ends at the beginning of the current month; the interest, obtained by that finishing maturity period for the corresponding asset. The goal of the portfolio problem is to maximize the income from interests for the predefined investment period.

3. Analytical Description of the Portfolio

The active management of the portfolio requires a dynamic form of the problem to be defined. Below we present our analytical description in discrete dynamical relations. The given data for the problem are:

-The investment period is chosen for 1 year (12 months).

-Maturity periods for three risk-free assets: deposits for 1, 3, and 6 months. The notations used are u_1 (k),u_2 (k),u_3 (k) means the number of deposits, which are open at the beginning of month k.

-The interest rates are denoted respectively with the parameters r1, r2, r3. These values are constant for the investment period.

-The initial investment resource for the beginning of the active portfolio management is M(0).

-The cash used at the end of each month is denoted with $R(k)$. These values are positive for the case of due payments of the company and negative for incoming cash flows.

-The reserve secure cash, required for the end of each month is a constant value of M. The cash amount is quantified in our national currency "lev".
-The goal function of the portfolio problem maximizes the sum of interests, yielded by all deposits for the duration of the investment period. Analytically, it has the form:

$$\max_{u_1(k), u_2(k),\ u_3(k)} \sum_{k=1}^{12}[r_1 u_1(k) + r_2\, u_2(k) + r_3 u_3(k)]$$

where the notation $u_i(k), i = 1,3;\ k = 1,12$ means the number of deposits opened for the overall investment period of 12 months. It is assumed that the deposits are made with an integer number of financial resource. For the three types of deposits, these values are denoted by m_1 , m_2 , m_3 and the portfolio solutions $u_i(k), i = 1,3;\ k = 1,12$ are also integer variables.

The constraint of the problem has to consider several requirements:

-The solutions $u_i(k), i = 1,3;\ k = 1,12$ must take non-negative values, $u_i(k) \geq 0$.

-At the beginning of each month, the available investment resource depends on the cash from the previous month.

-Making the investment per deposit, the company has to keep secure cash of amount Mc.

The set of constraints is explained in graphical way in Fig.1, illustrating the sequence of eligible actions in active portfolio management. The notation E(k), k=1,12 means the available resources, which can be invested in deposits at the beginning of each month. The amount of E(k) is a result of several components as algebraic addition from the components:
-The free resulting cash at the end of the previous month M(k-1);
-The number of deposits, which maturity horizons was ended with the previous month;
-The interest rates, obtained by the ended deposits for the previous month or

$$E(k) = M(k-1) + m_1 u_1(k-1) + m_2\, u_2(k-3) +$$
$$+ m_3 u_3(k-6) + r_1 u_1(k) + r_2\, u_2(k-3) + r_3 u_3(k-6)\ \text{, k=1,12.}$$

This relation contains time delays in its arguments $u_2(k),\ u_3(k)$. The reason is that the deposit with 3 months of maturity will provide its resource if it has been activated 3 months before the current time *k*. In the same way, the deposit with six months maturity, activated in time *k*-6 will give free resources after 6 months, respectively for the moment *k*.

The last component *M*(*k*) for the available free resources at the end of a month is evaluated after an investment in month *k* with the amount $m_1 u_1(k) + m_2\, u_2(k)\ +\ m_3 u_3(k) + R(k)$. Additionally, an algebraic summation with the predefined values R(*k*), *k*=1,12 is made about the set of active loans and/or received incomes from the company's current operation. *R*(*k*) has a negative value for the case of covering active loans and positive when the company has incoming cash flow. Hence the analytical relation about the free resources at the end of month *k* is

$$M(k) = E(k) -\ m_1 u_1(k) + m_2\, u_2(k)\ +\ m_3 u_3(k) + R(k).$$

Fig.1 presents graphically that the available resources can be used for investment in the three types of deposits till the end of *k*=6. Later, it is not applicable the usage of u_3 because its maturity time will overpass the investment horizon of *k*=12. The same reason we have about the usage of u_2 because after *k*=9 its maturity is longer than the investment horizon. The deposit type u_1 can be implemented even for the beginning of *k*=12, because its income will coincide with the end of the investment horizon. These relations graphically are presented with arrows, directed below. The upstream arrows denote the possible end of maturity for the different deposits. It is given that results from $u_2(k)$ deposits start from *k*=4 till the end of the investment horizon. Respectively, the long-time deposits $u_3(k)$ start their income from *k*=7 till the end of *k*=12.

Hence, the analytical description of the portfolio problem for active management is in the form

$$\max_{u_1(k), u_2(k),\ u_3(k)} \sum_{k=1}^{12} [r_1 u_1(k) + r_2\, u_2(k) + r_3 u_3(k)] \quad (1)$$

subject to $E(k) = M(k-1) + m_1 u_1(k-1) + m_2\, u_2(k-3) + m_3 u_3(k-6) + r_1 u_1(k) + r_2\, u_2(k-3) + r_3 u_3(k-6)$

$$M(k) = E(k) - m_1 u_1(k) + m_2\, u_2(k) + m_3 u_3(k) + R(k).$$

$$[r_1 u_1(k) + r_2\, u_2(k) + r_3 u_3(k) \leq E(k)\ ,\ (k) \geq \mathrm{M_c}\ ,\ u_i(k), i = 1,3;\ k = 1,12\ , \text{integer}$$

$$u_1(k) = 0, for\ k < 1\ , u_2(k) = 0, for\ k \geq 10\ , u_3(k) = 0, for\ k \geq 7\ .$$

Problem (1) is a dynamical discrete-time optimization integer problem. Its solution requires computational power and an appropriate software environment. This research illustrates the application of the software suite EXCEL for solving this discrete-time integer dynamical problem. Particularly, the optimization function SOLVER is applied, which performs the evaluations.

4. Numerical Definition of the Portfolio Problem

For the numerical simulations, the parameters of the portfolio problem have been chosen as follows:

- The 1-month deposits have yielded 0.1% per month. The required volume for a deposit is 1000 lv.
- The 3 months deposits have yielded 0.3% per month. The required volume for a deposit is 2000 lv.
- The 6 months deposits have yielded 1% per month. The required volume for a deposit is 3000 lv.
- The initial cash for investment is M(0)=19000 lv.
- The requested safe amount for the end of the month Mc = 1000 lv.
- The set of cash, which has to be paid or received at the end of each month is given by the vector **R**=[5000; -1500; -1800; 4000; 3000; -1800; 2000; -1500; 1300; 2300; 1900; -2400; 2100].

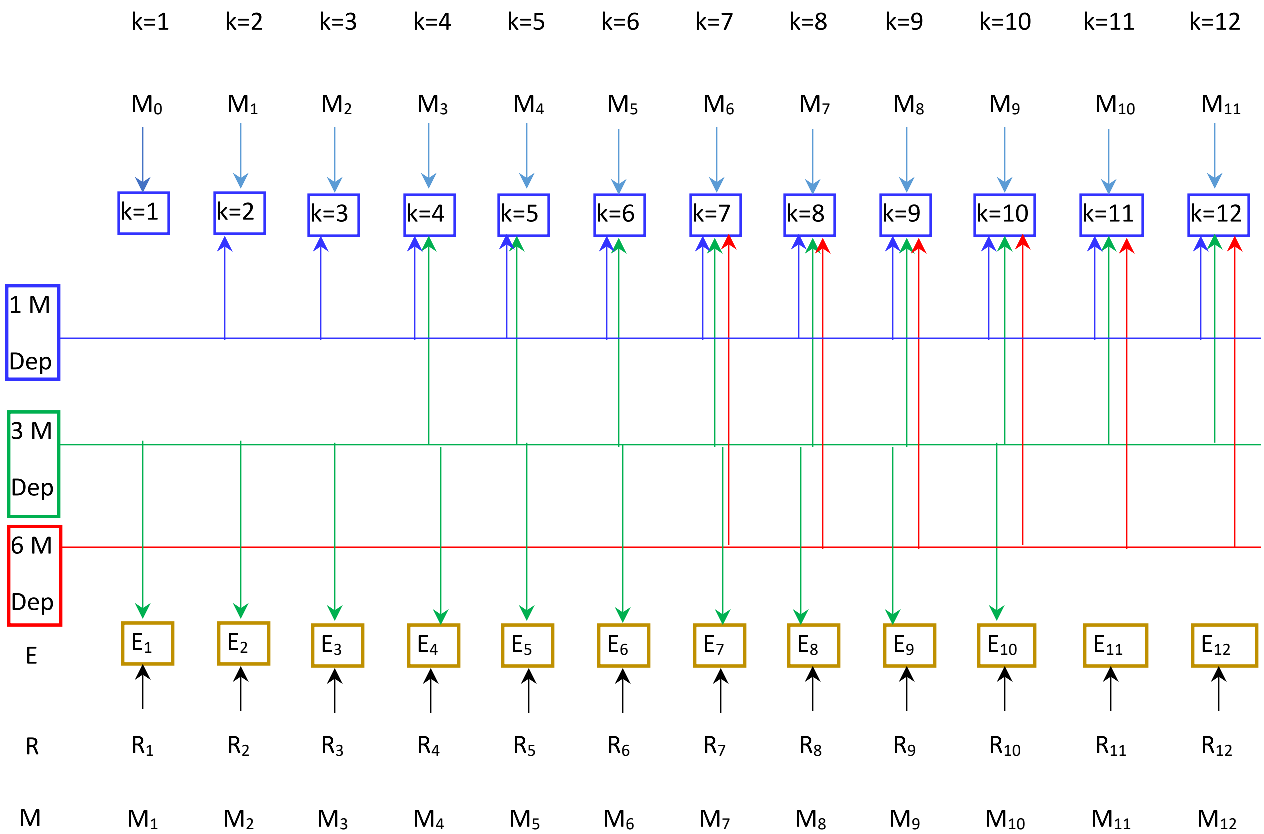
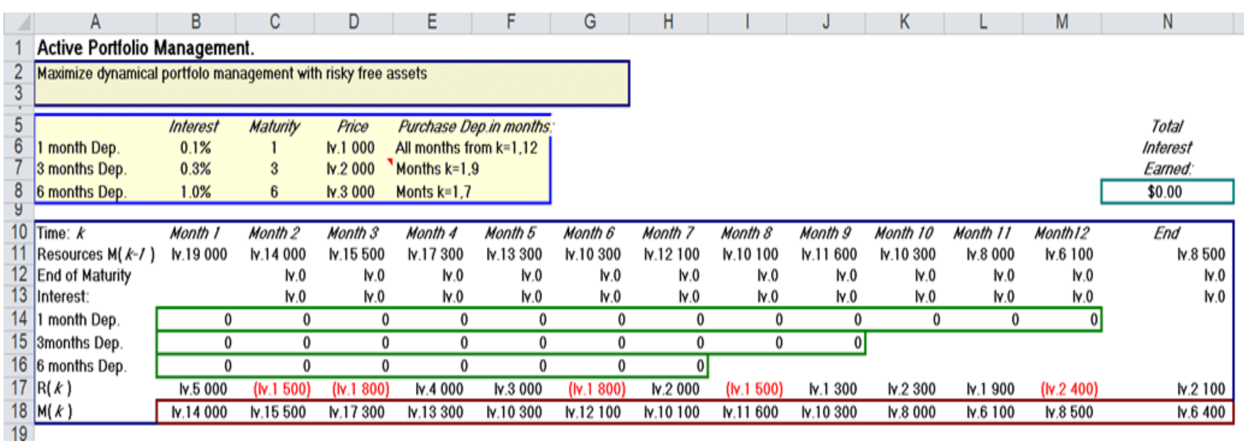


Figure 1. Eligible actions in active portfolio management

A graphical presentation of the main Excel screen is given in Fig.2.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Active Portfolio Management.													
2	Maximize dynamical portfolo management with risky free assets													
3														
5		*Interest*	*Maturity*	*Price*	*Purchase Dep.in months:*									*Total*
6	1 month Dep.	0.1%	1	lv.1 000	All months from k=1,12									*Interest*
7	3 months Dep.	0.3%	3	lv.2 000	Months k=1,9									*Earned:*
8	6 months Dep.	1.0%	6	lv.3 000	Monts k=1,7									$0.00
9														
10	Time: *k*	*Month 1*	*Month 2*	*Month 3*	*Month 4*	*Month 5*	*Month 6*	*Month 7*	*Month 8*	*Month 9*	*Month 10*	*Month 11*	*Month12*	*End*
11	Resources M(*k-1*)	lv.19 000	lv.14 000	lv.15 500	lv.17 300	lv.13 300	lv.10 300	lv.12 100	lv.10 100	lv.11 600	lv.10 300	lv.8 000	lv.6 100	lv.8 500
12	End of Maturity		lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0
13	Interest:		lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0
14	1 month Dep.	0	0	0	0	0	0	0	0	0	0	0	0	
15	3months Dep.	0	0	0	0	0	0	0	0	0				
16	6 months Dep.	0	0	0	0	0	0	0						
17	R(*k*)	lv.5 000	(lv.1 500)	(lv.1 800)	lv.4 000	lv.3 000	(lv.1 800)	lv.2 000	(lv.1 500)	lv.1 300	lv.2 300	lv.1 900	(lv.2 400)	lv.2 100
18	M(*k*)	lv.14 000	lv.15 500	lv.17 300	lv.13 300	lv.10 300	lv.12 100	lv.10 100	lv.11 600	lv.10 300	lv.8 000	lv.6 100	lv.8 500	lv.6 400
19														

Figure 2. Graphical presentation of the main Excel screen

The main parameters of the risk-free assets are constant parameters and they are given on the set A5 till F8: the income in percentage, the maturity periods, and the required level of cash amount. The time *k* defines the sequence of months for the overall investment period of one year (12 months). The initial investment resource is given in cell B11 with a value of 19000 lv.

The solutions to the optimization problem are in rows 14 to 16. Each cell in the set B14-M14 defines the number of monthly deposits, which is made at the beginning of the appropriate month *k*. Because the maturity time for this asset is one month, this gives the opportunity for the investment to be performed till the beginning of month *k*=12. It is illustrated that the investment can be performed on *k*=1, 12 with arrows, directed down, Fig.1. At the end of the same month, the yield of this investment is received, graphically presented with arrows, directed up for *k*=1, 12.

In a graphical way are given also the periods, when the deposits with three months maturity can be done. This is the period from *k*=1, 10. The corresponding arrows are directed down. The yields from these types of deposits can be received from k=4, 12. These arrows are directed up.

The peculiarities in the durations of the six months deposits require the investment to be done in months *k*=1, 7. Graphically this is presented with arrows, directed down for *k*=1, 7. Respectively, the corresponding income is available from months *k*=7, 12, and arrows are directed up (Fig.1).

The set B17 till N17 contains the values of the vector *R*(*k*), which gives the values of payments or incomes, that the company will have at the end of the month. The values "XX" are costs, which have to be paid, and the values "(XX)" mean that the company will receive such payments.

The cash M(1) is the amount, which the company will have at the end of month *k*=1. For the initial case, M(1) is calculated as

SUM(B11:B13)-SUMPRODUCT(B14:B16;$D$6:$D$8)-B17.

The first component SUM(B11:B13) defines the total investment resource, available for the first month. It comprises the initial investment amount M(0)=19000 lv. The volumes of previous deposits must be added to sell B12. But for the initial *k*=1, such amounts are not available. The interests obtained are given in cell B13. Hence, for the first month of the investment period, such values in B12 and B13 are not available. Thus, the initial amount of free resources for investment is evaluated by summation of cells B11:B13

The component SUMPRODUCT(B14:B16;$D$6:$D$8) evaluates how much of the investment resource is allocated for new deposits. The column B11:B13 gives the number of deposits and D6:D8 are the costs per category deposit. The function SUMPRODUCT() makes a vector multiplication between the sets B11:B13 and D6:D8.

The requested payments and/or incomes, defined by R(1) are subtracted from the investment amount SUM(B11:B13) and the resulting value M(1) is given in cell B18. This value is the initially available resource for month *k*=2, which is translated in cell C11 (or C11 contains the command =B18).

The next cells in row 18 contain the same evaluations as M(1). For illustration the content of cell M(18), for *k*=12 is

=SUM(M11:M13)-SUMPRODUCT(M14:M16;$D$6:$D$8)-M17 .

The evaluations for *k*=2 illustrate the resources, available for investment by SUM(C11:C13). The content of cell C11 is the free resources from the previous month M(1) from B18. The next component in C12 evaluates the volume of mature deposits. For k=2 only one-month deposits can finish in the second month. Thus, cell C12 contains the evaluation =B14*$D$6. Respectively, cell C13 will have the evaluated income from these deposits =B14*$D$6*$B$6. Sequentially, these evaluations follow till k=4, when the maturity of 3 months' deposits can arise. Hence, the amount of the investment resource for the beginning of month 4 will increase both with the deposits for 1 and 3 months if any. The cell E12 calculates =D14*$D$6+B15*$D$7 and the resulting income is in E13 as =D14*$D$6*$B$6+B15*$D$7*$B$7. The evaluations in this type continue till *k*=7 when a possible maturity of 6 months deposits would be available. The resulting amount of resources in cell H12 is =D14*$D$6*$B$6+B15*$D$7*$B$7 and the total income is evaluated in cell H13 like =G14*$D$6*$B$6+E15*$D$7*$B$7+B16*$D$8*$B$8.

These complicated forms of evaluations continue till the end of the investment period for k=12. For illustration, the content in cell M12 is =L14*$D$6+J15*$D$7+G16*$D$8 and the resulting incomes in M13 are =L14*$D$6*$B$6+J15*$D$7*$B$7+G16*$D$8*$B$8 .

The goal function of the problem maximizes the sum of all incomes for the investment period, *M*=1, 12. Its evaluation is given in cell M8, where all incomes are =SUM(B13:K13).

The descriptions above explain the manner of programming the Excel sheet for the definition of the problem (1). The solution to this problem is done by application of the SOLVER function. It insists on additional input parameters, given to the command window of SOLVER, Fig.3. We are using the function NAME() to notify the set of parameters with names for easier programming. The solutions for 1 month's deposits on B14:M14 are named "One_moths_CDs". Respectively, B15:K15 for the 3 months is named "3months_Dep" and for B16:H16 is "Six_months_CDs". The goal function in N8 is named "Total_interest". The resulting set M(k) from B18:N18 is named "Montly_cash".

The command window of SOLVER is programmed with the name "Total_interest" for the goal function; the problem solutions are One-month_CDs", "_3months_Dep" and "Six_month_CDs"; the constraints insist on integer arguments and the ended M(k) must be higher than 1000lv., M(k)≥ 1000, *k*=1,12. The solutions to the problem are given in Fig.2 with a total income of 137 lv.

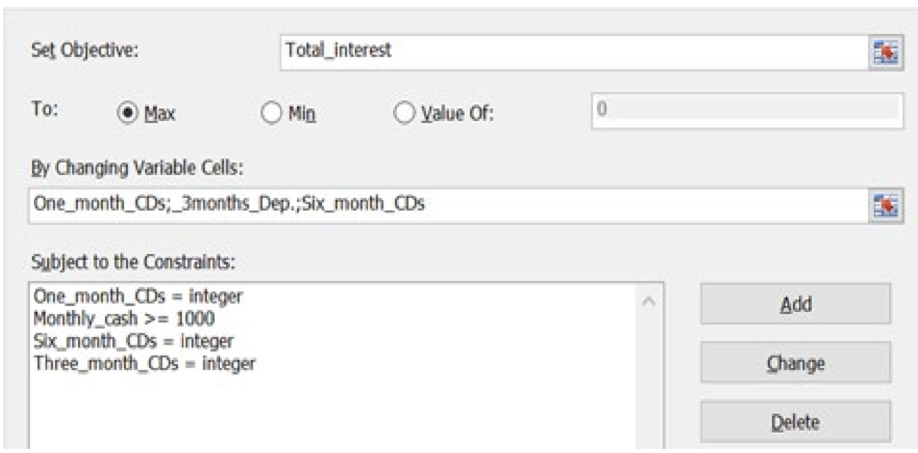


Figure 3. Command window of SOLVER

5. Conclusions

This research addresses the active management of a portfolio. The optimization targets the useful usage of free resources by means to increase the wealth of the business entity. Such optimal financial management is a prerequisite for sustainable production and/or business activities. The benefit of the presented problem is that it can be solved with simple computational resources. This is a prerequisite for its practical implementation in business entities. Particularly, the described portfolio problem contains risk-free assets with different maturity periods and integer solutions. With the increase in the investment period, respectively the scale of optimization, the time for solving could be impractical for real-time decisions. The problem has the potential to be extended with risky assets, but the portfolio problem has to increase its content with the values of risk for each asset as the correlations between the asset returns. But this can be a future development for the application of information technology solutions for the active portfolio management

Acknowledgments

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The impact of process innovations on maritime transport services in Bulgaria

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Abstract: The aim of this study is to analyse the impact of four key process innovations on maritime transport services provided by leading companies in Bulgaria. Specifically, the process innovations studied are: improved provision of the service; specification of services targeting new market segments; creation of better conditions for the realisation of the services offered; introduction of a new organisational innovation. In this study, a method is applied to identify the Factor Effect (screening) design, resulting from the numerical values of the indicator scores given by experts to managers of leading organisations in the Bulgarian maritime sector. The results of the overall study indicate that the introduction of process innovations in each of the four areas would be beneficial for the development of maritime organisations in Bulgaria. Furthermore, the synergistic effect of the innovations would be beneficial for the development of human resources and new management technologies of the maritime industry in Bulgaria.

Keywords: maritime transport services, innovations, entrepreneurship

1. Introduction

The COVID-19 pandemic caused significant disturbances in the maritime transport system despite the efforts made, including through the different nature of incentives for the commercial sector, which has made it difficult to secure the loading and unloading activities and transportation (Sohrabi et al., 2020). Undoubtedly, one of the greatest challenges that need to be overcome are the unprecedented procedures related to the replacement of freight vessel crews (Dimitrakieva, Kostadinov, & Atanasova, 2021; Kersan-Škabić, 2022; Margherita & Heikkilä, 2021). These difficulties gave rise to the risk that the imposed restrictions may create conditions for permanent reduction in the number of people employed in maritime transport and, respectively, for reduction of their income, while creating uncertainty among those employed with respect to the duration of the individual contracts due to the lack of possibility for replacement of the crew. The pandemic also had a negative effect on the preparation of the future senior staff who are expected to be involved in the management of the maritime transport system (Belev & Stoyanov, 2020; Stoyanov, 2021a, 2021b). It has been concluded that faster adaptation to the changed conditions and subsequent recovery of the entire transport system (Ozdemir, Sharma, Dhir, & Daim, 2022) need to be provided in order to avoid the risk of any threats to food security. The way toward the recovery of international trade is closely associated with the return to the normal course of development of maritime logistics services after the partial relaxation of the measures. This requires addressing the shortage of port infrastructure (Fratila, Gavril, Nita, & Hrebenciuc, 2021; Lin, Chang, & Hung, 2022) as a result of the sharp increase in the trade of products and the delayed deliveries caused by the more burdensome procedures for access before starting the loading and unloading operations. The pandemic, on the other hand, has made it possible to pinpoint the vulnerability of transport logistics activities more accurately and clearly, and, at the same time, has drawn the experts' attention to the need to search for new strategic opportunities to create greater flexibility and sustainability.

These factors have also had an adverse impact on maritime logistics services in Bulgaria. In search of strategic alternatives for development, logistics companies have taken into account the already existing factors that influence the development of maritime transport services, which are related to the country's crucial location, the existing transport infrastructure and its connections to the rail network (Bakalova, 2014; Mednikarov, Dimitrov, & Vasilev, 2018; Ministry of Transport, Information Technology and Communications, 2010, 2017; Narleva, 2019). The favourable factors are creating conditions for introducing new systemic innovations in the management of these services to allow faster adaptation to the new market restrictions.

The objective of this study is to analyse the impact of four key process innovations on maritime transport services provided by leading companies in Bulgaria. In particular, the process innovations studied are: improved provision of services on the existing markets; improvements in the service specifications targeting new market segments; creating better conditions for the delivery of the services offered; introduction of new organisational innovations.

2. Methodology of the study

This study applies the method of Factor Effect (screening) design derived from the numerical values of each indicator determined by experts working as managers in leading organisations in the Bulgarian maritime sector. The method allows to identify the impact of the four key process innovations and to identify the variations among the different results. Based on this, the research approach adopted provides us with the opportunity to conduct a comparative analysis of the expert evaluations and ensures reliability and validity of the results.

2.1 Methods for data collection from the logistics experts involved in the survey

Discussions in focus groups have been conducted in the course of the survey in order to better identify the attitudes of the logistics managers and experts involved in the survey toward the impact of different innovations on the more rapid recovery and development of maritime transport services. The participants in the focus groups for analysing the impact were selected based on their long-term experience (more than 10 years) and expertise in the field of logistics. The potential participants in the survey were familiarised with its objectives and methodology and only 3 out of 55 companies refused to participate. Two of the experts did not join the actual survey despite their confirmation of participation. All logistics experts that participated in the survey provided a confirmation of informed consent and knowledge of the methods of discussion in the focus groups and the methods of analysis for presenting the results of the survey. The survey was conducted between October 2021 and January 2022. Participants were given a questionnaire examining the impact of a combination of the four factors to be analysed and the experts had to provide a score on a scale from one to five, which was for evaluation of the input factors (where a score of 1 means that the factor has no impact, and a score of 5 means that the factor has a very strong impact) The scores were summarised and used to establish the relationship between input and output data when combining the impact of multiple factors. The combination of factors for building the model and identifying the scores is shown in Table 2 and is as follows: no impact of the factor (A1, B1, C1, D1) or very strong impact of the factor (A2, B2, C2, D2).

Table 1. Variable information.

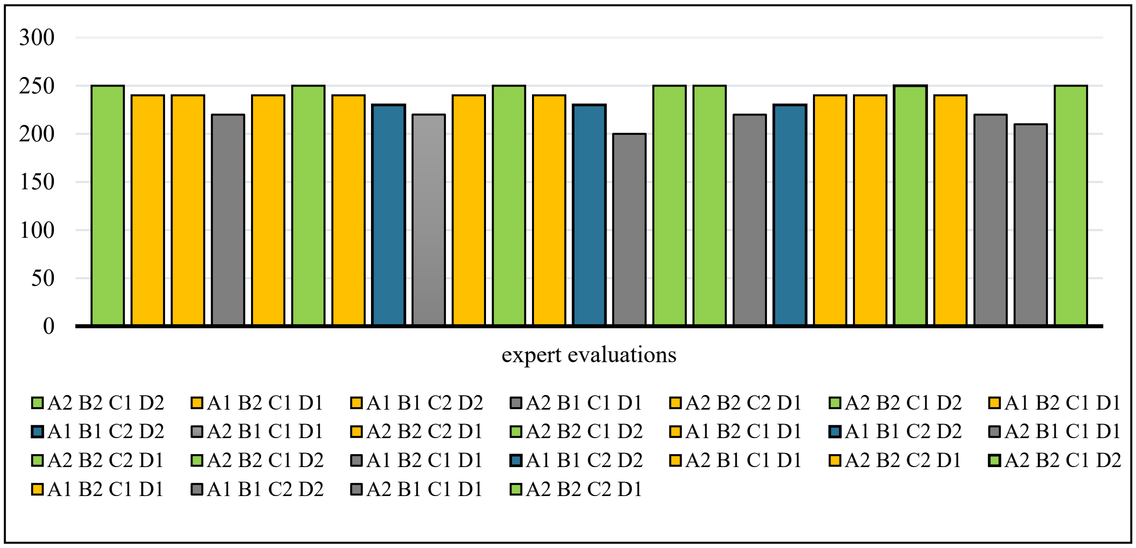
Improved provision of services	Introduction of new organisational innovations	Specification of services targeting new market segments	Creating better conditions for realisation of the services offered	Sum of the scores given by the experts
A2	B2	C1	D2	….
A1	B2	C1	D1	….
A1	B1	C2	D2	….
A2	B1	C1	D1	….
A2	B2	C2	D1	…..

The participants' responses were organised and summarised and the data obtained were used for further analyses.

2.2. Data analysis methods

Factor effect (screening) design (Cotter, 1979) allows to calculate the impact of the effect of the four factors studied, where the factor given the highest score in the different combinations will undoubtedly be the one with the strongest impact. The summarised data were analysed with XLSTAT Design of Experiments, Analysis of a screening design, Microsoft Excel (Addinsoft, 2021).

3. Results from the study



The comparative results (including the uncertainty of measurement) do not show any significant variations in the experts' scores on the impact of the different innovations on maritime industry. Furthermore, the results show that the most significant factor for maritime transport organisations is the introduction of organisational innovations (rationalising the processing of quotes and reducing the time for implementation), followed by innovations related to the development of new specific services targeting new market segments in the sector. The results also show the priorities of the sector and the problematic areas challenging its future development. The scores given by the experts, which were used to build the model, are shown on figure 2 (Experimental design) and vary from 200 to 250.

Figure 2. Experimental design

3.1. Organisational innovations in maritime transport services in Bulgaria

As shown on figure 1, the highest scores were given to the combination of factors where organisational innovations have received he highest score (B2). This is largely the result of the changed market conditions, which require using primarily internet commerce in a highly competitive environment as a mechanism for being awarded contracts in the maritime sectors. This sector could recover more rapidly if these electronic tenders for contracting services are not only based on the "lowest price" criterion, but also on organisational advantages related to the quality of implementation after signing the contract for the transport service. It has been recognised a long time ago that the shipping industry is rather conservative and it is difficult to introduce new technologies for process management or innovative methods for organisation based on the existing resources. The majority of experts that participated in the study shared that there is a rather one-sided view with respect to organisational innovations and that the projects or innovations introduced are primarily related to the port infrastructure or the shipping information technologies. The underestimation of the positive impact of organisational innovations covering both systems at the same time hinder the sustainable introduction of projects in the field of ecology. The introduction of innovative models of service or organisation of maritime transport services in the participating logistics companies over the past few years focus on two themes: one of them is improvements related to a specific problem that required and optimised solution in the work organisation (rationalisation of the processing of quotes and reducing the time for implementation) and the other one is related to projects for optimisation, where the final expected effect is the application of innovations in different parts of the two systems.

3.2. Creating better conditions for realisation of the maritime transport services offered

The overall international policy followed over the past few years supports projects for replacing road transport with maritime transport. Many regulatory reforms and coordination policies for investment in port infrastructure projects have been implemented. The changes in the market conditions during the pandemic deepened the increasing need to include maritime transportation in the transport services. This necessitates the implementation of realistic projects stimulating the complementarity between the different types of transport and the introduction of proper organisational management for their better compatibility. Most experts maintain that the strict restrictive measures for land transport introduced and overcoming the strict border control can streamline the efforts of logistics operators toward the unlimited capacity of maritime transport, which, among other things, does not require a lot of investment for the creation of maritime waterways. The higher scores were observed for combinations of factors where this factor has a strong impact (D2). The new market conditions created and the adaptation to the new "normality" require that efforts are focused on investment in innovations for the creation of better conditions for the implementation of the transport services. Investment in innovative concepts for shipping trade need to align with the coordination between all stakeholders in the "door-to-door" delivery in order to overcome the currently existing problems within the entire transportation chain related to the multimodal and intermodal transport systems. The use of ship transport for short distances could also result in the fulfilment of the environmental objectives to reduce the number of transport vehicles on the international roads for transportation and could help reduce traffic jams. The experts that participated in the study shared that the introduction of environmental standards related to the overall quality management could contribute to the more seamless introduction of innovations and opening of new business opportunities, which could compensate for the investment in this initiative in the long-term. These innovations require very close coordination between maritime, railway and road transport and thus, the development of a higher number of specialised terminals for the introduction of the transport services is a prerequisite, the lack of which would make investment in such innovations worthless.

3.3. Specification of services targeting new market segments

The results from the study show that the introduction of new technologies designed for new market segments lag behind as compared to the other novelties and that companies would rather rely on technologies that have already been adopted and welcomed in other market segments. The introduction and use of digital technologies is primarily related to the digitalisation in maritime transport, particularly in navigation systems. The study confirms that there are few innovations focusing on new market initiatives and development of new transport services and therefore the scoring of this factor is less significant (scores of C1 and C2 were given). The submission and processing of information in sea ports plays the key role in the provision of maritime logistics services that meet the clients' requirements. Therefore, innovations in this field would contribute to the development, however, innovations at present are primarily related to plans and programmes for paperless and automated procedures in the sea ports.

3.4. Improved provision of services

According to the experts that took part in the study, the lack of flexibility resulting from the uncertainty in the context of the crisis in maritime transport services has several dimensions related to the inaccuracy of the information, the rapidly changing conditions for closing the ports, the delay of information and the lack of possibility to meet the contractual terms caused by the inaccuracy of information. This situation requires to seek rapid solutions for improving the method of provision of transport services that corresponds to the uncertainty with respect to the exact time of the ships' calling at the ports. The main drawbacks of using innovations for improving the services provided (A1 and A2) is that they are often related to an increase in the costs as a result of the indirect transfer of cargo during the integration of this type of transport in the transport system to the end user. The lack of harmonisation in procedures, such as in the requirements or the processing of documents which are essentially different for the different types of transport makes the introduction of innovations difficult to implement, which is the reason why the experts have given the lowest score to this factor.

3.5. Analysing the impact of the four groups of innovations

Over the past few years maritime transport services have been significantly affected by the sharp changes in the conditions of the environment, the introduction of new (not only in the field of ecology) policies, regulations and laws of different nature and natural disasters. These services ensure food security and therefore any interruption in this chain could lead to significant consequences. To overcome these factors and the increasing competition, maritime logistics operators should continuously improve their capability to provide services in order to achieve a competitive advantage. The strategies to mitigate the consequences of these negative aspects are closely related to the introduction of innovations for improving the quality of services. Standardised coefficients have been examined in the study to analyse the impact of the four possible groups of innovations. The results are illustrated on Figure 3.

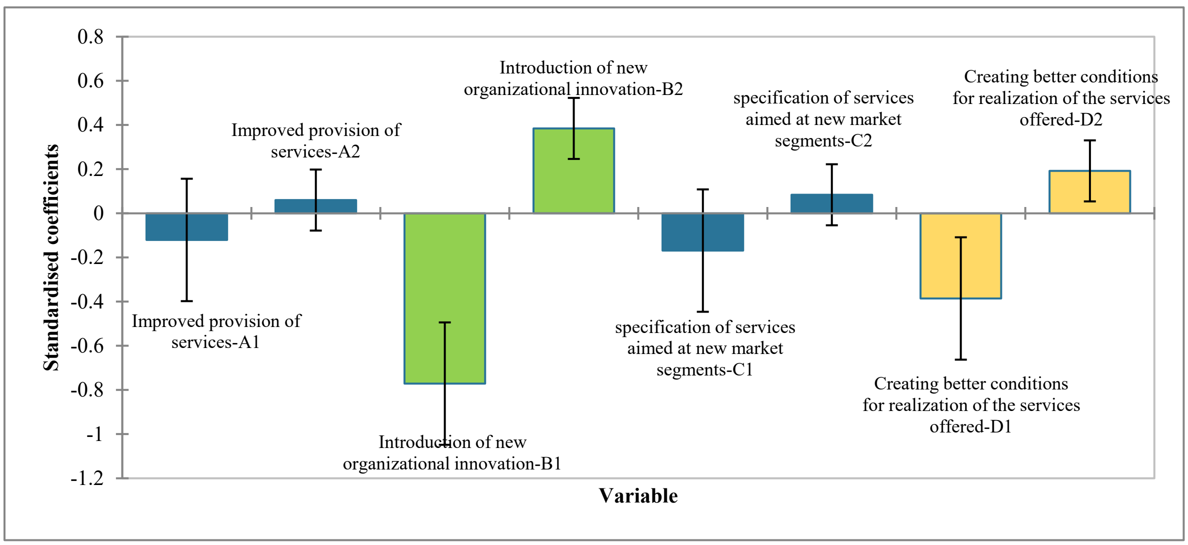


Figure 3. Standardised coefficients (95% conf. interval)

The results presented on figure 3 show the impact of each of the studied innovations for improving maritime logistics services, where the innovation with the highest variation has the greatest effect. After making repetitive studies for each combination of factors, the mean confidence intervals have been calculated. As a summary of the analysis a Pareto diagram has also been drawn (Figure 4), which clearly shows that the innovation related to the organisation of processes and their optimisation is the factor with the most significant impact, followed by the creation of better conditions for realisation of the maritime transport services offered.

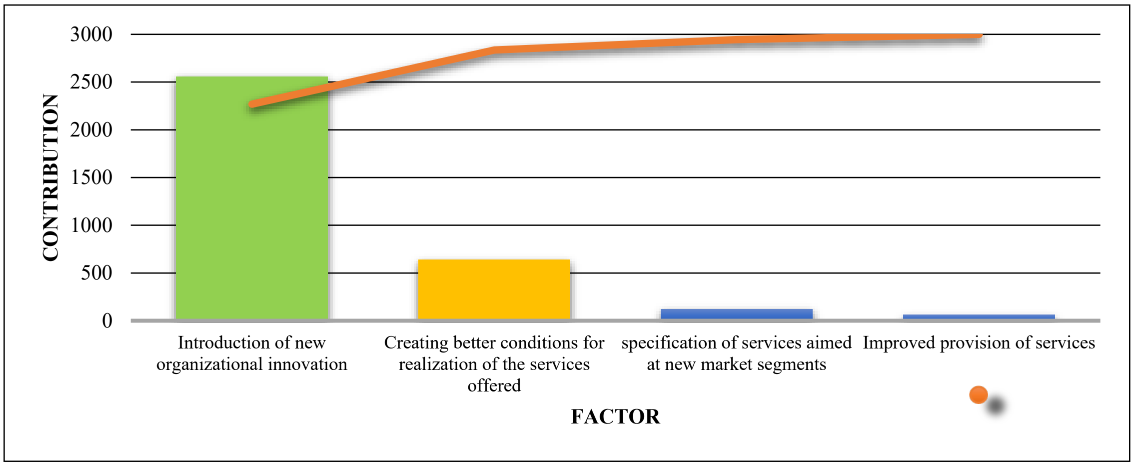


Figure 4. Contribution of the variables: Pareto charts

The other two innovations have a lower impact and should be used in combination with the impact of the others in order to have a significant effect. The combined effects of the innovations are presented (Figure 1) together with the scores given by the experts involved in the study.

4. Conclusion

The results from the overall study show that the introduction of process innovations in each of the four areas would be beneficial for the development of maritime organisations in Bulgaria. Maritime transport services include a lot of processes where innovations could be introduced and these are not just in the activities related to the conclusion of contractual agreements, loading and unloading operations and warehousing operations and the relevant accompanying documentation that could become fully digitalised, but also in many other areas, such as quality control, packaging, repackaging and environmental aspects. The changes in the market conditions related to the consequences of the pandemic and the fuel price increase create a greater uncertainty that needs to be overcome. Therefore, the synergistic effect of the introduced innovations with a combined impact should be sought, which could benefit the development of human resources and new technologies for management of the maritime industry in Bulgaria.

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The Predictive Ability of Ocean Freight Rates: Evidence from Japan and South Korea

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Abstract: This study examines the role of global ocean freight rates on local domestic transportation freight rates in East Asia. Japan and South Korea are chosen for this study because of extensive monthly domestic freight rate data available from their central banks, they are both highly globalized economies, and because prior research on the Japanese maritime industry has been limited. Data used for this study include monthly freight rate data on four different domestic freight transportation sectors in Japan. Measures of global ocean freight rates include measures from the Japanesee and South Korean central banks as well as the Baltic Dry Index (BDI). Our results indicate that the BDI can predict Japanese and South Korean ocean freight rates, and in turn Japanese and South Korean freight rates predict domestic transportation freight rates in their respective countries as well as domestic macroeconomic indicators. These results suggest that ocean freight rates may possess valuable economic information that can be used to predict future economic trends.

Keywords: Ocean freight rates, forecasting, Japanese freight transportation industry

1. Introduction and Literature Review

Much prior research has shown that ocean freight rates can significantly other economic factors. For example, dry bulk freight rates have been shown to predict stock prices (Manoharan and Visalakshmi, 2019, Lin et al., 2019), GDP growth (Bildirici et al., 2016), and exchange rates (Han et al., 2020). Some research has also shown other freight rates may be important economic indicators with forecasting ability such as container freight rates (Hsiao, et al., 2016; Kim and Chang 2017), and clean tanker freight rates (Li et al., 2018). However, only limited research has been done showing the interrelationship between ocean freight rates and domestic freight rates. U.S. ocean freights were found in one study to have no significant impact on road, rail, or air transportation freight rates in the U.S. (Shackman et al., 2021). This may be a result of the U.S. Jones Act, which makes sectors of the U.S. transportation industry uncompetitive. Japan, unlike the U.S., has a vibrant ocean transportation industry including some leading global competitors such as K-Line, Mitsui, and NYK. Similarly, South Korea has a vibrant ocean transportation industry including the major liner Hyundai Merchant Marine.

Research on freight rates in Japan has been very limited. Studies on trucking freight rates between destinations in Japan has shown imbalances between front-haul and back-haul freights (Guerrero, et al., 2021; Tanaka and Tsubota, 2017). Little recent research has been done on ocean freight rates in Japan, but some research has shown that global freight rates may predict economic activity in South Korea. Container freight rates have been shown to predict Korean shipbuilding activity (Kim and Park, 2017), tanker rates have been shown to predict raw material imports to South

Korea (Kim and Park, 2019), and dry bulk freight rates have been shown to predict South Korean agricultural commodity import prices (Ha and Shin, 2021).

2. Freight Transportation Industries in South Korea and Japan

The freight transportation industries are quite similar in both countries. Tables 1 and 2 show the breakdown of freight shipped by sector. Trucking dominates the freight transportation in both countries, counting for over 90% of domestic freight in both Japan and South Korea. Both countries have very fragmented trucking industries with a large number of small competitors. Water transportation comes next, with around seven percent of total domestic freight transported for each country. Air and rail only account for a small fraction of tons shipped, although air transportation likely accounts for a large portion of shipping by value rather than tonnage.

In terms of ocean transportation, Japan's maritime shipping industry has three large competitors. South Korea has four of the top 30 container liners in the world (AXSMarine 2022). Japan's Ocean Network Express is an alliance of three major Japanese airlines that is now the sixth-largest container liner in the world (AXSMarine, 2022). In terms of tonnage, South Korea's ocean freight industry is responsible for 63 million tons per year (Kim et al. 2022) whereas Japan accounts for 143 million tons this year (Japanese Shipowners' Association 2022). This is consistent with the relative size of their economies.

Table 1: Freight transported by sector in South Korea

Sector	Freight Transported (in million metic tons)	Percentage (ton-based)
Truck	1799.57	91.09%
Air Cargo	0.29	0.01%
Coastal	143.23	7.25%
Rail	32.56	1.65%
Total	1975.64	100%

From Korean Transport Institue (2018)

Table 2: Freight transportation by sector in Japan

Sector	Freight Transported (in million metric tons)	Percentage (ton-based)
Truck	4329.13	91.83%
Air Cargo	0.88	0.02%
Inland and Coastal	341.45	7.24%
Rail	42.66	0.90%
Total	4727	100%

From Japanese Shipowner Association (2021)

3. Data

Data for this involves monthly data from the Bank of Japan (BOJ) covering 1985-2022. The specific series used for this study includes data on domestic water transportation (inland and coastal), rail, road, and air freight rates. Similar data was taken from the Bank of Korea covering 1996-2022. Macroeconomic data on both countries were also taken from these sources, including industrial production, inflation (CPI), and trade volume (imports plus exports). We also obtained data on stock market indices from these two countries from MSCI Inc. For global ocean freight rates we used the BDI for dry bulk freight, the Baltic Clean Tanker Index (BCTI) for global tanker freight rates, and the Howe Robinson Container Index (HRCI) for global container freight rates.

Figures 1 and 2 show the trends of the freight rates up over time in South Korea and Japan. The data is relatively consistent between the two countries in that air and ocean freight rates are the most volatile in both countries whereas the other three freight rates are relatively steady. Ocean freight rates show a large spike in 2007 in both countries, whereas air freight rates show a spike in 2020 in both countries. Rail freight rates show the least volatility, as both countries' rail freight rates show a slow and steady increase.

Figure 1: Freight Rates in South Korea 1985-2002

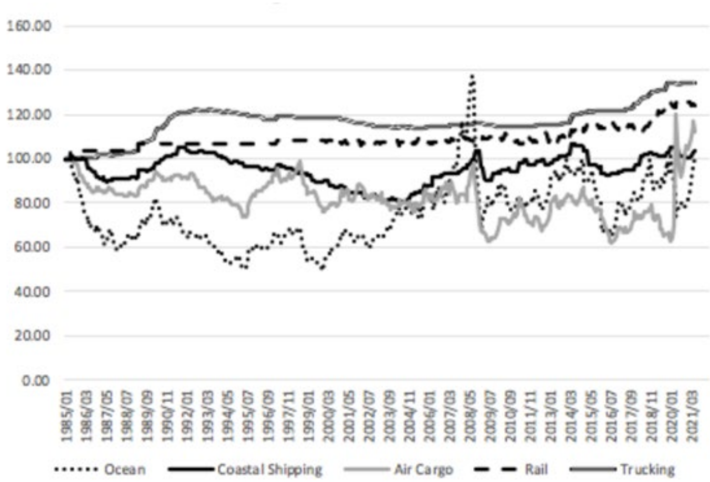
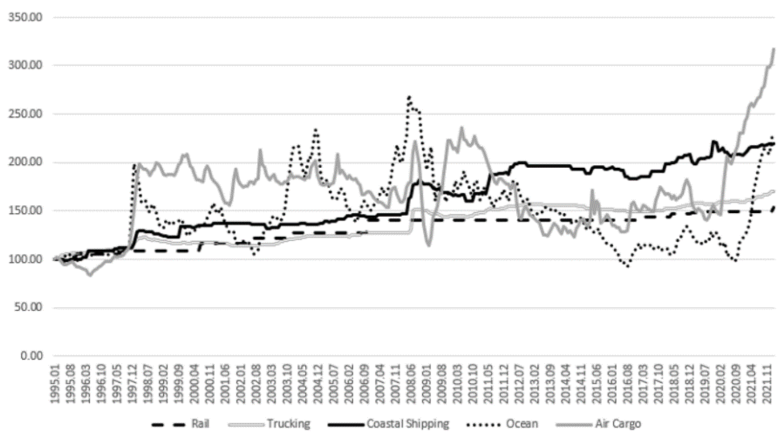


Figure 2: Freight Rates in South Korea 1985-2002



4. Methodology and Results

The method chosen for our analysis is based on the principle of Granger causality (Granger, 1969). We use this dynamic time series method to assess causal or predictive directions between different freight rates. The idea of Granger causality is that if a change in one variable in one period leads to a change in another period in the next period, it is evidence that the first variable has predictive power for the other variable. We use the vector autoregressive (VAR) model (Sims 1980) to assess Granger causality. VAR is a multivariate, multi-equation extension of simple Granger causality models, and allows us simultaneously to test multiple lead-lag relationships between the variables. We also transform our data into logged first-difference form, which means we are looking at how percentage changes in variables lead to percentage changes in other variables rather than levels.

VAR regression involves running a series of regressions of the first-differences of a dependent variable on lagged first differences of other explanatory variables along with lagged values of the dependent variable. In each regression, a different dependent variable is used so through these series of regressions causal direction can be examined. While numerous regressions were run as part of this process, an example of one equation is:

$$\Delta lnROAD_t = \alpha_0 + \alpha_1 \Delta \ln OCEAN_{t-1} + \alpha_2 \Delta lnOCEAN_{t-2} + \alpha_3 \Delta lnCOASTAL_{t-1} + \alpha_4 \Delta lnCOASTAL_{t-2} + \alpha_5 \Delta lnROAD_{t-1} + \alpha_6 \Delta lnROAD_{t-2} + \alpha_7 \Delta lnAIR_{t-1} + \alpha_8 \Delta lnAIR_{t-2} + \alpha_8 \Delta lnRAIL_{t-1} + \alpha_9 \Delta lnRAIL_{t-2} + \mu_t$$

In the above equation, current period's road freight rates is regressed against lagged values of other freight rates along with its own lagged values. This is done to see if past values of other freight rates can predict future values of road freight rates. Separate equations are run with ocean, coastal, air, or rail freight rates as the dependent variable but with the same set of independent variables to test for multiple directions of causality. Separate regressions are run with Japanese and South Korean data, and other models with BDI and other global ocean freight rates.

Figure 3 presents the main results of our Granger causality analysis:

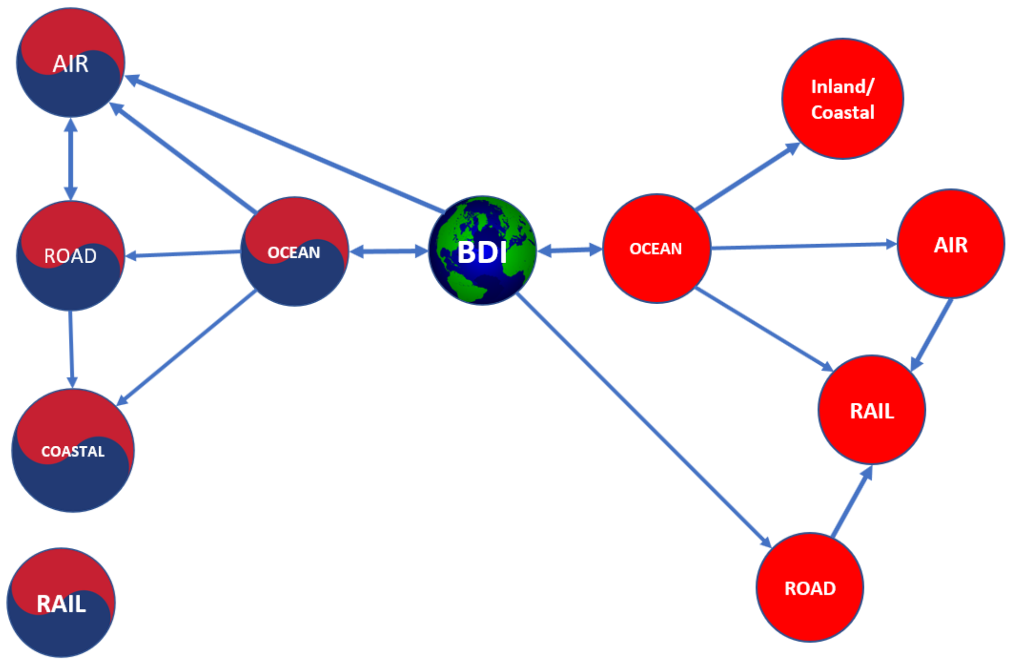


Figure 3. Causal relationships between ocean freight rates and domestic freight rates

On the left are South Korean freight rates, and on the right are Japanese freight rates

The order of our VAR models is as follows:

1. We run a VAR model with ocean freight rates only, including global rates (dry bulk (BDI), tanker, and container) as well as South Korean and Japanese ocean freight rates. We find no significant Granger causality for tanker or container rates. However, we do find bidirectional causality between BDI and Japanese and Korean ocean freight rates. We do not find any significant relationship between Japanese and Korean ocean freight rates. These results are seen in the center of Figure 1.

2. We run VAR models testing the relationship between BDI and domestic freight rates in South Korea and Japan. We find that BDI is a significant predictor only of Korean air freight rates and Japanese road freight rates.

3. We run a VAR model testing the relationship between Japanese ocean freight rates and the corresponding domestic freight, as well as a corresponding model with the South Korean data. We find that ocean freight rates have strong predictive power over domestic freight rates, with ocean freight rates significantly predicting three out of four domestic freight rates in each market. Most domestic freight rates only have little or no predictive power, with the exception of Korean road freight rates which significantly predict both air and coastal freight rates. Korean rail freight rates are not significantly predicted by any other freight rate, whereas Japanese rail freight rates are significantly predicted by three other rates.

As additional analysis, we ran another model with four domestic macroeconomic variables for each country included in place of domestic freight rates. Results for the model are shown in Figure 4 below. Of the four macroeconomic variables, industrial production, trade volume, and inflation are all significantly predicted by at least one ocean freight rate and in most cases two. While stock prices (MSCI) in South Korea are predicted by Japanese ocean freight rates, stock prices in Japan are not predicted by any ocean freight rate. Instead, stock prices in Japan predict both Japanese ocean freight rates and BDI in additional to industrial production and trade volume. A significant contrast between the macroeconomic model in Figure 4 and the freight rate model in Figure 3 is that the macroeconomic models show a more complex system of bidirectional causality between different indicators. The Figure 3 freight rate model has mostly unidirectional causality, mostly flowing from ocean freight rates to other freight rates.

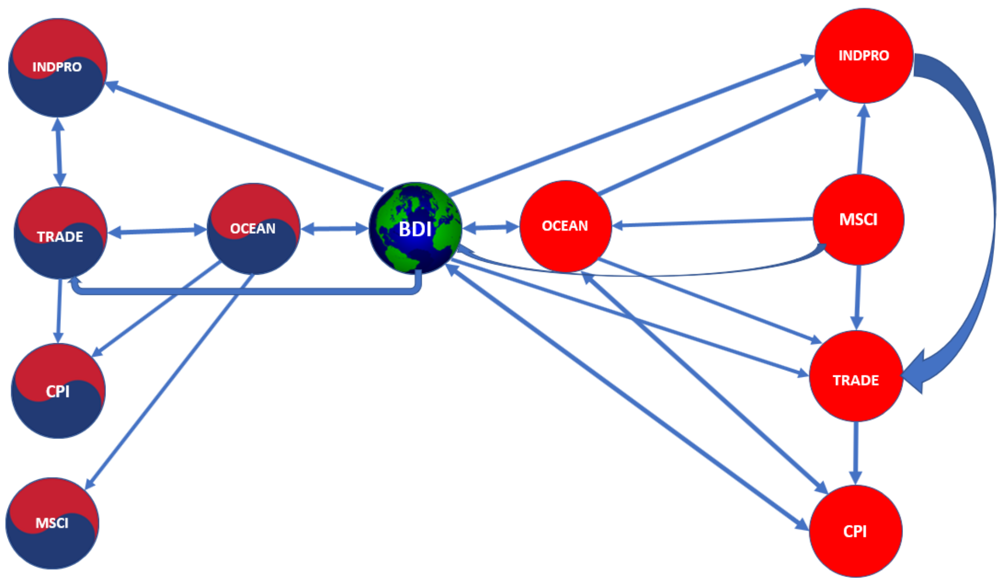


Figure 4. Causal relationships between ocean freight rates and macroeconomic indicators

On the left are South Korean freight rates, and on the right are Japanese freight rates

5. Conclusions

Overall these results demonstrate that both global ocean freight rates as well as national-level ocean freight rates are strong predictors of both domestic freight rates and domestic macroeconomic indicators. This confirms prior research that suggests that ocean freight rates possess valuable signals about future economic activity and freight rates in other modes of transportation. National level ocean freight rates have the strongest impact on domestic freight rates, with only minimal predictive power for BDI. Of the other transportation modes, road freight rates in South Korea show significant predictive power for two other freight rates. The predictive power may be due to the highly competitive and fragmented nature of the trucking industry in South Korea, which means freight rates are likely highly competitive and thus good indicators of economic conditions. Other non-ocean freight rates had little predictive power, which in the case of air and rail transportation may be due to the small amount of cargo carried in these sectors. Road freight rates in Japan only have minor predictive power, which may be a result of a shortage of truck drivers in Japan which makes rates less flexible.

Interestingly, ocean freight rates are shown to predict trade volume and not vice versa. Ocean freight rates seem to possess important informational signals that foreshadow future changes in international trade patterns. Future demand for freight services seems to be factored into freight rates. BDI is found to significantly predict industrial production in both countries. This may be because BDI is a specific measure of dry bulk freight rates, as it may predict future demand for raw materials needed by the industrial sector. A surprising result is that Japanese stock prices predict ocean freight rates, indicating a possible highly efficient stock market in Japan whose prices represent future economic trends. This may be a result of recent major equity market reforms in Japan.

The main implication of this study is that ocean freight rates at both the global level such as BDI or at the national level can be useful forecasting tools. Transportation logistics professionals may wish to use ocean freight rates to predict patterns of freight in other modes of transportation. Economic forecasts may be enriched and become more accurate if ocean freight rates are included in the forecasting models. A limitation of this study is that it only includes two countries. Whether or not the results of this study are unique just to these two countries could be assessed by examining similar models using data from other countries with strong maritime industries such as China or the EU region.

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Maritime Labour Market Dynamics (MLMD) and Futuristic Approach in Developing Skilled Global Maritime Labour (SGML)

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Abstract: Oceans are very vital for humans because holding 97% of water, 70% of the oxygen we breathe, ecosystem, food, energy, trade and leisure. The globalized maritime industry with more than 74,000 merchant ships transporting 90% of the world's cargo with around 1.89 million seafarers. The world will be experiencing a few megatrends demanding high skilled workforce. Sustainable development is impossible without upskilled force. LMD is always changing, attributable to demand and supply, matching efficiency, innovations, high-tech systems, education level, productivity, unemployment etc. Maritime labour market data shows a decline in job offers. Supply and demand affected during recent times due to Covid -19 pandemic and the Russian / Ukraine conflict. This paper highlights MLMD and SGML and suggests a futuristic approach for remodeling maritime labour skills. A survey through IAMU member universities will present a very clear picture of the issue. Paper suggests approaching IMO/IAMU to introduce MLMS Course in collaboration with the ILO and other maritime stakeholders. It also suggests IAMU Maritime Skilled Labour Data Program (MSLDP), IAMU Maritime Labour Market Data Program (MLMDP), and IAMU Maritime Skilled Labour Standards (MSLS) according to maritime industry requirements.

Keywords: Maritime labour market, Labour skills, Future demand and supply, model course, up skills

1. Introduction: Oceans are very vital for humans because holding 97% of water, 70% of the oxygen we breathe, ecosystem, food, energy, trade, and leisure (1). Almost 40% of the world's population lives near the coastline (2). Masses had been living around the rivers and coastline for their survival. Oceans regulate our climate and weather, if streams do not transfer heat from the equator towards the poles, life on some parts of the earth will freeze. Food has always been a basic human need. Seafood is the most essential part of our daily food intake. It adds nutritional value like sodium, calcium, magnesium, etc. Fish only, being the diet of billions of people, accounts for about 16% of all animal protein consumed globally (3). Oceans can best be the source of feeding people compared to other animals on earth. These are also very vital for sustainable development by creating millions of jobs. An OECD report estimates that, by 2030, ocean-based industries will employ more than 40 million people worldwide (4). Roughly, more than 3 billion people in developing countries rely upon oceans for their livelihood. The globalized maritime industry with more than 74,000 merchant ships transporting 90% of the world's cargo with around 1.89 million seafarers (5). If the oceans were a country, it would have the seventh-largest economy in the world (6). Millions of workers executing maritime operations on hi-tech ships, ports, offshore installations, and terminals. The world cannot survive without shipping and the shipping industry cannot operate without seafarers.

2. Shipping Industry and Seafarers: The shipping industry's role places it at the center of the world economy. It is a highly complex, innovative, committed, and global industry for the world's future sustainability with affordable import/export. Ships transport roughly, 11 billion tons of goods each year, which is around 1.5 tons per person based on the world population as mentioned by ICS. It is the cheapest mode of transportation. Fig-1 shown below explains the future of the shipping industry. Increasing human needs increases shipping as compared to population growth and relatively high GDP growth.

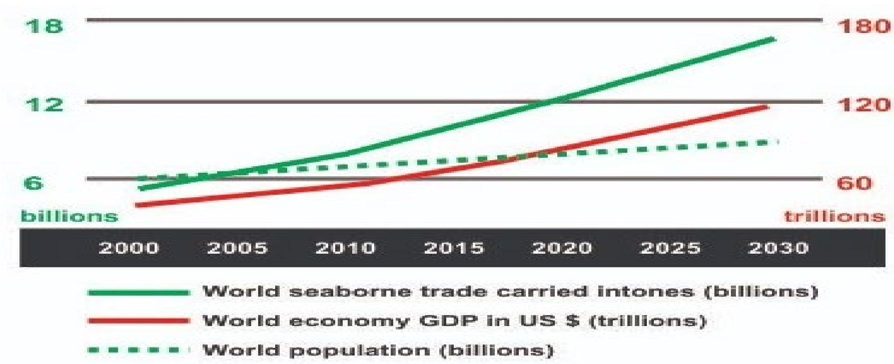

Fig-1 Predicted increases in world seaborne trade GDP and population (Source ICS)

Every global industry is striving for sustainable development. The Labour force in general and the highly skilled labour force are the keys to the success and sustainability of any industry. Despite its sensitivity, crucial and vital for global survival, it is very invisible and ignored as for as seafarers are concerned. Their due credit is not given. They are considered a highly paid and tourist type species. They are very brave, risk-taking, away from families, fighting against rough sea conditions, working round the clock, fatigued, stagnating lifestyle onboard ships and burning their midnight oil to run the global economic engine. If the world looks beyond their lucrative salary and fancy travelling schedule, they are the most neglected lot not only by the world organizations but by their countries also. "There are no ordinary citizens to witness the workings of an industry that is one of the most fundamental to their daily existence," Shipping is "the reason behind your cheap T-shirt and reasonably priced television. But who looks behind a television now and sees the ship that brought it?" Rose George writes in her book "Ninety percent of everything" "Life on the ship can be tough, and all personnel on board, goes through highly exhaustive and responsible work patterns. George then talks about the multi-cultural presence on board. However, not surprisingly, the number of Europeans and British seafarers is low, because of the exorbitant salaries they demand. The effect is so tremendous that, in 2009, Lloyd's List reported that Maersk had sent a memo that stated, 'Zero Recruitment in Europe' (p.59). Many global cruise liners are detained over wages and contracts, mostly ship owners' "make money" mindset, crew not looked after properly, safety laps, contracts, wages, and working hours, there are so many issues with the maritime labour market that no one is taking serious note of it. Some eyewash is done like seafarers' day, bill of rights etc. Global trade binds nations through shipping but little interest or capability at national and international levels when it comes to taking the challenging decisions of dealing with seafarers as stated by splash 247.

3. Survey Analysis: A survey conducted for analysis of the maritime labour market, job availability, skills, and IAMU role to develop a course and data for the labour market as well as availability of labour. The survey indicates the following:

3.1 Respondents from different countries and from maritime-related fields. A number of students in maritime faculties ranging from 200 to 4000 per year in different maritime majors like Nautical, marine engineering, port management, offshore installations, survey, transport, etc.

3.1.2 As for jobs available in the maritime sector, 33% of respondent's countries have more than 200000 jobs, 12% more than 100000 12% 50000 and 25% have less than 10000 jobs in their maritime sector. If we analyze the number of students and job availability, there is still a shortage of highly skilled labour as compared to job availability. (A wide range of surveys required for more details that are specific and that will be conducted during the IAMU research project)

3.1.3 About the conduct of "labour market skill course" in the maritime universities/institutes, 78% of respondents answered negatively. This encourages the development and introduction of this course by IAMU as well as IMO. That 22% conducting this course did not share the content, however, that is also not as effective as it could be to connect skilled maritime labour and the maritime labour market. Interestingly, 60% of the respondent's universities' other departments are conducting such courses.

3.1.4 As for labour market skills criteria/ standards, around 75% of institutes are following some criteria like STCW, ILO and some other international standards. However, we need to define such criteria in that course after feedback from all stakeholders (Fig-1 elaborates that). Sixty-five percent responded "yes" to having any feedback system from the employer regarding the emerging need for maritime labour skills. However, this can be solidified at the IAMU level for the benefit of all member universities

3.1.5 Most respondents agree that their students get jobs in their own country but maritime being the global industry, migration of labour is unavoidable and underdeveloped countries do not have more jobs. That is why it is important to have a database at the IAMU level to share with the member universities so that labour market data and skilled labour data can provide an opportunity to get jobs easily. About 77% of respondents shared that expatriates get jobs in their maritime labour market and that is the evidence of the maritime labour market being a global industry. About 33% of respondents say that they do not maintain any data about job opportunities for their students.

3.1.6 An important question in the survey was whether IMO should introduce a "Maritime Labour Market Skill course". Sixty seven percent of respondents responded in "Affirmative" and more encouraging was the response, 89% of respondents agreed, that IAMU may develop this course and all member universities may include that in their curriculum

3.1.7 The majority of respondents, 89% agreed that maritime faculties/universities should maintain data for the availability of maritime-related jobs. 88% were of the opinion that this data be maintained at the IAMU level to share among the member universities. Eighty nine percent were of the opinion that IAMU may have maintained the labour market job opportunity data also. Seventy-seven percent agreed that all member universities should open their labour market to each other.

4. Maritime Labour Market Dynamics (MLMD) and Maritime Labour Skills: In broader terms, Labor Market (LM) is defined as the demand and supply of labour for any job, any type of labour, skilled/unskilled viewed at micro and macroeconomic levels, gauging unemployment rate, labour productivity, wages and workload. Labour Market influenced by many factors like job opportunities, wages, labour age and skills, poverty, education, immigration, flow in/flow out, pandemics/wars, natural calamities, policies, outsourcing, new business trends, changing business environments, self-employment, multicultural/multilingual labour force, gender, caste and creed discrimination and competitiveness. At present, very fast hi-tech systems with automation displacing the labour force with a slow approach to inculcate matching skills have a major impact on the labour market. LMD refers to "changes in jobs that take place as well as entries into and departures from economic activity affected by hiring, separation and the establishment and closure of self-employment activities" (7). Labour Market Dynamics (LMD) is always changing, attributable to demand and supply, matching efficiency, innovations, high-tech systems, education level, productivity, unemployment etc. Maritime labour market data shows a decline in job offers especially ratings whereas officers are in access

"The impression portrayed is that in the past, organizations had a rigid hierarchical structure, and operated within a stable environment, thus, careers were predictable, secure, and linear. In contrast, the organizational system is now in a mode of all change, all dynamic, total fluidity, and thus careers are unpredictable, vulnerable, and multidirectional" (Baruch, 2006, p. 125) (8)

4.1 Maritime labour market trends, problems and labour issues are less emphasized in international forums despite a conviction on the critical role of the maritime industry in the global economy, but seafarers are the ignored species. If we look at the OECD labour market fact sheet 2021, it mentions all employment sectors except the maritime industry. In the recent past, drastic changes in MLMD like new shipping trends and technologies, Less crewing more workload, Autonomous shipping, ban on many nationalities to work on some flag state ships, Shore job lucrative salaries as compared to seafarers, discrimination in wages, Same rank/rate, different nationalities, different wages on the same ship, more globalization and digitalization, Pandemics / wars / unrest

4.2 The world will be experiencing a few megatrends like more globalization and digitalization, navigating towards a hi-tech-oriented work environment, and demanding high skilled workforce. Sustainable development is impossible without upskilled or reskilled labour force (5). This may be more diverse with the induction of autonomous shipping. Supply and demand affected during the recent Covid -19 pandemic and the Russian / Ukraine conflict because these two countries make up 25% supply of seafarers (6). In view of the changing dynamics, maritime labour needs to have skills that are more professional but in addition to that, they need comprehensive knowledge of labour market dynamics, job seeking/ retaining skills.

5. IAMU Maritime Skilled Labour Standards (MSLS): Skilled Global Maritime Labour refers to highly educated, well trained, experienced, dedicated; physically and mentally fit to perform complex tasks. That needs prolonged and extensive professional training to compete with the maritime labour market demands. It needs to know the labour market requirements, supply and demand and employee preferences. At present, seafarers-supplying countries are striving hard to achieve highly skilled labour but a grey area where ships are constructed in highly developed countries with very high-tech equipment and seafarers are produced mostly in underdeveloped countries where seafarers' training is inadequate due to basic education levels and financial issues. Minimum competence standard under STCW with time taking amendment process is another hurdle for high skilled labour. Although many countries have developed curriculums to compete with the maritime labour market requirements but those are changing very rapidly as compared to curriculum changes. The Global Maritime Professional – BODY OF KNOWLEDGE is a great effort by IAMU to improve seafarers' competence level, but it also does not mention maritime labour skills, matching to new maritime labour market trends, except for a small portion talking about Maritime Business. The IAMU members MET institutes while adopting a futuristic approach for remodeling maritime labour skills; train them in labour market changing dynamics, up skills, tricks, and trades for seeking and retaining a job, progression, and becoming an efficient, effective, and skilled maritime team member. A combined effort needed to develop maritime labour skills standards matching the day-to-day changing maritime labour market dynamics. That needs to develop Maritime Labour Market Skills Course. Paper suggests approaching IMO and IAMU academic committee to introduce Maritime Labour Market Skills Course, in collaboration with the ILO and other maritime stakeholders. IMO may also be approached to include this course in IMO model courses or make it part of STCW.

6. Suggested Course Description and objectives: Education and training are the key measures to help people meet changing labour market demands and skills requirements and this course will:

• Prepare students to understand Maritime Labour Market Dynamics (MLMD) and to improve their professional, interpersonal, managerial and teamwork skills

• Aim to improve working capacity as co-workers, subordinates, leaders and entrepreneurs and promote the availability of skilled labour for the maritime industry

• Improve the matching of the supply of and demand for skilled workers/labours because seafarer's skills development has an important role in the future maritime industry in managing challenges of changing job requirements with new technologies at the local, regional and global levels and enhancing possibilities of finding an appropriate/ suitable job or retaining one.

6.1 The main objectives of the course are:

• Provide participants with an introduction to the main functions, components, and applications of Labour Market Dynamics (LMD).

• Better, understand the skills anticipation and matching characteristics, methodologies, institutional arrangements, mechanisms, and modalities needed for identifying labour market imbalances in terms of skills, in addition to recognizing the current and future skills needed in a broader macroeconomic policy framework.

• Understand the main components Labour Market, Skills required for a successful carrier in the maritime industry. Understand labour statistics, main sources of labour statistics, and main uses of labour statistics. Switching jobs for a better future.

• Understand the main functions of the skilled Labour market, analysis, monitoring and reporting on policies, coordinating the interaction among different actors and institutions that produce and utilize labour market information)

• Analyze different methods and tools related to quantitative and qualitative methods to identify labour markets supply and demand imbalances and analyze different methods to measure skills matches and mismatches

• Understanding of function of international labour market skill criterion and information about ILO regarding rights and responsibilities of seafarers

6.2 Course Proposed Content: Although some course contents proposed, but this needs more deliberation with consultation of member universities and other maritime stakeholders, specially the employers, considering the maritime labour market demands. Attitude, Goal Setting, Etiquette, Ethics, Politics, and cultural diversity, Personal, Financial, Time and Stress Management. Organizational Skills, Quality Organizations and Service

- Accountability and Workplace Relationship and Human Resources and Policies
- Communication, Motivation, Leadership, and Teams, Conflict management and Negotiation
- Job Search and retaining Skills, Resume Package, Career Changes, Interview Techniques

- Labour Market Dynamics, Maritime Labour Market Dynamics, Skilled, low - skilled and unskilled Labour, Maritime employer skills requirements and Expansion of professional/high-tech education and Labour Market relationship. Developing Professional skills to coop up the fast-changing maritime industry

- New technologies, Compatible skills, Disparity between educational institutes and the modern labour market

- Recruitment and selection criterion of the maritime labour market (they are looking f

- A variety of skills/ occupational skills/employer preference). Impact of skilled and unskilled labour on the country's sustainable economic growth and Labour and global trade and economic growth

7. IAMU Maritime Skilled Labour Data Program (MSLDP) and Maritime Labour Market Data Program (MLMDP): IAMU activities are not widespread as compared to its organizational structure, influence, and strength. There may be reasons behind this due to the sovereignty of member countries, national curriculum, legal framework, and local maritime market demands. Member universities are versatile in many aspects. Many are seafaring providers, shipbuilders, big shipping companies, trade, and technologies. Thousands of jobs in the maritime sector are available in the member countries. Shipping is a globalized industry and needs multicultural/multilingual crew/labour. The idea behind this is to make a strong committee and facility to collect data from all member universities about their available skilled labour. Sophisticated software will be developed for member universities to upload that data. On the other hand, that software will also facilitate uploading data about jobs available in the maritime labour market of member universities. This will also facilitate that to keep upgrading time-to-time maritime labour market requirements, keeping abreast with the modernized shipping industry. Member universities will collaborate with the concerned national organizations to collect data about labour market demand and supply. A separate IAMU research project will be initiated for MSLDP and MLMDP. This Data will provide a very sophisticated way for the maritime labour market and maritime labour force to interact for future employment.

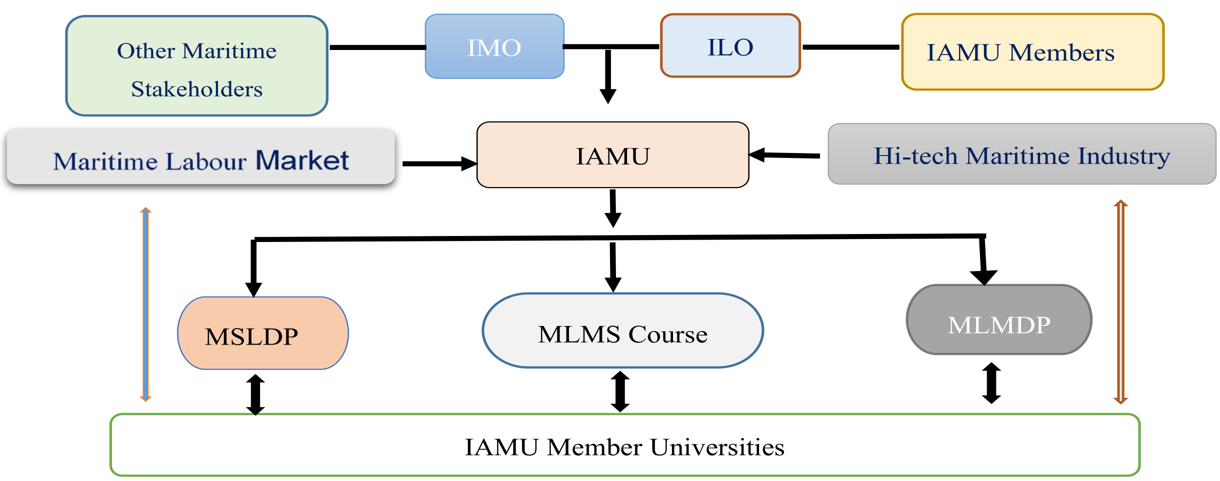

Fig-2 Cooperation between Maritime stake holders and IAMU ©

Fig-2 explains the IAMU collaboration with IMO, ILO, IAMU Member universities, the Hi-tech maritime industry, and the maritime labour market. Form Hi-tech industry, information regarding new maritime trends, technologies and required skills they intend to implement and need to operate their modern ships, ports, and other maritime entities efficiently. That information shared with the IAMU member universities to upgrade the maritime labour market skills course, already designed by IAMU. IAMU also prepares MSLDP and MLMDP. All information shared with the concerned stakeholders and a strong feedback network to improve maritime labour skills as well as to facilitate maritime labour to seek and retain jobs.

8. Template for MSLDP: In future, an IAMU research project will have more detailed data program for both maritime labour and maritime labour market. In that, all member universities be asked to provide available maritime skilled labour data of all ranks and rates. A small secretariat established at any member university or in the IAMU secretariat. A software will be developed to accommodate that data according to the skills, qualifications. Similarly a data of maritime labour market, meaning by jobs available in the countries of all member universities. Both type of data shared among the member universities. In addition, Maritime labour skills updating process will provide an opportunity to develop labour that is more skilled as per the maritime market requirements.

9. Recommendations:

a. Sustainable Ocean management system for sustainable development to get more benefits from the oceans, which is not being derived now.

b. IMO and IAMU academic committee to introduce Maritime Labour Market Skills Course, in collaboration with the ILO and other maritime stakeholders. IMO may also be approached to include this course in IMO model courses or make it part of STCW

c. A separate research project needs to carry out a detailed study and propose refined course contents, MSLDP and MLMDP through software because it needs a lot of consultation, regulations, and agreements between member universities

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The Role of Digitalization in the Shipbroking Business

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Abstract: The shipbroking discipline is the only non-regulated interdisciplinary subject providing consultancy service to the shipping world. Traditionally, practitioners provide tailor-made services to their clients by finding the best possible ships for the cargoes and, in return best possible cargoes for the ships. Consequently, brokers have to be familiar with the specific market such as supply and demand, specialization in the dry or wet market, sales and purchase market, specialized in specific geographical areas, and finally plays as a bridge between the principals and try to resolve any dispute with their diplomatic skills. There are no strict requirements to enter into this business, which makes the business more vulnerable, and as it is easy getting into this business, it is, in the same way, easy to get rid of the Shipping as well. The paper investigates the sustainability of the shipbroking business and its' short and long-term consequences and adaptability of the new technological developments and regulations that the shipping industry must comply with.

***Keywords*:** shipbroking, sustainability, supply and demand, structural holes theory, blockchain

1. Introduction

Shipbroking is a highly dynamic industry where practitioners continuously strive to keep up to date with the market's regulatory developments. A ship is a commercial enterprise that requires a considerable investment; therefore, the owners look for the best returns. The reward of the shipowners will depend upon the market and the time of entering into the industry. Apart from the supply and demand fluctuations, the investment return will depend on two factors:

1-) the technical aspect of the Shipping, where the Masters, the Chief Engineers, the officers and the crew of the ship have to work hard to make a whole approved and seaworthy ship "**Strictly Regulated**", and

2-) the economic aspect, where the shipbrokers will be playing a vital role by connecting the shipowners with cargo owners and negotiating the deals on their behalf. (Buskens) "**Not Regulated but competitive**".

In the past, the commercial side of the Shipping was performed by the previously experienced seafarer, but the commercial aspect requires more marketing than technical skills. However, knowing the ships, specifications of the cargoes, geographical features and the market in which the ships trade need be a central piece of knowledge that the shipbroking industry requires. Though the onboard experience will always be given preference, this experience will not be essential for shipbroking. However, brokers pre-involved in Shipping's operational, commercial and technical side will always be in considerable appreciation for performing their duties.

At a glance, the shipbroking business looks like the brokers are only functioning to find the cargoes and ships, but in reality, becoming a shipbroker is far apart from this, having long stand history behind it (Tonguç, 2021). Brokers are the drivers of Trade and Shipping, and for being sustainable, they have to reshape their structures as per the market pattern continuously (Patsadas, 2016, 2017). Because of the new development in the shipping industry, new trading routes, and the innovation of information technologies, the shipping industry has reshaped rapidly, so the shipbroking industry must comply with all changes (Zolkiewsky, Izrin).

2. Milestone of the Shipbrokers

Shipbroking business lies before 1000 AD. where Viking society called the brokers "brokunar-madr", which means "go-between" (Fischer, 1993). Brokunar-madr meant to define a person who acts between shipowners, shipbuilders and merchants and negotiate the deal with them. From the 1200s till the end of 1800, the broking business was regulated . The broker had to be registered for performing the business and granted a license against the £ 5 annual fee. To assure that the brokers abide by specific rules and behave in an honourable fashion, they must be sworn accordingly. Otherwise, any misbehaviour would be answerable to the Court of Aldermen . This system lasted for an extraordinary six centuries, giving rise to the term 'Honest Broker'.

"there shall be no brokers in the City except those who are admitted and sworn before the warden or Mayor and Alderman".

There have been many shipbrokers in western Europe since the 17th century when Shipbrokers activities were regulated by law. However, since most transactions, together with personal connections, continued to suffice, the demand for a broker remained relatively constrained until the post-1850 revolution in Shipping and Trade, which altered this system forever. After this alteration, a structure will keep the brokers standard at a certain level, and in 1903 "The Baltic Mercantile & Shipping Exchange Ltd" has been created. This institution's purpose was to keep the high professional standard and regulate the brokers' conduct. Brokers were previously acting as a principal. With the new adjustment, the profession changed from principals to a broker the only role and sign a "Broker's Letter". Shipbroking practitioners were giving their statement that they will be acting only on behalf of their clients. The main reason for all brokers to act and always sign "on behalf of" derived from this point onward.

3. Functions of the Shipbrokers

The shipping market is the interaction between supply and demand, where the shipbrokers have fulfilled a critical duty in this relation. They follow the demand and supply and create a suitable environment where they can match each other (Wang, 2019). In shipbroking, the demand means cargo owners/charterers and supply means the shipowner. Brokers have to keep a close relationship with both parties and provide the following services:

1. Continuously follow the supply (Ship-owners) and demand (Cargo-owners/charterer). Provide information for current, developing and projected markets;
2. Explore why individual efforts matter and how business can be more profitable;
3. Be an effective and efficient intermediary between the principals;
4. Coordinate the negotiations to conclude a "fixture";
5. Follow all fixture throughout the performance;
6. In case of any dispute, act "bona fide" as an arbitrator and try to bring the parties to an amicable agreement and avoid the parties going to the court, saving a massive amount of legal costs and time.

While performing the duties, the shipbrokers must also comply with strict regulations that owners and charterers must abide by. It is essential to underline that although the shipbroking business is not regulated, it deals in a heavily regulated industry (Prasad). This situation brings together that all brokers must be aware of endless legislative norms in Shipping.

Sustainability is the ability to reshape and adapt duties as per the new business environment (Dimitrakiev, 2010). The new regulations in the environmental issues and decarbonization require radical challenges, which brings uncertainties in the shipbroking business. This situation brings to mind the question if the broking business is adaptable! For shipbrokers to survive in the market, they must act sustainably and adapt to the new rules that the shipping business requires. So, adaptation make the business sustainable! The capability to survive during this technology evolution period depends on the fact that "it is not important how strong you are, but how adaptable to the changes you are"!

Sea Transport is increasingly becoming digitalized in the international market. Moreover, shipping business standards are continuously rising in an attempt to increase efficiency and profitability (Batrinca, 2008). The necessity to compete and survive, oblige the shipbrokers to adopt the daily technological developments and integrate into the digitalized world. One may ask, why the shipbrokers have to cope with digitalization? Is it the "Necessity" of increasing efficiency? It is at this point essential to remind the aphorism "The Necessity is the mother of all inventions". Shipbroking practitioners were adapting to new shipping market changes for the last hundred years, so they are still essential links between the shipowners and the cargo owners/charterers. The nature of the shipbroking business is a clear "link between the parties", and the role of the brokers can be re-described with Thomas Reid's Essays, that he published in 1785 under the name of "Intellectual Power of Man":

"In every chain of reasoning, the evidence of the last conclusion can be no greater than that of the weakest link of the chain, whatever may be the strength of the rest".

Shipbrokers are the link between the shipowners and the cargo owners, without which the business will not go further.

4. Shipbroking business versus digitalization

There is a concern about disruptive technologies and their impact on the Shipbroking business. The Shipbroker's job can be seen as an innovation to be managed and makes dialogue necessary. This profession is a business that heavily depends on know-how and relationship management. No electronic platform can replace that. The positive impact of new technologies should integrate into existing processes, which will ensure that broker businesses are not left out of the many networks that today rely on their expertise. The human factor was and always will be the natural winning element that leads the customer to choose one broker over another. By using the cloud and blockchain, broking companies can analyze data and improve their processes going forward by finding the optimal solution for the next client by running a few scenarios they had in the past (Viljanski, 2015). It also provides brokers with the edge when it comes to negotiation. There is a tremendous amount of inefficiency that we see in different industries where there are multiple intermediaries, and there is a lot of manual intervention and dependencies (Shen, 2013). To have something that one can work in real-time will bring risk-reduction and cost-reduction across the board. This process will inevitably improve operational performance.

A good example is smart contracts which provide the capability to convey logic into those inefficiencies. We have already seen the invention and early adaption of smart containers. With the help of smart containers, shipbrokers can anticipate any potential supply shortage on a global scale and provide solutions by reaching out to other prospective cargo owners to arrange a new transaction to fill the supply shortage. This means that actually, the current landscape provides an opportunity for brokers to not only intermediate but also to initiate trades (Sozen, 2010). In a sense, it shifts the current vertical business model into a horizontal one, where brokers can take a more proactive role. This horizontal business model fits better in the complex world we live in, especially the ways in which we work are changing. We operate in a genuinely complex and ever-changing environment where adaptive precision is key. Such situations outpace a single leader's ability to predict, monitor, and control. Teamwork is a process of reevaluation, negotiation, and adjustment. Adam Smith's "invisible hand" of the market - the notion that order best arises not from the centralized design but through the decentralized interactivity of buyers and sellers – is an example of emergent intelligence and decentralization. It stands in direct contrast to what Alfred Chandler dubbed the "visible hand" of management – the reductive planning that has dominated most organizations for the past century. In Shipping, technology had outpaced the capacity of any individual practitioner to be on top of it all. Today we find ourselves in an equilibrium defined by constant disruption. The connectivity of trust and purpose imbues teams with an ability to solve problems that a single manager could never foresee – their solutions often emerge as the bottom-up result of interactions rather than from top-down orders.

Evolution indeed occurs when you build a model to suit your company and change it when circumstances demand. That is, companies have to be nimble (Dimitrakiev, 2018). The pandemic has altered how we view the traditional office. Any team has to think about how to adapt when people are at different locations. This is especially true for the shipbroking business. For a ship-broking company to scale successfully, teams and employees should be able to work together successfully. To achieve this, we need an environment where we have less administration and more expertise and responsibilities. Unnecessary volumes of admin work can often get in the way of potential and the capacity of teams of people (UNCTAD, 2019). An effective distributed workforce requires a range of internal collaboration tools (Dachev, 2017). An organization's external, consumer-facing communications tech needs to integrate with the internal-facing tools used around the more comprehensive organization (Technology in shipping). Today's cloud communications solutions integrate with the new office standards, Teams and Zoom, to promote a collaborative and informed workforce, wherever the individuals may be.

Counterparty management is not just a process that could be optimized (Stefanova, 2022). It requires years of work, knowledge, responsibility, reliability, and many more angles which could not be replicated by technological advancement. In most businesses, there is a process known as **KYC**, where brokers particularly excel in. All this information is stored in a central database. The existing model rests on a database held at a trusted institution or intermediary and relying on that institution or third party to protect and manage the database robustly and securely.

Furthermore, this information sits in old paper archives that have not been updated with the latest available information in many instances. This introduces areas of risks that have to be mitigated, such as information tampered with. With the implementation of Blockchain technology, the concept of counterparty due-diligence rests on the premise that it is a distributed universal database to coordinate complex multi-party processes. **KYC**, **AML** (anti-money laundering), and **ESG** score are just a few of the dimensions that define the eligibility of a specific counterparty. Blockchain technology is a database where we need the approval of multiple participants in the chain to approve any change, making this database hard to change and essentially immutable. This situation boosts database security and can make counterparty management a robust and transparent process, where brokers would have on-demand access to the most up-to-date information related to the supply and demand side.

5. Conclusion

Technological advancements are the new norm. They do not put at peril the shipbroking industry. On the contrary - they complement the broker's role by increasing efficiency, transparency and flow of information. Distributed databases and horizontal management models are prerequisites for organizations to retain agility in an uncertain future of changing expectations. Brokers can use these tools to better forecast and manage the day to day tasks at hand. The roles of digitalization in the Shipbroking business can be improving relationship management through optimization and efficacy. It also makes easier decision-making processes when broking can take less time and effort but yield similar or better results.

The evolution of technology and intelligent ports can only enhance the shipbroking business rather than put its survival at peril. Where others might see a disadvantage, the shipbroking industry must adapt and grasp the opportunity to become more efficient and provide better, tailored solutions to its clients. This shift to a platform business model where the horizontal structure is based on team-of-teams could only lead to increased efficiencies and transparency, where all the information is stored on a decentralized database on the back of blockchain technology. Therefore, the shipbroking business's sustainability in this fast-growing technological era is a matter of finding the best route and optimal solution that requires human expertise, which can be enhanced by using digital tools, the internet of things and technological advancements big-data analysis.

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Session

Social Aspect

Analysis on influencing factors of career choice of Chinese students majoring in the navigation based on discrete choice model

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Abstract: In view of the current situation that the onboard employment rate of navigation students in China is declining year by year, this paper constructs a discrete choice model to empirically study the influencing factors of navigation students' employment. By analyzing the survey data of students from the Department of Navigation Technology and Department of Marine Engineering of a maritime undergraduate college in Shanghai, the study found that the love for navigation, the expected high income after graduation and the family's support for their children's maritime career are the main factors to promote the employment of navigation students working on board, while the strong social capital of the family is the biggest resistance. Based on this, this paper puts forward several targeted suggestions to promote the high-quality and sustainable development of the crew.

***Keywords*:** Students majoring in the navigation; career choice; discrete choice model

1. Introduction

Currently, more than 80% of the world trade volume is transported by sea. As direct participants in the shipping industry, seafarers are not only an important factor in the continued development of the shipping industry, but also an important player in China's efforts to achieve the strategy of a strong transportation and maritime nation and the Belt and Road initiative. At the same time, the contribution of seafarers to the national economy cannot be underestimated. A study of British crew members shows that seafarers contribute more to economic growth than the general workforce of society, with a return on investment of 4.8 times (Shan, 2017).

However, the shortage of high-quality seafarers in China is restricting the development of China's shipping industry. According to the Ministry of Transport's development plan for China's seafarers, it is clear that the demand for seafarers will increase gradually in the next few years, but there are still various problems in the training and reserve of high-quality seafarers in China. According to the data of the National Collaborative Group for Employment of Graduates of Maritime Courses, the proportion of undergraduate graduates of maritime courses going to ships for employment has been decreasing year by year, from 66.4% in 2007 to 43.85% in 2017. This will directly affect the healthy and sustainable development of China's shipping industry and the construction of a strong transportation country. It is urgent to build a crew to meet the national strategic needs and adapt to China's shipping development. The above-mentioned situation has prompted this paper to consider what are the factors influencing the career choice behavior of maritime students? What factors play an important role in the choice of seafaring students to get on board for employment? How to promote the cultivation of high quality seafarers in the process of the National Maritime Power Strategy?

The research object of this paper is navigation students, including students from the Department of Navigation Technology and the Department of Engine Engineering. Although the literature has analyzed the factors affecting the employment of navigation students from different perspectives, most of them are qualitative in nature and are not combined with the latest national policies, navigation talent training theory and career choice theories. Based on this, this paper conducts an empirical analysis of the factors influencing the employment of navigation students working on board. Taking undergraduates of a maritime university in Shanghai with related majors as the research object, the paper uses a discrete choice model in combination with theories related to career choice to explore in depth the influencing factors of seafaring students' employment on board ships. The results show that motivation, environment and social capital factors were the main influencing factors on the career choice of the students, and the support of their families and their love for sailing could promote their choice to work on board. Finally, the significance of the research to the career development theory of marine talents and constructive suggestions for promoting quality crew development are discussed.

2. Theoretical analysis

The career choice of navigation students is not only related to their personal situation, but also closely related to external environmental factors such as social development. Therefore, combined with the relevant career choice theory, this paper roughly divides the influencing factors of navigation graduates' employment on board into internal factors and external factors.

2.1. Internal factors

2.1.1. Motivational factor

Motivation factors are mainly divided into intrinsic motivation and extrinsic motivation. Intrinsic motivation includes the degree of love for the profession. Many students fill in navigation majors because they love navigation related occupations in the college entrance examination. Extrinsic motivation mainly includes salary and honor, and these rewards are also considered to be the most effective way to motivate and attract crew (Pauksztat, 2017).In recent years, with the continuous development of the economy, the salary gap between sea and land has decreased year by year, and the work of seafarers has lost its original attraction (Sulpice, 2011).Taking the deck officers of dry bulk carriers as an example, the wages of the master and the chief officer are quite different from those of the second officer and the third officer, and the former is three to four times that of the latter. According to statistics released by the National Bureau of statistics of the People's Republic of China(NBSPRC),the national average monthly wage for non-private sector employees was US$983 in 2017, while the salary of a new third officer is typically around US$1,000, almost the same as the wage of a non-private sector employee. Most navigation graduates start as interns after boarding the ship. At this time, the salary is only \$300~\$500, which is significantly different from the salary of onshore occupations (Qi et al., 2018). In addition, the competition for promotion and promotion of navigation graduates is fierce, and the honors they can obtain in the short term are limited. Four years after graduation, the vast majority of navigation graduates still work as third officer or third engineer, while two years after graduation, the vast majority of graduates are still interns (Yao et al., 2020). Due to the above factors, navigation students with extrinsic motivation are more likely to choose land work and give up relevant marine work.

2.1.2. Environmental factor

Environmental factors are mainly divided into work environment and family environment. The working environment of seafarers is relatively special, which requires seafarers to carry out high-intensity work in a relatively closed environment. The biological clock disorder caused by temperature and regional time difference, the noise interference of ships (Wang et al., 2005) and the increased workload caused by frequent port calls (Smith et al., 2003) have a serious impact on the health status of crew members. At the same time, the shortage of crew and the streamlining of personnel have greatly increased the workload of crew. Ellis and Sampson (2013) found that only 23% of the crew were fully rested. In addition, crew members who have been away from their families and countries for a long time, with multi-ethnic and multi-cultural backgrounds, limited recreational activities (Carotenuto et al., 2012) and recent frequent pirate hijacking incidents have also caused great pressure on the mental health of crew members.

The dual pressure of physical and psychological causes navigation students to give up the opportunity to work on board and change to other occupations.

Family environmental factors play an important role in the career choice of college graduates. Because the efforts and hard work of engaging in the navigation profession after graduation are much higher than those of other professions, and there are few opportunities for family reunion, and the lack of family companionship for a long time will have a significant negative impact on the mental health of myself and her family (Ulven et al., 2007), most parents are opposed to their children's engaging in the navigation profession, which also makes the navigation students more inclined to engage in land occupation after graduation.

2.1.3. Human capital factor

The shipping industry has the characteristics of high internationalization. Therefore, the language requirements for crew members are high. They not only need to read and write a large number of English materials, but also need to have good English expression ability to facilitate the communication within ships and between ships. The shipping industry has been a high-risk industry since ancient times, which puts forward high requirements for the operation technology of the crew. At present, China national maritime authorities have great difficulty in the crew examination, and the examination questions are relatively uncommon (He, 2017), which leads to some navigation students unable to successfully pass the crew examination, so students with high human capital are more likely to meet the requirements of boarding and employment. However, navigation students with high human capital face greater opportunity cost when choosing a career. Compared with working on board, it is more likely to prefer land sunrise industry.

2.1.4. Social capital factor

Family social capital has a significant impact on the graduation destination of children (Wen, 2005). The relatives of navigation students have been or are engaged in work related to the shipping industry, which will not only make them have more social relations in the shipping industry, but also increase the navigation students' understanding of navigation, which will help to solve the problem of "information asymmetry" in the labor market. In addition, parents' education level and family income have different effects on their children's first job (Zheng, 2004).

2.1.5. Perceived factor of industry environment

Since the global financial crisis in 2008, the shipping market has been in a continuous downturn. The excess capacity of the global shipping industry and the intensification of market competition have made many shipping companies lose money and get into trouble for years. In this regard, many people sing down the prospect of the shipping industry and believe that the shipping industry is a sunset industry and does not have development potential. The influence of external factors on career choice mainly depends on the evaluation and perception of this factor (Vondracek, Lerner & Schulenberg, 1986). Therefore, navigation students will repeatedly evaluate whether the current shipping industry can give them enough development opportunities when choosing a career. As the navigation students do not have an in-depth understanding of the shipping industry, they will be affected by the overall evaluation of the industry by public opinion when choosing a job, and carefully consider whether to choose to work on board. If they believe that the future of the shipping industry is deteriorating, they will evaluate whether their career choice can meet their expectations and then choose to work on board or switch to other industries.

2.2. External factors

2.2.1. Professional prestige factor

Sánchez-Beaskoetxea and Coca García(2015) found that seafarers are viewed negatively by the public as most marine accidents and pollution are attributed to negligence and operational errors by seafarers. According to the professional reputation questionnaire issued by the Chinese Academy of Social Sciences in 2010, the social reputation of crew ranked 68th, behind sanitation workers and farmers. This has led many navigation students to choose jobs with higher social prestige and give up the opportunity to become seafarers.

2.2.2. Economic development factor

When the material is scarce and the level of economic development is low, crew members are sought after because of their better salary. With the continuous development of economy, the wage gap between sea and land has gradually narrowed, and the family concept has become stronger. At this time, the disadvantage of becoming a crew has become increasingly prominent, which also makes many navigation students no longer choose to work on board.

2.2.3. Navigation Education Investment Factor

Compared with teaching in other majors, sailing education highlights students' practical ability, which makes investment in sailing education particularly important. In 2004, the average annual teaching cost for students majoring in navigation in my country was about 18,000 yuan, while the average annual government funding for students majoring in navigation was less than 10,000 yuan (Wang et al., 2005).The shortage of funds for sailing education still exists. In addition, a large part of domestic sailing colleges do not have the conditions to develop sailing practice (Xu et al., 2019). These factors lead to the fact that the current maritime education cannot meet the requirements of shipping enterprises for maritime talents, which in turn affects the work ability and international competitiveness of maritime students, which makes them more inclined to work on land when choosing a career.

3. Methodology

3.1. Data sources and descriptions

3.1.1. Data sources

The research data in this paper comes from a questionnaire survey of students from the Department of Navigation Technology and the Department of Marine Engineering in a maritime undergraduate college in Shanghai. This paper uses a combination of electronic questionnaires and offline questionnaires to investigate the first-year to fourth-year undergraduates majoring in navigation technology and marine engineering in this school from April to May 2021, and a total of 242 valid samples were received. There are 84 first-year students, 93 second-year students, 25 third-year students, and 40 fourth-year students. Among them, 76 students (accounting for 31.4%) chose to work on board after graduation. This result is consistent with the previous survey on the career choices of navigation students in undergraduate colleges (Qi et al., 2018). The sample data of this study were mainly male, with a total of 214 people (88.4%).

3.1.2. Variable

(1) Navigation students choose to work on board(onboard)

The questionnaire designed a question to ask navigation students whether they are willing to choose to work on board after graduation. The specific question is "According to your current wishes, what kind of work do you want to engage in after graduation?" (1 = prepare to work on board, 2 = prepare to apply for postgraduate or civil servant, 3 = prepare to study abroad, 4 = prepare to work on land, 5 = prepare to start their own business). Based on the research purpose of this paper, we divide the career choice of navigation students at graduation into choosing to work on board and other aspects. If the student chooses to work on board, onboard is 1, otherwise it is 0.

(2) Motivation-related variables (love, salary, honor)

In this paper, a five-point scale (1 = very small, 5 = very large) is used to express the influence of motivation factors on the decision of navigation students to work on board, and the motivation factors are divided into intrinsic motivation and extrinsic motivation. The intrinsic motivation mainly includes the love for navigation. The corresponding question in the questionnaire is "Do you like navigation?". Extrinsic motivation mainly includes salary and honor. The questions in the questionnaire are "What is your expected salary after graduation?" and "Do seafarers have room for promotion?".

(3) Environment-related variables (danger, challenge, support)

The paper divides environmental factors into work environment and family environment. The working environment mainly includes the navigation students' cognition of seafarers' working environment. The corresponding question in the questionnaire is "Do you agree that seafarers are a high-risk occupation?" and "Is the work of seafarers challenging?". The family environment mainly includes the degree of support of family members for navigation students to work on board. The corresponding question in the questionnaire is "What attitude do family members hold towards your work on board?".

(4) Human capital related variables (prize, English, certificate)

This paper describes students' human capital from the perspectives of school performance reward, English and certificate. Among them, the school performance reward is defined as whether the student has won a scholarship so far. If he has won a scholarship, prize is 1, otherwise it is 0; English proficiency is defined as whether students have obtained corresponding English certificates so far. If they have obtained CET-6 certificate, English is taken as 1; If CET-4 certificate is obtained, English takes 2; If you have never obtained the corresponding certificate, take 3 for English; Navigation level is defined as whether students have obtained relevant certificates of crew members so far. If they have obtained all certificates, certificate is taken as 1; If some certificates are obtained, certificate takes 2; If the corresponding certificate has never been obtained, certificate takes 3.

(5) Social capital related variables (education, income, shipping)

This paper describes the social capital of students from the perspectives of father's education, family income and whether relatives have working experience in the shipping industry. Among them, the father's education level is divided into 7 grades, namely primary school, junior high school, technical secondary school, high school, junior college, undergraduate and postgraduate (including master and doctoral students), and they are assigned in turn; the annual family income is divided into 7 grades, respectively Below 10,000 yuan, 10,000 to 30,000 yuan, 30,000 to 80,000 yuan, 80,000 to 150,000 yuan, 150,000 to 300,000 yuan, 300,000 to 1,000,000 yuan, and 1,000,000 yuan above, and assign values to them in turn. Whether relatives have work experience in the shipping industry corresponds to the question in the questionnaire "Has any relatives ever (or are) working in the shipping industry?".

(6) Perceived variables of industry environment (future, recognition)

The questionnaire asks respondents to answer whether they agree with the judgment on the industry environment (1 = very disagree, 5 = very agree), including the judgment on the future of the shipping industry and the public's recognition of engaging in the shipping industry. The corresponding question in the questionnaire is "Do you agree that the shipping industry is a sunset industry?" and "Do you agree that the public has a high degree of recognition for engaging in the shipping industry?".

This paper also includes variables of student demographic characteristics, including major, gender, grade, whether it is an only child, and the place of origin.

3.2. Model

Since the explaned variable, navigation students' choice to work on board, is a dummy variable, this paper uses the discrete choice model to analyze the influencing factors of navigation students' choice of work on board. Our model to be estimated is specified as follows:

$$\begin{aligned}\mathrm{onboard} = {} & \alpha_0 + \alpha_1\mathrm{love} + \alpha_2\mathrm{salary} + \alpha_3\mathrm{honour} + \alpha_4\mathrm{danger} + \alpha_5\mathrm{challenge} + \alpha_6\mathrm{support} + \alpha_7\mathrm{prize} \\ & + \alpha_8\mathrm{english} + \alpha_9\mathrm{certificate} + \alpha_{10}\mathrm{education} + \alpha_{11}\mathrm{income} + \alpha_{12}\mathrm{shipping} + \alpha_{13}\mathrm{future} \\ & + \alpha_{14}\mathrm{recognotion} + \sum \mathrm{X} + \varepsilon \qquad (1)\end{aligned}$$

where X represents a series of student demographic characteristic variables of navigation students, ε is a random error term. The dependent variable in this paper is a dummy variable, which needs to be estimated by logit model or probit model.

4. Results and discussion

4.1. Descriptive analysis

In this paper, the data is divided into two groups for descriptive statistics according to whether navigation students choose to work on board or not, in order to compare the characteristic differences between the two types of students.

As shown in Table 1, about 30% of navigation students hope to work on board after graduation. Column (1) and column (2) give descriptive statistics of the samples of choosing to work on board and not choosing to work on board respectively, and column (3) shows the difference between the two mentioned above. Through simple comparison, we can get some preliminary understanding. First, students who choose to work on board have stronger internal and external motivation. Second, among environmental factors, family environment is the main factor affecting students' work on board, while working environment is not the decisive factor. Third, strong social capital has a negative impact on students' choice to work on board. Fourth, the perception of the overall environment of the shipping industry has a significant impact on students' choice of boarding work.Next, this paper further analyzes the influencing factors through the econometric model.

Table 1Descriptive statistics

	Not selected to work on board (1)				Choose to work on board (2)				Diff:(1)-(2) (3)
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	
love	2.909	0.879	1	5	3.750	0.834	1	5	-0.840***
salary	2.843	1.100	1	4	3.579	0.853	1	4	-0.736***
honour	2.952	1.014	1	5	3.565	1.050	1	5	-0.614***
danger	3.771	0.944	1	5	3.605	0.924	1	5	0.166
challenge	3.783	0.947	1	5	3.986	0.945	1	5	-0.204
support	2.608	0.865	1	5	3.328	1.100	1	5	-0.721***
prize	0.343	0.476	0	1	0.329	0.473	0	1	0.014
english	2.301	0.766	1	3	2.566	0.639	1	3	-0.265***
certificate	1.952	0.667	1	3	1.763	0.690	1	3	0.189**
education	4.024	1.842	1	7	3.105	1.756	1	7	0.919***

continued Table 1

income	3.904	1.659	1	7	3.329	1.427	1	7	0.575***
shipping	0.133	0.340	0	1	0.078	0.271	0	1	0.054
future	2.939	1.110	1	5	2.421	1.146	1	5	0.519***
recognition	3.090	1.037	1	5	3.381	1.177	1	5	-0.291*
Observations	166				76				

Notes: ***, **, * denote the significance at 1%,5% and 10%, respectively.

4.2. Regression results

The regression results are shown in Table 2. From the perspective of motivation factors, the love of navigation students for navigation significantly promotes their willingness to go on board, which shows that the internal motivation factor is an important factor driving navigation students to go on board. The expected income after graduation is significantly positive at the 1% confidence level, indicating that the higher the expected income of navigation students after graduation, the more likely they are to work on board, which is contrary to the expectation. The possible reason for the above situation is that although the salary during the internship period is much lower than that of the onshore occupation, the internship period is short, and the salary has increased significantly after the internship, which improves the enthusiasm of navigation students to work on board.

From the perspective of environmental factors, the coefficient before the risk and challenge of navigation is negative, but not significant, which shows that the risk and challenge of navigation are not the main factors affecting the boarding work of navigation students. The degree of support of family members significantly promotes the willingness of navigation students to work on board, which shows that compared with the difficulty of working on board, the care and support of family members for students is the main factor to promote their work on board.

From the perspective of human capital factors, whether to obtain scholarships, English level and navigation technology are not the main factors affecting navigation students' boarding work.

From the perspective of social capital, the higher the father's education and annual household income, the less willing his children are to go on board. This may be due to the fact that the higher the father's education and annual household income, the higher his human capital and the stronger social network he possesses, and the more job opportunities he can offer to his children, thus leading to an increase in the opportunity cost for the children to choose to work on board and reducing their motivation to work on board.

From the perspective of the perceived factors of the industry environment, students who think that the shipping industry is a sunset industry are less willing to work on board; It is considered that the public's high recognition of the shipping industry will promote the navigation students' willingness to work on board, which is consistent with the expectation, but it is not significant, indicating that the perception factor of the industry environment is not the main factor affecting the navigation students' work on board.

Table 2 Regression results

	(1)	(2)
VARIABLES	Onboard (probit model)	Onboard (logit model)
love	0.716*** (4.02)	1.203*** (3.44)
salary	0.421*** (3.64)	0.786*** (3.31)
honor	0.119 (0.89)	0.262 (0.97)
danger	-0.095 (-0.71)	-0.178 (-0.71)
challenge	-0.038 (-0.25)	-0.081 (-0.27)
support	0.317** (2.41)	0.569** (2.05)
prize	0.163 (0.62)	0.387 (0.75)
english	0.282 (1.43)	0.466 (1.23)
certificate	-0.079 (-0.41)	-0.178 (-0.51)
education	-0.147* (-1.86)	-0.247 (-1.50)
income	-0.158** (-2.17)	-0.279** (-2.11)

continued Table 2

shipping	0.065 (0.20)	0.138 (0.23)
future	-0.033 (-0.30)	-0.066 (-0.31)
recognition	-0.047 (-0.38)	-0.080 (-0.32)
constant	-5.629*** (-3.77)	-10.123*** (-3.18)
demographic variables	Yes	Yes
observations	242	242

Notes: ***, **, * denote the significance at 1%,5% and 10%, respectively.

5.Conclusions and policy implications

Combined with the analysis of the influencing factors of navigation students' career choice, this paper first expounds the significance of career development theory for navigation talents. In the process of career choice of navigation students, idealistic motivation rather than utilitarian motivation is the main driving force for such students to choose to work on board. In addition, choosing a career as a seafarer requires more care and support from family members. If the family has a strong social network and can provide employment opportunities, it will inhibit the willingness of sailing students to become seafarers. In addition, choosing a career as a seafarer requires more care and support from family members. If the family has a strong social network and can provide employment opportunities, it will inhibit the willingness of sailing students to become seafarers. This result is a mixed blessing for the cultivation of maritime talents and the shipping industry. On the one hand, engaging in shipping work requires the professionalism and enthusiasm of the employees, and the professional training has created a strong professionalism and familiarity with the industry for navigation students. With firm support and endogenous motivation, students are more willing to integrate into the construction of a shipping power. On the other hand, idealistic pursuits and endogenous factors are difficult to compete with objective factors. Subjective factors are very easy to change after students are employed. Factors such as marriage and future career planning will make crew work a short-term transitional occupation.

Therefore, this paper puts forward the following suggestions to promote the cultivation of high-quality crew members:

(1) Multi-channel training of high-quality crew. The government should formulate a more scientific enrollment plan for sailing majors, optimize the medical examination conditions for sailing majors, and encourage non-nautical college students to participate in seafarer vocational skills training. To train students through the school-enterprise combination model, schools should connect with high-quality resources from enterprises to promote the smooth employment of professionals. In addition, relevant departments can help fishermen and demobilized soldiers to work as merchant mariners through peer-to-peer recognition and remedial training.

(2) Strengthen the publicity of navigation characteristics. Universities, primary and secondary schools promote maritime culture through literature, film and television, music and art, encourage the construction of maritime culture and education bases in various places, and organize activities such as summer camps for maritime colleges and boat trips. The whole media used agenda setting to strengthen public opinion guidance, publicize navigation culture.

(3) Improve the protection of crew rights and interests and service support. The management department can innovatively drive the construction of a high-quality crew team with a system based on extensive solicitation of opinions. Promoting the internet technology service is an important logistical support for crew work, so crew members have the right to enjoy low-cost communication network services in the sea area. Under the leadership of the government, trade unions, and industry associations, various departments have linked many shipping companies to build a service platform for crew career development, and optimize service mechanisms such as rights protection,

welfare implementation, training and promotion. The whole society should promote the crew culture, so as to form a good social atmosphere that respects the crew's labor and cares about the growth of the crew, and enhances the social recognition and reputation of the crew.

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Leveraging a visible learning process in higher distance education: a case study in International Maritime Management, M.Sc.

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Abstract: The article promotes "Strengthening Lifelong Learning in MET through Innovative Methodologies Application" and advocates for its implementation with distance learning approaches. The maritime domain is changing but it is not only the workplace aboard ships itself that puts very high demands on ships' crews and fosters incompatibility with family life. The effect is particularly intensified when seafarers become lifelong learners and the workplace aboard also becomes a place of learning; special requirements for educational programmes result. Based on this, the case study of International Maritime Management from Jade University of Applied Sciences (Germany) is presented, with which the compatibility of these aspects succeeds, so that both potential for further improvement and especially transferability to other members of the International Association of Maritime Universities can be shown. Moreover, this approach is particularly promising because the effects of COVID-19 have hardly affected teaching and learning here. Overall, it is about to generalise findings to the wider settings of MET and research.

Keywords: maritime education and training, distance education, lifelong learning, nautical officers

1. Introduction

The international shipping business transports more than 80% of the global trade by volume (UNCTAD 2021). The Seafarer Workforce Report (BIMCO 2021) estimates "that 1.89 million seafarers currently serve the world merchant fleet, operating over 74,000 vessels around the globe." Furthermore, it warns of a shortfall of approximately 90,000 officers by 2026.

In the beginning, the shipping industry employed a largely unskilled, labour-intensive workforce, which over the years has experienced a massive transformation. The impact of decarbonisation and digitalisation will have a further impact not only on the shipping industry (Stopford 2022) but also on the demand and education of the global maritime workforce (Duru 2019). The same development applies to MET and research (IAMU 2019). We find, for example, an increasing number of universities which offer undergraduate as well as postgraduate maritime degree courses leading not only to a navigational certificate of competency (CoC) but also to a university degree. This also resembles one sub-theme of this conference: "Strengthening Lifelong Learning in MET Through Innovative Methodologies Application".

Besides, changing understandings of roles and values have an impact on the times seafarers (from First World countries) spend aboard ships. Sea times become shorter as people look for their move ashore. They strive to make the best use of their available time. With regard to one's own work and life planning, it is increasingly about time wealth, time sovereignty, downshifting and 'new work' (Bergmann 2019). Relevance in terms of job satisfaction, performance and commitment as well as the reduction of stress prevails. Furthermore, there are developments and social changes due to mega trends (especially globalisation, digitalisation and emancipation). Considering all this, the question of staying aboard or leaving the sea behind periodically or even permanently confronts seafarers (Albert et al. 2016). This leads to two different discussions: the need of 1) further education and lifelong learning (LLL) for seafarers for their future occupations in the company management ashore and 2) a new skill set for future seafarers aboard modern ships.

Even if both topics are very important for the shipping industry, the emphasis within this article lies on the former. Taking all above-mentioned aspects into account, employees in general but seafarers in particular have to strengthen their skills with regard to self-management, LLL as well as finding the right work-life-balance. Based on this, the following research questions are in focus: Why are seafarers interested in continuing their own (lifelong) learning? What gives them the stamina needed for successful part-time studies aboard seagoing ships and how can such a programme facilitate seafarers' needs? Which favourable, but also inhibiting factors result from an on-board learners' viewpoint?

To arrive at the answers, this article consists of four chapters. The introduction (chapter 1) includes the research objectives and research questions. Following on from that, related work and definitions of this study are briefly elucidated (chapter 2). Chapter 3 presents the case study of International Maritime Management (IMM), which includes, due to limited scope, the methodology, data collection, data analysis and discussion. The article ends with a summary and conclusion (chapter 4), which not only includes key learnings and further research needs but especially shows potential for transferability to other IAMU members.

2. Related Work and Definitions

2.1 Lifelong Learning

LLL is "an organizing principle or 'master plan' for a potentially new approach to teaching and learning" (Slowey & Schuetze 2012, p. 3). Thus, two basic ideas form the overall concept: People learn throughout their whole life and they do not only learn in formal educational institutions but also in the workplace and social environments. In line with that, the European Commission (2001) defines LLL as "*all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences within a personal, civic, social and/or employment-related perspective.*" (p. 9, emphasis in original) LLL is voluntary and self-motivated and thus not compulsory. Therefore, self-taught learning comes to the fore and we find different learning situations in terms of the dimensions of place, time, and degree of structure, intention, certification as well as learner-teacher relationship. All learning activities pursue to improve the personal development, gain new qualifications, and add new skills and so on. In the light of above-mentioned changes, it is not sufficient for the future to concentrate on a rigid concept. Instead, concepts are needed which enable people to acquire skillsets of self-competence, responsibility and autonomy over time in order to be able to cope with ambiguity, new situations as well as changing challenges and requirements (Richards 2020).

2.2 Distance Education versus Emergency Remote Teaching

People learn by attending different education programmes (on-campus and distance degree courses, for example). This article focuses on distance education, which is often defined as "institution-based, formal education where the learning group is separated, and where interactive telecommunications systems are used to connect learners, resources, and instructors." (Schlosser & Simonson 2010, p. 1) Albeit the focus is on distance education in this article, we assume, that study courses and learning programmes in general are well planned irrespective of their design (see above). However, within the recent two years we have seen that the impact on education of the COVID-19 pandemic has been tremendous (and continues to be). As a result, the appropriate term of Emergency Remote Teaching evolved in the wake of the global crisis in the first half of 2020 for ad-hoc solutions (Hodges et al. 2020). They summarise the situation as follows: "Faculty might feel like instructional MacGyvers, having to improvise quick solutions in less-than-ideal circumstances [… and] many instructors will understandably find this process stressful." (for this transition in the maritime context see Bartusevičienė et al. 2021) Further, in this context it is very important that "[w]ell-planned online learning experiences are meaningfully different from courses offered online in response to a crisis or disaster." (Hodges et al. 2020; for impact, experiences and measures taken by MET institutions see IAMU 2021; 2022).

3. Case Study: International Maritime Management

3.1 Methodology

In the following, the methodology of the case study as research method and the reasons for its choice are briefly given. According to Yin (2018, p. 16), "the twofold definition—covering the scope and features of a case study—shows how case study research comprises an all-encompassing mode of inquiry, with its own logic of design, data collection techniques, and specific approaches to data analysis." Moreover, a *good* case study should have the potential to, among others (Yin 2018; Atkins & Wallace 2012): provide new or unexpected insights, challenge assumptions, and propose tangible approaches of action to solve given challenges or open up new discussions for future research. The idea is, unlike quantitative or experimental research, not to make use of a random or representative sample but understand the case in-depth and shed light on a new or given problem. In line with that, the group of nautical officers as lifelong and distance learners will be discussed and a brief introduction of the IMM degree course including its didactic concept will be given. Then, quantitative and qualitative data is presented and results are discussed in order to gain new findings and knowledge.

3.2 Nautical Officers as Lifelong and Distance Learners

Nautical officers (from First World countries) usually spend a few years aboard seagoing vessels before striving for adequate employment opportunities ashore. In preparation for this step, they express an interest in postgraduate degree programmes that can be studied part-time and alongside work; face-to-face courses are not compatible with the requirements of their jobs (Nause et al. 2018): nautical officers are absent for long and irregular times, ships and their crews are located in different (and changing) time zones, Internet services are typically not available, although emails (without attachments) can usually be sent and received. Based on that, (deck) officers constitute a group of lifelong learners. They have already acquired not only a CoC but often a Bachelor's degree, too. Besides, they may have a family as well as other commitments and interests.

The definitions and discussions above are not only the rationale for this article, but they were also the trigger and starting point for the development of the IMM distance degree course in 2012. So far, graduates of Nautical Sciences undergraduate degree courses can continue their education with maritime postgraduate on-campus degree courses *or* start their career aboard. Since the introduction of IMM, they can start their career at sea and thus gain work experience, whilst *simultaneously* achieving a Master's degree by means of part-time studies. IMM is the first such course in Germany to support mariners in this way. Based on that, exemplary career paths of nautical officers are shown schematically in figure 1 taking seagoing service times (times for holidays are excluded) for certification according to Chapter II of the Annex to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW), into account:

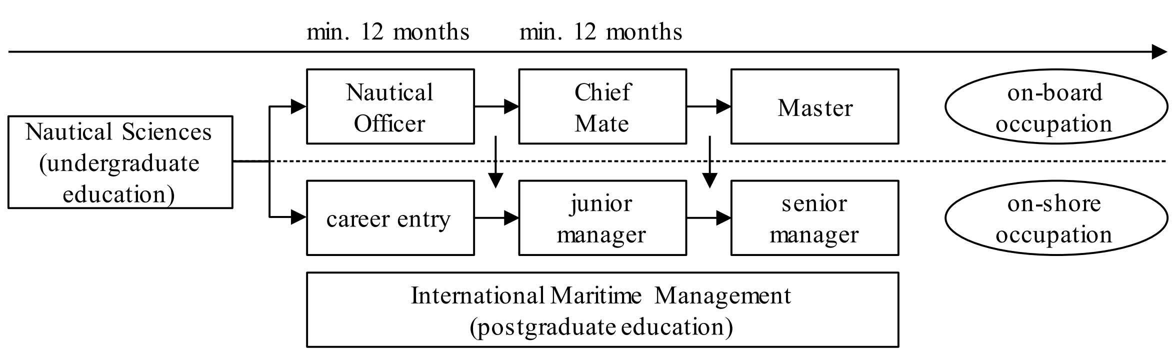

Figure 1. Exemplary career paths of nautical officers, source: Nause 2022, p. 47. (Note: the individual duration of the phases may vary. The figure does not reflect this.)

For the IMM programme and this article, respectively, two groups (out of seven; Slowey & Schuetze 2012) of lifelong learners are of importance. The first group are 'recurrent learners'. They return to the university in order to achieve a second (usually higher) academic degree and/or additional, diversified qualifications. In this context, nautical officers have acquired their CoC and Bachelor's degree and return to the university in order to achieve a Master's degree. The second group are 'refreshers'. They might have achieved a Bachelor's degree or even a Master's degree in the past but wish to renew and/or expand their knowledge at a university.

3.3 Didactic Concept

IMM caters for the unique requirements stated above. Therefore, a distance-learning concept applies, which is supplemented by a kick-off attendance phase; participation is strongly recommended but not mandatory. Therewith, the characteristics of the target group are in the foreground, which is of utmost importance (Means et al. 2014). The kick-off event takes place at the very beginning and serves for familiarisation purposes with the didactic concept, IT infrastructure and systems, getting to know each other, and networking, etc. This facilitates the students to start their studies as smoothly as possible. Furthermore, within the degree course different elements of flexibility apply (Li & Wong 2018). First, the course duration is flexible. The 90 credit points (according to the European Credit Transfer and Accumulation System; European Commission n.d.) degree course encompasses nine learning modules plus thesis which in total equals three semesters (1.5 years) full-time studies. As IMM students are studying alongside work, approximately five semesters (2.5 years) part-time studies is the average value. This flexible approach allows students to deviate upward and downward in such a way that it suits their individual situations. Moreover, students can set priorities in terms of content within the learning modules in a given setting (see below).

All learning modules have a uniform design in order to facilitate students' learning. At the very beginning of the learning modules, all relevant information is available. This includes the study text from the lecturers (*theoretical part*), further reading, self-assessment tasks and examination tasks. Therewith, students have the possibility to apply their individual practical questions and projects from their professional life, which they are interested in (*active part*). Alternatively, individual learning modules build on practical examples and business cases. This approach also enables people to study, even if they hide their studies from their employer or employers do not support students' studies for whatever reason, for example. With this approach, a theory-practice transfer becomes possible, whereby on the one hand the theory is implemented directly in the professional practice and on the other hand professional activities are reflected in a scientific manner which leads to mutual benefits. Throughout the semester, lecturers accompany students. Moreover, students exchange ideas with their peers and lecturers by means of forums (*communicative part*).

3.4 Data Collection, Data Analysis and Discussion

Within the two-year period of validation (September 2015 to September 2017), 213 test students participated in periods ranging from one to four semesters (Nause et al. 2018). 98 participants (46%) were actively participating and thus able to finish learning modules offered, eleven test students (5%) completed one or two learning modules and terminated their participation afterwards (dropouts), and 104 persons (49%) enrolled for the test phase but did not complete any learning module at all (non-starters). As per today, 221 ordinary students study or have studied IMM since its official start in September 2017: students (n = 112; 51%), graduates (n = 70; 32%), and dropouts (n = 39; 17%).

The student cohort consists of female (28%) and male (72%) students. IMM attracts not only German citizens, as 18% of the participants have a non-German background. International students are from Ireland, Spain, Poland, India and The United States of America, among others. In addition, students' backgrounds are heterogeneous: most of them started with a Bachelor's degree in Nautical Sciences (76%), which corresponds to the target group description. Alternatively, they have achieved a first university degree in Maritime Logistics (12%) or other areas (12%). Almost half of the students with a degree in Nautical Sciences (45%) work aboard ships, 14% of them with the rank of a Master.

The first author of this article is the co-ordinator of the IMM degree course. Therefore, this case study refers to pedagogical principles, day-to-day practice, evaluation results and conversation with both, students and lecturers. Based on that, this paragraph will discuss the most important aspects. Single aspects of this paragraph are discussed in more detail elsewhere (Nause 2022).

Experiences show that the compatibility and interaction between the different life domains (especially professional activities, further education, family and leisure) represent a (*the*) central challenge in terms of part-time studies in general and for seafarers in particular. This aspect is especially important because very long work-intensive phases aboard alternate with vacation phases ashore. Work at sea or family and friends as well as leisure time at home have the highest priority, followed by personal time and studies (in descending order). Observations and interviews show that learners' motivation (learning outcome/extrinsic versus learning process/intrinsic) differs, but has a major impact on balancing the different activities and stamina needed for successful completion of part-time studies. This aspect is particularly important because of individual time expenditure and time management (activities of the different life domains compete with each other). Moreover, the understanding of roles within the family plays a greater role today than in recent times. In addition, learners may have achieved their first university degree a few years ago, thus the aspect of learning to learn is of utmost importance. This is especially important because distance learning (besides other duties and interests) puts much higher demands on the learners in terms of responsibility and autonomy compared to the very structured undergraduate studies of Nautical Sciences, which go back to STCW requirements. Thus, a necessity is attendees' ability and willingness to change from knowledge consumers to active learners. In particular, data shows that students can work on the learning modules in parallel to their private and professional activities, although writing the Master's thesis proves to be a particular difficulty and regularly leads to an interruption (one or more vacation semester(s)), which accompanies an extension of the study period.

Besides, stress plays a decisive role, even if situations aboard differ greatly depending on the individual rank, shipping market, trade, ship, etc. Students also report that coincidences could facilitate or complicate the individual situation further (e.g. port-sea-ratio). As well, the individual perception of stress by people is different, too. Therefore, (preferred) segmentation and very high integration may be conceived as two ends of a continuum along which peoples' strategies lie in terms of boundary management (Ashforth et al. 2000). Further, seafarers describe their job and life on ships as a recurring routine and monotony. Simultaneously, the sea itself and all its unpredictability are always a constant concern. Thus, nautical officers may see learning activities as useful leisure time, positive distraction as well as a good possibility to break out of their everyday life at sea or to spend parts of their free vacation time as a 'meaningful leisure activity' at home.

4. Summary and Conclusion

Key findings are subsequently interpreted in the conceptual context and critically appraised, which also includes an outlook and future research areas. Moreover, knowledge gained from the data given is also presented, which aims at putting forward ideas and questions for further improvement not only for the IMM programme, but in particular for MET and research in general, including transferability to other IAMU members.

The overall experience is that IMM is crisis proven. There was no need for Emergency Remote Teaching activities in this degree course according to the COVID-19 pandemic. Pandemic-related consequences hardly affected IMM contrary to most other degree courses of Jade University and most universities in Germany or even around the globe. Jade University has been subject to restrictions and therefore it was not possible to carry out the attendance phases in person but rather by means of video conferences instead; participation in person at the kick-off event (voluntary but recommended) and three learning modules (mandatory) was planned. Therewith, IMM serves as an example of good practice in this regard and we see further development in combining the pros of both worlds (on-campus and distance learning designs) for different purposes in the future. Experience shows that face-to-face participation is dispensable and the acceptance of new(er) forms of teaching and learning including examination/assessment has increased, as there are fewer concerns from the teaching body; this is particularly noteworthy because resistance to change and a wait-and-see attitude usually characterise this topic. In other words, for educators, the COVID-19 pandemic has rapidly opened new questions and developed new perspectives. Suddenly, lecturers have experienced a steep learning curve while they implemented all sorts of digital tools and materials in their everyday work. In the light of the ongoing reaccreditation process in line with German regulations, this forced experience has proved to be an opportunity for and driver of innovation: IMM does not include mandatory attendance anymore in terms of examination, which has increased its overall flexibility for the entire student group and made it more attractive from an international students' angle. Moreover, experience can be transferred to on-board trainings and to (on-campus) degree courses, e.g. in times of lecturer absences for whatever reason or the use of flipped classroom settings. Besides, it is increasingly important that (future) graduates are able to organise and conduct video conferences.

In conclusion, it is time to implement some innovations in MET: 1) besides offering full Master's degree courses, it is necessary to also offer parts of it as short courses with a postgraduate diploma or postgraduate certificate upon completion. This especially serves the needs of 'refreshers' in the context of LLL who cannot or do not want to study a full degree course for various reasons but wish to renew their knowledge in a special field of interest. 2) Further strengthen the role of women in the maritime industry in line with social change but also in order to meet the training needs of the onshore and offshore labour market. 3) Develop education programmes in the context of LLL aiming to further educate and promote seafarers from ratings to officers in order to keep up with technical and technological developments as well as the predicted labour shortage. 4) Some students write their Master's theses in collaboration with other companies than their employers. This is a way of looking for and getting to know a potential new employer, but often constitutes the starting point for the step ashore. Further studies of career paths taken in shipping may reveal further knowledge and bear potential for the maritime workforce. 5) The virus that causes COVID-19 is changing, among other things, teaching and learning apace. Hence, we should think of flexible learning strategies for MET and keep them for the future. 6) Concentrate on actions to bring the unchangeable characteristics of occupations at sea in line with today's requirements in order to secure a skilled labour-force on board and on shore in the long term. 7) Determine and consider the view of companies with regard to LLL in the field of tension between a shortage of workers ('war for talents') and an increasing demand on employees, e.g. they have to do more work.

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Preliminary results of the identification of entrants' approach towards maritime career

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Abstract: In a perspective of diminishing attractiveness of a career at sea and the continued growth of the fleet, the aspect of promoting employment at sea among young people, is in the spotlight. The 2010 International Convention on Standards of Training, Certification and Watchkeeping (STCW) Convention encourages the international community to promote sea-going employment among young people, especially women. With tens of thousands' shortage in the number of qualified officers, the future of industry responsible for as much as 90% of global trade is at stake. Various solutions are proposed, including attractive cadet trainee programs, to encourage young people to work at sea and pursue their careers over the years. However, it remains unclear what are the main thoughts of the entrants while enrolling in a maritime education and training (MET) institution and how they change in the first years of education. To investigate this issue, a study has been performed on the newly-enrolled Navigation students of the Gdynia Maritime University by paper-based questionnaires distributed to them on one of their first courses at the University. Students complete a similar questionnaire again on one of the last courses, just before graduating from the university. At this point, they already have their first seagoing experience. The herein paper presents the initial results of the study which we intend to continue and possibly expand. Different aspects of entrants' attitude towards their career development like motivation to join the fleet have been investigated.
The results of this study may prove valuable in determining future seafarers employment and retention policy-making recommendations aimed at attracting new entrants and retaining them in a number sufficient to sustain the operations of maritime transportation. Additionally, identifying the social aspects of further seafarers can be important in relation to the prospective implementation of Maritime Autonomous Surface Ships. Future research directions include expanding the study involving cadets from other universities and departments (like Marine Engineering). Performing such cross-national study would be a good opportunity to also strengthen inter-MET cooperation and create a global framework for attracting new entrants.

Keywords: maritime education, maritime training, seafarers, employment policy, maritime transportation

1. Introduction

Shipping is responsible for the flow of commodities on a global scale [1]. As every industry, people are its central part - and only those designing and constructing ships, handling cargoes in ports and managing the process. The most critical workforce are the seafarers, without whom the ships would be nothing more than dead steel structures floating in the water. Even with postulated attempts to reduce the crews down to zero and implement autonomous or even crewless merchant vessels [2], the human element in maritime operations will not be eliminated. As a matter of fact, the employment gap in the number of qualified seafarers and officers is estimated as thousands of people [3], but it has also been argued that this may be an effect of a structural mismatch [4].

Nevertheless, it remains a fact that the shipping industry requires a constant flow of a new workforce to sustain itself. This workforce is a product of Maritime Education and Training (MET) institutions, which are run by private and public entities specifically to train young seafarers and increase the qualifications of those who already have a sea-going experience. From the global perspective however, it is the entrants that should be in focus, which has also been reflected in the Resolution 12 of 2010 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [5]. Therein, a number of actions are recommended to attract young people in the shipping industry.

To this day however, to the authors' best knowledge, no comprehensive, long-term study has been performed to investigate the motivation of young people to join the [merchant] navy, see the world, and how these change upon their first contact with the sea. Although it has been postulated in 2015 [6], the contemporary scientific literature still lacks the research on the attitude of entrants to their future profession. Some attempts have been made in this respect, but were rather isolated and focusing on different, selected aspects of the issue [7–12]. With our research, we intend to bridge this gap by approaching it in a long-term, comprehensive study on the cadets of Gdynia Maritime University.

The purpose of this survey is to support the ongoing discussion of seafaring aspirations and maritime profession perceptions by answering the following research questions (RQs):

RQ1: How is the perception of the seafaring profession changing in the first years of education?

RQ2: How long did the entrants initially plan to work after graduation and how did it change after completing the cadetship period?

RQ3: Can certain recommendations be made based on the above conclusions in order to maintain adequate motivation to continue working in the seafarer profession after graduation?

For this purpose, a four-year comparative study in the group of newly admitted students and after three years, shortly before graduating - after completing the maritime internship were carried out. The students participating in the study are from the Gdynia Maritime University, one of the three tertiary-education METs in Poland.

The herein paper is structured as follows. Section 2 introduces the process of data collection. Section 3 presents the results of the survey, which are then discussed in Section 4 along with formulation of policy recommendations and listing known limitations of the study. Final Section concludes the paper.

2. Materials and methods

The research aimed at identifying the motivations, fears and perspectives of the perception of the seafaring profession among newly recruited students was initiated by authors in 2015 at the Gdynia Maritime University in Poland. For this purpose, a questionnaire was prepared, which students filled in during one of the first classes. These studies are continued in an unchanged form so as to ensure a long perspective.

A group of students subjected to the first study in 2015 was again asked to fill out a similar questionnaire shortly before graduation in order to identify changes in their perception of the seafaring profession. This was in 2019, after some three years of a theoretical education at the University and at least a single contract as a cadet on a commercial sea-going ship. The last courses in the University are organized in small groups of maximum twelve participants, which makes it difficult to carry out this questionnaire among a large group of students. The same research was carried out in the group of students in subsequent years, which allowed for the comparison of these changes in the continuous period of four years 2019-2022.

Again, as in the initial questionnaire carried out by the new entrants four years earlier, cadets were asked to provide answers regarding their motivations, hopes, expectations and fears related to their chosen seafarer profession. The questionnaire questions were prepared in various forms. They included both open and closed questions, some of them based on expressing opinions through a 9-level Likert scale. In the herein paper, we only present the most relevant and interesting findings.

3. Results

By introducing an additional exit-questionnaire to the research that has been carried out already for seven years in total, the following issues were selected for the purposes of this article. Firstly, a comparison of how the perception of the seafaring profession changed in subsequent 2019-2022 years before starting education and just before graduating from the university, results of which are given in Section 3.1. Then, it was verified how long they initially (when entering the University) planned to work in seafarer profession after graduation and how it changed after completing the three years education and cadetship period, on which Section 3.2. elaborates.

3.1. Change in the perception of the seafaring profession

In the entry questionnaire, students mostly perceived jobs in the seafarer profession as well-paid and interesting. This perspective has not changed significantly over three years of education and the first experience with the future profession during on-board practice. In the exit questionnaire, these are also the perspectives with which the students agreed most. There has only been a slight change in the form of more of the strongest positive answers (completely agree). This change is presented in Figure 2

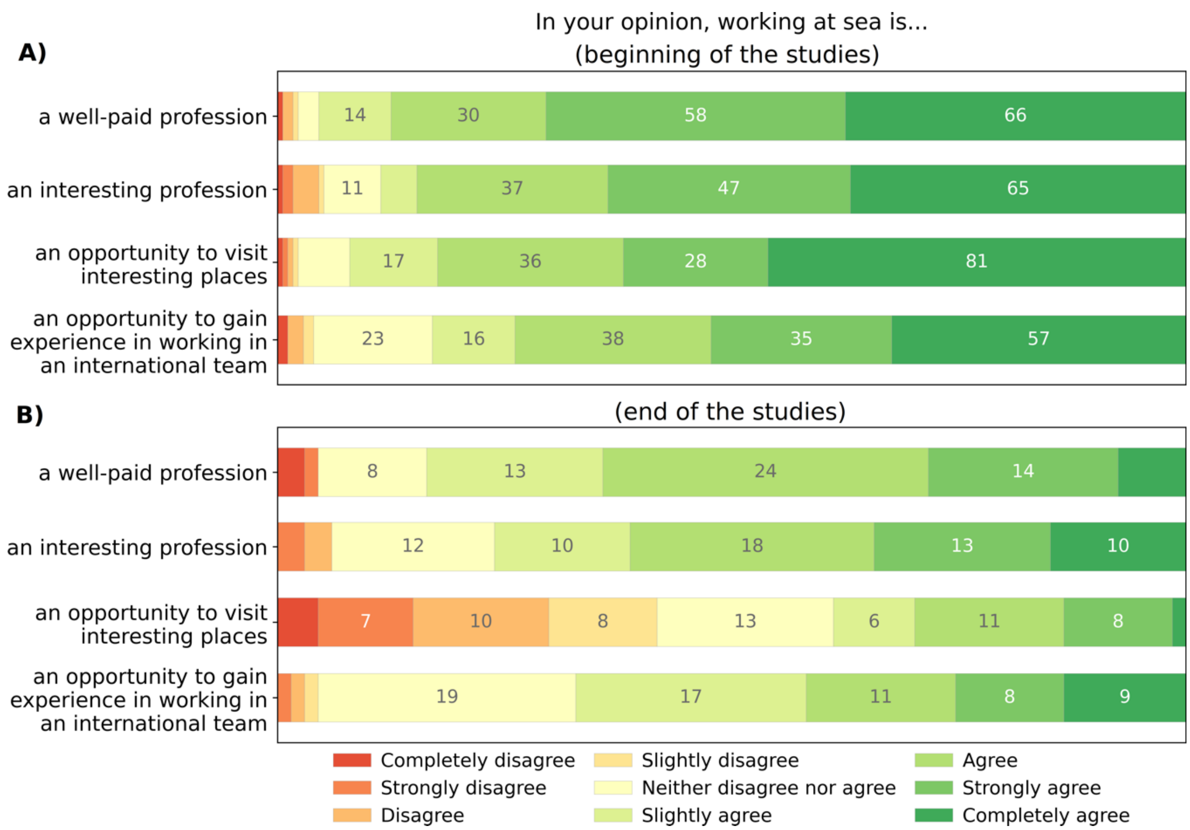

Figure 1. Change in the perception of the seafaring as a profession before and after first experience of working on board the vessel

On the other hand, there has been a significant change with regard to the perception of seafaring as an opportunity to visit interesting places. While in the entry questionnaire it was an option with which the students agreed most right after a well-paid and interesting profession, in the exit questionnaire, the students do not agree on this fact anymore. This perception could have been significantly influenced by the COVID-19 pandemic causing travel restrictions which have been referred to as a humanitarian crisis [13]. However, already in 2018 and 2019 it was observed that students who returned from their first cadet trip do not notice that the seafarer's profession will allow them to visit interesting places in the way they thought before starting their studies.

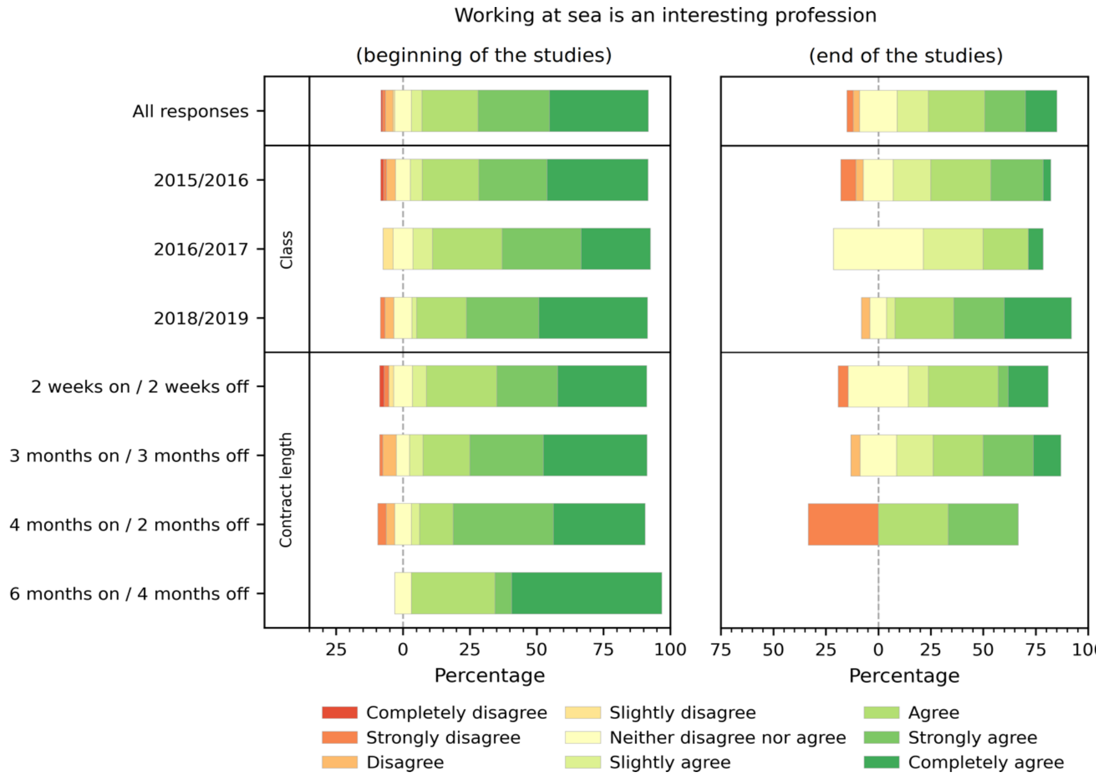

Figure 2. Change in perception of seafaring

With regard to the work regime, it can be noted that in the exit survey the entrants declared shorter duration of the contracts than during questionnaires filled at the beginning of the studies. This can result from a change of their perception caused by sea-going practice and onboard experience gained during the studies.

3.2. Plan to work as a seaman

Another aspect of which changes could be observed after the three-year period of education at the university and completed cadetship period on board the vessel is the assumed period of professional activity after graduation. In 2019 and each subsequent year, a significant change can be observed when comparing the expected career length declared in the entry and exit questionnaires. What is more, there is also an increase in the number of people who declare that they would not work at all in the seafarer profession after graduation, as depicted in Figure 3.

4. Discussion

The obtained results are discussed in Section 4.1. The consecutive Section 4.2. formulates recommendations based on them in order to maintain adequate motivation to continue working in the seafarer profession after graduation, while Section 4.3. discusses limitations and uncertainties related to the performed study.

4.1. Findings

The obtained results showed a significant change in the perspective of seafarer profession upon starting maritime education and before graduating from the MET (RQ1). The seafarer profession among the students surveyed in the second questionnaire is still considered well-paid and interesting, but not to the extent that they assessed it in the entry questionnaire. The reason for this change may be the lack of reliable information about the future profession before starting university education, as well as the first experience gained from the on-board practice. It may simply be that the perception of the occupation does not match the reality, at least from the cadet's viewpoint as an entry-level, low-salaried, and inexperienced worker.

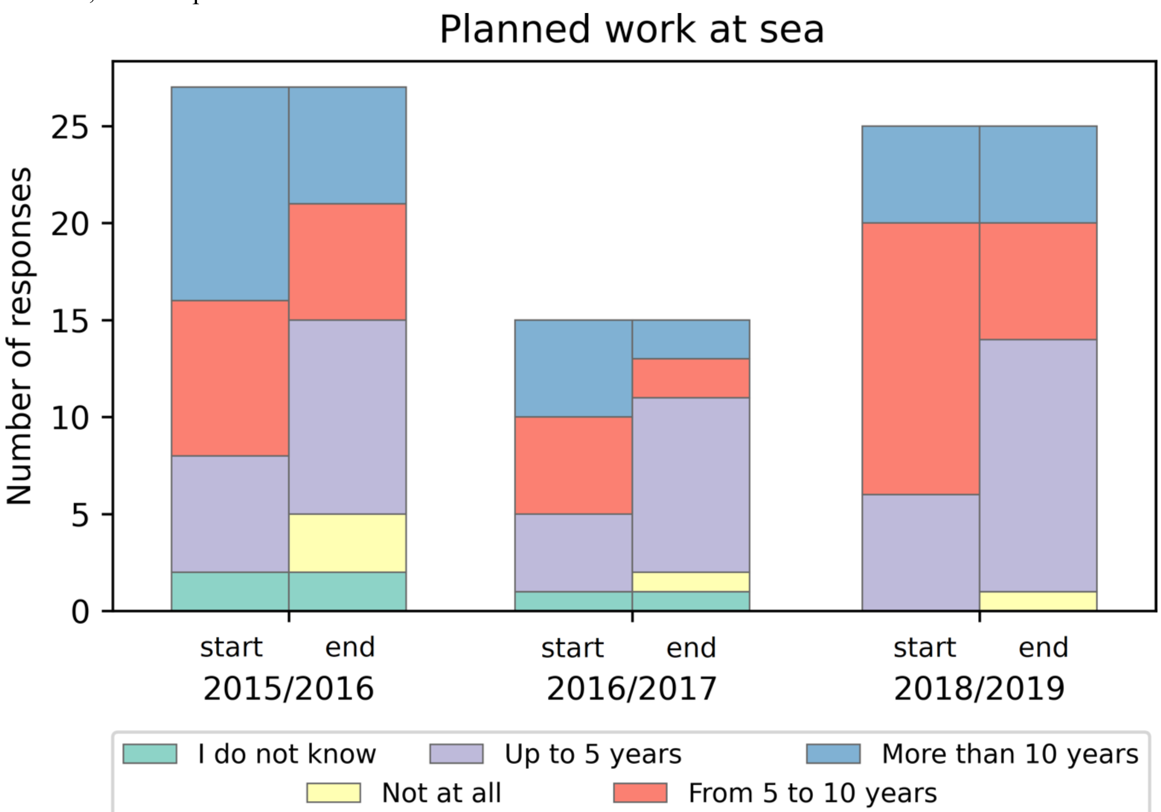

Figure 3. Change in assumed and actual plan to work as a seaman

Significant changes were also observed with regard to the assumed time of professional activity after graduation (RQ2). A large group of the new entrants who did not yet have experience in the seafarer profession assumed in the surveys that they would work in the profession for up to ten years or even more. For a group of cadets after their first years of education and on-board practice, subjected to an exit survey, these responses are rare. The largest group of people declares their willingness to work in the profession for up to ten years.

4.2. Recommendations

Based on the presented and discussed results, certain recommendations can be drafted (RQ3). The ultimate goal of these is attracting new entrants and maintaining an adequate level of cadets motivation to continue working in the seafarer profession after graduation. The maritime administrations, crewing companies, and METs shall therefore consider the following.

Consider increasing efforts to genuinely familiarize new entrants with all possible aspects related to the future profession. It is possible to achieve this by organizing additional seminars and meetings of cadets with people actively working in seaman's profession;

Improve the on-boarding process of entrants to make their first trip on a commercial vessel an introduction to the hardship of life at sea, but not a traumatizing experience. If it is the latter, these persons who might have been passionate and excited about their future job may simply walk out and never go back;

Carry out a more comprehensive survey on an international scale investigating cadet's perceptions and attitudes and how they change across their career span.

4.3. Limitations

The main limitation of the study concerns an unequal number of the respondents during initial and exit surveys. These inequalities may affect the results of the study, especially when a particular class or group is analyzed, but should not impact the general trends among the entrants. Therefore, the results presented as a share of the responses rather than number of answers should properly reflect the entrants' attitude and tendencies concerning their seagoing career.

5. Conclusions

The objective of the performed study was to investigate how the students' perspective of seafarer profession and career changed during their first years of education including their first seagoing cadetship period. To this end, 67 deck department cadets were questioned, members of four classes enrolling to Gdynia Maritime University. The survey is planned to be continued in the subsequent years.

The obtained results indicate that the perception of the seafarer profession and the planned length of the future professional career differ significantly from the initial assumptions of the new entrants. Therefore, it is necessary to take appropriate measures to maintain an adequate level of motivation to continue working in the seafarer profession after graduation and enable them to become familiar with the various aspects of maritime work as early as possible. This can be achieved by implementing recommendations that will be drawn up on the basis of research carried out on a wider group of MET participants from other universities at all stages of their education and at the beginning of their professional career.

Acknowledgement

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A Ranking of Critical Competencies for Future Seafarers in the Scope of Digital Transformation

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Abstract: The effects of Industry 4.0, which caused a paradigm shift in many industries in the light of digital transformation and autonomous systems, began to be seen in the maritime sector as well. Both the academy and the pioneers of the industry accelerated the studies on autonomous ships and started their sea trials. Accordingly, with the proliferation of autonomous ships, it is expected that the current competencies of seafarers will not be sufficient, and they will need new competencies in accordance with the digital age. Aim of this study is to rank critical competencies to contribute to the literature about the competencies that will be required in the digital era. Firstly, key competencies and sub competencies were extracted from literature. Then a fuzzy analytic hierarchy process was utilized to rank competencies with the data gathered from a survey designed to collect expert opinions. Results revealed that cognitive skills such as reasoning and decision making, problem and conflict solving, and critical thinking are expected to be most important competencies of seafarers in digital era. They are followed by operational skills, individual skills, and social skills. Study demonstrated that seafarers would need to be prepared new skills and competencies through Industry 4.0.

Keywords: maritime industry 4.0; maritime digitalization; digital transformation; maritime competence; fuzzy analytic hierarchy process

1. Introduction

Industry 4.0 has ushered in a new era of information technology, which has also affected the maritime industry. With the introduction and integration of Internet of Things (IoT), Big Data, Artificial Intelligence, Cloud Computing, Digital Twin, Blockchain and automation technologies in the previous decade, the Industry 4.0 digital revolution has evolved. This digitalization is forcing maritime industry, as well as all other industries, to look outside of their scope, forcing them to constantly redefine their previous practices in order to keep up with the changing world. The digital shipping revolution, Shipping 4.0 (Shahbakhsh et. al., 2022), paved the way for the concept of autonomous transportation in the maritime industry. Moreover, with the introduction of Maritime Autonomous Surface Ships (MASS) significant developments have taken place over the last few years by academics and the International Maritime Organization (IMO). These developments are mostly focused on technical advancements and implementations regarding autonomous systems. However, the gap among common practice, competence and future opportunities is observed to be growing (Oksavik et. al., 2021). It has been observed that the maritime industry's employment pattern will be drastically altered as a result of these technological advancements, necessitating the availability of highly qualified human resources (Cicek et. al., 2019). Therefore, the skill standards for seafarers will need to be reviewed as part of the digitization process (Sharma and Kim, 2021). This paper focuses on identifying and ranking the emerging critical competencies for future seafarers due to the reflections of Industry 4.0 in the maritime sector.

The aim of this study is to contribute to the literature about the competencies that future seafarers will need in the digital era. The rapidly widening gap between the current qualifications and the future needs shows that a strategy should be determined in the short, medium and long terms in this regard. While these strategies are being determined by all the stakeholders of the maritime industry, it is aimed to create a critical competency ranking that they can consider.

The future competencies were identified and structured preliminarily in the study. Data from maritime sector experts and maritime academics was gathered using a pairwise comparison table to rate the relative importance of competencies. Analytic Hierarchy Process (AHP) was applied to analyze data collected. Also, fuzzy logic is combined with AHP (FAHP) to reduce inaccuracies due to an inability to compensate for ambiguity in human logic.

The structure of this paper is as follows. The literature review is presented in section 2. Section 3 explains the theoretical framework involving the process of FAHP. The results of FAHP and discussion is given in Section 4 where the critical competency ranking for future seafarers are presented and finally the study ends with conclusions.

2. Literature Review

Despite Industry 4.0 has gained great importance in both production of goods and services, there is no significant definition but technologies such as big data analytics, autonomous and adaptive robots, cyber physical infrastructure, simulation, horizontal and vertical integration, internet of things, cloud systems, additive manufacturing and augmented reality are the necessities for a successful adaptation of Industry 4.0 (Ustundag & Cevikcan, 2017). Maritime industry started to follow the path opened by Industry 4.0 percept like many industries. Some pioneers in the maritime industry lead the way of digital transformation of shipping using those technologies onboard. Therefore, Shipping 4.0 may refer to digital transformation of shipping that enables digitalization in all aspects of shipping (Shahbakhsh et. al., 2022). The term emerged to describe the digitalization in shipping that reflects the similar developments in land-based industries under Industry 4.0 (Kavallieratos et. al., 2020). Digitalization, via Shipping 4.0, will result in several improvements to ship operations, crew, and automation that will together improve maritime productivity (Emad et. al., 2021). Hence, it can be said that the most important outputs of Shipping 4.0 are smart ports and autonomous ships. Although autonomous systems such as autopilot, e-navigation or the integrated bridge systems have been used on ships for a long time, Shipping 4.0 promises a future where ships can be managed remotely, or decision-making processes can be done by automated systems of ships. Since seafarers will be a part of this automation process as onboard crew or remote operators who have to deal with autonomous systems, it is safe to expect that new competencies and skills related to new technologies would be needed in the future shaped by Shipping 4.0.

The most important conventions regulating international shipping such as SOLAS and MARPOL were implemented after some disasters that affect both human life and marine environment. This was perhaps inevitable, as it was difficult to see the coming of these disasters in those years. However, as it is clear that digital transformation and Industry 4.0 will change the future of many industries, IMO has taken pioneering steps in the introduction of autonomous ships. Firstly, Maritime Safety Committee (MSC) specified that IMO should take the leading role in an environment where technological developments are advancing very rapidly and agreed to add commercially operated ships in autonomous mode to their agenda by starting to conduct a regulatory scoping exercise (RSE) after a proposal from several member states (IMO, 2017). Then, in 2018, integrating new and advancing technologies in the regulatory framework was included as one of the strategic directions in the Strategic Plan of IMO to facilitate a smooth transition process to the digital era in the shipping industry.

RSE for safety treaties was completed in 2021 with an outcome of MSC.1/Circ.1638, and supreme outcome of circular can be considered as defining the varying degrees of autonomy (IMO, 2021). The degrees of autonomy for the MASS were defined as shown in Table 1.

Table 1: Four Degrees of MASS (IMO, 2021)

Degree	Autonomy Level	Description
Degree One	Ship with automated processes and decision support	Seafarers are on board to operate and control shipboard systems and functions while some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.
Degree Two	Remotely controlled ship with seafarers on board	The ship is controlled and operated from another location. Seafarers are on board to take control and to operate the shipboard systems and functions.
Degree Three	Remotely controlled ship without seafarers on board	The ship is controlled and operated from another location. There are no seafarers on board.
Degree Four	Fully autonomous ship	The operating system of the ship is able to make decisions and determine actions by itself.

Another significant outcome of the RSE is highlighting the need for developing MASS terminology and definitions, especially for international agreed definitions and clarifications for the terms "master", "crew" and "responsible person" in Degree Three and Degree Four. Since Degrees 2 and 3 require a remote-control center and remote operators, addressing the functional and operational requirements of the remote-control center and the possible designation of remote operator as seafarer can be denoted as another high-priority outcome of RSE.

MSC has classified safety-related IMO instruments as high, medium, and low priority according to their potential to be affected by the transition to autonomous ships and has determined what changes each regulation needs for each degree of autonomy. The instruments such as SOLAS III, IV, V and STCW which directly affects the competencies and skills of seafarers were considered as high priority. For Degree 2 and 3, it was foreseen that amendments to their existing content or a completely new code should be implemented.

In the evaluation of STCW Convention under MASS process, there are two options which are the determination that remote operator will be a seafarer and the determination that remote operator will not be a seafarer in Degree 2 and Degree 3. In both degrees, in determining the remote operator as seafarer, MSC states that new requirements, amendments and flexibilities introducing modern technologies and automated processes can be made through existing code. In determination that remote operator is not a seafarer, MSC states that in addition to amending existing code, a new instrument including new provisions to address role and responsibilities of remote operator may be needed.

The Legal Committee of IMO have also included RSE on their agenda for the conventions under their authority. When the exercises of both committees are examined, it can be clearly seen that defining the role and responsibilities of master, officers and remote operators are high-priority subjects for MASS process and clarifying this subject was strongly advised for the future work.

IMO has not only studied the direction in which regulations will evolve in the future but has also prepared an interim guide to be applied today. "Interim Guidelines for MASS Trials" was approved by MSC to provide assistance to industry members dealing with autonomous shipping technologies and related authorities such as coastal states, flag states and port states to create an environment for autonomous ship trials that would not be less than current maritime safety and security levels (IMO, 2019). Sea trials of autonomous ships are done by some of the leading companies of the maritime industry today. NYK carried out a sea trial with an autonomous car carrier with seafarers onboard [URL-1]. Wartsila in corporation PSA Marine practiced a successful sea trial of a harbor tug project in 2019 [URL-2]. Rolls-Royce and Finferries have successfully completed a fully autonomous voyage and a remote operated voyage of a ferry including docking operations without human interference [URL-3]. Yara Birkeland operated by Kongsberg became the first fully electric and autonomous ship that also had autonomous loading, discharging and mooring systems [URL-4]. MUNIN is a project to create and test a concept for an autonomous ship, which is described as a vessel that is mostly steered by automated on-board decision systems but is managed by a remote operator at a shoreside control station [URL-5].

Like the progress in the industry, academic studies have gained momentum in recent years. Areas of focus on academic papers on autonomous ships can be classified as navigation and collision avoidance, cost and benefit analysis, financial and environmental sustainability, regulatory framework, and human factor and training (Veitch and Alsos, 2022; Bratic et. al., 2019). Although there are some studies on the responsibilities and competencies of seafarers in the era of autonomous ships, considering that they will be the operators of technological advances and new legal regulations, it can be considered that the studies on this subject are insufficient.

3. Methodology

The Analytic Hierarchy Process (AHP) proposed by Saaty (1988) is a widely used multi-criteria decision-making process that uses pairwise comparison to establish the weights of criteria and the rankings of alternatives in an organized manner (Liu et.al., 2020). However, AHP does not consider the ambiguity in human logic and is criticized for the inaccuracies resulting from this. As a result, the fuzzy sets proposed by Zadeh (1965) are combined with AHP as a prominent approach to reduce such ambiguity. The fuzzy set theory represents ambiguity that cannot be explained by conventional mathematical terms. It is well known that the theory is quite effective when dealing with problems that lack sharp boundaries and precise numbers. Furthermore, fuzzy numbers are similar to human natural language rather than rigid mathematical terms and equations. Therefore, fuzzy AHP (FAHP) is regarded as a suitable analysis method in this study. The steps of this method are explained below.

Step 1: Establishing the model

The problem was decomposed in a tri-level hierarchical model, which includes goal (ranking of critical competencies for future seafarers), key competencies, and sub-competencies. To determine the key and sub-competencies, a literature review was made regarding future seafarers' required competencies in the light of Shipping 4.0 as shown in Table 2.

Table 2. Overview of future seafarers' competencies

KEY COMPETENCIES	SUB-COMPETENCIES	LITERATURE
OPERATIONAL	Operations Monitoring and Analyzing	Cicek, K., Akyuz, E., & Celik, M. (2019), Oksavik, A., et.al. (2021).
	Information and Data Processing	Tran, T. N. M. (2018), Oksavik, A., et.al. (2021), IAMU(2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021)
	Programming	Tran, T. N. M. (2018), IAMU(2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Shahbakhsh, M., Emad, G. R., & Cahoon, S. (2022)
	Ability to Manage Cyber Security	Sharma, A., & Kim, T. E. (2021)
	STEM knowledge	Tran, T. N. M. (2018), IAMU(2019), Sharma, A., & Kim, T. E. (2021), Emad, G. R., Enshaei, H., & Ghosh, S. (2021), Shahbakhsh, M., Emad, G. R., & Cahoon, S. (2022)
	Law and Legislation awareness	IAMU(2019), Cicek, K., Akyuz, E., & Celik, M. (2019)
COGNITIVE	Problem and conflict solving	Nguyen, L. (2018), IAMU(2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Kilpi, V., Solakivi, T., & Kiiski, T. (2021)
	Reasoning and Decision making	IAMU (2019), Cicek, K., Akyuz, E., & Celik, M. (2019)

	Ability to cope with complexity	Tran, T. N. M. (2018), IAMU(2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021)
	Critical Thinking	Nguyen, L. (2018), Tran, T. N. M. (2018), IAMU(2019), Sharma, A., & Kim, T. E. (2021)
SOCIAL	Communication	Tran, T. N. M. (2018), IAMU (2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Oksavik, A., et.al. (2021), Shahbakhsh, M., Emad, G. R., & Cahoon, S. (2022)
	Teamwork	Tran, T. N. M. (2018), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Oksavik, A., et.al. (2021), Kilpi, V., Solakivi, T., & Kiiski, T. (2021)
	Adapting to cultural differences	IAMU (2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Oksavik, A., et.al. (2021)
	Leadership	Nguyen, L. (2018), Tran, T. N. M. (2018), IAMU (2019), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Oksavik, A., et.al. (2021), Emad, G. R., Enshaei, H., & Ghosh, S. (2021), Shahbakhsh, M., Emad, G. R., & Cahoon, S. (2022)
INDIVIDUAL	Adaptability and Flexibility	Tran, T. N. M. (2018), Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021), Kilpi, V., Solakivi, T., & Kiiski, T. (2021)
	Energy Efficiency Knowledge and Awareness	Tran, T. N. M. (2018), Cicek, K., Akyuz, E., & Celik, M. (2019)
	Sustainable point of view	IAMU (2019), Cicek, K., Akyuz, E., & Celik, M. (2019)
	Ability to work under pressure	Cicek, K., Akyuz, E., & Celik, M. (2019), Sharma, A., & Kim, T. E. (2021)
	Self-Learning Motivation	Nguyen, L. (2018), Cicek, K., Akyuz, E., & Celik, M. (2019)

Step 2: Survey implementation

The RSE indicated in MSC.1/Circ.1638 Annex that the potential designation of a remote operator as a seafarer was identified as a common theme in several IMO instruments and that is a high priority potential gap; especially their competency, responsibility, and the role as a remote operator.

Therefore, in this study masters with more than at least 5 years of experience and academics holding a master/chief engineer license were chosen as the sampling target. Other than the masters and chief engineers, academics with similar sea experience were also chosen because they educate and train seafarers to have the necessary competencies.

A questionnaire survey was used to collect data from selected maritime sector experts. Academic experts in the maritime industry examined and validated the survey's content. The questionnaire was divided into two sections. The first section involved demographic questions, and the second section was for respondents to rate the relative importance of paired criteria of the sub-competencies on a scale of '1 = extremely unimportant' to '9 = extremely important.'

Respondents were briefed about the 4 stages determined by IMO in the autonomous ship transition process, and they were asked to make their evaluations in terms of the competencies expected of seafarers who will take part in the degree 2 and 3 of this process. The data were collected via e-mail using a pair-wise comparison table prepared regarding the theoretical framework given in Figure 1. A total of 5 valid questionnaires were used for further analysis.

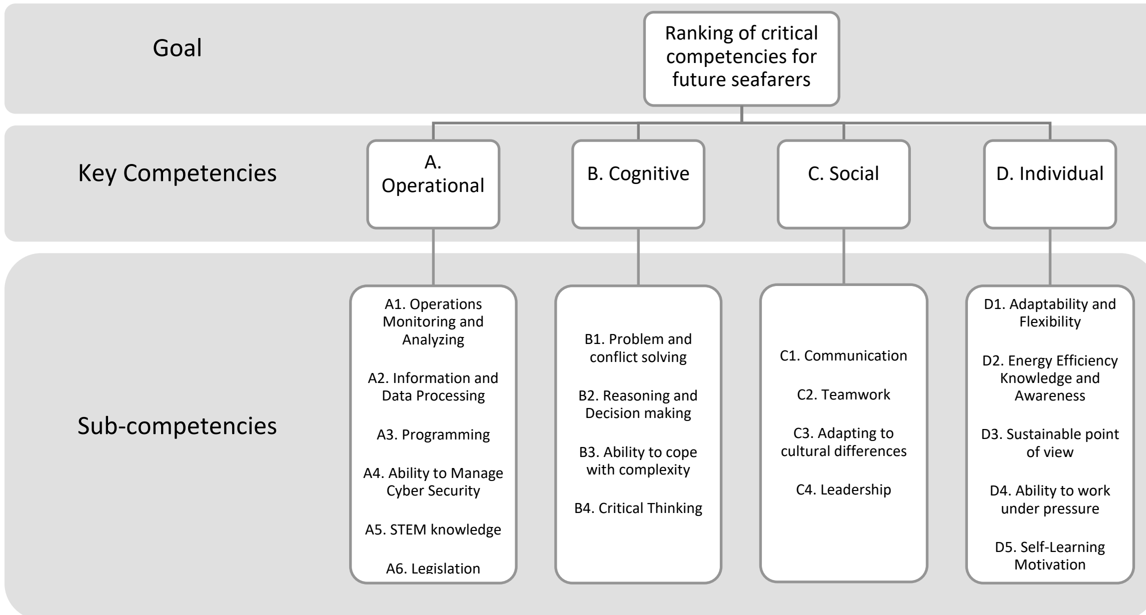

Figure 1. The theoretical framework of AHP

Step 3: Conversion into fuzzy numbers

Fuzzy numbers are normal and convex types of fuzzy sets. Although these numbers can be demonstrated by a variety of shapes, triangular and trapezoidal shapes are the most useful for practical implementations (Yoon, 1996). A triangular fuzzy number (TFN) consists of three points, represented by (l, m, u) where l, m, and u denote the smallest possible value, the most promising value, and the largest possible value providing a fuzzy set respectively (Chang, 1996). In this study, the triangular membership function which is defined below is used.

$$\mu_M(x)\begin{cases}\frac{x-l}{m-l}, l < x < m \\ 1, x = m \\ \frac{u-x}{x-m}, m < x < u \\ 0, l \geq x \geq u\end{cases} \tag{1}$$

Figure 2 shows the membership function of triangular fuzzy number, while Table 3 shows the triangular fuzzy numbers used in this study.

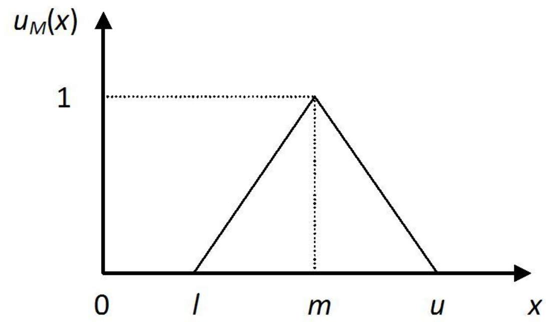

Figure 2. Membership function of triangular fuzzy number

Table 3. Triangular fuzzy numbers.

Relative importance	Linguistic Scale	Fuzzy Number	Triangular Fuzzy Number
1	absolutely low	1/9	1/9,1/9,1/9
2	very low	1/7	1/6,1/7,1/8
3	low	1/5	1/4,1/5,1/6
4	fairly low	1/3	1/2,1/3,1/4
5	medium	1	1,1,1
6	fairly high	3	2,3,4
7	high	5	4,5,6
8	very high	7	6,7,8
9	absolutely high	9	9,9,9

Step 4: Creating a Pairwise Comparison Matrix with Fuzzy Values

The geometric mean method is used to combine the 5 fuzzy comparisons that were collected. The consolidated fuzzy value of paired judgments is then used to create a comparison matrix. Matrix represents a n x n pairwise comparison matrix, as shown below.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix} \quad (2)$$

Step 5: The fuzzy weights

In order to calculate fuzzy weights (Wi) with combining the weights given by different experts, the geometric mean technique is used as shown in the below formula:

$$Z_i = (a_{i1} \times a_{i2} \times \ldots \times a_{in})^{\frac{1}{n}}, \forall_i = 1, 2, \ldots, n \quad (3)$$

$$W_i = Z_i \times (Z_1 \times Z_2 \times \dots \times Z_n)^{-1}, \forall_i = 1, 2, \dots, n \tag{4}$$

Step 6: The consistency ratio

The consistency ratio (CR) should be calculated to avoid inconsistencies in the comparison matrix. For the matrix's consistency to be acceptable, the CR must be less than 0.10. (Saaty, 1988). If not, the comparison matrix should be reviewed again. The CR can be calculated using the equations (5) and (6) where λmax is the eigenvalue of the matrix, CI is the consistency index, and RI is the random index which is used as 1,62 according to Hayrapetyan (2019) regarding the matrix size that is 19.

$$CR = \frac{CI}{RI} \tag{5}$$

$$CI = \frac{\lambda max - n}{n-1} \tag{6}$$

Step 8: Normalization

The BNP values should be normalized to compare the relative importance of key and sub-competencies:

$$NW_i = \frac{BNP_i}{\sum_{i=1}^{n}(BNP_i)}, \forall_i = 1, 2, \dots, n \tag{8}$$

4. Results of the FAHP and Discussion

The weights and ranking of key competencies and sub-competencies are shown in Table 4. The consistency ratio was calculated as 0,0691, less than 0,10. The most important key competency is evaluated as cognitive skills that comprises the three most important sub-competencies which are reasoning and decision making, problem and conflict solving, and critical thinking. Prominence of these competencies highlights that as digitalization progresses, making wise decisions will become more complex in maritime operations. This is supported by the fact that the other sub-competency of cognitive skills, "ability to cope with complexity" ranks 7th in overall.

Operational skills rank as the second most important key competency. Its sub-competencies, such as “operations monitoring and analyzing”, “information and data processing”, “managing cyber security” and “STEM knowledge” are also relatively high ranked, emphasizing the importance of seafarers having a thorough understanding of digitalization skills in order to manage, process, and comprehend increasingly complex data in order to handle and optimize operations. Also, the ranking of “law and regulations awareness” as 4th in overall may indicate that remarkable amendments in international maritime regulations are expected. However, low ranking of “programming” can be interpreted as the operator role of seafarer would retain.

The third important key competency is individual skills. Relatively high ranking of “ability to work under pressure” among other sub-competencies of individual skills can be an indicator of a working environment where the pressure on operators is increased due to a reduced labor force and increased computerized operations. It can also be interpreted that individual competencies are already required qualifications for seafarers and will continue as such. Besides, the low importance of energy efficiency awareness may be due to the thought that energy efficiency will be achieved as a result of decisions during the construction rather than the operation of the ship.

The fourth important key competency is social skills. The most important sub-competency here is communication. This is most likely due to communication still being a major barrier in multicultural workplaces such as maritime. Furthermore, there will still be people involved in MASS operations in the 2nd and 3rd degrees, leaving room for human error, albeit reduced. It is likely that there are similar reasons that leadership is relatively important in social key competency. Although there will be less human interaction in automated systems, taking efficient decisions in a complex computerized environment under pressure based on the data gathered from various electronic systems would still require a different kind of leadership skills. Sub-competencies such as teamwork and adapting to cultural differences were at the bottom of the ranking. One major reason for this could be that these competencies are already included in the skill sets that seafarers are expected to have at the very least.

Table 4. Analysis results of FAHP

Key Competency	Weights	Rank	Sub-Competency	Weights	Rank
A. Operational	0,2940	2	A1. Operations Monitoring and Analyzing	0.0673	6
			A2. Information and Data Processing	0.0705	5
			A3. Programming	0.0399	14
			A4. Ability to Manage Cyber Security	0.0560	9
			A5. STEM knowledge	0.0658	8
			A6. Law and Legislation awareness	0.0707	4
B. Cognitive	0,3645	1	B1. Problem and conflict solving	0.0772	2
			B2. Reasoning and Decision making	0.0847	1
			B3. Ability to cope with complexity	0.0665	7
			B4. Critical Thinking	0.0731	3
C. Social	0,1614	4	C1. Communication	0.0451	11
			C2. Teamwork	0.0342	16
			C3. Adapting to cultural differences	0.0191	19
			C4. Leadership	0.0414	13
D. Individual	0,1801	3	D1. Adaptability and Flexibility	0.0347	15
			D2. Energy Efficiency knowledge and awareness	0.0306	18
			D3. Sustainable point of view	0.0435	12
			D4. Ability to work under pressure	0.0480	10
			D5. Self-Learning Motivation	0.0318	17

CR=0,0691

5. Conclusion

This study contributes to the literature on the digital era competency requirements for future seafarers. The critical competencies gathered from the literature were evaluated by the determined experts based on the IMO's 2nd and 3rd MASS degrees and prioritized. In this context, the study first demonstrated that as the human-machine interface becomes more extensive, cognitive skills will become more prominent. On the other hand, law and legislation awareness, which is evaluated as one of the most important operational competencies within this study, has highlighted the importance of determining the legal framework that will enforce many sub-topics to evolve with the introduction of MASS. Furthermore, as reflected throughout the industry, the irreversible digitalization shift has demonstrated that seafarers will need to be prepared for skills such as information and data processing, as well as the ability to manage cyber security, in addition to their traditional training.

The IMO has already stated that STCW should be amended in MSC.1/Circ.1638. However, as revealed by this study, skills and competencies other than those provided in traditional maritime education will be required, necessitating a fundamental change in the curriculum of MET institutions, including training of trainers.

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Promotional Strategies for Gender Equity in Maritime Sector: Maritime Education Institutions

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Abstract: Women are most important and effective pillar of the successive economic enterprises. Due to customs and traditions of the many of the countries they were denied to showcase their talents in the public forum and they were forced to take care of their family and children. Gender equity in the workplace environment is the dream of the many social activists during 18th century and now it's become true by the continuous efforts from the bottom level to educate the women and providing promotional avenues in the workplace. Maritime sector is the most important economic sector which provide the direct and indirect employment opportunities to the majority of the world population. This study is an attempt to identify the factors influencing the women to join the maritime education institutions and barriers faced by the women seafarers to provide the promotional strategies to increase the number of girl cadet enrolment in the maritime education institutions. The snowball technique has been employed to collect the information from the 153 women cadets in the pre sea courses. It found that economic barrier is the one of the major problem for the women to join the pre sea courses. Girl cadets in the pre sea courses were suggested to promote the pre sea courses in the rural and semi-urban places with the career opportunities and also to provide more financial support for the women cadets enroll in the pre-Sea courses. This study suggests the strategies to promote gender equity through Government and Private parties involves in the Maritime sector should take necessary initiatives offer more fellowships or free ships to the eligible/meritorious Further, number of empirical studies have to be conducted among the women cadets in the pre sea courses in all the countries to identify the varied needs of them to ensure the prosperity of gender equality in the maritime sector.

Keywords: Maritime Sector, Maritime education Institutions, Women, gender Equity, Financial Assistance, Employment, Enrolment

1. Introduction

According to the word of Kofi Annan "Gender equality is more than a goal in itself. It is a precondition for meeting the challenge of reducing poverty, promoting sustainable development and building good governance" world is working for gender equity to ensure the balanced sustainable development. Gender equity or women empowerment is the most important element for the sustainable development of the society. Empowering women in the economy and closing gender gaps in the world of work are key Agenda for Sustainable Development to achieve in 2030. Women's economic empowerment includes women's ability to participate equally in existing markets; their access to and control over productive resources, access to decent work, control over their own time, lives and bodies; and increased voice, agency and meaningful participation in economic decision-making at all levels from the household to international institutions. Women's economic empowerment boosts productivity, increases economic diversification and income equality in addition to other positive development outcomes. Over the past three decades, International community of maritime sector given top priority to the Gender equity. The process began in 1988, when a program launched by the the International Maritime Organization (IMO) whose concept was parallel with the United Nations' generic approach to Women in Development (WID), and was later evolved into the Integration of Women in the Maritime Sector (Kitada & Tansey, 2018). Increasing women's and girls' educational attainment contributes to women's economic empowerment and more inclusive economic growth. Education, upskilling and reskilling over the life course especially, to keep pace with rapid technological and digital transformations affecting jobs are critical for women's and girl's health and wellbeing, as well as their income-generation opportunities and participation in the formal labour market. Increased educational attainment accounts for about 50 percent of the economic growth in OECD countries over the past 50 years. Women's economic equality is good for business. Companies greatly benefit from increasing employment and leadership opportunities for women, which is shown to increase organizational effectiveness and growth. It is estimated that companies with three or more women in senior management functions score higher in all dimensions of organizational performance.

Historically, Maritime sector is a male dominated industry, IMO concerted effort helps the industry move further and support women to accomplish a representation that is pertinent with twenty-first century expectations. IMO continues to support the participation of women in both shore-based and sea-going posts. With the slogan: "Training-Visibility-Recognition", IMO has taken a strategic approach towards enhancing the contribution of women as key maritime stakeholders. With the continuous effort positive trend in gender balance, with the report estimating 24,059 women serving as seafarers, which is a 45.8% increase compared with the 2015 report. Which represents only 1.2 percent of the global seafarer workforce is represented by the women ("Seafarer Workforce Report, 2021 Edition | International Chamber of Shipping," n.d.)`. Nonetheless, despite multiple efforts, the issue of gender equality in marine businesses and various sorts of maritime activities in general remains unsolved. In terms of women's involvement in the labour market and ensuring equal treatment for women workers, the marine sector has shown to be quite conservative. As per the statistics published in the International Transport Workers Federation, only around 2% of the world's marine workforce are Women. Women members of maritime unions were approximately 23000 worldwide (Women seafarers, 2019) and the cruise industry employs 40% of women (Review of Maritime Transport, 2019, p. 100).

The small number of women in the shipping industry makes them even more vulnerable to different forms of discrimination, which include:

- Demographic limitations of availability of the maritime education and training institutions
- Biasing while employing
- Unequal payment
- Inadequate facility
- Sexual harassment or abuse while at sea (Women seafarers, 2019).
- It also should be noted that the issue of gender inequality also extends to a variety of maritime-related activities. For example, according to the Maritime HR Association survey of shore-based maritime industry professionals in 2018: only 35% of the global Maritime HR Association workforce were female; over 76% of that female workforce work in administrative, junior, or professional level roles; just over 10% of those on executive leadership teams are women, with female Executives most likely to operate as Chief Financial Officers (Gender diversity in maritime).

According to the UNCTAD Review of Maritime Transport, women contribution is 22 percent of the port workforce overall from 2014 to 2018, with 34 percent of the management team and 12 percent of the operations team (Review of Maritime Transport, 2019, p. 76). The impact is even observed in the maritime-related industries with no specific physical requirements, where significant gender disparities exist. These figures raise concerns about the efficiency of existing legislative tools for protecting women's rights and preventing discrimination in the marine sector. This study is an attempt to discuss the promotional strategies for gender equity in maritime sector through maritime education institutions.

2. Objectives of the Study

- To review the major initiatives taken towards gender equity in maritime sector;
- To study the Socio-economic profile of the women cadets in the pre-sea courses;
- To understand the major issues faced by the women cadets in the pre-sea courses; and
- To suggest the suitable promotional strategies to ensure the gender equity in the maritime sector.

3. Methodology of the Study

The study on Promotional Strategies for Gender Equity in Maritime Sector: Maritime Education Institutions is descriptive cum analytical in nature. This study tries to describe the contribution of women in maritime sector and analyze the major problems faced by the women cadets and provide the probable promotional strategies to promote the gender equity in the sector. The study focuses on general and sectoral international legal instruments promoting gender equality in the maritime industries; the subjects of rulemaking in the field, as well as the peculiarities of their rulemaking processes; and the legal aspects of implementing policies empowering women in the maritime industry. As maritime law is a well-established domain of international legal regulation, the same methodology may be adopted for the issue of gender equality in maritime law. The transnational human rights concept also supplements this. Women cadet enrolment in maritime education institution are very less compare to the other kind of courses. The snowball technique has been employed to collect the information from the 153 women cadets in the pre sea courses. Women cadets learning pre sea courses were identified through snowball techniques to enquire the cadets to collect the information. Factor analysis was employed to understand the major reasons for lower enrolment of women cadets in the pre sea courses to draft the promotional strategies for women participation in maritime sector in order to achieve the gender equity.

4. Review of Major Initiatives towards Gender Equity in Maritime Sector

The legislative frameworks for the promotion of gender equality in ocean-related industries are a multifaceted issue that can be approached from multiple angles. There are a few aspects of the gender in the law of the sea issue that is emphasized by various international instruments of general or sectoral importance, which include the following:

- instrumental role of the Law of the Sea in protecting the human rights, including granting gender equality;
- gender equality in fisheries, including ensuring access to fishers by women fish-workers;
- protecting refugees, migrants and trafficked persons at sea with the adaptation of the gender approach;
- women on ships have safe and appropriate working conditions. Furthermore, it is possible to distinguish between general instruments dealing with forms of discrimination against women, regardless of sector or industry, and specific instruments devoted to women's rights and equal position in marine. Overall, various UN organizations have codified all of these instruments under the UN system.

The special attention to women's rights at the international level was first recognized in a UN Economic and Social Council (ECOSOC) Resolution on the establishment of a Commission on Human Rights and a Sub-Commission on the Status of Women on February 16, 1946, which stated (Para 2 of Section B) that "the sub-commission shall submit proposals, recommendations, and reports to the Commission on Hunan Rights regarding the status of women."

The sub-commission renamed the Commission on the Status of Women (CSW) in the following year, responsible for preparing recommendations and reports for ECOSOC "on promoting women's rights in political, economic, social and educational fields". The legally binding UN Convention on the Elimination of All Forms of Discrimination Against Women (1979) (hence – CEDAW), which is the key international instrument establishing legal frameworks for gender equality in marine and ocean-related businesses, took three decades to codify. Two CEDAW clauses in particular should be highlighted since they address the subject of ensuring equal rights for women in the maritime labour force to the maximum degree possible such as:

- Article 10 CEDAW is a United Nations Convention on the Elimination of Discrimination Against Women, which aims to ensure that women have equal access to education as men;
- Article 11 CEDAW, which calls for the elimination of discrimination against women in the workplace in order to achieve gender equality (para 1), as well as the prevention of discrimination against women on the basis of marriage or maternity and the effective enforcement of their right to work (para 2).

It is worth point out among the other general international instruments that are crucial for reinforcing women's rights in marine, which were approved under the auspices of the UN or its organizations:

- Declaration on the Elimination of Violence against Women (1994);
- Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children, supplementing the UnitedNations Convention against Transnational Organized Crime (2003);
- International Labour Organization (ILO) Maternity ProtectionConvention (2000);
- The Beijing Declaration and the Platform for Action of 1995, etc.

When considering provisions of specialized sectoral legislation that focus on women's status in the maritime, it becomes clear that they are of a distinct provenance for the most part. Indeed, such deeds are frequently motivated by the principles and ideas of sustainable development. Because of concerns about a lack of officers in the world fleet, the first IMO Strategy for the Integration of Women in the Maritime Sector (IWMS), issued in 1988, recognized women's integration as a criterion for attaining sustainable development. Focused on capacity building, in 2012, the IMO reaffirmed the strategy, including it under the new Millennium Development Goal 3 (MDG3) and renamed as IWMS: Strengthening Maritime Resource Development (MDG3/RD). The MDG3/RD program, according to the IMO IWMS Report, also serves to highlight the role of the Millennium Development Goals (MDGs). One of the outcomes of this approach is the identification and selection of women for career development opportunities in maritime administrations, ports, and maritime training institutes by their respective authorities ("Women in Maritime," n.d.).

This fact is specifically accountable for the differences in breadth between general treaties guaranteeing women's rights and specialized instruments addressing women in the marine sector.

In the past, most soft law sources dealing with women in maritime concerns have tended to suggest ways and means to tackle the difficulties of marine industry development, only lately they pivoted towards gender equality.

Furthermore, the specialized regulatory frameworks for achieving gender equality in maritime are substantially scattered due to the multiplicity of rulemaking areas.

The UN Convention on the Law of the Sea (UNCLOS) establishes States' general principles and duties in various marine zones. Also, the UNCLOS is in line with the UN Charter's Purposes and Ideals, particularly the principles of fairness and equal rights, which promote all peoples' economic and social advancement. As a result, it obligates the participating governments to respect women's rights and gender equality, as stipulated by UN agreements.

The most important specific obligatory agreements in the field are:

- IMO International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) (1978);
- ILO Maritime Labour Convention (MLC) (2006).

It should be emphasized that the above-mentioned conventions did not pay sufficient attention to the issue of gender equality in the outset, and were only supplemented with appropriate measures during the course of amending and modification. The Manila Amendment to the STCW of 2010 by Resolution 14 "Promotion of women's participation in the maritime industry," in particular invited States, is an example:

- top priority to secure equal access by men and women in all sectors of the maritime industry
- to emphasize the role of women in the seafaring profession and to promote their greater participation in maritime training at all levels of the maritime industry

In order to overcome the current hurdles of women's access to careers in shipping, the focus should be paid to issues such as the absence of facilities for women onboard training vessels and the availability of on-the-job training opportunities for women (IMO, 2010).

The MLC has been revised to include a number of clauses that address the needs of women in terms of working conditions onboard, such as requiring separate sleeping rooms and sanitary facilities for men and women (Standard A 3.1).

Finally, the IMO and ILO's own acts are the most comprehensive in terms of fulfilling practical aims of guaranteeing women's rights and gender equality in the marine industry. We can specifically point to a number of IMO programmes, such as the IMO Integrated Technical Cooperation Programme (ITCP) as a general framework and the IMO Women in Maritime programme, which provides a strategic approach to enhancing the contribution of women as vital maritime stakeholders and supporting women's participation in both shore-based and sea-going posts under the slogan "Training-Visibility-Recognition" ("Technical Cooperation," n.d.).

The transnational approach to the women in maritime issue are hybrid rulemaking processes, empowering strategies and complicity of jurisdictions. The predominance of soft law instruments developed within various international organizations (primarily CEDAW as a universal one, and IMO and ILO as sectoral ones) shifts the focus to a supranational body of law that aims to provide a legal framework for enhancing women's role in the maritime sector. The IMO and ILO's functions are particularly important for the shipping sector, since "both these regulatory organizations have become increasingly prominent as the business has moved out into areas where regulation is scarce or non-existent." With their internally devised rules, the aforementioned organizations have taken on the duty of filling the above-mentioned under regulated sectors, including women's issues in maritime. As a result, the relevant body of legislation consists mostly of resolutions, programmes, decisions, recommendations, and best practices, which collectively reflect united stances of respective international rule-makers rather than consistent views of national states. While the IMO encourages and supports women to train for both land-based and sea-based vocations, the ILO establishes minimum requirements for seafarers' working conditions, including the prohibition of violence and harassment. ("Women in the maritime community – Closing a gender gap as wide as the ocean? | Epthinktank | European Parliament," n.d.).

Furthermore, the internal legal process within the international organizations involved is focused on the well-known transnational law formula of loading, unloading, or transferring best national practices from one national legal system to another (Koh, 2006), as well as discouraging states from acting inconsistently. "CEDAW's internal processes are also exemplary of "living" law, as its Committee comments on country reports and publishes new directives," for example (Resnik, 2012).

The issue is also complicated by extremely disparate national conditions (political, cultural, economic, etc.) for women's access to jobs in shipping and other maritime-related industries, which makes it difficult to reach strict and specific interstate agreements that reflect all parties' common needs. Women sailors from developing and developed countries, for example, are said to have motivations for their jobs that are somewhat different. According to a cruise industry survey, while women from impoverished nations generally cited prospective profits as the most important motivator for working at sea, the biggest appeal for women from rich countries has been the ability to travel and "see the world for free".

Thus, depending on the country, it is required to solve different challenges, or at the very least to approach the same problem in different methods, in order to reach the same aim of achieving gender equality in seafaring. Only a set of techniques, providing a kind of toolbox with many voluntary ways and means based on internationally acknowledged UN publications and allowing every individual national government to choose the most appropriate for its needs, may be widely acceptable. The issue of selectivity of ways and means for achieving stated goals is also present in the field's compulsory international acts. Furthermore, local acceptance of treaties like CEDAW can domesticate its principles not only as preconditions for national adoption, but also as democratic processes for implementing and translating their rules. The small list of transnational rule-making themes in the field accounting their responsivity for introduction of standards for the respective policies and practices on ensuring gender equality in maritime) is said to be represented by:

- international organizations;
- national governments;
- employers' organizations;
- trade unions;
- individual employers;
- Maritime Education and Training (MET) institutions.

What's more, a reasonable number of rules and standards are developed using a hybrid rulemaking process that involves collaboration between various sorts of the stated subjects.

One example of a hybrid rulemaking procedure is the one described above, which is based on national governments submitting various surveys and reports and the IMO and ILO responding with judgments and resolutions. Other sorts of collaboration can be highlighted, such as between the IMO or the ILO and NGOs, or between NGOs.

For example, the International Maritime Organization's Assembly Resolution A.1147 (31) on Preserving the Legacy of the World Maritime Theme for 2019 and Achieving a Barrier-Free Working Environment for Women in the Maritime Sector discusses "governments," "maritime administrations," "the industry," and "the maritime sector" in two ways:

- urging all women to participate fully, safely, and without hindrance in the maritime community's activities, including seafaring and shipbuilding activities, in order to effectively facilitate the achievement of SDG 5 (para 2), by considering ways to continuously identify and overcome existing constraints (i.e. recruitment, training, capacity-building, technical cooperation, and promotions);
- supporting the sharing of best practices in attaining gender equality in the maritime community, with the goal of creating a barrier-free working environment for women. (para 3).

Furthermore, Resolution A.1147 (31) mentions a research being carried out by the Organization and the Women's International Shipping and Trading Association (WISTA) to give up-to-date information and data on the number of women working in the marine sector and the positions they hold.
On January 27, 2020, IMO and WISTA signed a Memorandum of Understanding on Technical Cooperation that specified four important areas of activity in the context of promoting networking and open discourse on problems related to empowering women and advancing gender equality (Para 5 of Resolution A.1147(31)):

- looking for opportunities to partner on maritime issues;
- promoting greater engagement for women in maritime, amongtheir members, the broader ocean business community, ocean stakeholders and the public;
- developing and participating in relevant training, workshops, among other business related to their areas of mutual interest;
- supporting implementation of Assembly Resolution A.1147(31) ("WISTA International and the International Maritime Organisation, IMO, sign Memorandum of Understanding," n.d.).

The collaboration between the IMO and NGOs is institutionalized and managed by the "Rules and guidelines for non-governmental international organizations' consultative status with the International Maritime Organization," which was updated by IMO Assembly Resolution A.1144(31) on December 4, 2019. (Rules and guidelines, 2019).
The Maritime Labour Convention is another example of hybrid rulemaking. The provision that "account should also be taken of the latest version of the Guidance on eliminating shipboard harassment and bullying jointly published by the International Chamber of Shipping and the International Transport Workers' Federation" was added to the ILO Amendments of 2016 (para 1 of Guideline B4.3.1 – Provisions on occupational accidents, injuries, and diseases) (Amendments to the Code relating to Regulation 4.3 of the MLC, 2006). Thus, the ILO legitimizes the instructions published by two non-governmental organizations representing ship owners and trade unions through an obligatory international convention. In turn, the Guidelines establish the recommended rules and duties for:

- Shipping companies to ensure that policies are in place for theelimination of all forms of harassment and bullying of seafarers on board their ships; and
- Seafarers' organizations and seafarers to ensure that harassmentand bullying do not take place (Guidance on elimination shipboard harassment and bullying, 2016).

All of this highlights the significance of private actors as rulemaking subjects, which include both non-governmental organizations and businesses. Essentially, the latter has the ability to improve gender equality through its internal company policies and practices. What's more, such corporate policies and practices could have a significant external impact in terms of raising overall awareness of the issue and forming common policies among the marine industry. These conclusions highlight the global nature of the rules governing gender equality and women's empowerment in the marine and maritime-related industries.
Another factor to examine when developing tools to ensure gender equality in the marine sector is how well they match with the concept of women's empowerment. The IMO has picked the topic "Empowering women in the nautical community" for World Maritime Day 2019. "Empowering women isn't just an idea or a concept," said the IMO's Secretary-General on the occasion of World Maritime Day. It's a necessity that necessitates bold, constructive action to overcome long-standing structural, institutional, and cultural hurdles" ("World Maritime Day 2019," n.d.).
Women's empowerment, according to the UN, means that women can take control of their lives by setting their own agendas, gaining skills (or having their own abilities and knowledge recognized), increasing self-confidence, solving difficulties, and developing self-reliance (UN Women & United Nations Global Compact, 2011). The concept of empowerment has been used since the beginning of IMO's initiatives to tackle the issue of gender equality. For example, the IMO's inaugural Women in Development (WID) programme established four primary goals in the field:

- to integrate women into mainstream maritime activities;
- to improve women access to maritime training and technology;
- to increase the percentage of women at the senior managementlevel within the maritime sector and;
- to promote women's economic self-reliance, including accessto employment.

All of the above aims were clearly socioeconomic in character, with a focus on modifying relationships within the maritime sector. To achieve such goals, a number of issues must be addressed, including allowing women the right to work, improving the industry's commitment to women employees, and so on. In general, "empowering women" means "providing women the freedom to choose their own way of life — the freedom to be whatever they want to be, without being evaluated based on gender stereotypes"

As a result, selecting empowerment policies as the primary tool for gender in maritime programmes has an impact on the application of relevant legislative instruments in the direction of profound individualization. "On closer examination, group identification and group empowerment appear to be characteristics of individualism."

When we consider the variety of national legislative orders that can be employed in the course of action to ensure gender equality in marine, the matter appears to be considerably more problematic. Essentially, there are at least five main jurisdictional concerns that may influence the specific conditions for women in terms of entry to the profession, participation in the labour market, and working conditions, which include:

- a nationality of a crewmember;
- a country of training institution;
- a country of a recruiting agency;
- a country of a ship owner;
- a flag of a vessel.

In terms of a person's individual rights, this results in a tangle of overlapping legal orders that may be incompatible with the execution of gender equality regulations and policies in the maritime sector. Such issues can be addressed through a transnational legal framework that empowers individuals as right holders while also attempting to overcome the ineffectiveness of state-centric international human rights law.

All of the above is reinforced by internal regulations, processes, policies, and practices of specific private subjects engaged in various maritime-related activities (for example ship owners or recruiting agencies). This significantly raises complicity while also emphasizing the significance of using soft law instruments and sharing best practices to build a gender sensitive regulatory environment for every female marine worker.

5. Socio Economic profile of the Women Cadets in the Pre-Sea Courses

Socio-Economic survey has been conducted among the 153 Women cadets enrolled in the PreSea courses of various maritime Colleges in Tami Nadu of India to identify the reasons to identify the lower enrolment of the women cadets. The survey results were presented as follows:

5.1 State of Origin Women Cadets in PreSea Courses

State of Origin will help to identify the level of awareness about the role of women in Maritime sector among the people. It shows that South Indians (Kerala (43%); Tamil Nadu (14%); and Karnataka (9%)) well aware about the future of women cadets in the Maritime Sector compare to the students from other parts. It clears that proper awareness campaign should be conducted to create awareness about the sector to enhance the contribution of the Women cadets.

5.2 Religion of the Women Cadets in PreSea Courses

More than three fourth (80 %) of the women cadets in the PreSea courses are from Hindu Religion and followed by Christian (11%), Muslims (7%) and Buddhist (2%). This shows that more awareness should be created among the other religion people about the safety and security in the sector and the future of women cadets in Maritime industry.

5.3 Nature of Native place of the Women Cadets in PreSea Courses

More than one third (43%) of the women cadets in the Presea courses are from Urban place and 32% are from Semi Urban places and 25% are from rural areas. So, more awareness should be created among the rural masses.

5.4 Annual Family Income of the Women Cadets in PreSea Courses

More than two third (38.4%) of the women cadets in the Presea courses family annual income is less than Rs.4,00,000 and followed by 5.3 % between Rs.4,00,000 to Rs.6,00,000 and Rs.6,00,000 and above (26.3%) respectively. It clears that majority of the women cadet's family spend their major portion of their annual income for their wards education.

5.5. Source of the Family Income of the Women Cadets in PreSea Courses

Majority (78%) of the women cadets in the Presea courses family depends on salary of the earning people and remaining (28.1%) are depending on the pension of their family members, this shows the absence of the second income and their difficulty in paying the tuition fees.

5.6. Number of earning family members in the Women Cadets in PreSea Courses

Majority (63.2 %) of the women cadets in the presea courses family have only one earning member in their family and 36.8 % have 2 earning member in their family which shows that lack of earning members in the family.

6. Major Issues faced by the Women Cadets in PreSea Courses

The survey result among the PreSea Courses reveals that many of the cadets were unable to arrange their tuition fees due to their family economic background. Few people are taken care by the single parent and more than two third of them having only one (70.5 percent) earning member in their family. Majority (45.5 percent) of their family annual income is under Rs. 2, 00,000 and 25 percent of them in the group of Rs. 2, 00,000 to 4, 00,000 and most of them (97.7 percent) of the women cadets in Pre-Sea Courses requesting financial assistance from the external funding agency which would be helpful to them economically and enable the students to concentrate in their studies and training to complete their courses and become a competent seafarer in the future. Most of them reported that their parents are struggling to arrange the tuition fees and telling them to join in the normal courses in which the tuition fees are lower compared to the Maritime education sector. The survey results highlighted that economic barrier is the one of the major problem faced by the Women cadets to pursue the PreSea Courses. The economic freedom should be provided to the women cadets by the financial assistance/scholarships in order to pursue their studies and increase the number of enrolment in Maritime studies in future.

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

Majority (94.7%) of the women cadets in the presea courses were looking for financial assistance to continue their studies clears that financial assistance is the one of the key factor to promote the maritime courses among the women cadets in-order to maintain the gender equality.

8. Promotional Strategies for Gender Equity in Maritime Sector

- Popularize the maritime industry opportunity for the women from the grassroot level;
- Awareness should be created from the school level to the women cadets because many of them said that they know the course only when they got enroll for their siblings in the maritime institutions;
- Famous celebrities to be engaged during the awareness campaign to create center of attraction;
- Maritime education institutions should popularize the importance of maritime courses for women by separate admission campaign;
- Women Cadet Admission targets to be fixed for all the maritime education institutions (likely to be a reservations system) in all parts of the world (atleast 50 enrolment);
- Appreciate the maritime Education institutions achieving maximum enrolment during annual General Conference of International Association of Maritime Universities;
- Separate weightage to be given to the Women Cadet Enrolment ratio for the IAMU PIMET (Performance

Indicators in Maritime Education and Training) Ranking;
- Many of the women cadets doubt about the career growth in the maritime sector, so proper awareness should be created among the general public about the career opportunities and career growth possibilities among the general public;
- Loan facilities to be arranged to the women cadets enroll in the pre-sea courses;
- Financial assistance provided to the women cadets enroll in the pre-sea courses in order to increase the enrolment; and
- Scholarships to be introduced as 50% waiver to increase the women cadet enrolment in the pre-sea courses. **5.**

9. Conclusions

Women being backbone of the economic prosperity of the sustainable development of any sector of the nation. Gender equality is still the vision in many of the economic sector, especially in the Maritime sector where only 1.2 percent of the positions of the entire workforce is occupied by the women cadets. Pandemic is the one of the reason for the reduced employment opportunities due to bounded with lock down and job insecurity in the maritime sector (Thiruvasagam G & R, 2021). The transnational approach to the legal framework for guaranteeing gender equality in the maritime industry has a lot of potential for explaining practical ways to achieve the goals of protecting women's rights and empowering women in the off-shore and on-shore maritime industries. A number of reasons have contributed to this. For starters, this is a result of the field's major developments being linked to the Sustainable Development Goals. Second, the regulation process for maritime sectors involves a diverse variety of stakeholders, including international organizations, national governments, non-governmental organizations, and corporate entities. Third, the emphasis on empowering techniques leads to the use of specific ways and means that are highly customized and subjective, and hence trans-jurisdictional. Finally, the regulatory environment is complex, based on a patchwork of multiple jurisdictions and legislative orders, as is typical of any form of maritime activity. Even after the tremendous efforts made by the IMO due to the economic barriers women are unable to attain their formal pre-sea courses. Economic condition of the women cadets and earning capacity of the family members are the one of the major factor deciding the enrolment of the women cadets in the PreSea Courses. Due to the economic status of women cadets in the PreSea Courses are requesting financial assistance to continue their studies. The financial assistance encourages the women cadets and family members to make them to admit girl student in the PreSea course without worrying about the economic difficulties like other courses available in the education sector. This study suggest promotional strategies to increase the number of enrolment in the pre-sea courses and participate in the global agenda of empowering women in the economy and closing gender gaps in the world of work are key Agenda for Sustainable Development to achieve in 2030. Further, number of empirical studies have to be conducted among the women cadets in the pre sea courses in all the countries to identify the varied needs of them to ensure the prosperity of gender equality in the maritime sector.

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Knowledge representation in MET

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Abstract: Maritime education and training are under constant pressure to follow and adapt to the advances and trends in technology to satisfy the needs of the labour market and industry. To do that, besides revising the necessary knowledge and competencies, it is also important to properly communicate them. In that sense, the paper aims to provide insight into how maritime professional knowledge is represented and communicated in various sources. The results presented here were obtained through a corpus-driven analysis of different sources presenting maritime knowledge. Quantitative corpus data and statistical calculations from a corpus consisting of more than a million tokens, or running words, showed the main semantic domains each subcorpus focused on and provided information about word frequencies. Corpus analysis identified the underrepresentation of psychomotor and affective domains and a smaller share of higher-level competencies in the source texts, thus indicating possible areas for further improvement.

Keywords: STCW knowledge representation, GMP, semantic analyses

1. Introduction

Maritime education and training (MET) may be described as a systematic process utilised to transfer knowledge and accumulated experience to students. The scope and extent of subjects to be delivered are predominantly determined by the job description and assumed responsibilities. Consequently, there are different levels, both in scope and depth. The minimum knowledge and competencies for different levels and functions are internationally agreed upon and codified in the International Convention on Standards of Training, Watchkeeping and Certification, 1978 (STCW).

Due to recent accelerated technology development, many have raised the question of the "appropriate" level of knowledge and competencies for future seafarers. The knowledge and competencies traditionally delivered at MET institutions are confronted with changing shipboard organisation, new technologies (particularly communications and AI), accelerated business activities, etc. At the same time, the core set of competencies given in the STCW Convention has not been updated since 2010 or in several subject areas even since 1995. Consequently, the skills gap between given standards and industry needs is clearly recognised (SkillSea, 2020). The number of new or revised non-mandatory courses is increasing as well as a list of IMO approved Module Courses, with more extensive stakeholders' involvement than ever. Even the GMP initiative, promoted by the IAMU, may be understood as a response to these needs by systemising and generally improving the knowledge delivery at the global level, thus improving the efficiency of the MET as a whole.

The maritime professional knowledge, once a sole responsibility of the national authorities, today is to a large extent internationalised and represented in internationally recognised documents. Due to the numerous proficiency levels and activities, maritime knowledge is dispersed in numerous documents, with different obligatory levels, scopes, objectives, styles, structures, etc.

However, in most cases, professional knowledge is represented as statements describing the abilities the students should master during the educational process (Davis, 1993). Such an approach, in general, follows the well-known Bloom's taxonomy. It is understood as a common language to facilitate communication on learning objectives across persons, subject matter, and levels. Yet, it is not used consistently, and in different documents, the target competencies, although very similar, are represented in very different arrangements.

Therefore, the research presented here deals with the modes of knowledge representation in MET and their characteristics in different documents**.** It is based on the semantic analysis of the knowledge statements in relevant international sources using a corpus-based approach, relying on the concept of semantic frames (cf. Fillmore & Baker, 2010).

2. Research objectives, methods and outcomes

According to one of many definitions, *professional knowledge is traditionally seen as knowledge that has undergone a formal rationalisation, knowledge that is systematic, codified and generalised, hence abstract. It thus accords with the norms of academic education, supporting the argument for professional education to be situated within the universities* (French, 2007). Maritime knowledge definitely corresponds to this definition.

To semantically analyse maritime knowledge, it was necessary to select the sources representing maritime knowledge in systematic, codified and generalised form. Unfortunately, there is no single source; in fact, maritime knowledge, as in many other areas, is dispersed across many sources in highly different forms and structures. Consequently, the authors decided to analyse a range of sources presenting maritime knowledge differently, starting with a highly formal structure (thus the most condensed) to more elaborate but less formal representations. The selected sources (corpora) include:

1 Core STCW competencies for deck and engine crew members, i.e. competencies (knowledge, understanding and proficiencies) formally described in respective STCW tables (Chapters II and III) in the form of the statements describing required capabilities at different levels.

2 Extended STCW competencies (competencies as represented in the STCW Code A & B, without Chapter I, i.e. the core competencies supported with other competencies, recommendations and guidance related to these competencies.

3 Model Courses (Deck, Engine, ETO), i.e. guidance for developing curricula of study programs required for officers at the management and operational level. Here, the competencies are described in more detail and also include guidance on delivering, references, teaching aids, etc.

4 GMP Body of Knowledge (Manuel, 2019), as a document encouraging IAMU member institutions "*to examine the learning outcomes agreed in the BoK and thereafter within the academic freedoms and requirements of their own jurisdictions, develop a curriculum (syllabi, learning activities, assessment methods etc.) that will aim at the achievement of these learning outcomes in a consistent manner.*"

5 IAMU AGA proceedings (AGA 19, 20 and 21), as a corpus representing contemporary MET teachers' perspectives and interests.

6 WÄRTSILÄ Encyclopaedia of Ship Technology (Babicz, 2015), as a comprehensive and systematic representation of the current technological state of the art.

Each corpus represents the common maritime knowledge differently, depending on goals, point of view, intended scopes, audience, etc. It is important to note that selected corpora cover all aspects of maritime knowledge: factual, conceptual, procedural, and metacognitive knowledge (as defined by Krathwohl, 2002) and domains, and therefore may be considered representative of the language register.

The corpora include 1,423,975 tokens, or 1,146,955 words. The basic analyses are accomplished using the Sketch Engine corpus analysis tool. In addition, several analytical tools, such as textual similarity measures and readability, have been implemented in R to gain insight into the semantic similarity or distance among these sources.

The linguistic analysis for each corpus includes:

– identification of the most frequent words (verbs, nouns, collocations and multi-word units),

– the usage of the action verbs identified as the preferred ones for use when developing Model Courses (IMO HTW, 2020),
– readability statistics.

Since complete analyses include numerous outcomes, only a selected set of outcomes is presented in the following paragraphs.

Corpus analysis enables the detection and description of typical patterns and frequent forms that would otherwise be unnoticed, and this shows how communication is a highly structured activity with patterns which are not random but cognitively motivated. The corpora compiled for this study serve to target specific research questions and therefore had to be representative of the area under study and balanced in terms of diverse texts that were incorporated. To meet these requirements, the texts included in the corpora were selected according to the criteria recommended by the EAGLES group, encompassing external (non-linguistic) criteria, such as style and origin, and internal (linguistic) criteria, such as genre and topic.

The basic quantitative data that corpora provide is the frequency of different linguistic units. In particular, the frequency data about action verbs ((IMO HTW, 2020) provided interesting insights into the presentation of maritime knowledge in different corpora. As Figure 1 shows, the action verbs belonging to the cognitive domain are most frequent in all corpora, while those from the psychomotor and affective domains have a smaller share. This might be attributed to the fact that the cognitive domain involves the understanding or recall of specific facts, procedures, and concepts directly related to the topics in the maritime domain. Therefore, they are more easily identified than skills or attitudes related to the psychomotor and affective domains. On the other hand, corpora compiled from STCW have the greatest frequency of psychomotor action verbs, while affective action verbs are most frequent in GMP BoK.

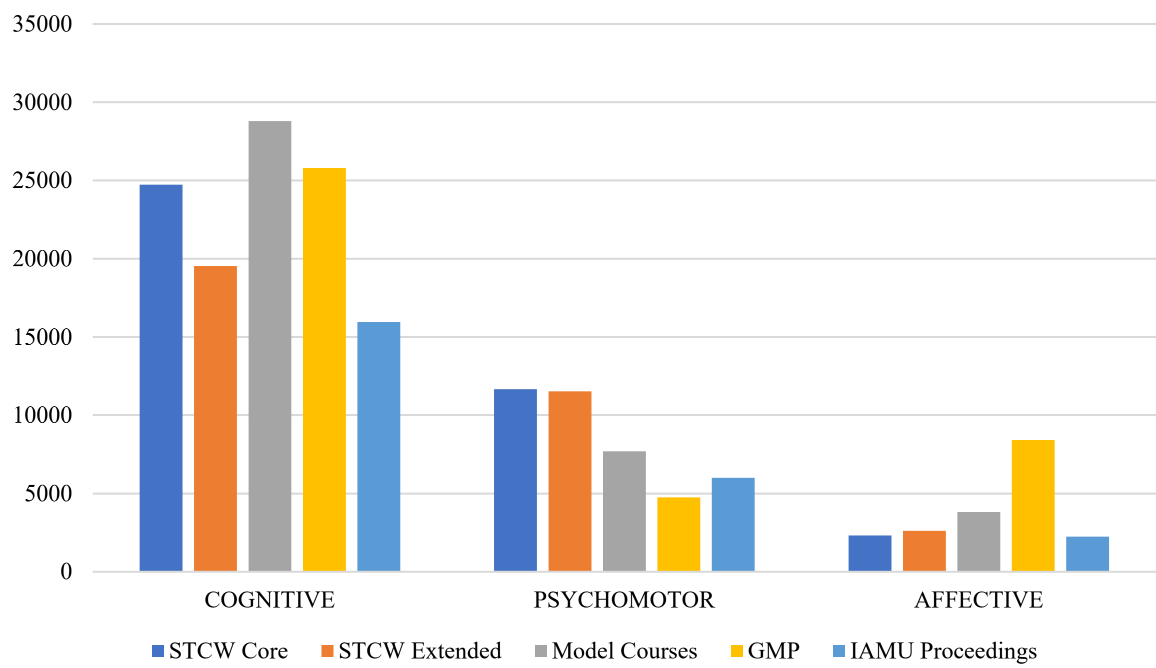

Figure 10 Distribution of the IMO-defined action verbs in corpora by domains

Taking a deeper insight into the cognitive domain, the frequency of related action verbs shows that the emphasis is on the application as the medium level of complexity, particularly in STCW, while higher complexity levels are much less represented. The exception here is the GMP BoK, in which the action verbs of all levels of complexity have similar frequencies, showing its equal dedication to all levels.

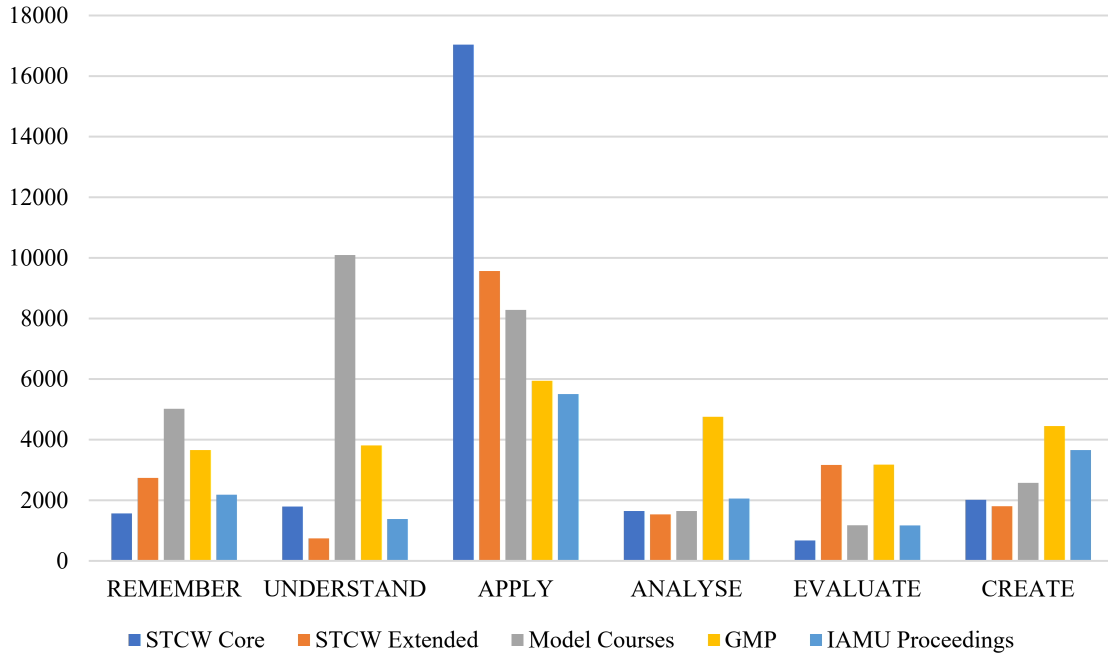

Figure 11 Distribution of the IMO-defined action verbs in corpora by knowledge domains

Furthermore, keyness score analysis was also conducted in Sketch Engine, which indicates the words or phrases typical or key in a certain context, i.e. characteristic for a specific text as opposed to another, in this case, the corpus of general English language EnTenTen20. Keyness is a textual feature providing insight into the main semantic domains of a certain text. The conducted keyness score calculation, shown in Figures 3, 4 and 5, singled out the key terms for IAMU AGA Proceedings, WÄRTSILÄ Encyclopaedia of Ship Technology and GMP BoK, which indicate the main areas the corpora are focused on. In that sense, IAMU AGA Proceedings focus most on education (maritime education, model course, learning outcome, met institution), soft skills (risk assessment, human error, risk management) and future developments (autonomous ship, cyber security, wave energy).

Figure 12 Key terms in IAMU AGA Proceedings

As expected, WÄRTSILÄ Encyclopaedia focuses mostly on technology, while the GMP BoK addresses mostly the topic of knowledge acquisition.

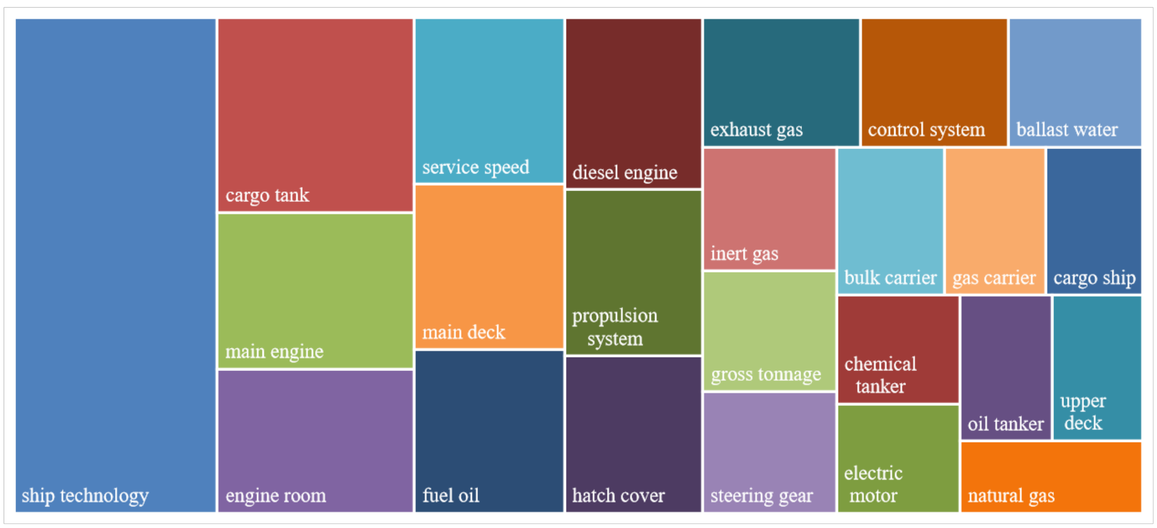

Figure 13 Key terms in WÄRTSILÄ Encyclopaedia of Ship Technology

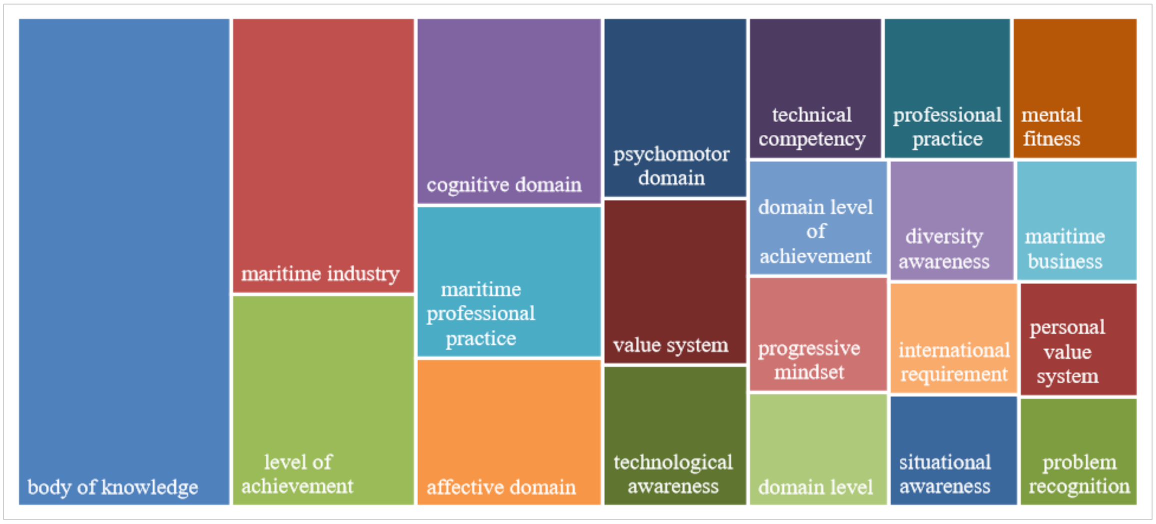

Figure 5 Key terms in GMP BoK

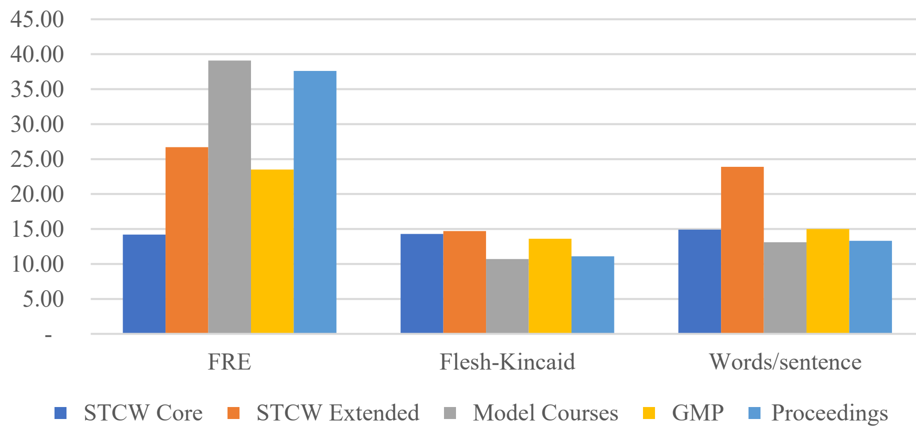

Figure 14 Readability of different corpora

The analysis also included statistical indicators of readability, which quantifies how difficult a text is to read, taking into account several factors, such as the number of syllables in words or the number of characters in a word indicating semantic difficulty, number of words in sentences indicating structural difficulty. According to the diagram in Figure 6, Model Courses are the most readable texts with 13 words per sentence on average, while GMP BoK and STCW would qualify as the least readable with 15 and 23,9 words per sentence, respectively.

Other corpus analysis data and statistical indicators omitted due to space restrictions, such as keyword frequencies, collocation strength and semantic similarity, showed certain distinctive features of individual subcorpora. Further research could be directed towards identifying semantic frames in different maritime corpora, providing insight into the level of their compatibility.

3. Conclusions

Following the outcomes presented in the previous paragraphs, the main conclusions of the research (in part presented here) are as follows:

1. Psychomotor and affective domains are clearly underrated in all considered documents, the only notable exception being the GMP BoK. Although these domains are much more difficult to codify and formalise, their importance is significant, and further developments in these areas of maritime education are highly welcomed.
2. Most action verbs used to describe required knowledge deal with the application level. Although fully understandable and in line with predominant understanding in the shipping industry in the past, it is highly questionable whether a focus on the application is sufficient to enable future seafarers to operate highly sophisticated ships or onboard systems. Again, the only notable exception is GMP BoK containing more action verbs defining higher knowledge levels. Such a low level of dedication to higher, more creative levels of a knowledge domain is not satisfactory for maritime universities, which are assumed to pursue those higher levels in their curricula.
3. Key terms identified as the most important in the IAMU AGA Proceedings show the broad interest of contributing authors, somehow equally distributed between new technologies and demands (e.g. autonomous ships, emission factors, and cyber security) and educational subjects (e.g. model courses, MET institutions, learning outcomes).

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Determination of critical risk factors that prevent in-ship communication during ship operational processes

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Abstract: In-ship communication is critical for the successful execution of operational processes such as loading, unloading and maneuvering on ships. Interruption of in-ship communication for any reason not only causes these operational processes to fail, but also can lead to serious accidents. In addition, as a result of these accidents, death, injury, damage to ships and port facilities, environmental pollution and legal problems may occur. In this respect, establishing an effective and uninterrupted in-ship communication during ship operations will significantly reduce the risk of accidents. In realizing this, it is of great importance to determine the critical risk factors that create barriers for in-ship communication. In the study, as a result of detailed examination of publications, circulars, safety guides as well as consulting expert opinions, risk factors that prevent in-ship communication were determined. Using these risk factors, a comprehensive survey was created and an assessment of each risk factor was taken by an expert group familiar with ship operational processes. Obtained feedbacks were prioritized by performing Analytical Hierarchy Process (AHP). As a result of the analyzes made, it was concluded that the risk factors that most negatively affect on-board ship communication are due to the lack of training and individual factors.

Keywords: communication barriers; critical risk factors; prioritization; numerical risk analysis

1. Introduction

In-ship communication is critical for the successful management of many operational processes such as ballast, cargo and berthing on ships. In cases where effective in-ship communication cannot be provided on ships, the potential for accidents increases [1]. In addition, it is seen that communication-related failures are effective in the emergence of many maritime incidents/maritime accidents [1- 9]. As a result of these maritime accidents, not only property losses, but also loss of life and major environmental disasters can occur. In this respect, an effective on-board communication is of great importance in order to carry out safe operations and to prevent possible maritime accidents. In order to establish this, it is thought that many issues, from the communication tools used on the ships to the individual factors of the ship's crew, should be examined in detail. The study aimed to determine the risk factors that prevent an effective in-ship communication and to prioritize them. In this context, the risk factors that hinder the on-board communication were evaluated in the presence of experts and weighted using the Analytical Hierarchy Process (AHP) method, and thus they were prioritized. The study consists of a total of 5 main sections. First section presents brief information about in-ship communication. The second section summarizes the AHP method applied to the study. The third section details the application of the AHP method in the company of experts for the identified risk factors. The fourth chapter evaluates the findings of the study. The fifth chapter is the last chapter and concludes the study.

2. Methodology

The AHP approach is a mathematical technique that provides an effective choice in multi-criteria decision-making processes. This technique was developed by Thomas Saaty in 1980 [10], and has its own problem solving processes. It is among these specific processes that multi-criteria problems are resolved in a hierarchical order [11].

Within this hierarchical structure, there are different components consisting of various levels. In the first level, there is a goal specific to the study. At the second level, criteria that interact with the goal and have a causal link at a certain level are positioned. At the third level, there are sub-criteria that are semantically related to each criterion group. At the lowest level, alternative options that are most effective for the achievement of the goal can be written [12- 14]. In addition, AHP implementation steps are described below [15]:

i.) Identifying the problem to be solved,

ii.) Establishing the analytical hierarchical structure,

iii.) Creation of pairwise comparison matrices for each criterion and sub-criteria,

iv.) Receiving expert evaluations for the created pairwise comparison matrices,

v.) Calculation of weights for each criterion and sub-criteria,

vi.) Consistency control.

Many scales can be used in the evaluation processes of binary comparison matrices. In the study, the binary comparison scale proposed by Saaty was used [10, 16-17]. In addition, measuring the effectiveness of the judgements received from the experts plays a critical role in obtaining meaningful results. In this respect, consistency analysis was performed for each pairwise comparison matrix in the study. The consistency analysis was applied by following the steps proposed by Saaty [16]. In this respect, the following equations (1)-(4) are utilised respectively [10,16]:

$$E_x = \frac{d_x}{w_x} \tag{1}$$

Here, Ex and dx are intermediate values, while Wx represents criterion weights.

$$\lambda_{max} = \frac{\sum_{i=1}^{t} E_x}{t} \tag{2}$$

λ_{max} symbolizes the largest eigenvalue, while t gives information about the size of the matrix.

$$CI = \frac{\lambda_{max} - t}{t - 1} \tag{3}$$

CI stands for consistency index.

$$CR = \frac{CI}{RI} \tag{4}$$

CR symbolizes consistency ratio, RI stands for random consistency index, the The CR value may vary depending on the size of matrix. The consistency of the matrices can be mentioned when the CR value is less than 0.10 [10, 16].

3. Quantitative Risk Analysis

In the study, first of all, the risk factors/criteria that prevent communication within the ship were determined [1-9, 18]. Identified risk factors are classified into 3 main groups. In addition, using these risk factors, the Analytical Hierarchy structure specific to the study was created and given in Table 1.

Table 1. Identified risk factors and analytical hierarchy structure of the study

Items	Description
GOAL	Risk factors that prevent in-ship communication
Main Criteria (C)	Risk factors originating from communication tools
Sub criteria (C1)	Battery failure of communication tools
Sub criteria (C2)	Insufficient number of communication tools
Sub criteria (C3)	Lack of back-up communication tools
Sub criteria (C4)	Non-standard communication tools
Main Criteria (D)	Individual factors

Sub criteria (D1)	Lack of self-confidence
Sub criteria (D2)	High power distance between ship officers and ratings
Sub criteria (D3)	Prejudice/Bias
Sub criteria (D4)	Lack of adaptation to cultural diversity
Main Criteria (E)	Lack of Training
Sub criteria (E1)	Insufficient use of Standard Marine Communication Phrases (SMCP)
Sub criteria (E2)	Not to be familiar with ship working language (English, etc.)
Sub criteria (E3)	Timing error
Sub criteria (E4)	Misunderstanding

Then, pairwise comparison matrices were created for both the main and each sub-criteria group. In this context, a total of 4 binary comparison matrices, 1 for the main criteria and 3 for the sub-criteria, were designed. Expert opinions were consulted to evaluate the superiority of each criterion in the created matrices to each other. In this context, the profiles of the experts who contributed to the study are given in the Table 2.

Table 2. Details of the marine experts

Experts	Position/Rank	Sea service (Years)	Education Level
Expert 1	Master	20	Bachelor Degree
Expert 2	Master	18	Bachelor Degree
Expert 3	Master	15	Bachelor Degree
Expert 4	Master	14	Master Degree
Expert 5	Master	19	Bachelor Degree

While making pairwise comparisons, experts benefited from the pairwise comparison scale detailed by Saaty [10, 16-17]. In this context, the pairwise comparison matrix obtained for the main criteria as a result of the evaluations of 5 different experts is given in Table 3, and the paired comparison matrices obtained for each sub-criterion are given in Table 4.

Table 3. Binary comparison matrix for main criteria

	C	D	E
C	1	0.36	0.19
D	2.77	1	0.28
E	5.26	3.57	1

Table 4. Binary comparison matrix for sub-criteria

Pairwise comparison of the sub-criteria of the main criterion C				
	C1	C2	C3	C4
C1	1.00	4.16	3.13	0.32
C2	0.24	1.00	0.32	0.14
C3	0.32	3.13	1.00	0.24
C4	3.13	7.14	4.16	1.00
Pairwise comparison of the sub-criteria of the main criterion D				
	D1	D2	D3	D4
D1	1.00	0.27	0.34	2.93
D2	3.70	1.00	2.93	7.14
D3	2.94	0.34	1.00	4.17
D4	0.34	0.14	0.24	1.00

Pairwise comparison of the sub-criteria of the main criterion E				
	E1	E2	E3	E4
E1	1.00	3.23	3.33	4.34
E2	0.31	1.00	3.33	4.21
E3	0.30	0.30	1.00	2.76
E4	0.23	0.23	0.36	1.00

The matrices formed as a result of the feedback received from the experts were first normalized. After, the weights of each main and sub-criteria were calculated within the framework of the AHP approach [10, 15-16]. In this context, the weights calculated for the main criteria C, D and E were found to be 0.104, 0.233 and 0.663, respectively. In addition, the weights obtained for the C1, C2, C3 and C4 sub-criteria included in the main criterion C are 0.260, 0.058, 0.132 and 0.550, respectively. Considering the sub-criteria of D, the weights of D1, D2, D3 and D4 were calculated as 0.138, 0.538, 0.264 and 0.060, respectively. Finally, the weight values of the E1, E2, E3 and E4 sub-criteria in the E group were calculated as 0.497, 0.284, 0.264 and 0.060. Furthermore, in order to measure the consistency of the created matrices and to see that meaningful results are obtained, a separate consistency analysis was carried out for each of the 4 matrices by using equations (1)-(4) respectively. In this context, the calculated CR values for each matrix are detailed in Table 5.

Table 5. Designated matrices and calculated CR values

Matrices	Calculated CR values
C-D-E	0.025
C1-C2-C3-C4	0.052
D1-D2-D3-D4	0.040
E1-E2-E3-E4	0.089

4. Findings and Discussion

As a result of the consistency analyzes for all matrices, the CR values were found to be less than 0.10. In this respect, it is seen that the outputs obtained in the study are reliable and consistent. Also, as a result of the analyzes made for the main criteria, it was concluded that the most critical risk threatening in-ship communication in operational processes is the lack of training with 0.663 criteria weight. This is followed by 0.233 weighted individual factors and 0.104 weighted risk factors originating from communication tools, respectively.

When the analyzes of the sub-criteria related to the risk factors arising from the communication tools were evaluated, it was concluded that the sub-criteria with the highest potential to disrupt in-ship communication was non-standard communication tools with 0.550 criteria weight. After these sub-criteria, the highest weighted criteria were found to be battery failure of communication tools (0.260), lack of backup communication tools (0.132) and insufficient number of communication tools (0.058), respectively. In this respect, the use of non-standard communication tools should be avoided for an effective communication on ships. In addition, the batteries should be checked, it should be ensured that there are always backups of communication tools, and a sufficient number of communication tools should be used in the operational process.

When the sub-criteria related to individual factors were examined, it was found that high power distance between ship officers and ratings constituted the greatest threat to in-ship communication in this group with 0.538 criteria weight. The second most critical threat was found to be prejudice/bias. Then, lack of self-confidence (0.138) and lack of adaptation to cultural diversity (0.060) were found, respectively. In this respect, high power distance should be avoided in officer-rating communication within the ship. All ship operational processes should be carried out with mutual understanding and courtesy. In addition, psychological support should be provided to the personnel to gain self-confidence. Especially on ships where multinational personnel work together, orientations should be made for the adaptation of crew members to each other and to the ship environment.

On the other hand, the sub-criteria related to lack of training were examined, it was determined that the sub-criterion with the most negative potential to affect in-ship communication in this group was insufficient use of SMCP with 0.497 criteria weight. This was followed by other sub-criteria as not to be familiar with ship working language (0.284), timing error (0.144) and misunderstanding (0.075), respectively. In this context, a language that is as short, concise and understandable as possible should be used in operational processes on ships. In this regard, the effective and adequate use of SMCP should be encouraged [18]. In addition, a common working language, such as English, is determined on ships where international personnel generally work together. In this context, the common language used on board should be well known by the personnel. Furthermore, reports should be made on time and clearly during ship operations.

5. Conclusion

In the study, risk factors that have the potential to impede on-board communication were examined. In this context, it has been concluded that the biggest threat to effective communication in ship operational processes is the lack of training. In addition, it has been concluded that the second biggest risk factor is the risks arising from individual factors. In addition, it has been determined that the third biggest threat is the risk factors arising from communication tools. In this context, comprehensive suggestions have been made in the study, from the effective use of SMCP to providing psychological support to crew members. In addition, a quantitative risk analysis was carried out by using the AHP method in the study.

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Mitigating maritime unemployment in Georgia: A Maritime Education and Training perspective

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Abstract: Despite the trend that qualified seafarers are globally in shortage, some maritime education and training (MET) institutions, including the Batumi State Maritime Academy (BSMA) - Georgia, are struggling to find employment for their students. This paper addresses the employment challenges faced by cadets in Georgia and identifies possible solutions from a MET perspective. Secondary data analysis was conducted using the published survey data about BSMA graduates as well as employers. There was a gap identified between MET provided and employers' feedback about BSMA graduates' knowledge and skills. Employers were generally unsatisfied with the graduates of marine navigation, particularly in their ability to draw conclusions; theoretical knowledge; applying knowledge in practice, and ability to work in a team. In reality, the majority of marine navigation graduates (82.6%) found a job outside of their specialization. Nevertheless, another document analysis reports new development for MET in Georgia in terms of infrastructure which help consider future opportunities for quality MET. In conclusion, the paper also looks into the lifelong learning opportunities for Georgian seafarers to strengthen their capacity in human capital development and provides recommendations for MET in Georgia in preparing for sustainable shipping globally.

Keywords: Maritime Education and Training (MET); Georgia; unemployment; higher education curriculum; lifelong learning

1. Introduction

It is globally reported that qualified seafarers are in shortage and the seafarer demand is always higher than the actual seafarer supply (BIMCO and ICS, 2021). Despite this trend, some maritime education and training (MET) institutions, including the Batumi State Maritime Academy (BSMA) - Georgia, are struggling to find employment for their students. According to the BSMA graduate survey in 2019, deck and engine cadets who found a job were 52% and 50% respectively[1]. At the national level, the Maritime Transport Agency of Georgia (2021) reports that among 264 graduated students from three maritime universities in Georgia, only 171 were employed as cadets by the authorized crewing companies, indicating that the unemployment rate among cadets was 53%.

Nevertheless, maritime employment is an important career opportunity for young people in Georgia as its seafarer employment has been increasing in recent years. In 2020, a total of 3,553 Georgian seafarers, including 1,749 officers and 1,804 ratings, were employed (Maritime Transport Agency of Georgia, 2021). On the other hand, the youth unemployment rate (aged 15-24) in Georgia was recorded as 39.7% in 2020, which appeared to be the worst in the region (World Bank, 2021). It is therefore urgent to minimize the unemployment of MET graduates and further increase maritime employment for Georgian youth.

This paper addresses the employment challenges faced by cadets in Georgia and identifies possible solutions from a MET perspective. Secondary data analysis was conducted using the published survey data about BSMA

[1] See the BSMA Quality Service (https://bsma.edu.ge/page/xarisxis-samsaxuri#3)

graduates as well as employers. The analysis helped understand the current problems with the BSMA graduates and identify a gap between MET provided and employers' feedback about BSMA graduates' knowledge and skills. Employers were generally unsatisfied with the graduates of marine navigation, particularly in their ability to draw conclusions; theoretical knowledge; applying knowledge in practice, and ability to work in a team. The BSMA student survey also shows that the majority of marine navigation graduates (82.6%) found a job outside of their specialization. Based on these results, a series of document analyses were conducted to analyze the current BSMA curriculums in terms of possible causes for the identified gaps. In addition to the gap analysis, another document analysis about new development for MET in Georgia was exercised to consider future opportunities for quality MET. Such new development includes the Poti branch of BSMA and a multifunctional pool for practical training. It is assumed that new MET development in Georgia, including lifelong learning opportunities, will facilitate the mitigation of unemployment among MET graduates and increase maritime employment opportunities.

2. Mass stranding of cadets in maritime employment

BSMA offers vocational, bachelor's, and master's degree educational programs. There are three major faculties in BSMA: Faculty of Navigation, Faculty of Engineering, and Faculty of Business and Management. In recent years, applications for maritime navigation and engineering faculties have been high, for example, in 2020, BSMA announced 200 vacant places for Maritime Navigation where 760 applications were received. Similarly, for 120 vacant places for Marine Engineering, 689 applications were registered and for 75 vacant places for Marine Electrical Engineering, 623 applications were received[2]. These statistics demonstrate that maritime educational programs are very popular and attractive among young Georgians. Pallis and Ng (2011) stated that students choose maritime education because of its prestige and skills they acquire, which are considered to be portable and flexible.

Despite this BSMA's success in attracting young people to maritime courses, many of BSMA graduates suffer from high unemployment in the desired maritime positions. According to the BSMA graduate survey in 2019, deck and engine cadets who found a job were 52% and 50% respectively. In 2020, a similar survey, targeted at employers and strategic partners, only 30 % of BSMA graduates were employed by 31 participating companies which consisted of 40% of the total numbers in database and only 19% stated that they had signed a memorandum of cooperation with BSMA. At the national level, the Maritime Transport Agency of Georgia (2021) reports that among 264 graduated students from three maritime universities in Georgia, only 171 were employed as cadets by the authorized crewing companies, indicating that the unemployment rate among cadets was 53%. A general trend in the number of recruitments is decreasing in addition to the impact of COVID-19 pandemic (Fig. 1).

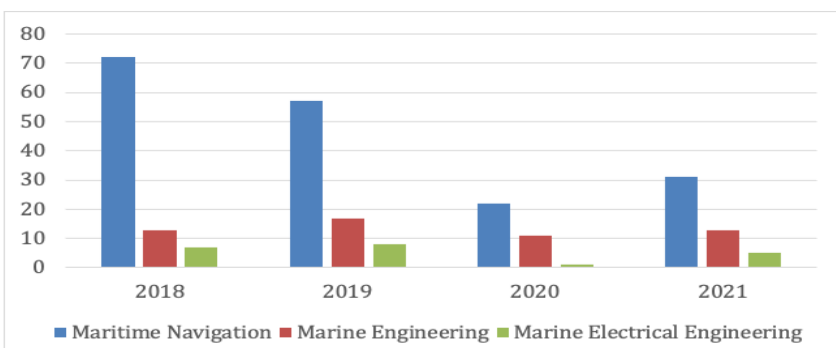

Figure 1. BSMA employment statistics, 2018-2021 *(Note: survey respondents only)*

[2] Data were retrieved from the National Assessment and Examinations Center (NAEC), Ministry of Education and Science of Georgia and the BSMA online resource (https://bsma.edu.ge/page/sabakalavro-saganmanatleblo-programebi#1).

3. Understanding the employment gap

The paradox that young Georgians are interested in maritime studies but the employment rates are low can be explored from further surveys conducted with employers and BSMA students. In the 2020 employer survey, while they noted various strengths of BSMA graduates (e.g., application of theories in practice, sociability, responsibility), employers also identified the weaknesses of BSMA graduates in the areas of knowledge of foreign languages (e.g., English, and in some cases, basic level of Russian and Turkish) as well as the ability to apply theoretical knowledge in practice. In the previous survey period (2017-2018), the results of the student survey revealed that the majority of marine navigation graduates (82.6%) found a job outside of their specialization. A survey for employers in 2017-2018 also highlighted that they were generally unsatisfied with the graduates of marine navigation, particularly in their ability to draw conclusions; theoretical knowledge; applying knowledge in practice, and ability to work in a team.

In the first semester of 2021-2022 academic years, BSMA published another survey about students' satisfaction research report. The aim of the research was to identify the BSMA students' attitude towards educational process/format, educational programs and exchange programs/international projects. Over the half (53%) of students participated in the study; of which 78.3% were the students specializing from maritime navigation and engineering faculties. The key findings of the study can be summarized in three areas.

First, overall, students were satisfied with the e-learning/distance/hybrid learning format; however, most of them indicated that they preferred auditory learning. They also mentioned that they would like to upgrade the student portal and participate in schedule creating. Second, many students (58.4%) indicated that they were satisfied with educational programs, although they believed that some programs needed to change teaching methods and formats and they must be engaged in the improvement; they also commented that much more time should be devoted to the use of simulators. Third, students expressed their will to change the grading system. And finally, nearly half of the students (45.2%) said that they were given an opportunity to participate in exchange /international programs, but 37.5% had no information about current and on-going projects.

In summary, employers are often dissatisfied with the knowledge and skills of maritime students, however students have also identified the areas that MET institutions should improve in order to achieve better learning experience for students. Based on two perspectives from employers and students, the next section examines how competences are taught in the MET institutions.

4. Review of BSMA curriculum design and delivery

Both the Maritime Navigation and Marine/electrical Engineering educational programs are designed to issue the sea navigators and marine engineers with management, operational, and support levels, who will meet the relevant requirements of the STCW 1978 Convention, as amended. BSMA has designed the curriculums in 4 academic years (8 semesters), hence students can gain 30 ECTS per semester, resulting in 240 ECTS in total in order to earn Bachelor's degree. In this study, the BSMA curriculum design and delivery were reviewed by using document analysis. The reviewed documents were BSMA's curriculum documents (e.g., syllabus, teaching calendar) and other documents specifying the allocation of teachers and other resources.

4.1 Learning outcomes

In the document titled "Formulation and evaluation of program learning outcomes", BSMA states that, evaluating the learning outcomes of an educational program consists of four stages: (1) Formulation of learning outcomes of the educational program; (2) Curriculum analysis, during which it is determined whether the program provides students with sufficient opportunities to achieve the learning outcomes of the program; (3) Evaluate the learning outcomes of the educational program, which includes data collection, analysis, and interpretation by students to determine the achievement of the desired level of learning outcomes; (4)Curriculum analysis, during which it is determined whether the program provides students with sufficient opportunities to achieve the learning outcomes of the program.

To achieve learning outcomes, BSMA uses the map of compliance with program aims and learning outcomes (Table 1):

Table 1. Program aims and learning outcomes

Program aims	Learning outcomes						
	I	II	III	IV	V	VI	VII
Program aim 1							
Program aim 2							
Program aim 3							

After formulating program-learning outcomes, BSMA starts program design and development to achieve learning outcomes. Table 2 is the curriculum map which is a table that presents the learning outcomes of the program as well as the mandatory teaching courses, activities, and research components offered by the educational program:

Table 2. Teaching course and program learning outcomes

Teaching course	Program learning outcomes					
	I	II	III	IV	V	VI
1	Intro		Intro/Strengthening		Deepening/ Strengthening	
2		Deepening		Deepening		Strengthening
3	Intro				Strengthening	

Using this guide, BSMA educational programs are created. In this paper, a sample of Maritime Navigation program is presented in Table 3.

Table 3. Maritime Navigation program and its learning outcomes (NB: emphasis made by Authors)

Aim of the program	Learning outcomes
Aim of the program is to: 1. **Train** sea navigators of management, operational and support level, who meet national (industry specification "Maritime navigation") and international STCW convention (A-II/1, A-II/2, A-II/3) standard requirements. On the basis of appropriate training and recognized seagoing practice navigators **will gradually be able to get an officer position** on an ocean merchant ship; 2. **Train** a practice-oriented worker who will be able to identify navigation threats, solve problems and think critically within acquired competence	After successful completion of the educational program graduate will be able to: 1. **Plan** navigational and cargo operations; 2. **Navigate** in different weather conditions; 3. **Provide** safe navigation; firefighting; 4. **Use** of safety and survival crafts in emergency situations; 5. **Provide** first medical aid; knowledge of survival at sea techniques; 6. **Provide** hydro meteorological observation and read synoptic charts; 7. **Use** navigational information, charts and electronic charts, control ship positioning and movement; 8. **Use** celestial bodies and equipment; 9. **Use** ship radio and electric navigational, radiolocation and navigational automated systems; 10. **React** adequately on Master's orders; 11. **Properly organize** navigational watch and work of crew members; 12. **Use** of informational and communication technologies; 13. **Provide** safety, survival and rescue operations in English language based on international regulations requirements; 14. **Use** all kinds of Radio navigational systems in accordance with Radio Regulations

Based on Table 1, program aims and learning outcomes are aligned and narrowed according to the STCW convention (A-II/1, A-II/2, A-II/3) standard requirements that include all the competencies needed for the industry. In developing learning outcomes, it is advised to use Bloom's taxonomy's key verbs that indicate the complexity of the learning outcomes in the cognitive domain (Kennedy, 2007). Most frequent verbs that are used in given learning outcomes in Table 3 are: "*use*" and "*provide*" at the level of "applying" – which corresponds to its initial definition of the Bloom's taxonomy, that is "solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way" (Sideeg, 2017). On the other hand, "*identify* navigation threats" and "*think critically* within acquired competence" are at a higher, cognitive level that corresponds to "analyzing" and "evaluating" respectively. Considering this fact, learning outcomes must meet this entanglement of the program's aims.

4.2 Teaching schedule and subject distribution

Maritime Navigation covers the competencies and knowledge according to Section A-II/1 and Section A-II/2 of STCW, and this program is mapped out in such a way that students are equipped with fundamental knowledge of technical sciences (e.g. mathematics, physics) at the beginning of the studies (mostly in the two semesters). Teaching the relevant and profession-specific modules of the program starts from the 3rd semester and continues until the 8th semester; the 5th semester for all academic programs is devoted to the onboard training (30 ECTS). Additionally, the delivery of the English language course, including Maritime English, starts from the 1st semester and finishes in the 6th semester.

Nevertheless, it is noticeable that several subjects (highlighted in Table 4) were detected as they did not correspond to learning outcomes provided by the BSMA's Maritime Navigation learning outcomes (Table 3). In particular, physical training with 4 ECTS is not the competence of gradually promoting officer in charge of the navigational watch.

Table 4. Maritime Navigation program schedule (highlighted by Authors)

BATUMI STATE MARITIME ACADEMY
ბათუმის სახელმწიფო საზღვაო აკადემია

I Semester	1.Intermediate English MF I or 2.Upper Intermediate English MF I 5 ECTS	Physical Training I 2 ECTS	Mathematics MF I 5 ECTS	General Physics I 5 ECTS	Selective Component 3 ECTS	Navigational Routes 5 ECTS	Seamanship 5 ECTS
II Semester	1. Intermediate English or 2. Intermediate+ English MF I 5 ECTS	Physical Training II 2 ECTS	Mathematics MF I I 5 ECTS	General Physics I I 5 ECTS	Industrial Chemistry 4 ECTS		Information Technologies in seamanship 4 ECTS
III Semester	Maritime English MN1.1 5 ECTS	International Regulations for Preventing Collisions at Sea 5 ECTS	Marine Navigation I 5 ECTS	Maritime Safety Rules MN 5 ECTS	Celestial Navigation I 5 ECTS		Types, Constructions and Technical Equipment of ships 5 ECTS
IV Semester	Maritime English MN1.2 5 ECTS	Ship Handling and Maneuvering 5 ECTS	Marine Navigation II 5 ECTS	Marine Communication and Radionavigation Systems 5 ECTS	Celestial Navigation II 5 ECTS		Ship Stability 5 ECTS
V Semester	Onboard Training MN 30 ECTS						
VI Semester	Maritime English MN2 5 ECTS	Navigational gears 5 ECTS	Prevention of Pollution of Marine Environment and anti-pollution procedures 5 ECTS	Ship Power and Electric Systems 5 ECTS	Marine Meteorology 5 ECTS	Maritime Law 5 ECTS	
VII Semester	Quality Assurance and Marine Risks Management Onboard 5 ECTS	International Maritime Organization (IMO) Conventions 5 ECTS	Ship Commercial Management 5 ECTS	ECDIS I 5 ECTS	Radar Systems 5 ECTS	Cargo operations on dry cargo vessels 5 ECTS	
VIII Semester	Professional Knowledge and Competencies MN 5 ECTS	Marine Risks Assessment and Management 5 ECTS	Leaderships and Ethics 5 ECTS	ECDIS II 5 ECTS	Ship Management 5 ECTS	Bridge Resource Management 5 ECTS	

BSMA states that "on the basis of appropriate training and recognized seagoing practice, navigators will gradually be able to get an officer position on an ocean merchant ship". Subjects related to "Ship commercial management", "Quality assurance and Marine risks management", "Leadership and Ethics", and "Maritime Law" ought to be considered "gradually" after taking "appropriate training and recognized seagoing practice" as it is indicated in the program's aim. Furthermore, the subjects on "Ship commercial management" and "Ship management" seem to repeat the same purposes, so narrowing this subject down or uniting, thus using the rest of the ECTSs for higher-cognitive level training would be appropriate to fill the gap that employers complain about, for instance, lack in theoretical knowledge or draw conclusions. This can be done by, for example, allocating more teaching hours to profession-related subjects, such as Marine Navigation, and Ship stability. Such "constructive alignment" is the key for outcome-based education at higher maritime education (Biggs, 2014). The assessment system is in accordance with "Order No. 3 of the Minister of Education and Science of 5 January 2007": a 100-point system in each component of the educational program. Learning outcomes are evaluated for each component of the educational program with a mid-term and final assessment. The syllabi of each course include all the forms, methods, components, and criteria for knowledge verification.

4.3 Resource allocation and new development

The learning activities in the BSMA's maritime courses include lectures, group work, seminars, practical training, laboratory work, and sea-going training. A number of human resources are distributed accordingly (Table 5). The number of academic and support staff involved in the Maritime Navigation program is 71, which correlates the number of maritime navigation students. BSMA is using all available resources (hardware and software), laboratories, and Seafarers Training and Certification Centre simulators and equipment for achieving those programs' learning outcomes.

Table 5. Resource allocation at BSMA

Courses	Professors	Associate Professors	Assistant Professors	Assistants	Invited teachers	Total
Maritime Navigation	6	24	2	5	34	71
Marine Engineering	5	19	1	4	30	59
Marine Electrical Engineering	5	18	1	3	30	57

BSMA strives "itself to the development of MET leaders through academic excellence and community service"[3]. In October 2020, Poti branch of BSMA was opened in Poti that is equipped with the latest simulators and equipment for issuing professional seafarers for market needs. In 2021, 25th of June, the BSMA with the support of the Ministry of Economy and Sustainable Development, the Maritime Transport Agency and the Government of Adjara opened the multifunctional pool that will serve current students and seafarers for mandatory practical training in accordance with the standards developed by the International Maritime Organization[4]. Consequently, we could assume that in terms of infrastructure, the BSMA has the full support and receives the latest updates for the education and training needs.

5. Conclusion

This paper addressed the observable challenges in Georgian MET, which was reported by the BSMA surveys over the years. The main issue is an identified gap between the competence gained by the students and the expectation by employers, resulting in high unemployment rates despite great popularity in MET among young Georgians. Using a document analysis method, relevant curriculum development and delivery were examined from three areas: learning outcomes, teaching schedule and subject distribution, and resource allocation and new development.

Traditionally, seafarers' education and training were based on acquiring practical skills and cognitive skills to perform various and specific tasks on board. In contrast, maritime higher education focus is to develop analytical and

[3] Quality Manual (2022) can be accessible at the BSMA website (https://bsma.edu.ge/media/files/15a6edd2-5cff-496a-ba23-b718cb3bbba5.pdf)
[4] The Ministry of Education and Science of Georgia provides the information about the new MET development. https://www.mes.gov.ge/content.php?id=12308&lang=eng

critical skills. The modern and global tendency for MET connects academic components with vocational education, to give a student an academic degree. This brings new challenges to curriculum development, legislation in a global industry, and the needs of the shipping industry (Manuel, 2017). MET curriculum must take into account the "voices" of all interested parties: academia, the industry, and relevant authority or regulatory institutions, and use more effective teaching methods (De Agua et al., 2020). In this regard, BSMA is expected to further strengthen their partnerships with the government and shipping companies and promote lifelong learning in MET in order to adapt the changing industry needs.

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Enhancing "soft skills" management for maritime and shipping business personnel using interactive educational methods

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Abstract: The paper presents an interactive approach for educating and enhancing "soft skills" management for maritime and shipping industry personnel. Described are the most common and general soft skills which often appear as part of the cause for maritime incidents- leadership through positive influence, decision making, team work, communication, negotiation, conflict management and time management. Professionals working in the maritime sector acknowledge implementation of soft skills. This will ultimately facilitate better onboard working environment leading to improved productivity. Presented are initial empirical results from applying the case study method to develop soft skills among a group of students from four different countries and maritime academies.

Keywords: soft skills; case study method; maritime safety;

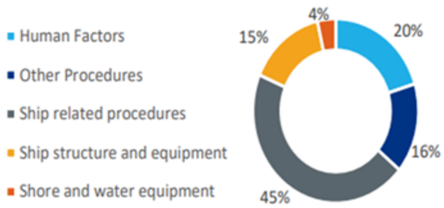
1. Introduction

Considering the growing numbers of maritime incidents caused by human errors due to communication problems, intercultural and gender differences, leadership, ethical or moral issues a comprehensive framework for teaching "soft skills" will contribute to the contemporary level of education of maritime personnel both onshore and onboard. The ongoing developments related to globalization of the markets, the global transport and supply chains, the economic and financial interdependences have increased the understanding on the concept of soft skills in maritime education referring to a number of personal qualities, habits, attitudes and social characteristics that make someone a good employee or member of an organization who is preferable to work with. The most common soft skills which often appear as part of the cause for maritime incidents- leadership through positive influence, decision-making, team work, communication, negotiation, conflict management and time management require some academic methodological approach to refine the general knowledge and the practical implementation. This will ultimately facilitate better onboard working environment leading to improved productivity.

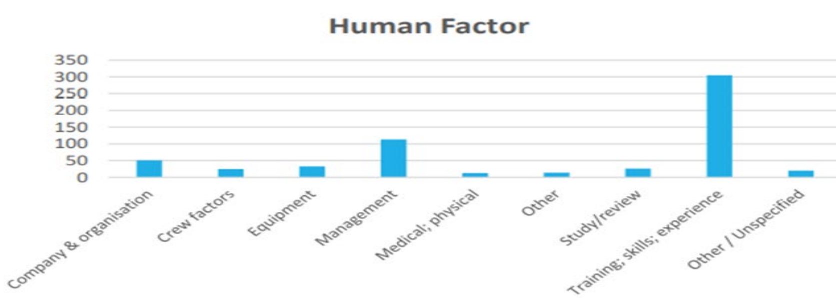
2. Human factor and the role of the "soft skills" for maritime safety

For many years, the shipping industry has concentrated on the physical condition of the ship and has spent little time on the other aspects that are now seen as equally important - the human factor, the performance of the master, officers and crews, and the manner in which the ship is operated. Good ship management requires control of all aspects related to the system "ship-people-operation". The human factor is the most common cause of ship incidents. The incidents include pollution, collisions and grounding. Nevertheless, it rarely appears as the only factor and is usually a result or combination of additional technical circumstances or force major conditions. According to some authors, human factor is described even in context of an intelligent security system. This human-operator must possess and develop his natural intellect, which is the ability to collect, to process and to disseminate information through thinking and decision-making, to train and prepare, to accept the environment in order to adapt effectively and individually to solve each task. (Kachev, 2015)

In the maritime incidents, there is an evolving chain of errors leading to a negative outcome of the emergency. So, each accident has its own characteristics, should be carefully analyzed and examined. The examination shall address the probable causes, the crew reactions, the equipment performance, the procedures order, and the preventive and/or corrective follow up actions. Based on that assumption EMSA (European Maritime Safety Agency) offers an overview on the maritime safety fields addressed in the organizations' recommendations for improving the maritime safety conditions and competence



Human Factors	600
Other Procedures	468
Ship Related Procedures	1343
Ship Structure and Equipment	446
Shore and Water Equipment	105
Total	2962



Company & organisation	51
Crew factors	25
Equipment	33
Management	113
Medical; physical	13
Study/review	14
Training; skills; experience	305
Other/Unspecified	20
Total Human Factors SR/AT	600

Fig.1.Distribution of safety recommendations/actions taken by focus area for 2014-2020

Source: Annual Overview of Marine Casualties and Incidents 2021, p.45

20% of the causes for maritime incidents are caused mainly by a human factor followed by a detailed overview on the categorization of the human factor types.

Fig.2. Distribution of safety recommendations/actions taken by focus area "human factor" for 2014-2020

Source: Annual Overview of Marine Casualties and Incidents 2021, p. 45

The statistics shows critical relevance of the training, the skills and the experience, followed by good management practices both of the crewmembers as well as of the shipping company or organization. The latter considers communication culture and effectiveness of communication whereas other factors influencing the human factor are diversity, leadership behavior, emotional climate, stress, fatigue, perception etc. In every of the mentioned aspects are incorporated some personal characteristics or combination of personal attitudes that contribute to someone to work in compliance with other people. Soft skills are prerequisite for better performance immediately leading to increase the safety environment and successful decision-making process. Incorporation of soft skills helps improve the career growth, the preferences of crew or team members to someone personal qualities, emotional intelligence, conflict management skills, empathy and situational awareness regarding the emotional climate among teams.

3. Teaching “soft skills” in the maritime domain using interactive educational method: the case study

A case is “a description of an actual situation” that usually involves a challenging situation or a dilemma, which requires analysis of the situation and the environment and leads to decision making. (Erskine et al.1981). The case study research method is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used”. (Yin, 2009)

A case study is a documentation of events and situations that have occurred in an organization or in a business. These events or situations are reported in their sequence by an interviewer and there is also a description of how the person/s concerned reacted to the situation. Case studies report already occurred events, with no judgmental opinions of the author, and thus stimulates the reader to think from his own perspective. The way in which the managers have responded to the situations or events are documented and this allows the reader to analyze the facts and make a decision. The most interesting case studies generally allow the reader to empathize with the key character in the situation and respond to a dilemma or a challenge. The case study does not focus on getting the right answer; in fact, there never is a single right answer for the case unless it is a mathematical problem. Emphasis is laid on the behavior of the involved persons, their manners and reactions during the process of copying with the situation, the deliberations involved and the practicality of the solution. (Vintzilaios, 2021)

The case study method is generally associated with Participatory Training that includes not only lectures and group discussions, but also role-play, simulations, structured exercises and instruments, case studies in a variety of forms, etc. Several other experiences are also used in Participatory Training, such as field visits, practice sessions, games, self-study, video review and others, which enhance the impact of learning. Therefore, according Vintzilaios “Guidelines for teaching case studies in the maritime domain”, the purpose of most trainings is a combination of developing knowledge, changing attitude and enhancing skills. Effective achievement of this purpose will depend on choosing the most appropriate method for each aspect. A useful framework to understand which learning methods are best suited for increasing knowledge, which ones for awareness and which ones for skill. (Vintzilaios, 2021)

A maritime case study seem to be a way to share the experience and wisdom embedded in the stories of shipping officers and other team members. Presenting a real descriptive event in a form of lively story engages participants intellectually and emotionally through their involvement in virtual decision-making, sharpening their analytical, problem-solving, and critical thinking skills. As a valuable outcome, they can understand events, interdependences or systems in the context of good seaman practices, leadership approaches or general good maritime practices. Case studies may be presented in written or verbal forms or through a filmed videos or filmed interviews. Interesting details should be taken into consideration, namely cultural preferences, appropriateness or even age-defined facts of the trainees. According the most experienced school in case study use, The Harvard Business school model, the cases are rigorous and challenging in nature as they comprise complex and often convolute qualitative and quantitative information. (Rebeiz 2011)

Managerial skills such as decision-making skills, leadership skills, communication skills, interpersonal skills, teamwork skills and integration abilities can be borrowed from the good business practices and implemented in modern maritime environment. So, putting the trainees in the shoes of the main decision maker, a person from the desired future-working place, from a prominent shipping company, from the global maritime business tend to attract the trainees' caution and curiosity. Here comes the role of the teacher/professor whose contribution to the studied skills is crucial part of this educational method as well.

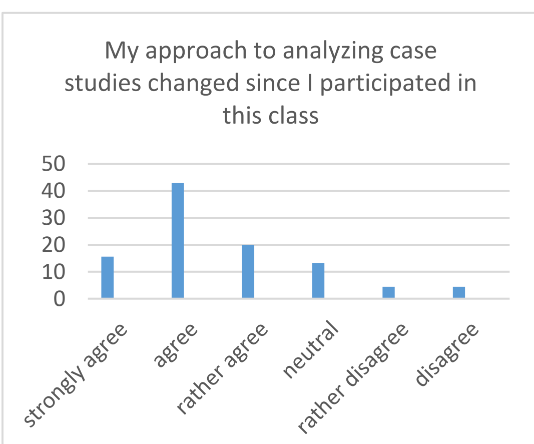
The trainer has a number of roles and responsibilities when conducting a case study training based on creating a good "feeling" with the trainees, a calm and disturb less learning atmosphere. Important might be to "shorten the distance" between professor and student, to be accessible and not distant, to predispose the trainees to ask clarifying questions, to try to get to know each student by dialogue and exchange of personal information. The practical implementation includes careful planning of the teaching process starting from providing the study material (the case study) through accurate briefing about the task, maintaining strict control over the trainees and navigate them what to do, when to do it and how to do it, monitoring the task performance, debriefing, summarizing and contributing with own input, knowledge and expertise.

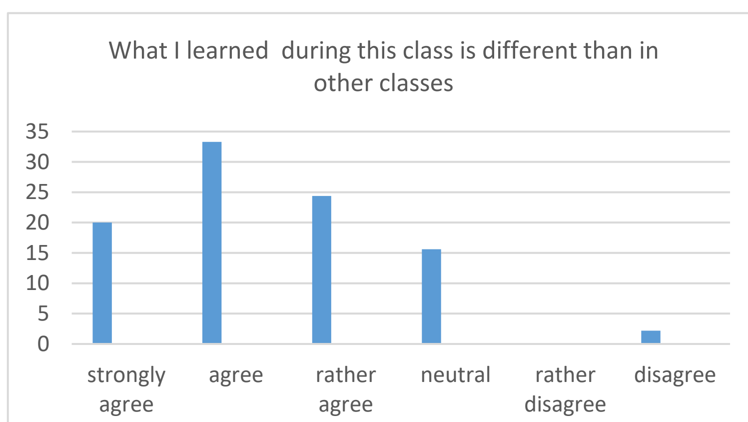
4. Empirical testing of "soft skills" case study teaching method in the maritime domain

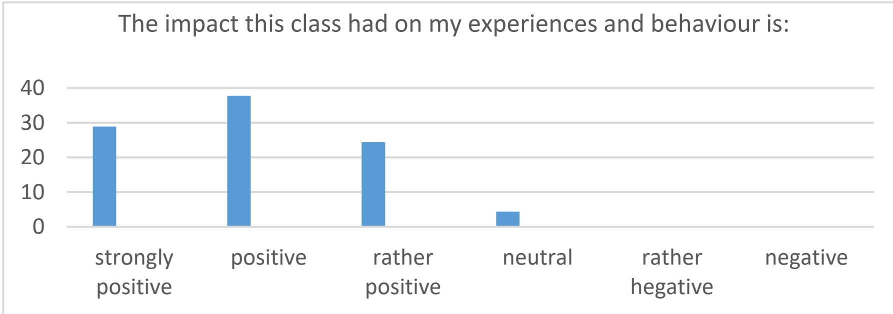
A testing of methodological approaches from teaching "soft skills" through case study method was conducted among 46 students from four maritime universities from four countries: Greece, Romania, Turkey and Bulgaria in April 2022 in Chios Island, Greece. They were all third year students from different specialties: maritime business and economics as well as navigation and ship engineering. The course was designed in five days testing five case studies, one case study prepared from each maritime academy. Five areas of "soft skills" were covered by the case studies: Communication based on trust; Leadership behavior to overcome gender bias; Personal conflict between superior crewmembers and steward department; Resilience case study onboard during COVID-19 pandemic; Leadership and teamwork in time shortage dealing with oil spill situation.

The teaching methodology followed the abovementioned approach: providing the text, clarifying the exact situations, the persons involved, the reactions, helping the students to understand all technical terms, assure that they get familiar with the whole process of the narrative. The students were divided in teams and by teacher's navigation and control they had to solve different problems related to the implemented "soft skills", they draw conclusions about advantages and disadvantages, explained why and situation outcome was positive or negative and finally, they were encouraged to share personal opinions, to think about alternatives in the decision-making processes. The case study lesson finished with summarizing the students' performance, as well as receiving some additional remarks from the teachers. At the end, they filled a questionnaire testing their views, level of gained knowledge, the teaching methodology etc.

Example (Greek case study, first testing on initial impressions and methodological approach):







The initial results show high percentage of satisfaction among the students with a slight "mind change" effect that gives the legitimation to continue to teach and develop educational tools through the tested methodological approach. The specific working environment where members have significant differences based on national affiliation, culture, gender, and age requires establishing self-awareness in multi-directional aspects.

5. Conclusion

In the last decade, the issue of developing and maintaining "soft skills" in the maritime profession is growing on importance because of various trends including increased implementation of information technology and automatization of the processes, standardization of the seafaring profession and related qualification training as well as some trends in the career development whereas younger officers are promoted faster due to labor market circumstances. Leadership and team management skills, diversity management skills and advanced communication skills related to the specifics of the seafaring profession should be assessed in more continuous, integrated and sustainable way using model courses on teaching "soft skills" where the case study method seems to meet the prerequisites for academic and good learning practices. By using real stories and events university students as well as professionals that are more experienced can be attracted to the topic and upgrade their skills.

Acknowledgements

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The Importance of ESP (Maritime English) in the Maritime Industry for Safety Maintenance Onboard and Ashore

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Abstract

The 21st century is an era where the knowledge of the English language plays a pivotal role in the Maritime Industry. Seafarers must know General and Maritime English to operate and communicate successfully onboard and ashore. Since the crew members could consist of different nationalities and the English language might not be their mother language, ambiguity and confusion may take place while communicating, which can lead to human error and can be the direct cause of accidents. That is why Maritime English, as one of the sub-fields of ES, is built on specific terms and phrases elaborated and adopted by the maritime and shipping community. In 2001, the SMCP entered the Maritime field. As IMO suggests, they have been developed to cover the most important safety-related fields of verbal shore-to-ship (and vice-versa), ship-to-ship and onboard communications. The aim is to get around the problem of language barriers at sea and avoid misunderstandings which can cause accidents. (http://www.imo.org/en/OurWork/Safety/Navigation/Pages/StandardMarine Communication Phrases). Hereafter, the major goal of these terms and phrases is to decrease human error accidents caused by language and communication. This paper considers the importance of effective communication in ESP, namely, Maritime English, for safety maintenance on the vessel and ashore. It highlights international developments aimed at ensuring that seafarers gain the appropriate skills and knowledge to communicate effectively and efficiently in ESP for the avoidance of the regulation of safety standards resulting from miscommunication among non-native speakers of English. The article aims to identify the gaps in ESP competence (at the level of receptive and productive skills) in the current curriculum for safety operations, elaborate effective strategies for improvement of the learning component of the curriculum, and offer practical solutions and recommendations for redesigning existing teaching methodology in the ESP. To achieve the goals mentioned above, a small-scale blended survey was conducted among undergraduate Bachelor's students a and teaching staff of Batumi State Maritime Academy.

Key Words: Maritime English, ESP, Human factor, Competency-based learning outcome, safety

1. Introduction

We all agree that English as an International Language is the most powerful communication tool for people from different parts of the world to share a common code even with different language experiences. Although we are all aware that differences can still be traced in the choice of words and expressions, depending on age, job, education level, and region, we, as global citizens, are keen to adopt new words and phrases from different people using English as Lingua Franca (ELF), while at the same time combining them with local communicative needs as well (English as a GLOCAL LANGUAGE (Global + Local). English is also defined as a Global Language because it is spoken by people around the world, even if with different uses (Braj Kachru's theory of the "3 circles", L1 speakers-

UK, Ireland, USA, Australia, New Zealand, Canada- more than 350 million people, L2 speakers (India, Nigeria, South Africa more than 430 million), EFL speakers- the rest of the world) [2].

At the same time, ELF is used by people of all ages, as nowadays, in the digital era, speakers from all around the world tend to communicate and interact with each other using commonly shared new words, phrases, and constructions based on their common interests.

English is also the international language for academic literature and research, Business, and Higher Education. A new language for specific purposes is practiced: English for Academic Purposes, as several academic programs are being delivered in English, both in presence and online, especially during the recent Pandemic. Consequently, having a good command of English is necessary to serve ***occupational*** and ***study purposes*** as a tool to share best practices and expertise. For students engaged or willing to get involved in International Exchange programs (i.e., Erasmus) and courses, English is the most common means of communication before and after enrolling in the program. They use it with course companions, administrative and teaching staff, and invited visiting scholars, as nowadays, increasingly more Universities are attracting foreign guest lecturers, visiting professors, and students from all over the world. English is their common working language outside their lecture halls, as are their online resources, open access journals, and research reports. It also assists scholars in networking and socializing, especially in webinars, conferences, and seminars. Nowadays, English is the language of travel and tourism, as it is of international news, both oral and written, and it is important to have a mastery of it so as not to need translations. Furthermore last but not least, English is a working language in Maritime Profession on board the ship and offshore. Therefore, Maritime Professions naturally require a good command of both General English and ESP, as seafarers and marine employees need to communicate for Business via General English and when performing their immediate duty requires using English for Specific Purposes for safety maintenance on board the ship.

2. Emergence of ESP

Teaching English for Specific Purposes (ESP) in the EFL field seems to have become a popular trend, and it is recognized as a separate activity within it. ESP emphasizes learners' interest in the interpersonal communication requirements of a given profession. ESP professors are thought to have developed their teaching approach and classified it as a distinct field of applied linguistics with its features. As a result, ESP has always strived to effectively communicate in the tasks given according to their field of study and work-related surroundings, even when distanced from the well-established standards of ELT [3].

Definitions of ESP emerged in the middle of the 20th century when it became clear that General English courses did not meet learners' and employers' professional needs. Since English is known to be the lingua franca in various professional fields, including business, media, technology, science, medicine, and maritime industry, the demand for the latter has been significantly growing in the countries with EFL playing main and subsidiary aims [4].

ESP is generally related to teaching and learning English for specific professions or, in general, for business. According to Robinson, ESP is "Goal-Oriented Language Learning" [5], which once again justifies the need for a good mastery of ESP for the representatives of different professions.

According to Fiorito, ESP "assesses needs and integrates motivation, subject matter, and content for the teaching of relevant skills" [6], which means that learners of ESP immediately apply the knowledge of the subject matter acquired through English in their daily lives and professional fields, being rewarding. For this purpose, ESP is actively taught in HEIs worldwide, including in Georgia and Poland, to prepare future specialists in various activity fields. It is supported by the international organizations and employers organizing specializing courses for their workforce to increase their proficiency level of English and, at the same time, their competence in various professional areas.

3. Maritime English from the Standpoint of Safety

Currently, the Maritime Industry relies heavily on mastering the English language. In order to operate and communicate efficiently onboard and ashore, seafarers must know General and Maritime English. Maritime English is an umbrella word for ESP used by both aboard and onshore mariners.

Since the vessels have to ship and anchor in different countries, crossing oceans and seas commonly, vessels are operated by different nationalities. Hence, knowledge of Maritime English is one of the main priorities in the maritime industry. According to Marine Society, 'Maritime English,' also known as 'Standard Maritime Communication Phrases (SMCP),' is the lingua franca at sea and is vitally important for a multitude of reasons; the safety of the crew, the efficiency of daily tasks and the integrity of the ship' [20].

As mentioned above, the main language spoken at sea today is English. The key role of using it is to avoid misunderstandings among crew members and not only, to avoid confusion and ambiguity while communicating ashore and onboard. Neglecting these elements might be the cause of mishaps caused by human error. That is why, in 2001, the SMCP entered the Maritime field. As IMO suggests, they 'have been developed to cover the most important safety-related fields of verbal shore-to-ship (and vice-versa), ship-to-ship and onboard communications. The aim is to get around the problem of language barriers at sea and avoid misunderstandings which can cause accidents' [16].

Maritime safety is a broad term that encompasses everything from ship design to personnel professionalism. The shipping company's current obligation is almost always to offer the best possible circumstances and resources for a ship's safe operation at sea. Therefore, the first SOLAS (International Convention for the Safety of Life at Sea version), in response to the Titanic catastrophe in 1914, was accepted, followed by the second in 1929, the third in 1948, and the fourth in 1960. The tacit acceptance mechanism is included in the 1974 edition, which states that an amendment will enter into effect on a set date unless an agreed number of Parties object to it before that date. The current revised version of the Convention is known as SOLAS 1974 and consists of 14 chapters [17].

Moreover, maritime personnel must know these rules for safety maintenance on board. Various training and workshops are held for seafarers' education, which meets the requirements of the SOLAS (Standards of Training, Certification, and Watchkeeping Convention) 1978. Thus, Maritime Education and Training (MET) is traditionally defined as an educational process providing students with the knowledge, understanding, and proficiency required to assume different duties on board ships. Consequently, maritime education is carried out at MET institutions delivering structured educational programs which are, in most countries, required for the certification of seafarers at the management level [18].

In order to gain knowledge in the above-mentioned maritime fields, seafarers must communicate in fluent English to speak and write effectively. Because of certain disruptions (noise, fog, etc.) that occur at sea during the transmission of the message, as well as for the sake of secrecy and maintaining traditions, marine professionals frequently use both verbal and nonverbal types of communication, which are regulated at both the national and international levels. Current marine communication standards must comply with the SOLAS (Safety of Life at Sea) convention.

It is worth mentioning that when at sea, many other factors are to be considered, i.e., used code, physical channel transmission, massages, their state, etc. Though, we need to single out the following main types of communication among the marine professionals:

Communication between ships – is required due to the following factors, i.e., types of information; the necessity to identify the vessel, asking for a pilot to come on board; transmission of warnings; granting assistance in case of the ship sinking, damages, on fire, running aground, running into collision and when a rescuer boat, a helicopter, medical or other fire-fighting assistance is required [19].

Communication on board the ship – is held through internal communication means, i.e., telephone, giving commands, face-to-face communication, etc. Therefore, for effective and clear communication, it is of utmost importance that the Captain's orders – being the message's sender depend largely on the crew's competence and training to timely and efficiently implement them.

Communication for other purposes – and finally, another type of communication, on all seas and oceans of the world and in foreign ports is held in English, which once again illustrates the importance of effective communication skills for marine professionals.

In order to avoid any language barrier and misunderstandings will be noteworthy to use the following: The speech should be slow and on point; explanation should be required; while having dialogues, check for understanding regularly; figurative speech, idioms, and slang should be avoided.

4. Language Barriers and Miscommunication is the Cause of Maritime Accidents

According to different studies, more than 60% of employers look for soft skills while hiring, and more than 70 % want a candidate with strong communication skills. In the maritime industry, communication skills are even more important, considering the industry is extremely global, with people from different parts of the world working together. Maintaining effective communication with them is highly important to ensure efficient delegation of work, avoid misunderstandings, and maintain a safe working environment [20]. Communication involves transferring information through verbal messages, written words, or non-verbal signals. As it is well known, maritime communication manifests itself on three levels: onboard communication, ship-to-ship communication, and ship-to-shore communication. Language, whether spoken or written, is a means of communication. However, lack of understanding and incorrect interpretation of language could become a communication barrier and result in the desired outcome not being achieved. Language barriers and miscommunication are often mentioned as causes of maritime incidents. This is not surprising as most merchant ships are operated by multilingual and multicultural crews [18]. Poor communication has been the main factor in numerous maritime casualties, varying from groundings and collisions to entire ship losses and, even worse, fatalities. Many studies have attempted to investigate the impact of national culture on human failures at sea, revealing that the lack of a common language could make the ship a high-risk work environment. Crews from various nationalities have different mother tongues, body language, and gestures, while different cultures may interpret things differently. Meanwhile, communication is a complex concept of its own, involving emotional triggers and audiovisual perception, and barriers to its effectiveness vary from physical to physiological factors.

To address language differences, in 1983, linguists and shipping experts created Seaspeak, a system of communication setting the rules on how to talk on a vessel's radio. The number of words can be said limited, and English was chosen as the principal lexicon. In 1988, IMO made Seaspeak the official language of the seas.

Unfortunately, there have still been examples of incidents where better language skills could have avoided accidents and, in some cases, could have saved lives [21].

Mistakes in this industry are costly. Language barriers and miscommunication on board merchant vessels primarily cause accidents at sea every year. Merchant vessels are multilingual and multicultural, so it is very difficult to communicate with fellow crew members or with other vessels and shore with assistance from bridge equipment, which helps reduce the risk of collision or other accidents on board.

5. Methodology

In order to demonstrate the role of ESP, in Particular Maritime English, for safety maintenance on board and ashore the ship, quantitative research was carried out. The questionnaire targeted two groups; accordingly, two questionnaires were distributed, one for the Bachelor 4th grade students and another for the ESP instructors, Lecturer/Sailor, and Lecturer. The online survey was disseminated via the link of google forms, where 52 students took part. For the 2nd group (ESP instructors, Lecturer/Sailor, and Lecturer), 25 respondents took part in the survey.

5.1 Results

The survey consisted of 15 close-ended questions, and respondents were asked to choose from a 0-5 complexity scale, with 5 being the most complex. The questionnaires were circulated for five weeks through an e-management portal of BSMA. The informants of the survey provided the following answers:

In the 1st statement, ***'Language barriers can be a major reason for misunderstanding, confusion, and ambiguity among seafarers,'*** *59 % of* Students strongly agreed, and 25% of students agreed that language barriers could be a major reason for misunderstanding, confusion, and ambiguity among seafarers. As for the 2nd group of respondents (ESP instructors, Lecturer/Sailor, and Lecturer) - 68% strongly agreed, and 24% agreed with the statement mentioned above.

63,5 % of students strongly agreed, and 25% agreed with the statement that '***Good command of Maritime English is a precondition for safety maintenance on board and ashore.*** Whereas 80% of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, and 12% agreed with this statement.

55.8% of students strongly agreed, and 28.8% agreed with the 3rd statement, 'Good ***command of Maritime English considers good at both receptive (reading/listening) and productive (speaking/writing) skills.*** Whereas 62.5 % of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, and 29.2 % agreed with the statement mentioned above.

53.8% of students strongly agreed, and 26.9% agreed with the 4th ***statement*** that '***Bad command of ME causes a violation of safety regulations resulting from miscommunication on board and ashore.*** Whereas 43.5 % of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed and 47.8. % agreed with the same statement.

50% of students strongly agreed, and 19.2% agreed with the 5th statement that '***Low competence of ME can be resulting from the gaps in the existing curriculum,'*** and 25 % neither agreed nor disagreed with this statement**.** While 44 % of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, 44 % agreed with the same statement. This shows that students and academic personnel members have a different opinions in this regard.

41. 2% of students strongly agreed, and 29.4% agreed with the 6th statement that '***Redesigning the learning curriculum will facilitate bridging the gap of miscommunication in ME on board and ashore.*** Moreover, ***19,6 %*** neither agreed nor disagreed with this statement**.** Though 44% of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed and 44 % agreed with the same statement, which once again demonstrated differentiated approaches towards problem-solving.

42.9% of students strongly agreed, and 36.7% agreed with the 7th statement, '***'While redesigning the learning curriculum, a major focus must be made on receptive skills, especially listening,'*** and 14,3 % neither agreed nor disagreed with this statement**.** Even though 36 % of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed and 40 % agreed with the same statement, and 16% neither agreed nor disagreed. This difference shows that both target groups share the idea of the importance of listening skills.

44.2% of students strongly agreed, and 38.5% agreed with the 8th statement, ' ***While redesigning the learning curriculum, a major focus must be made on productive skills, especially speaking,'*** and 15,4 % neither agreed nor disagreed**.** Whereas 64% of the 2nd group respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, and 28% agreed with the statement highlighting the importance of productive skill-speaking.

55.8% of students strongly agreed, 26.9% agreed, and 13.5 % neither agreed nor disagreed with the 9th statement, '***Knowledge of IMO SMSP can facilitate safety maintenance on board and ashore***. As for the 2nd group, an absolute majority, 72% of the respondents (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, and 16% agreed with the statement. This underlines the knowledge that IMO SMCP can facilitate on board and ashore.

48.1% of students strongly agreed, 36.5% agreed, and 9,6% neither agreed nor disagreed with the 10th statement, '***Testing student's receptive/productive skills with special simulations will facilitate identifying miscommunication gaps at an early stage*** .'Whereas, an absolute majority, 70.8% of the respondents of the 2nd group (ESP instructors, Lecturer/Sailor, and Lecturer) strongly agreed, and 16.7% agreed with the statement, which once again differentiates students' opinion from the one provided by BSMA academic staff.

On the remaining five questions, which mostly measured respondents' competencies in different areas, the following results were obtained:

On Question N 11, which asked respondents **to '*Provide the self-assessment of your English proficiency to understand the meanings set in issues 1-10'*** for 76.9% majority of the content was clear. In the 2nd group of respondents, 92% agreed with the same statement.

On Question N 12 which asked respondents to evaluate the curriculum against the cognitive learning domain - Cognitive: I am recalling and explaining the important information; I am solving closed-end and open-end problems; I am creating "unique" answers to the problem; I am making critical judgments based on a sound knowledge base. The following results were received: 44.2 % of students strongly agreed, and 30.8% agreed, whereas 19.2 neither agreed nor disagreed. As for the 2nd group of respondents, 37.5% strongly agreed, 41.7 agreed, and 16.7 neither agreed nor disagreed.

On the Question N 13 which asked respondents to evaluate the curriculum against the learning domain- Affective: I am willing to listen; I am willing to participate; I am willing to be involved.

The following results were received: 51.9 % of students strongly agreed, 19.2% agreed, whereas 25% neither agreed nor disagreed. As for the 2nd group of respondents, 45.8% strongly agreed, 37.5% agreed, and 12.5% neither agreed nor disagreed.

On the Question N 14 which asked respondents to evaluate the curriculum against the learning domain – Psychomotor: I am mentally, emotionally, and physically ready to act; I can perform acts with increasing efficiency, confidence, and proficiency. 54.9 % of students strongly agreed, and 25.5% agreed, whereas 19.6% neither agreed nor disagreed. As for the 2nd group of respondents, 37.5% strongly agreed, 45.8% agreed, and 12.5% neither agreed nor disagreed.

On the Question N 15, 'What are one to three specific things about the English course that could be improved to better support student learning to enhance proficiency (academic performance, self-efficiency in linguistic intelligence, and linguistic competence)?. The 1st group of respondents gave the following answers: 67.3% - teaching and learning materials; 51.9% assessments methods; 40.4 voted for the content of the course; 44.4% gave preference to the issue of teaching and learning Materials (incorporating Maritime companies' policy/procedures/Guidelines); The second respondents gave different voting preferences to the solutions for improving student proficiency. In particular, 76% voted for Teaching and learning methods; 56% voted for Assessment methods; 52% voted for Teaching and Learning Materials (incorporating Maritime companies' policy/procedures/Guidelines), and 44% for the content of the course (incorporating academic writing and business communication).

5.2 Discussion of Results

Based on the survey's key findings, the language barrier is a major reason for misunderstandings, confusion, and ambiguity among seafarers. To overcome the problem of language barriers, the majority of the surveyed once again highlighted the importance of good command of ME, which simultaneously guarantees safety maintenance on board and ashore. This means that both students and teaching personnel are equally aware of the problem of potential misunderstanding resulting from the language barrier and, at the same time, acknowledge the role of ME in overcoming the latter. In addition, both groups surveyed declared that a good command of ME considers having good receptive and productive skills.

An absolute majority of the surveyed declare that the violation of the safety regulations mostly results from miscommunication onboard and ashore, primarily preconditioned with a bad command of ME. Therefore, in the 21st century, industry knowledge requires employees to have a good knowledge of a subject matter combined with the four basic language skills: reading, listening, speaking, and writing.

As seen through the analysis of the questions related to the gaps existing curriculum needs to be redesigned to bridge the gap of miscommunication in ME on board and ashore, and redesigning the curriculum means focusing on receptive and productive skills. And finally, knowledge of IMO SMCP can sustain safety maintenance on board and ashore, as declared by most respondents. On the whole, the major responsibility falls on us, educators, who need to test students' corresponding language skills with special simulations, identify gaps at an early stage, redesign the curriculum by integrating new teaching/learning methods, update the content of the course, revising and improving assessment methods and lastly, incorporating authentic teaching/learning materials from the maritime industry.

6. Conclusion

English is the first language spoken in the maritime industry, but for many crew members, this is not their native language, as is the case for Georgian Seafarers. Working with international crews worldwide, it became clear that working on English language proficiency is a good start but not enough. We concluded that addressing the problem of intercultural misunderstandings is also important. That leads us to develop additional components to enhance the learning course that seeks to help prevent misunderstandings between crew members with different cultural backgrounds and develop cross-cultural communication competencies. This helps them to understand how people from different countries and cultures will often have their perspectives and learn to recognize 'symptoms' of possible intercultural misunderstandings, and build bridges between different cultural perspectives in a very practical way to prevent human errors as the product of incorrectly made decision or action due to language barriers and miscommunications.

It is very relevant for educators – language teachers to recognize that to train complete total learners, there is the need to teach and evaluate the learners in the three domains (cognitive, psychomotor, and affective). In this stance, the cognitive and psychomotor domains are comprehension, writing, and grammar, while the affective are listening and speaking skills.

There is a need to strengthen teachers methodologies in language teaching through improved and adequate instructional materials. The proposed enhancement in the English Maritime Text manual may be considered. The proposed program for Maritime students’ English proficiency can be utilized by all English teachers guided by syllabi and instructional materials.

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The Impact of The Russia-Ukraine War on the Development of Cruise Tourism in the Black Sea Region

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Abstract: Not fully recovered from the two-year coma caused by the pandemic and its repetitive Covid-19 waves, the cruise industry has received another blow at the worst possible time. Geographically European military crisis has left almost no one aside and is impacting economic, political, and social life worldwide.
The paper studies all the variables and aspects of the cruise industry on the scale of the region and recent events. The study aims at providing a thorough analysis of the crisis and its impact on the cruising perspectives of the region. The analysis is based on external and online desk research methods. The data contains market analyses, official journals, expert opinions, and industry reviews.

Keywords: cruise industry, military crisis, black sea cruises, Russia-Ukraine war

1. Introduction

The Black Sea region represents an inviting, not hackneyed cruise destination that encompasses the cultural diversities of Bulgaria, Romania, Georgia, Ukraine, Turkey, and Russia. Almost equal distances between the major ports of the six countries allow the voyagers to experience the whole spectrum of the culture of the Caucasus and Eastern Europe within one week. Tourists traveling along the Black Sea can take scenic one-day trips and enjoy inexpensive visits to the countries with no time, waste, or hustle.

Due to the infamous Covid-19 and the recent unrest in the region that evolved into the Russian-Ukraine war, cruise lines have suspended their operations in the area. Naturally, all the cruise industry experts have one crucial question how long the crisis will last and what are the possibilities for getting out of it. For a complete understanding of the problem, it should be remembered that crises in passenger shipping in the Black Sea area periodically arise due to the stubbornly repeated drama of historical events.

According to Selivanov, the first passenger lines between the ports of the Black Sea began to operate in 1859. Passenger transportation in the Black Sea basin had been steadily developing till 1914. The following wars and revolutions have stipulated the *first crisis* in passenger shipping in the Black Sea region, which lasted for about 15 years. The new page of the Black Sea cruise lines began at the end of the 20s. The Crimean-Caucasian cruise line became incredibly popular in the USSR from the 30s of the last century until the Second World War, which was the turning point and the beginning of the *second crisis*. Furthermore, again, the period of the crisis lasted about 15 years. The heyday of the Crimean-Caucasian cruise line began in 1960 and lasted until the collapse of the Soviet Union. The Crimean-Caucasian cruise line ceased to exist in 1992 and marked the beginning of the *third crisis* period. After a sharp decline in BSR (Black Sea Region) cruise activities from 1992-to 2006, since 2007 (15 years later), a new wave of revival begins. Up to 200 foreign cruise ships have called at Crimean (Yalta, Sevastopol) ports alone this time. [7]

Since 2011, the size of the ships calling at the Black Sea ports has significantly increased. (2011 -10% of incoming ships' size exceeded 270 m; 2012- 50% of BSR incoming ships' size was over 270 m). [7] That was the wake-up call and turning point for the BSR cruise infrastructural development. In response to the unfolding possibilities, some ports immediately announced cruise terminal reconstruction (Batumi Port 2015), some renovated their infrastructure, and some even exceeded all the expectations (Galataport, Istanbul 2021- world's first underground cruise ship terminal). For today Yalta, Odessa, and Sochi seaports, as well as the Romanian Constantza, can safely receive and serve large vessels (up to 300 m) in the BSR. Recently, the Black Sea port capacity limits were the main reason cruise lines refused to enter the BSR.

The year 2013 became the best and the most successful year in the Black Sea cruise history. According to the MedCruise Statistics report 2014, the Black Sea became the most dynamic region in 2013, with cruise calls-419 and passengers- 213.840. These numbers resulted in a "passenger movements" annual growth of 35,7% and 55,2% of "cruise calls. Consequently, the BSR seaports were successfully developing as international passenger terminals and had excellent development prospects and the interest of international investors.

In February 2014, Russia annexed the Crimean Peninsula from Ukraine. Due to the situation, major cruise companies had an instant reaction and officially announced the cancelation of any cruise voyages in the BSR. Since 2014 all the statistics have gone down (Figure 1).

For all indicators, this event marked the end of the BSR cruises' heyday and the possible beginning of a new, the *fourth crisis*. However, this time it appears to be more complex.

2. Impact of the War

The Black Sea cruise tourism has borne the overwhelming brunt of Russia's Invasion of Ukraine, which has also affected some parts of the Baltic Sea. Prominent cruise lines reacted relatively quickly to the upcoming distress. The three cruise giants Royal Caribbean, Carnival Corporation, and Norwegian Cruise Line Holdings, have canceled their trips to the Black Sea region and swapped Russian destinations for Swedish. According to the managing director of Fred. Olsen Cruise Lines Peter Deer, the safety of their passengers is the number one priority, which is why they have altered their itineraries to no-Russian-ports destinations. [1] MSC Cruises, AIDA Cruises, and TUI Cruises have followed the Norwegian Cruise Line's suit and scrapped all their trips to Russia and Ukraine ports.[2]

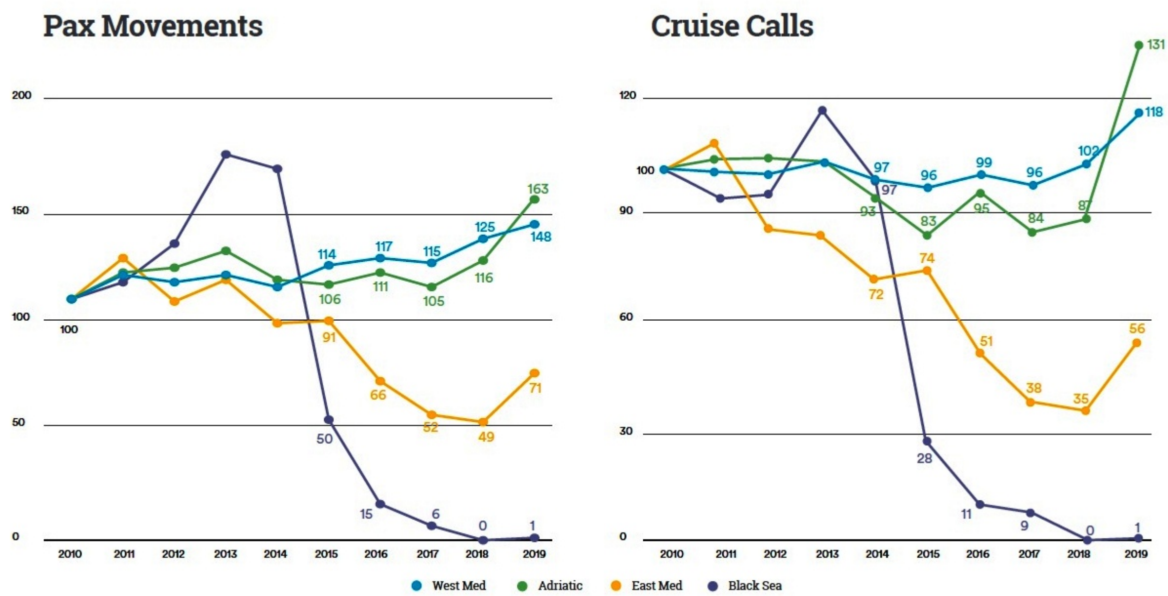

Figure 15 Source: MedCruise Ports| Statistics Report 2019 (2010=100)

After the 2020-2021 cruise stock depression caused by Covid-19, which resulted in $ billions of loss, cruise lines are facing another crisis. This European humanitarian catastrophe reveals financial results that are more than disappointing.[3] The Black Sea region appears to be utterly deserted of cruise ships without any perspective to flourish in the light of the war.

CLIA (Cruise Lines International Association), in its 2022 report, states that the industry has proven its incredible resilience, and passenger flow will surpass 2019 levels by the end of 2022. [4] The forecast for the cruise world is more than promising. Meanwhile, in the sight of the unfolding Black Sea countries crisis, the cruise picture of the region is changed almost completely. According to Cruise Industry News, 21 cruise ship was scheduled to operate in the Black sea region in 2022. [5] However, the only cruise line claiming a full go for the Black Sea program is Russia-state owned cruise company "Black Sea Cruises" [6].

The year 2014 turned out to be a part of the wider ongoing Russia-Ukraine War. From 2014 to 2018, the number of cruise ships visiting BSR has fallen to zero. (Figure 3) MedCruises characterized the fact as a "dramatic collapse" and claimed a politically "unrest situation" to be the reason for such a significant decline. The cruise vacuum had been slightly broken in 2019 with two total calls (1200 Pax.) at Constantza and Odessa ports. Following the crisis of Ukrainian annexation (2014), catastrophic waves of coronavirus disease slammed the world's economy in the worst possible way. [9] And again, in 2020, BSR hit the ground, and the cruise ships were becalmed as never before on a torpid sea of Covid-19. (Figure 3) However, the industry has proved its incredible resilience.

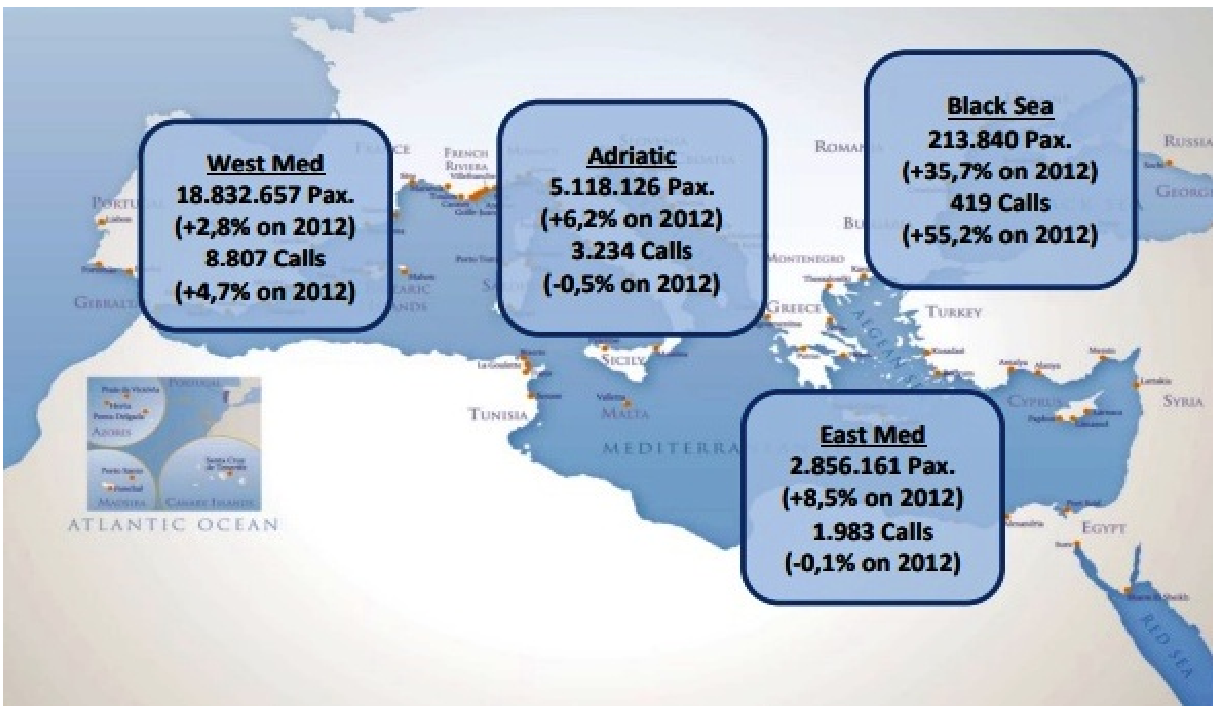

Figure 17 Source: MedCruise Statistics 2014 | Cruise Traffic by Region

2.1 Political Impact

The full-scale invasion of Ukraine returns the world to the severe Cold War relationship with non-democratic states chaired by Russia. The attack on Ukraine raises two key questions: What impact will the Russian invasion have on maritime security in the Black Sea, and how should the cruise industry respond?

Citing Dr. Deborah Sanders, Defense Studies Professor at King's College: "In a worst-case scenario, Russia could effectively turn Ukraine into a landlocked country." Following the statement, control over the west Black Sea coast gives complete dominance in the BSR. This kind of scenario questions the geopolitical stability and security of the region.

Cruise Lines International Association (CLIA) has repeatedly stated in its Policy that "a safe, secure, healthy and sustainable cruise ship environment" is the number one priority for the cruise industry. There is no reason the cruising community and businesses would risk the reputation and safety of their clients. That gives a comprehensive response to the questions raised. No cruise ship calls are expected at the BSR ports until absolute security is assured.

The cruising community has openly supported Ukraine against the armed aggression of Russia. The president of the MedCruise Association, Figen Ayan, has noted that the Association supports Ukraine and the Black Sea region in general and offers assistance. "We, as the MedCruise Association, are in regular and active communication and dialogue with our SVP, VP and Board Members and are closely monitoring the unfortunate situation in Ukraine," said Ayan. "We are in touch with the executives of the Port of Odessa, and we are in close contact with our Black Sea members too to relay the message that MedCruise Family is there for them in case of need. Our priority is to make sure that our friends in Ukraine and the Black Sea region are safe and secure while hoping and praying for peace to be restored and the war to be over the soonest," added Ayan. (10]

2.2 Economic Impact

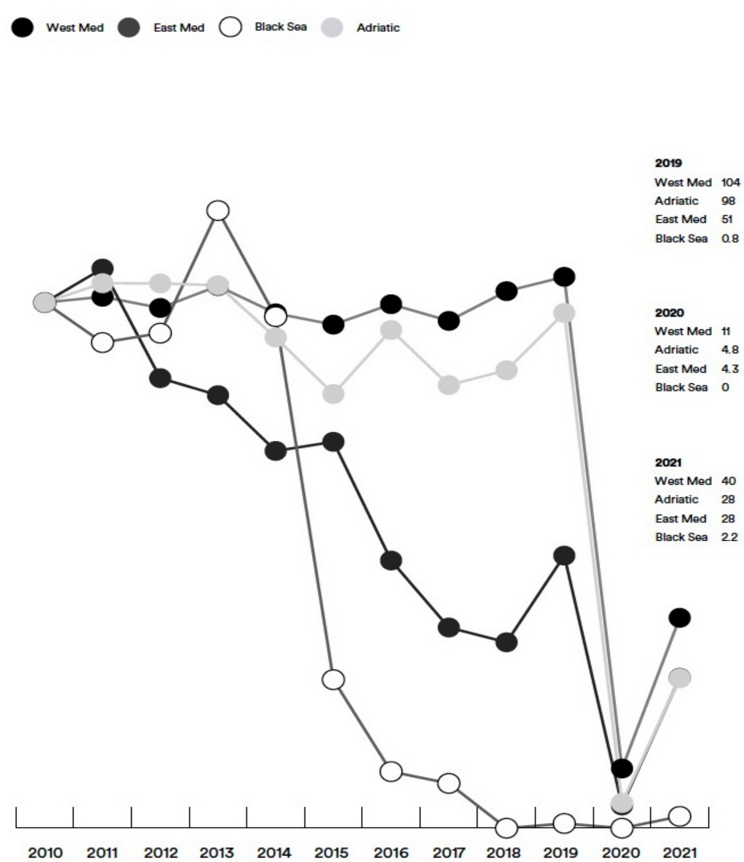

Figure 18 Source: MedCruise Statistics 2021 | Calls Index by Region (2010=100)

The specifics and benefits of the cruise business in the Black Sea region are that the ports operate as partners, not competitors: the more ships call at the Black Sea region, the more each port's benefits. Given this feature, in 2012, at one of the international cruise exhibitions in Yalta, the idea was put forward to create a non-commercial marketing project to promote the Black Sea cruise destination and create a single brand of the Black Sea, "*Cruise Black Sea*."The essential condition for effective brand development is maximum involvement of BSR countries in promoting activities and participation in relative organizations. MedCruise (The Association of Mediterranean Cruise Ports and adjoining seas) is the one that promotes the cruise industry in the Black Sea region and unites the ports of the area. However, for today, only Burgas, Constantza, Odessa, Trabzon, and Varna are member seaports of the Association. That makes 4 of 6 BSR countries.

According to experts, cruise tourism in the Black Sea countries has good prospects for growth. Firstly, European cruise tourists are tired of the traditional Mediterranean itineraries and want to explore new regions. Secondly, the number and size of the cruise fleet are growing worldwide, and new ships (from 300 meters in length) are crowding out smaller ships from the transcontinental market, which need to look for new ports of call. That makes BSR a perfect solution and promising destination. In addition, experts believe that the recognition of the Black Sea region will constantly grow due to the constant promotion of the brand among cruise companies and operators of the world. In case of additional catalysts, such as visa facilitation or expansion of the cruise network, one can count on even more excellent market dynamics.

Pandemic has confirmed the significance and scale of cruise economic impact. With a total $154 billion contribution to the global economy (2019), and 1.17 million cruise-supported jobs (2019), the industry is recovering and positions itself as a titan of the business world. According to the CLIA 2022 Report upside forecast, the passenger volume will exceed 2019 levels by the end of 2022.[4] (Figure 4)

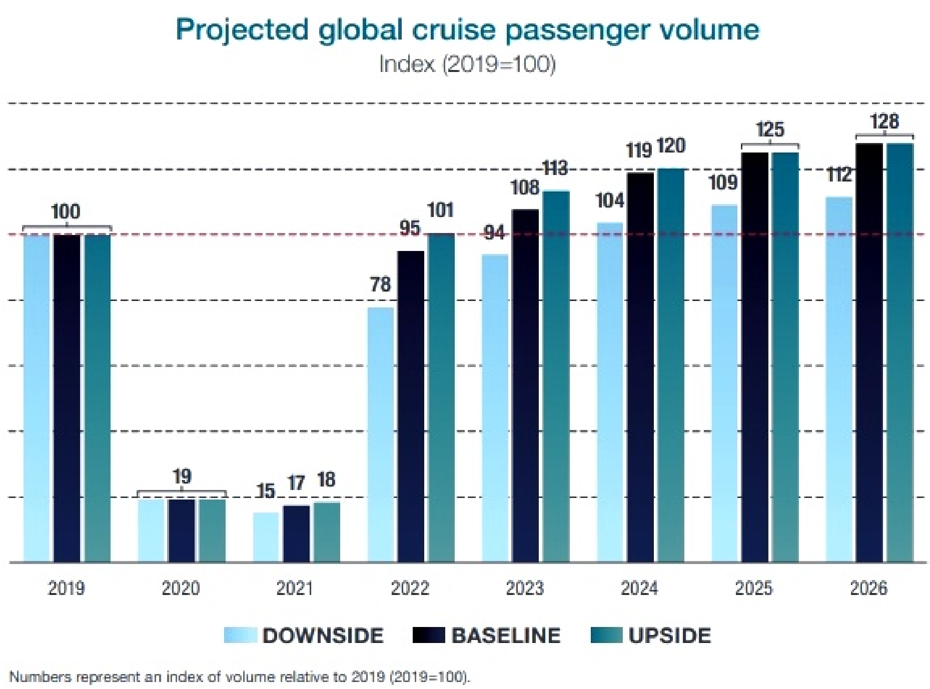

Figure 20 Source: CLIA 2022 Report

Thus, being out of the cruise industry every year means millions of income and thousands of job losses for BSR.

3. Conclusion

Based on the historical timeline and pieces of evidence presented, it can be concluded that 2014 appears to be the beginning of the fourth cruise crisis in the Black Sea Region.

According to the economic development of BSR countries and port infrastructure, the region is ready to accept and serve cruise ships up to 300 m in size. There are no significant infrastructural obstacles to the mid-sized cruise ships' activities. The attractiveness of new itineraries, along with the cultural diversity and rich history of the area, makes BSR countries full-fledged players ready to engage in the cruise industry. However, the military conflict that started in 2014 proved to be an insurmountable barrier to cruise world life. Safety is an unconditional obligation and the basics of any cruise protocols that define cruise operations in any territory. Hence, the only way to revive the Black Sea Region is to end the conflict as soon as possible. Staying out of cruise life leaves fewer and fewer chances for BSR countries to successfully engage in the cruise industry with possibilities of keeping up with global trends in the cruise community and global maritime culture in general.

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MET in Ukraine in time and after of Russian invasion

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Abstract

Ukraine is one of the leading crew supply countries. Most world-famous shipping companies and recruiting companies have representatives in Ukraine and work with Ukrainian seafarers. On the 24th of February 2022, with the Russian invasion, the world was changed. The ongoing armed conflict between the Russian Federation and Ukraine presents a severe and immediate threat to the safety and security of crews and vessels operating in the region. Ukrainian ports are closed, and some Ukrainian cities are under temporary occupation by Russia. There are four IAMU member institutions in Ukraine: Kherson State Maritime Academy, Kherson; National University "Odessa Maritime Academy," Odessa; Odessa National Maritime University, Odessa and The State University of Infrastructure and Technologies, Kyiv.

The war in our country is the main obstacle for providing students and cadets qualitive MET. Educational institutions can provide online education only and no practical training. More than one-third part of lecturers is out of Ukraine. The Government's financial support to the educational institutions is reduced to a critical minimum. The onboard training is a massive problem for our cadets due to the Government's ban on leaving Ukraine for men aged 18-60. Due to logistical challenges, many cadets onboard the vessels cannot return home. Many students and cadets try to continue their education onboard in Ukraine. Unfortunately, maritime education is not a priority for the Ukrainian Government during the war and post-war devastation. International efforts of the marine industry are needed to support maritime educational institutions in Ukraine.

Keywords: MET, War in Ukraine

Introduction

International shipping is a truly global industry, transporting over 11 billion tons of cargo to various parts of the world each year. It is not unusual for sea voyages involving a series of international port calls to be serviced by a ship owned, managed, and crewed by companies located in different jurisdictions and registered in another flag State. The ship is also likely to be crewed by seafarers of several different nationalities, certified by labor supply countries that are different from the ship's flag State [1].

The global demand for STCW-certified seafarers in 2021 is estimated at 1,881,320. There is a demand for approximately 883,780 officers and 997,540 ratings [1]. Since the 2015 BIMCO Seafarer Workforce report, the supply of STCW-certified seafarers available to the international trading world merchant fleet has increased, with both numbers of qualified officers and ratings continuing to grow. The number of STCW-certified officers has now estimated at 857,540 - a percentage increase of 10.8% since 2015 [1]. According to data from shipping companies, the five main nationalities of STCW seafarers working within the world merchant fleet are shown below.

	All seafarers	**Officers**	**Ratings**
1	Filipino	Filipino	Filipino
2	Chinese	Chinese	Chinese
3	Ukrainian	Ukrainian	Indian
4	Russian	Indian	Ukrainian
5	Indonesian	Russian	Indonesian

Tab. 1 Five main nationalities of STCW seafarers as indicated by shipping companies 2021 (BIMCO Seafarer Workforce Report 2021 Source) [1]

Following the BIMCO Seafarer Workforce Report 2021, Ukraine is one of the five main nationalities of STCW seafarers.

1. MET in Ukraine

Main advantages of Ukrainian seafarers and cadet’s programs:

- High motivation of Ukrainian citizens to work in officer positions in international shipping;
- High potential to increase the number of ship officers due to the ability of educational institutions to increase the number of cadets and students;
- Relatively low tuition and an opportunity for the best students to study at the expense of the state;
- Favorable conditions for education and training of the foreign citizens;
- A flexible system of training and certification of seafarers to get an opportunity to become junior officers in 4 years;
- Use of active marine officers as lecturers and instructors;
- Support of maritime universities and academies of Ukraine by the shipping industry, cadet programs;
- English language learning and training.

There are four IAMU member institutions in Ukraine: Kherson State Maritime Academy (KSMA), Kherson; National University "Odessa Maritime Academy" (NU "OMA"), Odessa; Odessa National Maritime University (ONMU), Odessa; and State University of Infrastructure and Technologies (SUIT), Kyiv..

The total number of MET students and cadets in these Institutions is about 20 000 (Fig.1).

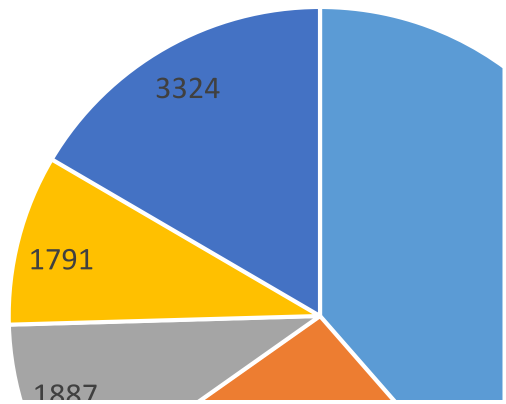

Fig.1 Number of MET students in institutions in Ukraine in 2020

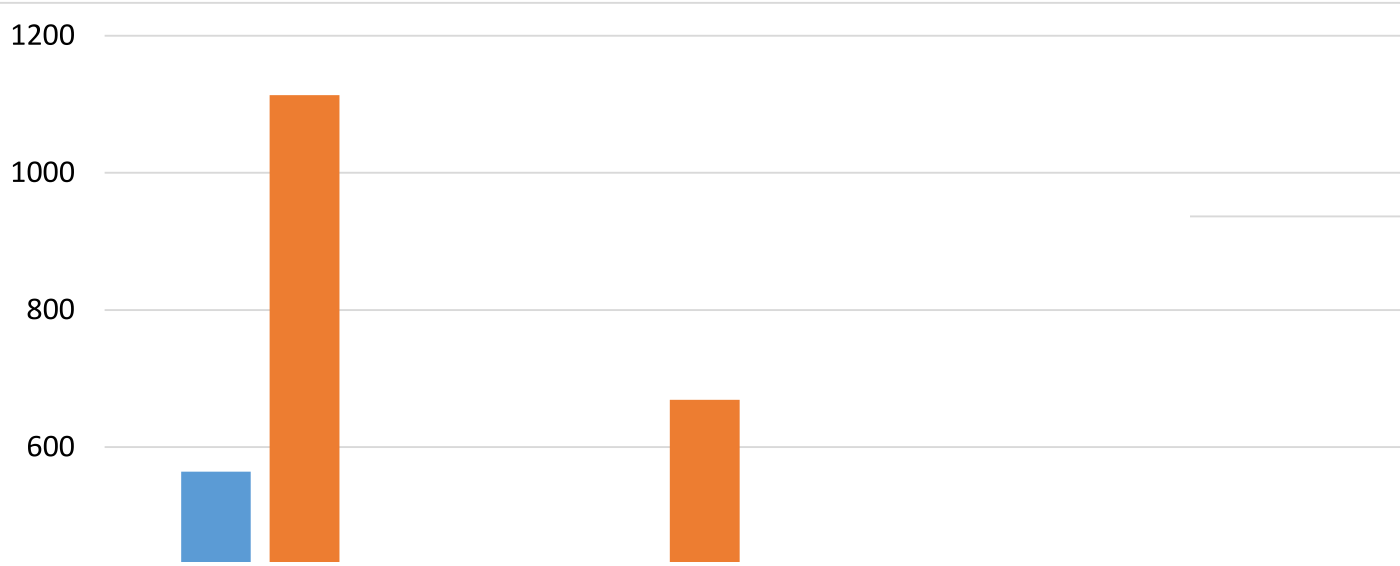

Fig.2 Number of MET students Admission to IAMU member institutions in Ukraine in 2020

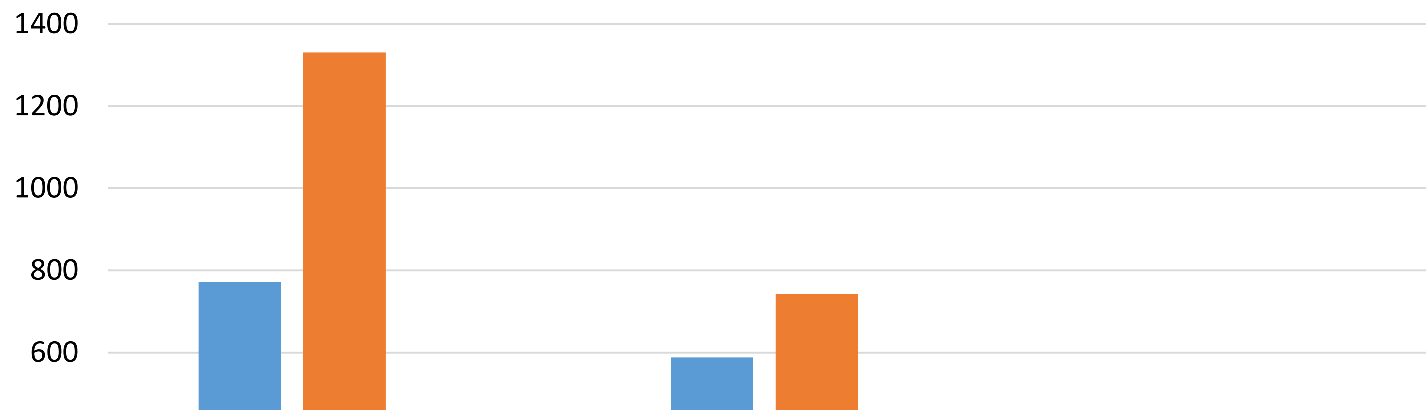

Fig. 3 Number of MET graduates in IAMU member institutions in Ukraine in 2020

2. The Russian invasion of Ukraine and MET

The world changed on the 24th of February 2022 due to the Russian invasion. The ongoing armed conflict between the Russian Federation and Ukraine presents a severe and immediate threat to the safety and security of crews and vessels operating in the region. Ukrainian ports are closed, and some of the Ukrainian cities are under temporary occupation by Russia [2].

Russia invaded Ukraine in February, but Ukrainian forces retook large areas around the capital, Kyiv, in early April after Russia abandoned its push towards Kyiv. Following the withdrawal from the north of Ukraine, Russia has refocused its efforts on taking control of the east and south of the country.

Russian forces initially made rapid gains in the south, with their main objective being the creation of a land corridor between Crimea, which has been annexed in 2014, and areas held by Russian-backed separatists in Donetsk and Luhansk. However, strong resistance from Ukrainian forces near Mykolaiv in the west and Mariupol in the east significantly slowed down Russian advances.

The port of the city of Mariupol, which has been encircled since the start of March, is now under the control of Russian forces. Civilian people are under continuous pressure from the Russian forces.

Fig. 4 Map the Russian invasion of Ukraine (BBC Source)[4].

To the west, Russia aimed to take control of Odessa and cut off Ukraine's access to the Black Sea. However, its forces were blocked by a staunch defense in Mykolaiv and forced back towards Kherson by Ukrainian counteroffensive in March.

Russian forces regroup in the area to resume attacks on Mykolaiv, and significant efforts are being made to reach the administrative border of the Donetsk and Luhansk regions. Thanks to the heroism of the Ukrainian military and international support, the offensive of the Russian troops was stopped, and fierce battles continued. Financial problem is the main problem for maritime educational institutions in Ukraine during wartime. Martial law reduced the financial support for maritime institutions from the Government, and the universities' incomes have considerably decreased.

The Azov Maritime Institute of the National University "Odessa Maritime Academy" is in the city of Mariupol, it is destroyed and temporarily occupied by Russia.

Fig.5 90 % of the City of Mariupol was destroyed by the war.

Cadets and students from Mariupol will continue education at the National University "Odessa Maritime Academy" in Odessa. For NU "OMA," this is an additional complex problem organizing accommodation, financial support, education and training, and employment for cadets, students, and the Azov Maritime Institute staff.

Kherson is under temporary occupation now. The administration of the Kherson State Maritime Academy moved to Odessa and tried to organize distance work of all staff at the Kherson State Maritime Academy and continue the educational process in such critical conditions. The war in our country is the main obstacle for providing students with qualitive MET. Unfortunately, maritime education is not a priority for the Government in the warring country and the post-war devastation. International efforts of the marine industry are needed to support maritime educational institutions in Ukraine.

Our Lecturers provide online education and no practical training now. More than one-third part of our lecturers is out of Ukraine. The onboard training is a massive problem for our cadets due to the Government's ban on leaving Ukraine for men aged 18-60. Due to logistical challenges, many cadets onboard the vessels cannot return home. Many students and cadets try to continue their education onboard in Ukraine.

The total number of NU "OMA" staff is 1025. Part of the administrative and service personnel is official in downtime due to the martial law and only receives a minimum salary. According to Article 34 of the Labor Code of Ukraine, "Downtime is the work suspension caused by luck of organizational or technical conditions necessary to perform the work due to unavoidable force or other circumstances." The total number of lecturers and instructors is 318; about 30 % of lecturers are abroad now.

The World Bank analyses the war in Ukraine to slash Ukraine's GDP output by over 45% [3]. Blockade of the Ukrainian sea ports destroyed the shipping in Ukraine and caused traders to change logistics for shore-based transport. Ukraine is one of the leading crew supply countries. Most world-famous shipping companies and recruiting companies have representatives in Ukraine and work with Ukrainian seafarers. The reorientation of these shipping companies to other crew supply countries inflicts terrible damage on Ukrainian crewing and Ukrainian MET. The war in Ukraine will be a reason for the shortage of qualified seafarers for global shipping.

Conclusion

We believe the war will end, and we can return to normal life and work.
We might call post-war perspectives which must be a priority for us:

- Visa-free regime with the EU, permission to work in the EU countries, the status of a candidate for membership in the European Union;
- Marshall Plan for Ukraine, international support for economic development;
- Support Ukrainian MET by foreign partners;
- Favorable conditions for business development, preferential taxation;
- Odessa should become the center of international maritime business due to a visa-free regime and developed infrastructure that has not suffered because of the war.

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Re-envisioning Maritime Education and Training – Technology facilitated lifelong learning for future ship operators

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Abstract: The increasing introduction of novel and digital technologies on-board ships is changing the landscape of work and the seafaring skill and competencies required to perform the job. The maritime industry currently finds itself in a dynamic evolutionary continuum culminating in the techno-saturated realm of Maritime Autonomous Surface Ships (MASS) of the future. This ongoing transition to future ships foregrounds the continuous and lifelong learning for seafarers to remain relevant as the industry irrevocably progresses and evolves. Meanwhile, the imperative incorporation of new technologies in Maritime Education and Training (MET) during the COVID-19 pandemic disrupted the traditional classroom-based teachinglearning process. Even though this accelerated technology adoption in MET was not free from challenges, it cemented the trend of technologically facilitated maritime blended learning and e-learning. This paper notes the need for lifelong learning in an industry in a flux and the maritime education system undergoing a transition. Seafarer training as we know today cannot serve the needs of future operators who would not be physically present on-board autonomous ships. This paper suggests that the proliferation of on-board technology needs to be complemented by technology in education and training. Furthermore, technology facilitated lifelong learning is imperative for current seafarers to remain relevant.

Keywords: Maritime Education and Training; Lifelong learning; Blended learning; Learning technologies; Maritime Autonomous Surface Ships; Activity System

1. Introduction

The maritime industry currently finds itself in a transition to future shipping that will ultimately culminate in fully autonomous unmanned vessels capable of independent decision making and action (Narayanan & Emad 2020; Sharma, Kim & Nazir 2021. The future ships require trained and competent operators, and seafarers who are relevant to the needs of the changing industry. A complete transition to autonomous ships is still a few decades away as in the beginning it would largely be restricted to resource rich developed nations. Furthermore, due to the lack of a comprehensive international regulation for MASS (STCW 1995, 2010 as amended; IMO 2021), autonomous craft would first ply in national/coastal waters or with bilateral/multilateral agreements between littoral states. It is expected that in the coming decades we could see mixed traffic scenarios wherein manned and unmanned craft operate in the same waters posing challenges beyond the scope of this paper (Baldauf *et al.* 2018). The International Maritime Organisation has identified 4 degrees/stages of MASS operations (IMO 2018, 2019). These stages highlight the increasing introduction of technology on-board ships on one hand, and a decreasing human presence on the other. In stages one and two of MASS, human operators are present on-board, whereas in stages three and four, they will operate and monitor from ashore. We are currently in stage one of MASS operations with other stages under development.

Thus far, MET is playing catch up with developments in the industry; it incorporates technology in curriculum design and delivery as on-board technology increases. The increasing introduction of technology into MET specially when exacerbated by the COVID-19 pandemic disrupted the traditional teaching-learning process tied to the physical brick and mortar spaces of maritime training institutions (Renganayagalu, Mallam & Hernes 2022). Although the process to impart blended learning was already in place at the maritime training establishments for students pursuing distance education, however, the pandemic served as a catalyst to accelerate the move. Communication and network technologies such as Zoom, and Skype were utilised for

lesson delivery during the pandemic. The Learning Management Systems (LMS) were increasingly utilised to share content with the MET students, irreversibly altering the way MET was undertaken before.

This paper captures maritime higher education and training in transition as it evolves to serve the training needs of present-day modern ships. It identifies trends in the literature that are impacting shipping and education to envision what maritime training and education can look like for future shipping. This paper suggests that increasing technology in MET is supportive of the characteristics of lifelong learning and would benefit seafarers remain relevant in the dynamically evolving industry.

2. Literature review – a brief snapshot of MET in the digital age

Lifelong learning is well established in the literature (Laal 2011) and is making inroads in the maritime domain (Sogor 2021). Lifelong learning is a largely voluntary self-initiated, self-motivated undertaking. It indicates a continuous approach to learning and has characteristics that enable an individual to engage in personal and professional growth and development that maybe informal or formal in nature. On the professional front it highlights an adaptable and flexible approach that keeps one sharp, competitive and relevant in a dynamic market (Collins 2009). Lifelong learning can help shape the career trajectory and contribute towards long-term employment of seafarers as marine operators of future ships. Sogor (2021) considers lifelong learning as a useful skill for 21st century mariners in addition to their functional 'core professional skills', 'general transferable skills', and dynamic '21st century skills'. Formal education has been considered less important by firms in a study of current and future competence needs of a maritime cluster; continuous learning is found to be valuable and social and meta competences are regarded important for the future, namely problem solving, flexibility, and management of competence (Kilpi, Solakivi & Kiiski 2021). This indicates a preference for short training/courses for lifelong learning over formal education.

Due to increasing automation and digitalization on-board ships MET is undergoing a transition to meet current and future needs. Gaps between requirements and competences would grow, particularly when technology continues to develop at a faster pace than MET. These technological advancements require the development of appropriate curriculum (Phewa 2021), the cultivation of pertinent digital, information processing skills, and non-technical soft skills in the workforce (de Água *et al.* 2020; Sharma, Kim & Nazir 2021). MET would also need to address and incorporate the rapidly growing blockchain technology into the training regime (Nasaruddin & Emad 2019). Empirical research into MET during the disruptive COVID-19 pandemic has revealed challenges that need to be overcome within technologically assisted distance learning to ensure success. Inequalities in the availability of technology, internet connectivity, as well as technopedagogical skills of faculty and students would need to be addressed to reap the benefits (Renganayagalu, Mallam & Hernes 2022). An increasingly important role will be played by novel emerging technologies such as virtual reality, augmented reality, mixed reality, and cloud-based simulation training in MET in the future, however the research is in its nascent stage and widespread adoption is some time away (Mallam, Nazir & Renganayagalu 2019). Maritime simulator training research utilising the sociocultural perspective of Communities of Practise highlights the relevance of computer supported collaborative work to maritime operations in real life (Sharma *et al.* 2019). Computer technology, internet, and shipboard communication equipment play a positive role for mariners to access updated training on-board ships (Belev & Daskalov 2019), however, this is dependent on robust network connections which may not always be available. MASS technologies and operations impact MET. Maritime training would need to cater to each level of MASS. Additionally, a higher level of knowledge and competence would be required in complex MASS technologies such as Cyber-Physical

Systems, Integrated Bridge System, algorithms for collision avoidance and path planning, information fusion to accurately perceive environmental information, track control, Internet of Things, big data etc. (Deling *et al.* 2020).

The technological developments in MET point towards the ease in availability, access, convenience, and flexibility that are supportive of lifelong learning. To meet the training challenges of the digital age, MET would benefit from incorporating lifelong learning; inclusive, equitable education, and a shift of focus from formalized learning to creative solutions that capture the 'big picture' (Alop 2019; Alop 2021). Sociohistorically situated activity system analysis permits the holistic capture of the MET 'big picture'. An understanding of the constituents reveals that increasing technology in shipping and MET are supportive of tenets of lifelong learning.

3. Activity System

This paper wholistically views education and training in the maritime domain as an activity system positioned under the socio-historical Cultural Historical Activity Theory (CHAT) (Engeström 1999; YamagataLynch 2010). The theoretically well-established activity system triangle facilitates the holistic identification and visualisation of the entire activity system at a glance and its constituent components. It further helps identify the interconnections and challenges/contradictions in the system, if any. The contradictions make us identify the problems that need to be addressed for a successful outcome.

4. Transitioning Activity System for MET higher education

The current activity system for maritime higher education has been identified as part of the first author's ethnographic doctoral research on MET (see Figure 1). Components of the activity system evolve over time and help us identify the changes and their impact on other aspects within the activity system and the final outcome. Changes in one activity system also impact other connected activity system(s) and vice-versa. For instance, the outcome of the maritime higher education activity system is competent seafarers. These seafarers and the quality of their competence form a key component of the shipboard activity system (Rajapakse *et al.* 2019) and will impact work and safety on board. An understanding of related activity systems and their connections provide a holistic picture and help us identify the gaps requiring attention.

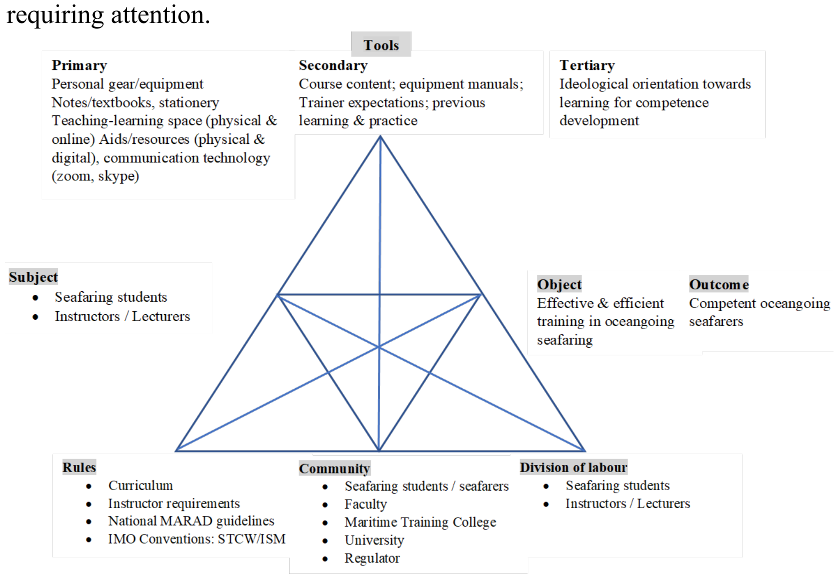

Figure 1. MET Higher Education Activity System – in transition
Source: Adapted from (Emad & Kataria 2022, forthcoming)

The MET higher education activity system is undergoing a transition to keep pace with current and future requirements. The primary drivers of this transition are advancements in the shipboard workplace and the new technologies incorporated into MET design and delivery, particularly in the wake of the COVID-19 pandemic. A sharper understanding of the current MET higher education activity system in transition and the direction in which the industry is heading helps extrapolate and envision the education and training system for future shipping as elucidated in section 3.2 (see figure 2).

4.1. **Education and Training Activity System for future ships**

An increasing introduction of technology on-board ships has impacted the adoption of technology in MET, curriculum design, development, delivery and the teaching learning experience. An education and training activity system for future shipping helps us holistically visualise the components that cater to future shipping, particularly congruent with stages 3 and 4 of MASS operations (IMO 2021). The subject is no longer limited to the oceangoing seafarer. Operators, including marine, IT and other shore-based professionals are the subject of this new activity system. Accordingly, the community of stakeholders expands in the activity system of future ships. Changes are also seen in the division of labour in the new activity system, and the increasing policies/regulations the activity system would be subject to. A major change is seen in the tools of the education and training activity system for future ships. Teaching, learning, and training tools would now include novel technologies such as the digital twin of the ship - an exact digital replica of the physical ship on which humans would not be present in stage 4 of MASS (Smogeli 2017). This permits training to be undertaken on the actual digital workplace taking it into the realm of workplace training thereby increasing its effectiveness (Narayanan & Emad 2020). Just as the digital twin frees the workplace from the physical entity, similarly ubiquitous availability of online training and related educational technology frees training from the physical brick and mortar spaces. These developments are conducive of lifelong learning and development.

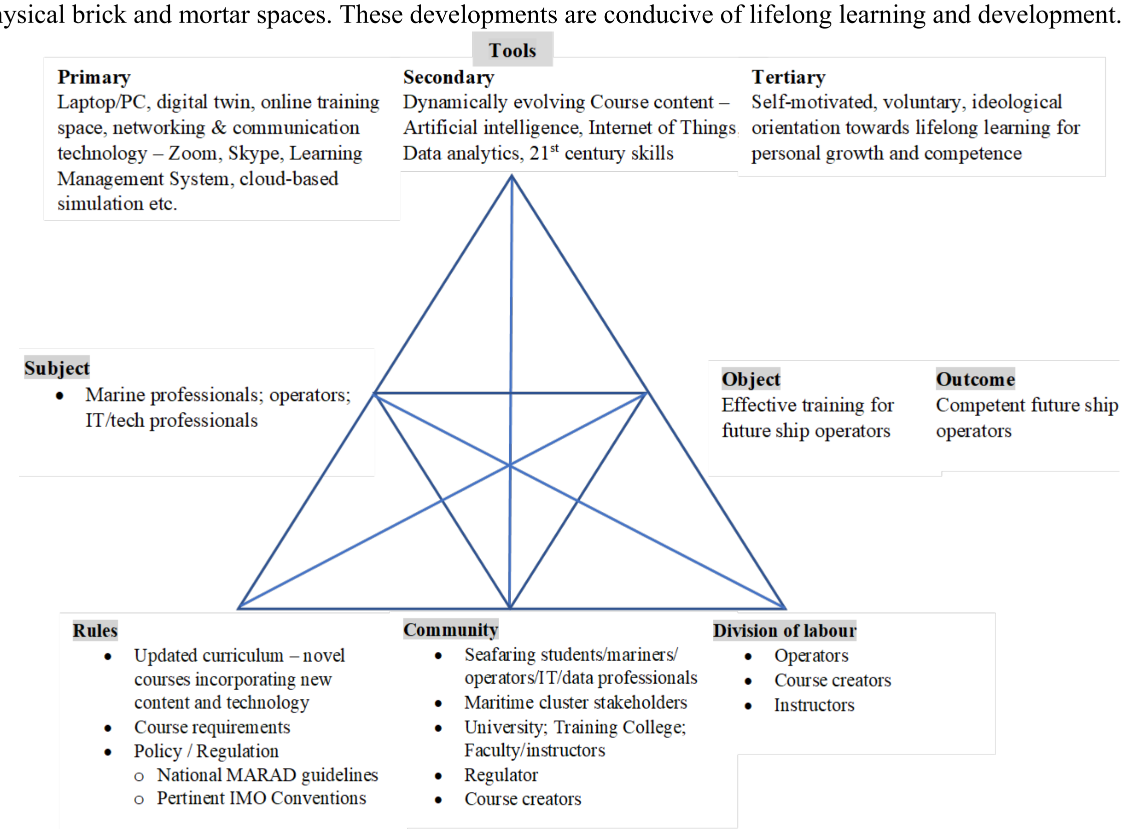

Figure 2. Education and Training Activity System for Future Ships. Source: Authors

5. Technology facilitated lifelong learning for future ship operators

The education and training activity system for future ships (figure 2) highlights the technological developments in the tools of the activity system. The digital twin of a vessel is a game changer in MET. It permits access to the digital working replica of the physical ship with all of its data (Smogeli 2017). The digital twin *is* the workplace in MASS stages 3 and 4. It frees the workplace from physical confines and makes it available to disparate geographically distributed operators and teams, thereby enabling training and learning to take place in the digital workplace. The digital twin is an industry trend that lends itself well to the pursuance of continuous lifelong learning. The increasing adoption of technology in MET delivery, particularly in the wake of the Covid-19 pandemic made education available beyond the confines of the physical classroom. The developments in cloud-based simulator technology push the boundaries of simulator training to make it widely available to geographically distributed individuals. Though these technological developments are not free from challenges (Kataria & Emad 2022, forthcoming; Renganayagalu, Mallam & Hernes 2022), they indicate growth and are commensurate with the industry findings of their preference for lifelong learning over formalised education (Kilpi, Solakivi & Kiiski 2021). In order to remain relevant for future ship operations, a maritime training establishment would do well to develop training modules and content meeting the needs of MASS operations across the four stages. Similarly, to remain relevant and employable in the changing maritime industry, a current seafarer would need to engage in continuous lifelong learning supported by technology.

6. Conclusion

Technology facilitated continuous lifelong learning is the way forward in the maritime industry; for seafarers/operators, training establishments, and stakeholders within maritime clusters. This paper captured the maritime higher education activity system in transition utilising activity system analysis. Additionally, the paper utilised the trends identified in the literature – increasing digitalization and on-board automation, and the increasing adoption of technology in MET to extrapolate and depict the education and training activity system for future ships. MET as it currently stands is inadequate for MASS operations. Furthermore, the industry preference for lifelong learning over formalised education will shape training for future MASS operators in the years to come. In the technology rich environment, industry and education stakeholders will increasingly design and provide modular training aligned with MASS requirements to support seafarers/operators along their journey of lifelong learning.

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The (ir)Relevance of Current Maritime Education and Training in the Transitioning Workplace: An Activity Theory perspective

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Abstract: The maritime industry is experiencing a phase of rapid digitalization and automation. Modern ships are increasingly fitted with novel technologies and complex tools that are changing the ways in which seafarers perform their jobs. However, researchers are questioning the efficacy and ability of the present-day maritime education and training in developing the skills and competencies needed in a dynamically evolving work environment. The investigation reports of many maritime accidents and incidents, point to seafarers' lack of expertise in timely responding to developing hazards. A review of literature indicates a paucity of studies focusing on cognitive human factors and competence development of seafarers, relevant for a high-technology workplace. This paper partially addresses that gap by proposing a novel, practice-based approach to analyze the challenges arising onboard ships during the transition period to a digitalized future. We utilize the cultural-historical activity theory (CHAT) or simply, Activity Theory as a lens that provides a holistic socio-technical perspective. Within this, learners, mentors, technologies, pedagogical values, roles/identities, and rules/cultures act as interdependent elements of a collective activity system. Resolving any contradictions, incoherencies, and dilemmas existing between these elements, is essential for achieving the desired outcome, i.e., competent mariners who can safely operate highly digitalized future ships.

Keywords: Maritime Education and Training; Cultural-historical activity theory; Digitalization; Automation; Human-machine interactions; Cognitive Human Element.

1. Introduction

The rapid advance of digital technologies over the past few decades is transforming the shipping industry. Increasingly, novel automated systems using Information Technology (IT) is deployed on board ships, and that is altering the ways in which human operators work (Man, Lundh, and MacKinnon 2018; Narayanan and Emad 2020). While the ongoing digitalization and automation drive has always been an attempt to enhance safety and increase competitiveness, it has also made the work of seafarers onboard more demanding and complex (Man et al. 2018). Further, these technologies demand new skill sets for future mariners when working with or within such automated systems (Lutzhoft, Hynnekleiv, Earthy, and Petersen 2019; Sellberg and Viktorelius 2020), and new ways of learning and competence development (Narayanan and Emad 2020; Sellberg and Viktorelius 2020).

The relevance of human element in the maritime domain becomes evident through studying the maritime accidents and incident reports of the recent past, blaming the failure on the many mistakes, poor decision-making, or lack of communication, of the mariners involved. Some of the recent analysis point to the fact that to get a full understanding of such causal factors, it is necessary to view the human element as part of the larger system, that includes the technology, organization, work practices, and the work environment (Grech, Horberry, and Koester 2019). Thus, it becomes evident that accidents and incidents occur whenever there is a breakdown in the socio-technical system. Such a breakdown could be related to, or caused by, for example, poor design of the equipment or any inconsistencies between the work practice and written procedures (Grech et al. 2019; Rajapakse, Emad, Lützhöft, and Grech 2019). Hence, there is always a need to look beyond the individual and see the system as a whole. However, in all the recent research on the effects of digitalization and automation in shipping industry, primarily focus appears to be solely on the effect of the technology rather than addressing the human factors involved (Lutzhoft et al. 2019). Hence, there is an urgent need to address the skill requirements, training needs and, moreover the requirement for providing adequate human support to technology before introducing any autonomous systems.

A review of the literature reveals that many issues pertaining to the preparation of maritime workforce for the upcoming digital transformation have been studied in detail by various authors. For example, Relling, Lützhöft, Ostnes, and Hildre (2018) highlighted the requirement for many new competences for personnel involved in the future ship operations, in view of dramatical restructuring of onboard work processes. Sharma, Kim, Nazir, and Chae (2019) also carried out a detailed study to verify the seafarer competence standards required in future digitalized ships. They concluded that the internationally mandated maritime education training and certification standards as described under the STCW Convention will require a thorough revision. Their study highlighted some of the competences that may remain relevant even in a digitalized future. But they have also identified many other competences that will become insignificant as and when the related onboard functions are taken over by automation technologies.

Although, digitalization and automation on board ships is being introduced with the claim of reducing human error, Lutzhoft et al. (2019) warns that may not always be the case, in reality. Authors feel that even if in future vessels start being operated remotely from shore, any drawbacks connected to humans will arguably move with the people from ship to shore. Fan et al. (2020) did a study on the operational risks related to future shipping. They too concur with the view that human factors will not be fully removed from the system during remote operation of ships. Firstly, any such shore-based operator will need to possess specific skills and professional knowledge at least similar to that of the existing crews of traditional ships. Moreover, any data that they receive from the vessel can be related not only to ship navigation but also to machinery and other critical systems. This means that their knowledge of ship operations should cover both deck as well as engine functions. If the remote operator is expected to simultaneously monitor several ships operating across various geographical locations and numerous environmental conditions, that may also impact his/her quality of judgement and decision making. Authors also caution about the fact that the remote operator is detached from the real sea conditions and the onboard environment. This will not only impact their ability to fully grasp the context, but also diminish their situational awareness.

Some authors feel that with fewer people onboard ships to operate the vessel or during the remote operation of ships from ashore in future, there will be occasions such as emergencies that will require operator to promptly take over from the machines. This means, future marine operators will need to be trained to react quickly to avoid errors due to delays in decision-making, also known as human-out-of-the-loop syndrome (Janßen, Baldauf, Müller-Plath, and Kitada 2021; Lutzhoft et al. 2019; Porathe, Prison, and Man 2014). Janßen et al. (2021) further argues that it is not just the training, but also the experience of future vessel operators that matters. Authors highlight the dangers of missing seafaring experience in future vessel operators who will just rely on displays of technical data for decision-making. They recall the collision incident between two ships in the fjord of Kiel in 2014, wherein the navigating officers on both ships fully trusted the ECDIS data without ever realizing that there was a GPS failure in that area.

All the studies mentioned so far have touched upon various aspects of training requirements of future seafarers. However, what is lacking is a comprehensive study that encompasses the whole process, that follows a sequential order, ascending from the abstract and reaching to the concrete. Such a study needs to investigate human practices in a socio-cultural perspective, across multiple contexts and networks, as a developmental process wherein the individual, organizational, societal, and cultural levels are dynamically interrelated. The Cultural-Historical Activity Theory (CHAT) or simply, Activity Theory, fulfills such a requirement.

In this paper, we propose the use of CHAT as a theoretical lens to analyze the challenges arising onboard ships during the transition period to a digitalized future. The CHAT provides a holistic socio-technical perspective, wherein the learners, mentors, technologies, pedagogical values, roles/identities, and rules/cultures act as interdependent elements of a single collective activity system. In the next section, we will describe the cultural-historical activity theory (CHAT), and the various interdependent elements. It is argued that it is only through resolving any contradictions, incoherencies and dilemmas between those elements, we can facilitate the achievement of the desired outcome, in this case, competent mariners who can safely operate highly digitalized future ships.

2. Cultural-Historical Activity Theory (CHAT) as a theoretical framework

The Finnish educationalist Yrjo Engeström (2016) built upon the earlier works of Vygotsky, Leontiev and other cultural-historical psychologists from the Soviet school and expanded their activity theory framework for exploring transformative work activities. He broadened Vygotsky's original 'mediated-action' triangular model by adding the components of community, rules and division of labour as illustrated in the figure 1 below. In this multi-triangle model of an activity system, the apex triangle represents Vygotsky's original mediated-action model comprising of the *subject*, the *object*, and the *tools* (and signs). A vertical flip of this triangle introduced the *community* as a mediator, thus extending the model to social and collective activities; A side-wise flip of the triangle introduced *rules*, thereby incorporating historical traditions, rituals, guiding values etc., as a mediator between the subject and the community; A side-wise flip of the triangle to the other end introduced *division of labour,* thereby defining the social, or organizational roles as a mediator between the community and object. The object itself is depicted within an oval shape, suggesting that 'object-oriented actions are always, explicitly or implicitly, characterized by ambiguity, surprise, interpretation, sense making and potential for change' (Engeström 2001, p. 134). Finally, an activity *outcome* is added, that could form the basis for starting a fresh new activity.

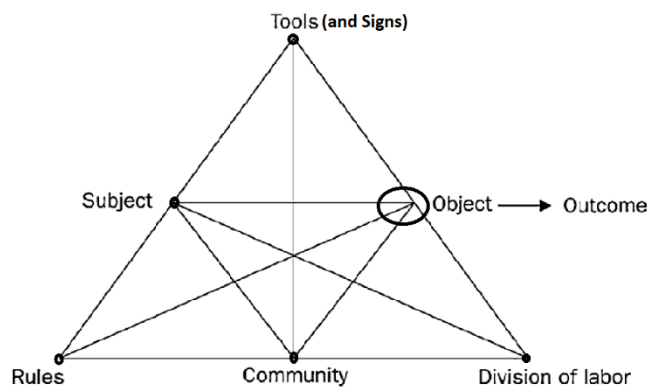

Figure 1: Activity System (Engeström 2001, p. 135)

Contradictions or tensions or any disturbances can arise within and between the constituents of an activity, or between two or more different activities, or within and between activity systems as they evolve over a time. Analysis of such contradictions is the key to understand the sources of trouble as well as the basis for innovative and developmental potentials and transformations of the activity system (Engestrom 2000).

3. Contradictions within the onboard activity system due to introduction of digital tools

The STCW Convention has mandated the maritime education and training (MET) to include a phase of apprenticeship training onboard ships for all seafarers. The reason for making the onboard training mandatory was to help the trainees develop their disciplinary knowledge and competencies by means of workplace learning through legitimate participation in real work onboard ships (Emad 2017). Moreover, the onboard phase of training will afford a learning environment characterized by situations, activities, and real-life challenges that the students will continue to face on board ships in the future (Emad 2011). The influx of high technology is rapidly changing the work environment onboard ships, and this, to a great extent, is precluding many of the traditional and authentic learning opportunities that earlier existed during the onboard apprenticeship (Emad 2017). For instance, digitalization may result in intransparent or opaque systems as the work or decision-making processes directed by (hidden) algorithms may not be readily observable to a bye-stander, thus affecting his or her learning process (Emad 2017; Harteis 2018).

The introduction of novel digitalized tools and systems onboard ships is gradually and irreversibly obliterating the need for the 'expertise' on manual systems that the senior experienced personnel possessed. In some ways, this is annihilating parts of work activities that were dependent on the competences based on the experience of more senior crew (Harteis 2018). This in turn has led to the creation of 'distributed expertise', democratization of the onboard workplace, and furthermore, to a break-down of the strict hierarchical controls that traditionally existed onboard ships.

Digitalization of onboard systems has resulted in an increase in the speed and power of the work processes. It has resulted not only in more efficient (quicker or denser) processes but also merger of few processes, and thus, the introduction of a variety of new processes. Onboard modern ships, with limited number of crew overseeing multiple and complex tasks, the job intensifies, thus, causing operator's cognitive overload, error in judgement, and in many cases, costly accidents. The investigation reports of some of the recent maritime accidents and incidents point to the improper use of technology as among the major causal factors. All this underscores the urgent need for re-addressing cognitive human factor and competency development of seafarers, relevant to the use of the modern technology and human-machine interactions.

Digitalization and automation onboard may also bring some drastic changes to the onboard mentoring process. As stated earlier, the almost unidirectional flow of competence and expertise, from the senior (master) to the junior (novice), is now disrupted with introduction of new tools and equipment. With onboard workspace more democratized with the new emphasis on team building and shared expertise, the trainees may often find better mentorship by junior officers who in most cases are more at ease and familiar with the digitalized tools when compared to their seniors on board. This, in future, will lead to more onboard learning through shared mentorship and leadership. As such, a team member could simultaneously be an expert in, and contribute to one task, but a novice in, and ready to learn in the very next. Furthermore, a multi-directional information flow can support open, transparent communication that can clarify and address some of the opacity of work processes introduced by digitalization and automation onboard.

Thus, it can be seen that digitalization and automation process is introducing many new contradictions and tensions among the components of the onboard learning activity system consisting of the learners, mentors, technologies, pedagogical values, roles/identities, and rules/cultures. The idea of contradictions as a source of change and development plays a constitutive role in Engeström's theory of expansive learning (Engeström, 2014; Engeström, 2016; Engestrom and Sannino 2010). Expansive learning within an activity system can be implemented through setting up a 'change laboratory' involving a series of interventions ranging from Questioning, Analyzing, Modelling, Examining, Implementing, Reflecting and Consolidating as described in Engeström, Rantavuori, and Kerosuo (2013). Engeström (2014) through his change laboratory experiments in various workplaces has shown that successful resolution of any contradictions within or between activity systems, can lead to development of new practices, or in other words, expansive learning. In view of ongoing digitalization onboard ships, the identification, and the resolution of any such contradictions, incoherencies and dilemmas between the elements becomes paramount for achieving the desired outcome, i.e., competent mariners who can safely operate highly digitalized future ships.

4. Conclusions

This paper presents activity theory as a novel, conceptual framework for modeling, analyzing, and redesigning onboard learning of mariners in view of steadily increasing digitalization and automation onboard ships. Using the elements of Engestrom's activity system, we suggest specific transformation towards digitalized future in a democratized learning environment onboard that appears well-aligned to the needs of future mariners. It is our hope that this proposal will provide industry stakeholders a practical modus operandi for bringing reforms to future onboard learning programs and thereby meet the 21st Century knowledge and future skill requirements of the shipping industry.

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From Enterprise Resource Planning (ERP) to Universities Resource Planning (URP)

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Abstract: The article discusses and analyses the importance of the Enterprise Resource Planning (ERP) principles in the University environment. It is crucial to properly evaluate and assess the effectiveness of the university's administrative and academic staff performances as an organizational form. In the last couple of years, besides the negative impact, COVID-19 positively impacted the technological development at the HEIs. So, the ERP system remains a powerful program that allows businesses to systematize all important processes. Drastically, doing so reduces costs and the possibility of making mistakes, thereby increasing efficiency and profitability. The ERP system comprises the main sections of an organization, such as financial, human resources, production, logistics, etc., but to the present does not cover the whole university's administrative and learning activities. Thus, most HEIs effectively implement technologies and E-Systems but, in most cases, are fragmented and do not cover whole university activities. The purpose of the article is to create one united platform based on an ERP system, whereby we will get the new model of the University Recourse Planning (URP) system and will be implemented and facilitate the: unified digital database, improvement of university efficiency, less bureaucracy, delayed decisions and the and quality improvement. As a result, all the data will be shown as a "Dashboard" to the top management of HEI, which will perceive information about the weaknesses and gaps for achieving specific objectives.

Keywords: E-University; ERP; URP

Introduction

In 2018, we started working on the article, which includes introducing the ERP system in Higher Education Institutions (HEIs) as a unified platform that will improve the effective quality enhancement of HEIs in compliance with its mission, vision, and strategic goals. Besides, we examined four outstanding Georgian universities *(these HEIs did not allow us to publish their names)*, and none of them did not have fully implemented ERP systems. Some of the aspects are used by them, but they are fragmented.

Recently, many international HEIs tend to be globally recognized and competitive in an education environment, but unfortunately, around 60% of all ERP systems fail to meet expected outcomes. In fact, due to the significant investments of resources made by organizations to adopt or shift to ERP systems, researchers have a strong desire to explain the causes and the factors that lead to good performance with ERPs.[1] We studied that the factors of failure are mostly related to the modern technological skills of employees. Academic and administrative staff who are more than 50 years old were not able to work in high technological softs, but nowadays - since COVID 19 almost 90% of employees more or less have gained such skills.

Optimistically, we can now revive implementing the ERP systems process as a unified platform for Georgian and foreign partner universities. The data used for the study are automatically resolved rationalizations of ERP adoption introduced by universities. Subject evaluation is used for these data. There is some proof to recommend groups are deemed to engage an obedient role to equipment and methods at the university.[2]

The world is moving toward maximizing the simplicity of human functions and duties. Over the last few decades, the technological capabilities of humankind have increased colossally, which has facilitated the transfer of monotonous and routine labour work to high technological activities. Thus, technology is being integrated into any field. By simplifying all organizational functions, small or large businesses are keen to lower costs and higher benefits.

Imagine the critical importance of ERP strategy implementation. Take a glance at the organization's integrated strategy, which covers various operational levels of the organization’s structure, such as Human and asset management, Customer Relationship Management (CRM), Manufacturing resource planning, Supply chain management (SCM), and Financial management.

The ERP system's genuine value lies in the company's new methods to make its business successful. Many functions become redundant, and due to the quick access to the necessary information, the time to perform other tasks is significantly reduced. Based on new technologies, many large companies have been developing information systems since the 1972s. One of the most successful projects was creating a software product by the German company SAP AG called R/3.[3]

We could create and develop a new project form of ERP system for universities based on research. As a result, we will get a new form of Enterprise Resource Planning (ERP) for Universities Resource Planning (URP).

Figure N1. The Enterprise Resource Planning (ERP) in University Environment

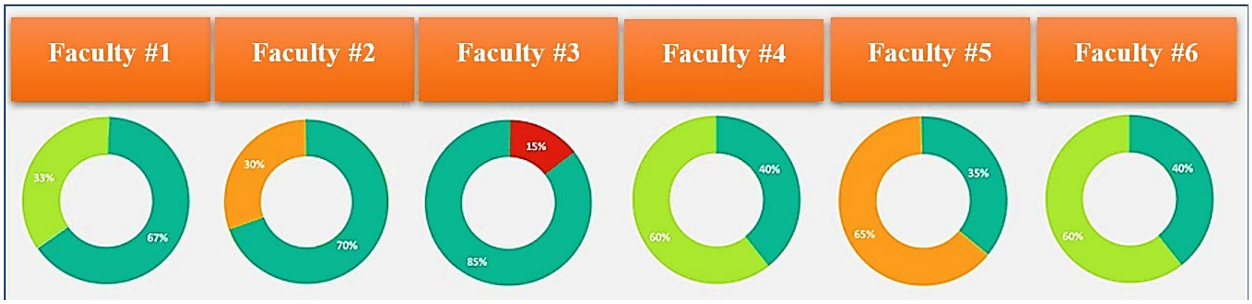
Source: The URP Structure is compiled by us. Batumi 2022. The dashboard is created in IT – Tech Operations.[4]

In **Figure N1**, we describe the main idea of how the URP system permanently might be presented to the top management. According to the faculties/departments/divisions or units, almost all universities have an action plan and try to report information by the end of the fiscal or academic year because the missing current achievements and progress of the university activity very often is time-consuming and inefficient.

With this dashboard, the top managers can see current progress, which of the structural unit is succeeding, and follow the planned activities. Which structural unit is behind its plan, and generally, what is the university's capability and actual performance?

For example, on the framework of the URP system, the top manager can click on the HUMAN AND ASSETS MANAGEMENT button and see detailed information according to the Faculties, which will be divided into two-part, Administration Staff and Academic Staff. The dashboard will show all faculties achievements and staff progress separately.

Figure N2. University Structural Unit (Faculties) performance



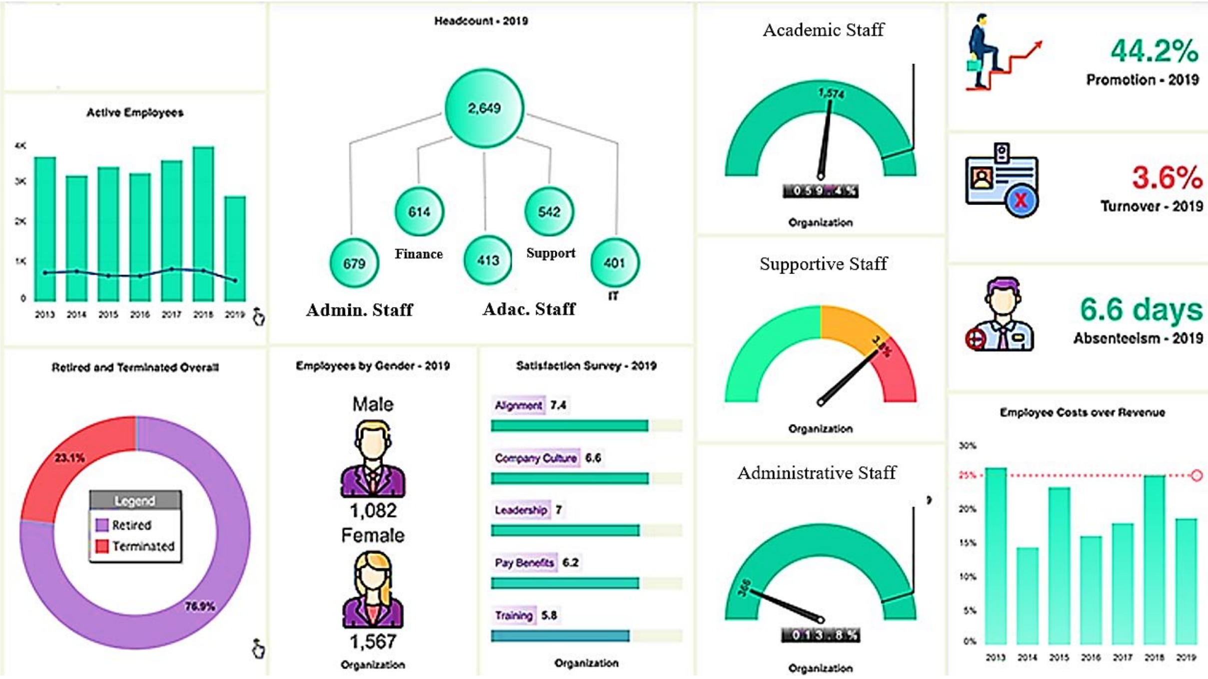
Source: The URP Structure is compiled by us. The KPI dashboard is created in SketchBuble. Batumi 2022 [5]

In **Figure N1**, we described the university's overall performance. Once the top management identifies the current problem, he/she can investigate that the university cannot use its capabilities, so they can go in deep and find why particular faculty could not reach the goal and discover the reasons for failure.

Figure N2 shows general information *(in our case)* on the faculty achievement progress. The Green coloured pie chart shows goal achievements, while other colours show the gaps in achievements. In this case, the best result has accomplished by Faculty #3, and the worst result has provided by Faculty #5. If we click on Faculty #5, we can see the detailed performance of each employee.

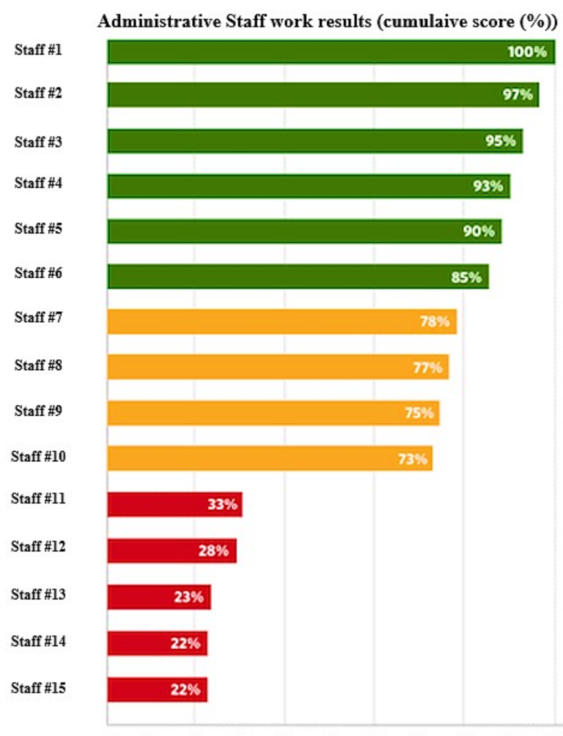
Figure N3 demonstrates the results of Faculty #5. From this dashboard, the management can easily find out which staff is not working efficiently or does not work at all. In our case, the Administrative Staff has the worst results, which reflects the overall result of the faculty, and in the end, it will be shown in the University results. After the URP System identifies the problem, the management can go into detail and determine which administrative staff does not work correctly.

Figure N3. Faculty #5 performance (%)



Source: The URP Structure is compiled by us. Batumi 2022. Generate Custom HR Dashboard & Reports [6]

Figure N4. Administrative staff work results cumulative score (%)



After problem identification, the management can click on the next button, Administrative Staff. This area will provide the complete staff evaluation of their work done. From staff #1 to #6, the results are excellent, staff #7 to #10 are evaluated as expected, but staff #11 to #15 have a worse result.

Now, the management has rated his/her employees and its time to start analyzing why some of the staff have the best results and others are passive. The top management needs staff whose efforts are energized, directed, and sustained toward attaining a goal. Which of the McGregor's Theory X and Theory Y [8. Pg. 272-293] belongs to his/her staff and why? How to motivate and train them? Maybe the jobs are not fairly distributed among them? Thus, when top management will

Source: The URP Structure is compiled by us. Batumi 2022.[7] create a proper Job Characteristics Model (JCM); almost all staff will be motivated and well organized.

Figure N5. The overall annual performance assessment of the academic staff (%)

The overall performance assessment of the academic staff		17	%	Assessment by Admin. and Acad. Departments						The annual workload of academic staff. The minimum mandatory workload is 1800 hours			1	2	3	4	5		
Academic position	Name and Surname	Attending faculty council meetings (17 Council meetings during the academic year)		Dean's assessment (20 points)	Acad. Department (15 points)	Evaluation of the Internationalization Service (25 points)	Evaluation by Quality Assurance Service - Auditory Attendance(40 points)	Sum	Research & Scientific activity (minimum requirement 100 points)	The minimum mandatory workload is1800 hours	annual workload of the academic staff	Comparison with minimum requirement (%)	Evaluation of students (evaluation with max. 5 points) "Average evaluation by groups in %"					Academic integrity & Personality Traits - Max. 100 points (Sociability; Conscientiousness; Punctuality; Purposefulness; Responsibility)	The overall average performance assessment of the academic staff
Professor	Lecturer #1	17	100	20	15	25	40	100	320	1800	2400	133	0	0	0	4	96	98	150
Assoc. Professor	Lecturer #2	16	94	18	13	22	36	89	220	1800	2100	117	1	1	0	8	90	95	123
assist.professor	Lecturer #3	14	82	16	13	18	32	79	180	1800	2000	111	0	0	5	10	85	91	109
Professor	Lecturer #4	10	59	12	11	17	25	65	170	1800	1950	108	4	0	4	11	81	82	97
Assoc. Professor	Lecturer #5	10	59	12	10	15	20	57	140	1800	1900	106	10	0	0	15	75	78	88
assist.professor	Lecturer #6	9	53	10	8	15	20	53	110	1800	1900	106	2	6	10	12	70	60	76
Professor	Lecturer #7	8	47	9	6	15	16	46	100	1800	1800	100	10	5	10	20	55	55	70
Assoc. Professor	Lecturer #8	6	35	6	5	12	15	38	90	1800	1750	97	9	1	25	15	50	50	62
assist.professor	Lecturer #9	2	12	5	2	8	15	30	80	1800	1600	89	30	5	15	10	40	45	51
Invited teacher	Lecturer #10	1	6	1	1	7	13	22	80	1800	1450	81	45	14	0	6	35	35	45

Source: The URP Structure is compiled by us. Batumi 2022.

In **figure N5**, we tried to present the overall performance assessment of the academic staff. One of the essential activities is to attend the faculty council meetings. In our case, let us suppose during the Academic year held 17 meetings and lecturer #1 has attended all 17 meetings; thus, he/she has 100% attendance and the best performance comparison to other academic staff. The next activity is assessing academic staff by the university administration units and academic departments. This measurement will be crucial in terms of project involvement and internationalization activities. Quality Assurance Service evaluates the academic staff and will be graded a maximum of 40 points. The following assessment is based on the research & scientific activities of the academician. The annual workload, evaluation of students, and academic integrity & personality assessment (Sociability; Conscientiousness; Punctuality; Purposefulness; Responsibility) will allow the management to determine the overall average performance of the academic staff.

We believe that all universities use the triangulation method in the evolution process, but they are not centralized and, in most cases, fragmented. Evaluation criteria of all structural units of the organization should be designed in advance.

Similar methods and approaches will be used with the rest structural units of the HEI. The management can measure the financial, HR (CRM) results, Quality assurance, and other departments. Despite the classification of the gap in the operation activities, with a centralized and unified database, the management can easily create a new project. Particular unit managers should investigate how many staff they have, what qualifications they need, and which academic or administrative staff are currently free to be involved in the project. Even though they will need to have information about university financial situations and whether the university can finance a particular project or not? For planning such activities, the most critical part is material resources, where should work for the project team, how many and what kind of equipment is needed for project development, and how to measure the results?

Conclusion

ERP Systems in Higher Education Institutions (HEIs) have increased substantially over the past decade. Though this demand continues to grow. Thus the idea of the article is to **create a URP project for HEIs** on the bases of an ERP system. Implementing a URP system in the HEI requires a team of professionals. It is necessary to be entirely aware of the business processes of the organization in order to be able to optimize the system for the specific requirements of the university. But after the development and implementation of this software, all the data will be shown as a "Dashboard" to the top management, which will merely perceive information about the difficulties and gaps in achieving specific objectives. The URP program will have students learning process and analyses their academic results. Thus, the result is to create a commercialized product that will involve partner universities, create a commonwealth development strategy, and compare ratings according to created criteria. Thus, we believe that in Georgia and even in the Caucasus region and East Europe, E-university (URP) system will be an innovative, demanding, commercialized and profitable project.

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Session

Policy Aspect

IMO Session in Classroom: A Case in Experiential Learning

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Abstract: Modern maritime training formats have become student-centric and curriculum designs have evolved based on domain taxonomies and action verbs defining the learning objectives. Such instructional design formats must have scope for the pursuant to learn about the industry's regulators and stakeholders.

An extracurricular activity was undertaken by the University to gain insight into the knowledge about International Maritime Organization. An experiential learning process was envisaged. In this exercise, the functioning of the IMO's Committees was recognized as the related knowledge and a model was framed to impart this knowledge. The model involved role plays and mock action-theatre ambience. The processes for tabling, discussing and adopting resolutions were taken as the learning objectives for the act. Student groups drawn from the University's campuses were arrayed to play the roles of stakeholders. External experts having experience in attending the actual IMO sessions acted as the mentors.

Student Groups went through the 'mock sessions' under a competitive format. The most impressive student groups were brought up to a final confluence, while maintaining the 'twinned' nature of the functioning of the IMO's Committees. The entire implementation was done through online modes but for the Campus groups being present in their stations physically. These groups followed the social distancing norms etc. Peers with previous experience who had been attendees at the IMO sittings and similar fora were invited to witness and judge the presentations. The winning teams were awarded prizes and certificates.

This paper presents the organic development of this experiential learning model. It is also proposed that this exercise could be extended to global/regional levels involving participation of Maritime Education and Training Institutes of other Member States. The winners can be rewarded with visits to the actual IMO sessions etc.

Keywords: maritime knowledge; IMO; peer experience; lifelong learning

1.0 Introduction

In the industry parlance, Maritime Education and Training (MET) is largely seen from the perspective of seagoing careers. The knowledge-evolution of the sea career was hence built with patterns of a vocational or trade fabric. The organic development stages were marked by technological developments such as the materials of construction (wood to steel), propulsion (sails to propellers) and powering (wind, steam, diesel engines) etc. With this evolution on ship safety, constructional standards etc., a necessity for structured training was also seen. The Industrial Revolution (IR 1.0) and the World War II could be the historical points of reference for the growth of maritime knowledge. The IR 1.0 brought the winds of change for swifter and enhanced maritime trade and the need for safety (*propter hoc* sinking of the Titanic, particularly) and standardization.

Post WW II, shipbuilding and trade flourished and the International Maritime Organization (IMO) was established. Safety, regularization and quality were the keywords and a plethora of Conventions followed. Never before was the necessity for structured learning felt as much in this phase of the 20th Century. A curriculum became imperative for the growing number of seafaring aspirants across the globe. Also, there were innovations of other forms of cargo carriage such as LASH (Lighter Aboard Ships), box ships etc. The container carriage stayed as a popular option and brought in the dimension of multi-modal transportation. With these, the shipping business and logistics underwent a sea change, and there was a need for structured learning in maritime management also.

1.1 Approaches to MET

Curriculum means 'a path to run', whereas the terminus could be the completion of a set of learning objectives. The means and materials for obtaining the objectives must be contained therein. The earlier training formats prevailed on curricula where preparing the aspirant for the sea was antecedent to the knowledge. The knowledge-skill set acquisition was supposed to attain substance on board. The continuum of the Standards of Training, Certification and Watchkeeping (STCW) reflects this treatment (of seafaring as a vocation). The STCW (1978) Convention, the concerted attempt to standardize MET in its current form, differentiates the training needs based on the on-board operational manpower resources, layered by responsibilities. It stands as a paradigm for indicating professional competencies based on support, operational and management levels. The competencies are compartmentalized under broad functional areas.

The IMO Model Courses reflect the Convention's framework. The Model Courses carry the universal application of not only identifying the competency for the professional level but also help in identifying the assessment modes. The Model Courses cater to a range of short to long term, as also mainstream training programs. Though the Courses are developed by industry professionals and incorporate the objectives, the action verbs for many learning objectives had always been found wanting for better alignment from the aspect of the learning domains and in the process, Bloom's Taxonomy has found favour.

Benjamin Bloom's (Bloom et al., 1956) learning pyramid model was based on three domains, namely Cognitive, Psychomotor and Affective. After decades of experience, the taxonomical pyramid underwent a rearrangement of the levels to define the knowledge to be learned and the learning process (Anderson and Krathwohl, 2001). With the taxonomy, the learning objectives and the action verbs could be tabulated in the Instructional Design (ID) development. Furthermore, the assessment techniques also could be clearly recognized with the learning objectives.

ID formats based on the taxonomies and outcome based learning (OBL) with a student-centric approach rather than the traditional teacher-centric approach have emerged in MET also. The Global Maritime Professional Book of Knowledge (BoK) (IAMU, 2019) is one work in contention. The work comprehensively addresses the ID development from UG to PG levels based on the domains and appears suited to be applied for various disciplines under maritime learning. While employing the Bloom's taxonomies for all the domains, the BoK uses the Simpson's taxonomy (Simpson, 1972) for the psychomotor domain. It is justified that while Bloom's levels range from 'imitation/mimicking to automatization/naturalization' of psychomotor domains, the Simpson's taxonomy includes 'perception, set, guided response mechanism, complex overt response, adaptation and origination'. Though the detailed teaching syllabi (DTS) would use the action verbs based on the domain-compartments, it can be seen that the domains will overlap. Table 1 includes the brief description of the domains.

Table 1. Domains in OBL Taxonomies. (IAMU, 2019)

Cognitive	Knowledge development. Individual's mental skills; understand, recollect ideas and concepts	**Head**
Psychomotor	Motor/physical skills development. Individual's abilities to handle materials/objects with neuromuscular coordination Competency based MET curricula lay greater emphasize on these skills.	**Hand**

Affective	Emotional traits development. Individual's learning outcomes covering issues related to feelings; actions guided by quality of character, conscience	**Heart**

1.2 Constructivism and OBL

In all these shifts, the philosophical change has been towards pragmatism, with employability as the driving purpose. The mushrooming of a number of specialization courses and the IDs focusing on upskilling and upgrading stand in evidence. With reference to context, it is apparent that the ID architecture under OBL shifts the perspective from teacher to the learner.

In traditional objectivist approaches, the teacher developing the ID prioritizes and sequences the learning content to facilitate the learner (Jonassen, 1991; Ertmer and Newby, 1993). The learner's role is to assimilate the taught knowledge and be assessed on the extent of reflection. In the Constructivist approaches, the learner is required to construct his/her own knowledge rather than remaining outside of it (Ertmer and Newby, 1993; Vrasidas, 2000; Driscoll 2007). Obviously this approach will require real life problems, case based studies and reflections (Jonassen, 1991).

All these approaches can be experimented with in the Competency Based Education structure of MET. Significantly, the schema would reflect experiential learning on many facets. Amongst many, MET accommodates experienced professionals as teachers (with sea experience, shore industry experience etc.). The shore based regimen and practical training adumbrates the training on board (which is to follow). For a shore based career training, a similar parallel can be drawn, wherein an internship may be equated to the ship board training.

The merits of this student-centred learning would be Learner control (Wilson and Cole, 1991), Self-awareness in Knowledge construction (Honebein, 1996), Student autonomy and initiative (Brooks and Brooks, 1993) etc. John Dewey (Dewey, 1938), an early exponent of Constructivism, opined that practical, hands-on activity must be the centre of education and curriculum must be continually constructed through shared experience. The OBL curricula can be supported by bringing in experience from an extra-curricular dimension also.

For a University, refinement of learning processes must be a perennial endeavour. The survival of universities depends upon how good their services are and this would also set them apart from the rest in terms of quality (Aly and Akpovi, 2001; Kanji et al., 1999). The quality of a higher education institution (HEI) can be judged as perfect/exceptional or can be defined by fitness for purpose, value for money etc., (Harvey and Green, 1993). HEIs' quality might even depend on the perceptions of a stakeholder (Middlehurst, 1992) or measured by the degree of achievement of the set objectives (Vroeijenstijn, 1992). All these would depend on its continuous efforts in bringing the real life experience into the learning ambience. The activity of playing out the IMO Sessions can be termed as one such effort. The learning space was to be a HEI, the Indian Maritime University (hereafter the University; IMU) and its Campuses.

2.0 IMO Classroom Mimic Session: Matching the Learning Objectives

The BoK (IAMU, 2019) comprehensively identifies four skillsets for the Maritime Professional. 'Maritime Law, Policy and Governance' is one of the elements under Professional-Technical Skills. The crucial role of the IMO, though included in the syllabi, was seen as a candidate-topic for experiential learning exercise. Elements of these incorporated in the DTS of the Bachelor of Technology (Marine Engineering) Program were taken up to build the extracurricular learning method. The section covering the learning objectives about IMO, extracted from the DTS is shown in Figure 1.

The learning objectives of the main syllabi are disseminated through lecture mode. In an attempt to bring completeness to the learning on the functioning of the IMO, mock sessions of the sittings of the Organization were planned. The dissemination was creatively structured based on the actual conduct of such sessions, mentored, supported and judged by the industry personnel who had actually participated in them.

In this extended ambience, the learning objectives were also enhanced. In the format, the students had to act out the part of the participants (Member States: developed/man power supplying/oil exporting country; Flag of Convenience etc.), relying on the experience passed on by the experienced elders. The students were thus motivated into constructing their idea of the IMO. Furthermore, since the students were to structure the talking points and debate on the chosen topics, learning objectives under the Affective domain were also considered. This is depicted in Table 2.

It can be seen from Figure 1 and Table 2, the outcomes from the learning objective of understanding the functions of the IMO are defined with the action verbs. In the extended design, the IMO 'mock' sessions in the classroom were assumed to be the happenings or the phenomena that the students experience. Herein, the outcome was elevated to a level where the students were required to discuss and debate on issues affecting the maritime sector. The students had to necessarily internalize several aspects (though guided by the experienced mentors), reflect on conceptualizing ideas and present them in a coherent manner.

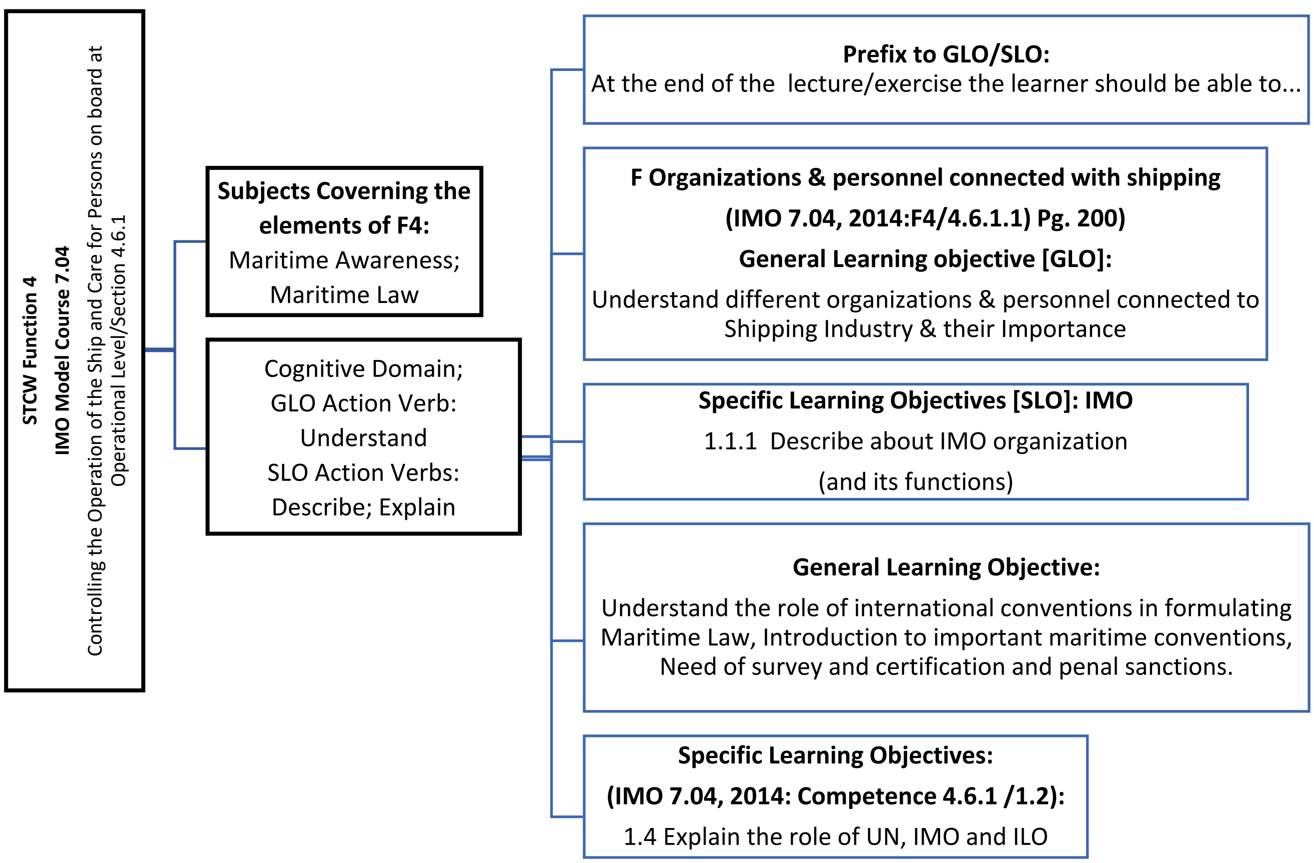

Figure 1. DTS Extract relevant to learning objectives on IMO.

Table 2. Obtainment of Learning Objectives on IMO.

Action Verb	Domain Level	Descriptor	Learning Objectives: Means/Processes
Describe	**Cognitive**		Lectures; Presentations
	Remember	Recall and test factual information	
	Understand	Paraphrase information or construct meaning from content	
	Evaluate	Examine/Judge the values of ideas	
	Affective		Guidance from Faculty; Industry Experts
	Receiving phenomena	Awareness, willing to hear, selected attention	
Discuss	**Cognitive**		Guidance from Faculty; Industry Experts
	Understand	Paraphrase information or construct meaning from content	
	Affective		IMO classroom sessions
	Receiving phenomena	Active participation of the learners; Participates in class discussions; gives presentations; questions new ideas, concepts etc.	

Note: Psychomotor domain descriptors for the Action Verbs not included, being non-relevant to the context.

With the pedagogic approach and learning objectives aligned, the exercise for the 'mock' or the mimicking of the IMO sessions was scheduled. Two topics were chosen for the exercise:

1. Human Element, Training and Watchkeeping (HTW): Development of Measures to ensure quality of On-board Training as a part of the mandatory seagoing service (required under the STCW Convention).
2. MARPOL: Amending the Annex V of MARPOL 73/78 so as to protect the Marine Ecosystems from vessel based (Marine) plastic litter.

2.1 IMO Classroom Sessions

The entire exercise from conceptualization to complete execution was done in a period of about 5 months. The University's website and a portal were used for registration, announcements etc., during the progress. While experienced industry personnel volunteered for being the Guides for the teams, their field experience and expertise were taken into cognizance and lots were drawn to allocate them as Guides for various teams. The Teams were formed in the Campuses and their assigned roles were defined by certain attributes as shown in Table 3.

A Team comprised of 4 students. A total of 95 (MARPOL) and 53 (HTW) Teams registered for the exercise. Each team, being guided by the experienced industry personnel, then prepared the base papers in the formats available in the IMO website. At the stage of base paper submissions, the Campus teams had the option to see the works of other role players with similar topics but not the works of their own role play category [i.e., Team playing a 'Developing Nation (A)' can see the works of other role players B, C, D, E and F but not of any team under (A)]. This, while maintaining the competitive format, provided an insight into other viewpoints on the same topic. Another deliberated decision was to maintain the team names based on category role plays (Team A, Team B etc.) and not assign the name of any Member State/Country.

Table 3. Team Characteristics for Role plays.

Factors	Developing Nation (A)	Developing Nation (B)	Developed Nation (C)	Developed Nation (D)	FoC (E)	NGO (F)
Manpower	International Supplier	National Supplier	Limited Seafarers	Limited Seafarers	Large number of Seafarers; Little Training	Welfare Focus only
Tonnage	Limited	Large	Limited	Large	Large	NA
R & D	Limited	Large	Medium	Large	Limited	Strong
Trade	Medium	Large	Large	Large	Limited	NA
Legislation Implementation	Moderate	Limited	Very Strong	Strong	Moderate	NA

FoC: Flag of Convenience; NGO: Non-Governmental Organisation; R&D: Research & Development

The Judges evaluated the base papers and prepared the responses. A Secretariat, ably guided by an industry veteran who had attended the IMO Sessions on numerous occasions, helped with the evaluation, feedback for improvements and final publication of the papers. At these stages, several documents were referred to and in particular, the students were urged to peruse the MSC-MEPC.1/Circ.5/Rev.2 (MSC-MEPC, 2020) issued by the IMO. A total of 109 Base papers only were received, out of which 32 for HTW and 43 for MARPOL qualified.

After the initial rounds of mock sessions at intra campus level (within each of the 6 Campuses), the teams were advised to revise and update the papers prior to the inter campus level mock sessions. The winning papers were lined up for the final round. The Judges for all levels and for the final debates, included personnel with experience at IMO and from the Indian Maritime Administration. Figure 2 shows the flow of the exercise.

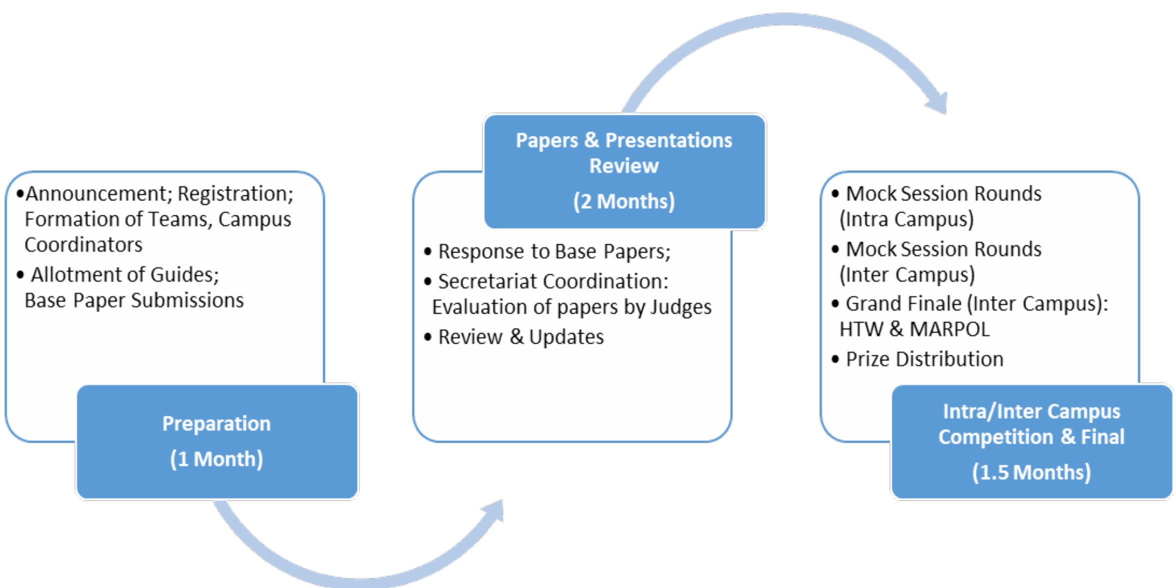

Figure 2. IMO Sessions: Process Flow.

The schematic representation of the sessions is shown in Figure 3. In the Final Inter Campus round, 8 teams from HTW and 10 from MARPOL competed. Each Category of HTW (STCW) and MARPOL had 4 Teams placed from top to 3 Runner-up positions. Each category was awarded a shield and cash prizes. The cash prizes totalled ₹60000 (about €750).

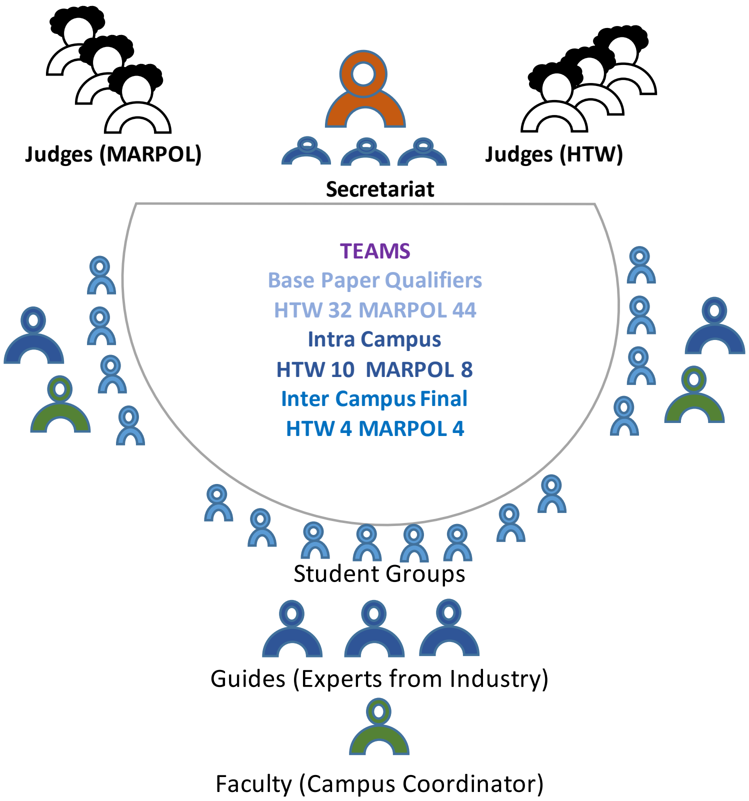

Figure 3. IMO Sessions (schematic).

A significant part of the exercise was the special Working Group discussions where the students were allowed to extend their discussions on the functioning of the IMO. This helped in fathoming the interest and curiosity of the students and also for gauging the extent of understanding while the exercises were progressing. Following the OBL format, the captured knowledge was assessed through formative assessments (quizzes, presentations etc.). Further, after about 5 months, the faculty and students attended a webinar on IMO and its working. In the following 2 months, a quiz program on IMO was organized for the students and the faculty. This inter campus quiz program was based on the realized experience from the mock sessions and webinar. The learning experience was thus reinforced in a way.

A limitation to the whole exercise was that the treatment could not be extended to all the students in the competitive format. Also, not all the students could articulate the ideas coherently in the initial stages. However, the exposure by showcasing the events on social media (Google, YouTube) witnessed noticeable changes in presentation styles and self-confidence of the students. Understandably, the feedback from the students confirmed that the learning objectives were finding home. However, the assessment mechanisms that verified the attained learning objectives (e.g., examination questions etc.) have not been discussed in detail.

A parallel learning experience was gained by all those who had actually attended the IMO sessions during their career and those who had never. Under the OBL format, this learning experience of the industry members, counts well for the lifelong learning one would envisage.

3.0 Conclusion

Under the learner-centric approach, the attempt to bring a real world experience of IMO session is bound to have a lasting effect in the young minds. The actual value addition needs to be ensured with continuous assessments and evaluation processes. Such blending pedagogy approaches are already in vogue. The experiential project-based learning format intertwined with an engineering curriculum is worth a mention (Raina and Choudhary, 2020). The maritime profession, with its multidisciplinary nature and assured international standards offers scope for similar approaches. The future beholds a digitized shipping world. This requires reimagining MET at HEI levels in bringing the real world experience. The benefit of these educational solutions will then extend beyond commercial operations into research and real world problem solving.

For a Maritime University, the industry is the major stakeholder. The employability of the University's graduates would depend on their competencies demonstrated on problem solving, decision making and analytical thinking. The stakeholders' demands are bound to change with the developing technologies. The curricula have to consistently attune itself with new approaches to learning and at times, the policy itself might require revisions.

India's New Education Policy (2020) envisages several measures including multidisciplinary curricula, provision for accumulating credit banks, outcome based education etc. At macro levels, an increase in the Gross Enrolment ratio (GER), technically sound workforce with abilities to solve real life problems etc., are expected. The role of specialized HEIs such as IMU would be crucial to the industry and the developing nation in creating vibrant educational ecosystems.

Moves towards Micro Credit Courses bringing dynamism to curricula, creatively equipping students with purposeful education and recognizing the knowledge gain with Minor degrees etc., are some efforts energized and gaining traction at IMU. The IMO Mock Session is an effort which has been received well and shown tangible improvements in students' cognitive and communication skills.

The exercise is being planned for the students of all affiliated Institutes of the University. On a broader format, this can be extended to global regional levels (e.g., Asia, Oceania etc.). The winning students can be rewarded with visits to the actual meetings of IMO. It would be encouraging and enlightening for the future global citizens, who are being groomed under the maritime sphere.

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Analysis and Consideration of the Navigation Support Capability of Arctic Shipping Route in China

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Abstract: In order to have a more systematic understanding of China's navigation support capability of Arctic Shipping Route and to form a basic perception of the situation to inspire the subsequent work related to its development, this paper makes a targeted analysis and functional classification of China's navigation support in all aspects for Arctic Shipping Route at the present stage, and makes a comparison from the actual demand, so as to point out the shortcomings and explore the sustainable development.

1. Introduction

With global warming, the sea ice in Arctic has diminished and part of the Arctic Shipping Route is navigable seasonally. As a shortcut for trade among the economically active regions of Asia, Europe and the United States, as well as an important global energy source, the Arctic Shipping Route has the advantages of being short in distance and time and low cost, so this "golden route" is bound to change the pattern of world shipping. To ensure the safety of navigation on the Arctic route, the charts and publications, aids to navigation, maritime communications and other necessary navigation support services are indispensable.

The White Paper on *China's Arctic Policy* released by the State Council of People's Republic of China in January 2018 clearly states that "On the basis of the principles of 'respect, cooperation, win-win result and sustainability', China, as an important stakeholder in Arctic affairs, is ready to cooperate with all relevant parties to advance Arctic-related cooperation under the Belt and Road Initiative, so as to build a community with a shared future for mankind and contribute to peace, stability and sustainable development in the Arctic." (State Council Information Office, 2018) An accurate grasp of the basic needs for navigational support in the Arctic Shipping Route and practical strategies that China can adopt in related areas are of great significance in further promoting China's participation in the development of Arctic Shipping Route, Arctic affairs, connectivity in the Arctic and the construction of the Polar Silk Road.

2. Arctic Shipping Route and its Current Status

2.1 Arctic Shipping Route

The Arctic Shipping Route, also known as the Arctic Passage, refers to the oceanic route that crosses Arctic Ocean while bridging Pacific Ocean and Atlantic Ocean. The Arctic Shipping Route consists of three main routes:

Northeast Passage. The Northeast Passage, also known as the Northern Sea Route, begins at Murmansk in Russia and passes through Barents Sea, Kara Sea, Laptev Sea, East Siberian Sea, and Chukchi Sea from west to east, bypassing the Bering Strait till the North-East Asia, with the total length of approximately 2,936 nautical miles (ARCTICC, 2013).

Northwest Passage. The Northwest Passage, a route linking the Atlantic Ocean and Pacific Ocean, starts in the north of Baffin Island in northern Canada, passing through Davis Strait and Baffin Bay and heading west through the waters of Canadian Arctic Archipelago to the Beaufort Sea in the north of Alaska of the United States (ARCTICC, 2013).

Central Passage. The Transpolar Passage, also known as the North Pole Route, which starts in the Bering Strait and crosses the central area of Arctic Ocean to Greenland Sea or Norwegian Sea (ARCTICC, 2013).

Compared with the traditional sea routes from Northern Europe to East Asia, the Arctic Shipping Route not only reduces the distance and time of the voyage, but also is significant in reducing the nontraditional security threats in passing through the Panama Canal or the Suez Canal.

2.2 Current Status of the Arctic Shipping Route

Due to the harsh weather conditions, the Arctic Shipping Route is covered under sea ice for most of the year and only from July to September can the Route be navigable with the assistance of icebreakers. In recent years, with the global warming, the melting of sea ice, the continuous improvement of ice-breaking technology and the increasing capacity of the Navigation Support for the Arctic Shipping Route, its environmental conditions for navigation have hence improved and the navigable period throughout the year has increased.

Opened in the 1930s, the Northeast Passage is a straight route with relatively good navigable conditions and has been used commercially on some scale. At this stage, the navigable period can last up to five months in a year (from July to December). According to data from the Russian Northern Sea Route (NSR) Information Centre, the freight volume of the Northeast Passage increased from 3 million tonnes to 30 million tonnes from 2011 to 2019, exceeding 33 million tonnes in 2020 and 35 million tonnes in 2021. In addition, 617 different vessels were recorded between 2016 and 2020, reaching a gross registered tonnage (GRT) of more than 8.7 million tonnes, with a total of 241 ship owners, 27 different flag states and 28 ship types.

The Northwest Passage has complex terrain along its route, with many straits and islands, and also reefs and shoals in the way. It opens for navigation for three months (from July to October each year). At this stage, the Northwest Passage has not been used commercially on a large scale and is only used for experimental freight transport.

And the last is the Central Passage, which is far from the mainland and is only used for scientific investigation, tourism and military activities now due to the high density of multi-year ice in the central area of Arctic Ocean.

Countries concerned and international organizations observed that sea ice in Arctic Ocean has been diminishing over the past five decades, and this trend has been intensifying over the past 20 years, with satellite data showing an average annual decrease of 3%. In recent years, Arctic temperatures have continued to rise at a rate twice the average global warming, and sea ice area has been shrinking at a rate of 10% per decade, especially in summer when the total amount of multi-year ice has declined sharply. Some scientists predict that there may be no ice in the Arctic Ocean for part of the year by 2030 at the earliest (Feng, Li & Ma, 2016).

3. Navigation Support Capability of Arctic Shipping Route

3.1 Concept of Navigation Support Capability

Navigation Support Capability refers to the ability to provide a range of comprehensive services to ensure maximum safety of the ship during navigation.

Navigation Support Capability includes nautical charts and publications, marine hydro-meteorological services, aids to navigation, the broadcast of communication information and so on.

3.2 Requirements for Navigation Support Capability of Arctic Shipping Route

The Arctic Shipping Route is located in Arctic Ocean, with high latitude, remote waters, ultra-low temperature, strong storms, ice area and complex geomagnetic environment. Although there are no restrictions on ship size and draught, and the aids to navigation and radio facilities have been set in some waters, the Route still faces more difficulties than traditional routes due to both the geopolitical conditions and geographical and climatic conditions like high latitude and ultra-low temperature of the Arctic. In particular, there are greater challenges in terms of the accuracy of nautical charts and publications, the rationality of the aids to navigation, the accuracy of satellite communication positioning and the promptness of safety information broadcast.

4. Analysis to the Navigation Support Capability of Arctic Shipping Route and its Future Construction

4.1 Nautical Charts and Publications

China has now published two navigation guides, *Guidances on Arctic Navigation in the Northeast Route*, published in 2014, and *Guidances on Arctic Navigation in the Northwest Route*, published in 2015, as well as other materials concerned with Arctic navigation such as *Atlas of Arctic Navigation* (2015) and *Guidances on Arctic Communication in the Northeast Route* (2017), which provide data guarantee for ships flying Chinese flag and seafarers to navigate safely on Arctic Shipping Route (Ding, Liu & Wei, 2017). The two navigational guidances cover aspects of the awareness of the polar environment and climate change, and also provide information and services related to navigation support for ships that transit the Arctic Shipping Route.

Unavailability of related nautical charts is one of the concerns. There are currently no Chinese versions of charts in both printed and electronic copy for Northeast Passage and Northwest Passage. The charts for Northeast Passage, from Bering Strait to the waters of northern Norway, are mainly Russian versions on a scale of 1:100,000 to 1:3.5million. Soundings in those charts are sparsely marked, even around recommended routes; charts for the Northwest Passage is mostly the US, Canadian and Danish versions. The chart sequence for northern Alaska, southwest Greenland, and the Canadian mainland coast are relatively complete, but smaller in scale than conventional waters, with a large number of areas that have not been mapped. Besides, the sounding data is age-old, and track or single point sounding is mostly used outside the main passage. The language barriers and the fact that the chart information involves a number of terms such as chart coordinates and magnetic variation have caused hindrances for relevant staff in the use of the charts (Wu, 2020). Furthermore, only about 9% of the Arctic Ocean has been mapped based on international standards, and most of the waters have not been explored. There are currently no charts available for navigation in areas north of 75°N.

There existing nautical charts and publications are not corrected and updated timely and the correction channels are poor, in addition, most of the data sources are age-old, with marine data of the year 1941 to 1989 and land data from 1953 to 1992 (Maritime Safety Administration, 2017). The difficulty of access to that information makes it difficult for China to grasp information on the natural environment and actual geographical conditions of the Arctic Shipping Route, thus harder in providing basic and necessary guarantees for safe navigation.

4.2 Applicability of Aids to Navigation

The IALA A maritime buoyage system is used for the Northeast Passage, which is deployed seasonally, and the location of those aids is not fixed. The number of aids to navigation varies greatly along the coast, with the Barents Sea and the White Sea having the largest number and the Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea having only a few seasonal ones. As it is foggy along the Northeast Passage, its visibility is poor. Therefore, there are audible aids such as foghorns, radar transponders and radar ramarks or radar aids (Maritime Safety Administration, 2014).

The Northwest Passage is sparsely marked with aids to navigation, mainly in important channels and headlands, and not much of radar transponders. The coast north of Alaska is not marked with aids to navigation, and the range of those facilities only covers a short distance north of the Bering Strait. The navigational aids along the Bering Sea coast in the northern Aleutian Islands serve mainly trawlers and fishing vessels. There are also several areas of Aleutian Islands Chain where navigational aids are in place to serve local and trans-Pacific shipping. The majority of vessels navigating in the Northwest Passage pass through the central channel, away from the shoreline, and rely mainly on satellite positioning for real-time positions (Maritime Safety Administration, 2014).

The high latitude and complex geomagnetic environment of the Arctic waters make the automatic north finding moments of traditional navigational instruments low and traditional navigation systems such as the gyrocompass and magnetic compass deviate considerably. As no radio positioning system has been established in the Arctic, ships rely more on satellite navigation. There are four major satellite navigation systems in the world, which are, Global

Positioning System (GPS) from the United States, GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS) from Russia, the EU Galileo Satellite Navigation System (GSNS) and China's BeiDou Navigation Satellite System (BDS), can all achieve polar navigation and positioning at this stage, among which GPS is the most mature one.

4.3 Maritime Communication and the Broadcast of Safety Information

Communication on Arctic Shipping Route has always been a difficult issue for the stakeholders due to the surface curvature and high latitudes. Distress alerts and ship-to-shore communications have been difficult to secure the Arctic navigation.

Shore-based Communication. The Arctic shore-based communication infrastructure is poorly developed, with little equipment in coast radio station, and is only distributed in some important waters. In 2007, IMO added five NAV/METAREA zones to Arctic Ocean. The coordinating country for the XX and XXI zones in the waters of the Northeast Passage is Russia, with ground communications facilities such as MF/HF SSB, DSC, and also the INMARSAT to communicate and acquire service along the coast. VHF, MF and HF coast radio stations were set up along the Northeast Passage (Northern Navigation Service Center, 2017); VHF coast radio stations were constructed in its important waterways, and southeast Alaska, northern Bering Sea, southwest Greenland and Svalbard. Due to the special geomagnetic environment in the Arctic, the shortwave communication is not stable, so the communication service is not good. Coastal states in the Arctic are trying to solve this problem, for example, by establishing ionospheric observation stations, so that ships can take appropriate measures based on ionospheric parameters.

Satellite Communication. The existence of blind sectors in satellite coverage at high latitudes makes it difficult to achieve real-time signal transmission between geostationary satellites over the equator and communication terminals in the Arctic. The International Maritime Satellite (INMARSAT) system is unable to cover areas above 75°North latitude. The US Iridium Satellite communication system was approved for Global Maritime Distress and Safety System (GMDSS) services in May 2018 as a GMDSS communication equipment is widely used in Arctic navigation. China's BeiDou Navigation Satellite System (BDS) is also accelerating its application in the global maritime sector. At the 99th session of Maritime Safety Committee of the International Maritime Organization, China submitted an application to endorse BeiDou Messaging Service as a GMDSS service provider, and at the NCSR7 of the IMO in January 2020, a proposal to join the pre-assessment of GMDSS was adopted, which will be carried out by IMSO for technical and operational assessment. At present, the Beidou's messaging service system will still face uncertainties brought by the on-site technical evaluation of IMSO and the revision of international recognition standards. Once successfully joined GMDSS, it can effectively drive the overall development of BDS.

4.4 Thoughts and Suggestions on the Future Construction of the Navigation Support Capability of Arctic Shipping Route

With the continuous warming of the climate, the conditions for large-scale and regular operation in the navigable period of Arctic Shipping Route in summer have been preliminarily met, and the shortcomings of the navigation support capability of Arctic Shipping Route in China are of vital importance for the enhancement of its navigation capability. But the navigation support is systematic and comprehensive, with high requirements for financial support, technical equipment, personnel training and other basic needs. Meanwhile, the special geopolitics of the Arctic should also be taken into account. Therefore, in view of the particularity of the navigation support work of the Arctic Shipping Route, we must seek for the breakthrough and focus point in our research.

(1) Strengthening the construction of infrastructure. Through in-depth cooperation with "Polar Silk Road" countries, China will strengthen communication and cooperation with Arctic coastal states, provide financial, material and technical support for port infrastructure, and jointly build infrastructure for navigation support of Arctic Shipping Route. Also, the Loran/Chayka navigation system, Automatic Identification System (AIS), hydrography, coast radio station and other infrastructure in the Arctic will be promoted.

(2) Intensifying satellite communication. We will continue to strengthen the construction of the Beidou communication system. With the launch of China's BeiDou-3 Navigation Satellite System, we will keep deepening the development of its function in accordance with the concept of "China's Beidou, the world's Beidou, and also the first-class Beidou". We will give full play to the application of Beidou short message communication technology to

provide more timely and accurate information services such as marine meteorology and notices to mariners for Arctic navigation.

(3) Deepening international cooperation. We should make full use of various maritime organizations and related regional platforms to step up international cooperation on navigation support for Arctic Shipping Route. At the same time, we also should pay attention to the International Maritime Organization (IMO), International Hydrographic Organization (IHO), International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), International Telecommunication Union (ITU) and other international organizations concerning Arctic navigation support, focus on the priorities of relevant organizations in the work of Arctic navigation support, and contribute better solutions based on our real conditions. We will work together with other users of the Arctic shipping routes to formulate the agenda and standards for navigation support in the Arctic, so as to reflect the demands of countries using the Arctic Shipping Route. Also, China will strengthen its participation in research and development and international cooperation in core technologies and equipment for polar navigation support, and also in scientific investigation of the navigation environment in the Arctic, so as to better offer China's contribution to the Arctic waters, including nautical charts and publications, marine hydrometeorology, cultural environment and other fields.

(4) Establishing domestic Arctic navigation support system. China has integrated its domestic Arctic research institutes, enterprises and public institutions to jointly build a navigation support platform for the unified Arctic Shipping Route in terms of vessel navigation aiding, marine communication and navigation and weather forecast, which has achieved information sharing and could provide dynamic information services for ships in a timely manner. In building a national navigation support system for the Arctic, the focus should be on strengthening technical support and support capabilities for distant and remote voyage. In hydrographic survey, we should continue in the research of satellite remote sensing technology, and also carry out the survey of Arctic coast and waterway depth to encourage ships flying Chinese flag to participate in bathymetric survey and establish bathymetric data sharing. Nautical charts and publications should enrich the types of Arctic nautical book products and promote the data update. In terms of maritime communication, shortwave communications in the eastern and western Arctic waterways would be promoted through on-board tests. In addition, special vessels conducting scientific investigation and rescue service will be constructed, with the ability to carry out Arctic survey, traffic environment investigation and emergency preparedness and rescue.

5. Conclusion

This paper systematically introduces the characteristics of the Arctic Shipping Route and situation about navigation support. As the navigable conditions of the Arctic Shipping Route improve year by year and the number of navigable vessels increases, the backward navigation support infrastructure and inadequate capacity have become the bottleneck restricting the improvement of its navigable capacity. The construction of navigation support for the Arctic Shipping Route is also an important part of China's participation in Arctic affairs, and a concrete step of China's policy goal of "understand, protect, develop and participate in the governance of the Arctic".

As a responsible major maritime country and an observer of the Arctic Council, China should plan and build a navigation support system for Arctic Shipping Route as early as possible to provide more timely, accurate and refined services of navigation for Chinese ships and ensure the safety of vessels passing through the Arctic.

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Identification of Features Associated with University Dropout-a case study of University of Split, Faculty of Maritime Studies

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Abstract: The primary goal of higher education institutions is to provide a quality educational process. Maritime higher education is an essential element in acquiring the knowledge, and skills needed on board a ship. One of the indicators of potential problems in this educational process may be a high number of dropouts in the early years. Predicting student success and dropout, or identifying students who are at higher risk for dropping out, is critical to improving the quality of higher education. An analysis of the academic performance of students at the University of Split, Faculty of Maritime Studies (PFST) was conducted a high dropout rate was revealed. This research aims to improve early prediction of student dropout by identifying the most relevant features. The data is processed and the features that influence dropout are extracted through an attribute selection algorithm and machine learning techniques such as a random forest. The results of our research suggest that higher education institutions should be aware of the need to identify early the profile of students who are at potential risk of dropping out. Moreover, the developed model is useful for strategic planning of additional mechanisms to improve the efficiency of study at maritime higher education institutions.

Keywords: maritime higher education; dropout; machine learning; feature selection; Faculty of Maritime Studies Split

1. Introduction

Term dropout refers to students leaving their university studies before having completed their study program and obtained a degree. [1] Dropout can be considered as one of the key indicators of the quality and attractiveness of the educational program, which emphasizes the existence of serious difficulties and barriers in the high educational system that students face to graduate. It could be a serious problem for the students, their families, high educational institutions, labor market and the society in generally.

According to the latest data from countries that belong to the Organization for Economic Cooperation and Development (OECD), many young people leave education between the ages of 18 and 24. The latest data shows that 47% (almost half of them) have left education system. The average age of first time tertiary graduation was 25, while 86% of them graduated before they turned 30. In addition, women are more likely to enter the tertiary education between ages of 25 than man is. The most common tertiary qualification is Bachelor degree. [2] In 2019, the OECD highlighted that on average 12% of students who entered a full-time bachelor's program, have left the tertiary system before beginning their second year of study. Furthermore, this share increases to 20% by the end of the program's theoretical duration and to 24% three years later. [3] Percent of students who dropped out of the higher education system vary across the countries and regions. For example, authors in the report from Latin America and Caribbean region state, despite the concentration of dropouts at the beginning of their student careers, almost 30 percent of all dropouts leave the system after spending four years in it. [4]

For this reason, many universities within European Space of Higher Education take into account in their strategic plans reduction of the rate of students' dropout as main objectives. [5] The national quality assurance agency in its requirements specified in European Qualification Framework (EQF) considers dropout rate as one of measurable factor of studying success. For this reason, the University of Split and Faculty of Maritime Studies, as one of its faculties, take into account in their strategic plans as main goals to reduce the rate of students' dropout.

The students that enroll Faculty of Maritime Studies Split have various educational background (various high schools and education profiles, different levels of success measured according to average grades at schools or state examinations). As stated in [6] combination of these factors, together with current student engagement probably have effect on their success in the early phase of their studies. Predicting the student's success in the early phase of their studies helps faculties in redirecting activities to less performing students in order improve their success. Similar is with dropout rate. It is of genuine importance to limit dropout, and therefore, the aptitude to predict students' dropping out could be very useful. [5]

Dropout can be caused by different factors. Some of them can be the family and personal reasons, poor level of previous technical knowledge that depends on graduated secondary school, poor academic performance, and low motivation rate. As is stated in [7], the higher risk of abandoning studies is implied for students with weak educational strategies and without perseverance to attain their aims in life. These students also have low academic performance and low success rates.

This paper aims to investigate the potential benefit of using the feature selection algorithm for enhancing the classification accuracy of the applied classifier to identify at risk students in advance and help them. The research focuses on multi-classification and developing machine learning predictive models for diagnosing student dropout. The objective is to identify the profile of students who tend to drop out. Three classes represent the students: ACTIVE, GRADUATED, and DROPPED.

2. Research approach and methodology

The methodology proposed in this study for predicting the features affecting the dropout of students belongs to the process of Machine Learning. 70% of the data was used to test the accuracy of the model, and 30% of it was used as training data. The workflow of research approach is shown in Figure 1.

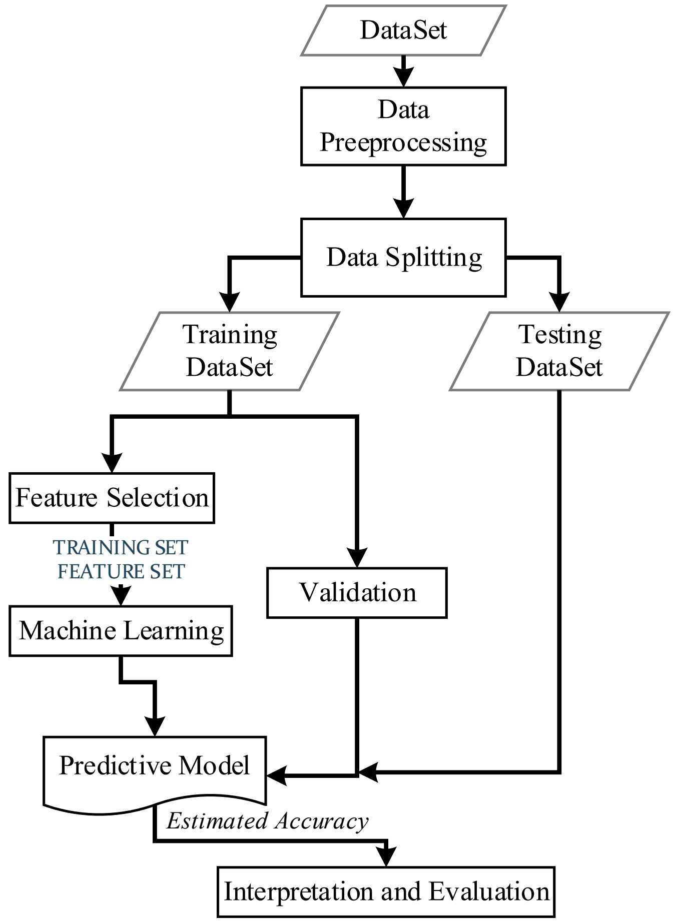

Figure 21. Research workflow

2.1 Data Collection

The data were gained from the student's database available in the Information Sys-tem of Higher Education Institutions (ISVU) introduced in the University of Split, Faculty of Maritime Studies. The data were taken for the pure generations comprising only students who had been enrolled to the first semester (first academic year) for the first time. Due to the fact that there are no registered dropped students at the Master's level, the analyzed data specifically covered the Bachelor’s level in five study programs: Marine Engineering (BS), Nautical Studies (PN), Marine Electrical Engineering and Information Technologies (PEIT), Maritime Yacht and Marina Technologies (PTJM), and Maritime Management (PM). Since, the expected time of graduation of students is between 3 and 4 years (in the faculty, each study program under analysis has the curricula, with six semesters), from a temporal point of view, the data were extracted for six academic years (from 2012 to 2018). In the considered period, it has been observed that student’s study above expected time of graduation (for 4 years and more). Using this time framework, 1436 student's records have been collected, 1095 males, and 341 females, according to Figure 2. The most students studied Nautical study, and the most of them graduated gymnasiums.

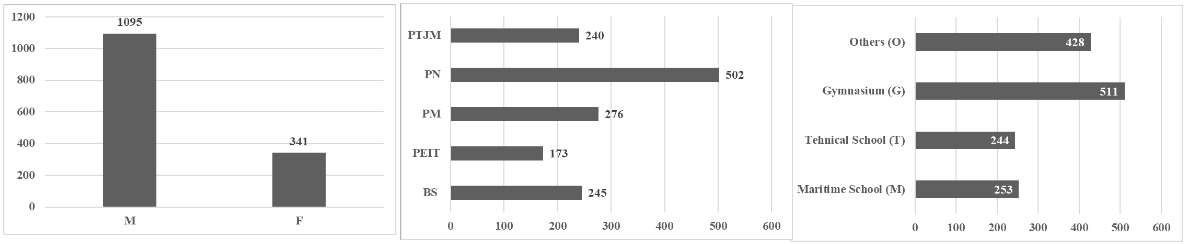

Figure 22. Gender, study and graduated school histogram graphs

2.2 Data preprocessing and splitting

The initial dataset consisted of 1436 records and 30 features. Data preprocessing included following actions: cleaning features, removing redundant features, handling improperly formatted and data normalization. Some of features associated with student's personal information are cleaned. Additionally, some features were irrelevant for our study e.g., the "Post Code", "Birth place", "Faculty name" and "Faculty identification number" and they have been also removed from started dataset. To identify and remove redundant features, all features were transformed into numerical and the pairwise correlation coefficients were calculated evaluating associations among features as shown in Figure 3.

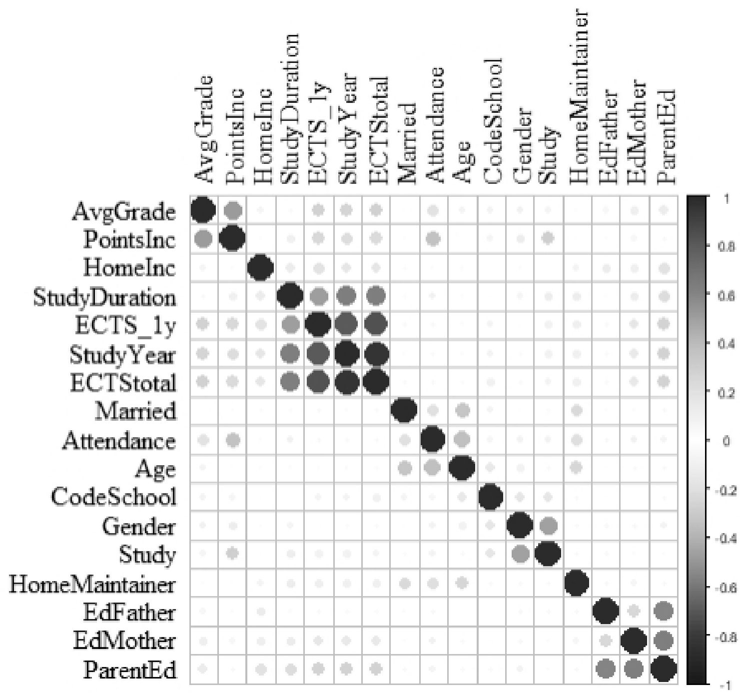

Figure 23. Correlation coefficients for all features

The color intensity is proportional to the correlation coefficient. Thus, the stronger the correlation (i.e., the closer -1 or 1), the darker the square. Two pairs of features showed a high correlation coefficient: "StudyYear" and "ECTStotal", "ECTStotal" and "ECTS_1y". "StudyYear" and "ECTStotal" were subsequently removed since their values were highly correlated with the feature "ECTS_1y" (> 0.7).

After data pre-processing phase, the final dataset contains 18 features. The feature "DropOut" is the target variable and 17 remaining features are the predictors. These features are summarized in the Table 1.

Table 1. Overview of features with the description

Feature	Metadata
Gender	Sex of the students
Age	The age when a student enrolled the study
Married	Marital status of the student
HomeMaintainer	It includes information about who maintains the student. Also it contains information of family support
EdMother, EdFather ParentEdBackground	Educational background of student's mother, father and parents/guardian, respectively
HomeInc	A description of the occupational position of the father and mother
CodeSchool	It refers to type of a high school which students graduated
AverageGrade	It refers to the grade average to two decimal places in four grades of high education
PointsInc	It represents the total points achieved at the end of the high education program. It includes points gained from high school and the final state exam
DropOut	A categorical variable which denotes whether the student graduated, still studies or dropped
Study	Type of graduated secondary school
Attendance	Mode of study
StudyYear	The last academic year in which the student enrolled
StudyDuration	Estimated values from first year of admission and last year of admission
ECTS_1y	The number of credits that the student gained during the first study year (the first enrolment).

Since the purpose of the research is to predict the regularity of dropouts and retentions, three categories of students were identified and therefore the target label "DropOut" has three categories.

Active: This category involves students who enrolled in the last academic year and have not yet graduated. A total of 422 (or 29.39% of all instances) students belonged to this category.

Graduated: involves students who successfully finished their study. 569 (39.62 %) observed students finished her study.

Dropped students: This class involves students who or were registered as dropped on personal request or have had at least two academic years without enrolling and they have not yet graduated. 445 (30.99 %) students were considered as dropped. The analysis revealed that there is no scientific difference between the percentage of female students and male students who dropped out (~ 30%). 44% of females and 38% of males graduated.

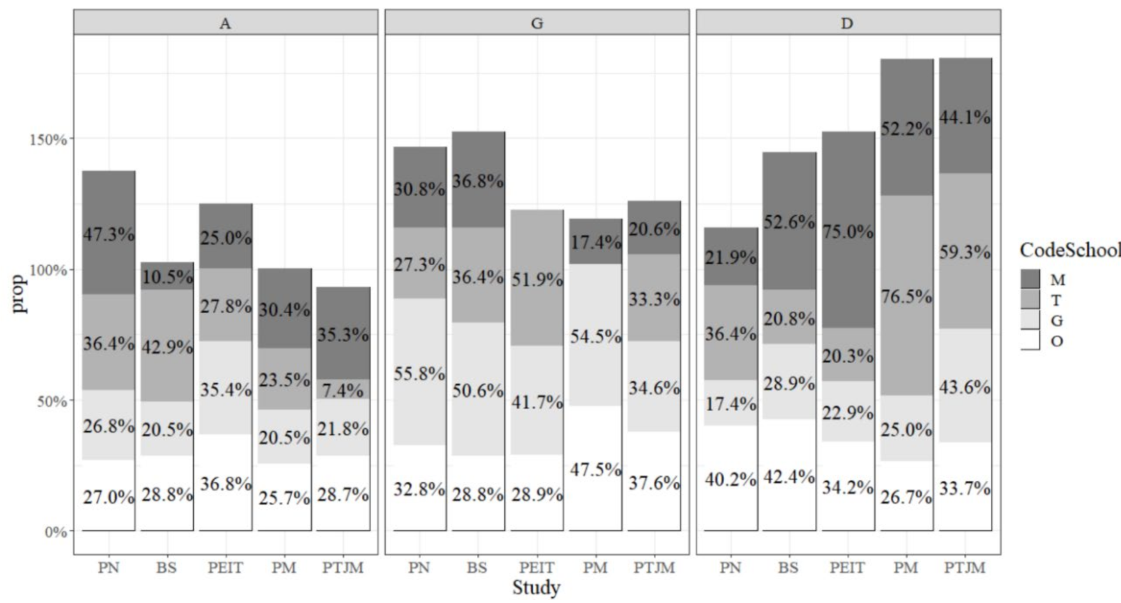

Figure 24. Student status according to their study and graduated school: A-active students, G-graduated students, D-dropped students

2.3. Feature Selection

Machine learning techniques use features (variables) to generate predictive models selected by applied feature selection algorithm. Feature selection consists of identifying the relevant features for building a predictive model with the goal of obtaining a suitable combination of features that will increase the application's performance. The use of the proper feature selection algorithm reduces the size of the dataset and might have effect of increasing the precision and accuracy of developed model, reduces requirements for computer memory and gains speed. In this study three different feature selection methods were applied creating three different feature subsets. The Recursive Feature Elimination (RFE) method is a recursive feature selection approach. This method effectively selects features in a training dataset that are more or the most relevant for the prediction of target variable. The RFE method recursively ranks features regarding some metrics of their importance. At each iteration feature importance was measured. The less relevant one was removed, and model was built on the remained features. [8]

Genetic algorithm (GA) is an algorithm based on the mechanisms of natural selection and natural genetics. GA applies the law of the survival of the fittest to the in-formation sharing system and thus improving the performance of searching information. Instead of randomly collecting information, extracted genetic algorithms, by using efficiently collected information predict new search points for improvement of the performance.[9] GA are often applied in data mining where GA can be implemented as the classifier or as a result of the optimizer. [10]

The Boruta algorithm was developed to determine all important features within a classification framework and it works on random forest (RF) method.[11] Boruta tries to select a set of important features by comparing the importance of the real predictors with those of random predictors using statistical testing and several runs of RFs. Unimportant features and randomize variables are removed and the previous steps are repeated until the number of RF running don't reach set maximal number of times RF is running.

Table 2. Overview of selected features after fusion of dataset

Algorithm	Selected features by applied feature selection algorithm
RFE	HomeMaintainer, ECTS_1y, StudyDuration, AvgGrade, PointsInc
GA	ECTS_1y, PointInc, CodeSchool, Attendance, HomeMaintainer, StudyDuration, PointsInc, Gender, AvgGrade, Married, EdFather, Age
Boruta	StudyDuration, HomeMaintainer, HomeInc, EdFather, EdMother, Attendance, Married, PointsInc, AvgGrade, ParentEd, CodeSchool, Study
Fusion Dataset	HomeMaintainer, Attendance, ECTS_1y, StudyDuration, CodeSchool, AvgGrade, PointsInc, EdFather, HomeInc

Table 2 shows selected features by each algorithm regarding their importance. In the second step, accordantly with proposed method in [12], the five top and repeated features selected by any of the applied features selection algorithms were fused and applied in our final experiment.

2.4. Multiclasification modelling by random forest

The random forest algorithm (RF) is a machine learning algorithm widely used in classification and regression problems. It contains an ensemble of independent decision trees built on different data samples. Each tree is generated by randomly selected variable. The main advantages of random forests are high predictive accuracy and their applicability in high-dimensional problems with highly correlated variables. The variable importance measures obtained by random forests have also been suggested for the selection of relevant predictors in the analysis of student's dropout.

3. Results

During the research, the random forest algorithm was trained and tested on different dataset of selected features. The five classification models are compared by using the following well known evaluation measures for classification: overall accuracy, % of correctly classified instances, Accuracy, Precision, Sensitivity, and Specificity. According to Table 3, the random forest applied on the dataset of the fused features has the highest accuracy rate. The accuracy rate is addressed to the ratio of correctly estimated samples to the number of all samples. In our research, it is 85.15% for RF applied on fused dataset, which represent excellent results.

Table 3. Validation metrics: Accuracy of applied classifiers

Model		RF_all fetures	RF+RFE	RF+GA	RF+Boruta	RF+fusion
Accuracy		0.8023802	0.736271	0.8415842	0.8316832	0.8514851
Kappa		0.7006138	0.6369138	0.6383908	0.6505090	0.7227834
Accuracy	A	0,8138	0,8014	0,8138	0,8014	0,8229
	D	0,9325	0,9241	0,9325	0,9241	0,9552
	G	0,8934	0,8934	0,8934	0,8934	0,8934
Precision	A	0,7222	0,6894	0,6924	0,6656	0,701
	D	0,8359	0,7828	0,7901	0,7701	0,8139
	G	0,757	0,7996	0,7787	0,774	0,7927
Sensitivity	A	0,667	0,6782	0,674	0,6399	0,6816
	D	0,8379	0,8237	0,8249	0,8254	0,8469
	G	0,8478	0,8165	0,809	0,799	0,821
Specificity	A	0,8442	0,83	0,8301	0,817	0,8361
	D	0,9415	0,9221	0,9257	0,9201	0,9361
	G	0,8655	0,8822	0,8713	0,8676	0,8812

Table 4. Importance of features for the best model

Variable	Importance
StudyDuration	0.21185714286
ECTS_1y	0.09994285714
HomeMaintainer	0.01256571429
AvgGrade	0.00805714286
EdFather	0.00759428571
PointsInc	0.00628000000
Attendance	0.00465142857
CodeSchool	0.00108000000
HomeInc	0.00009714286

4. Discussion and Conclusions

While tracking the study performance at the Faculty of Maritime Studies University of Split, a large dropout is noticed. The analysis shows that a large number of students are studying for more than 3 years, which is above the expected time of graduation. To improve the performance of studying and faculty rating, in order to identify potential risks of dropouts and prevent students from leaving studies, a more fundamental approach should be used.

Results also show that students from other schools (except maritime, technical, and gymnasium) have a greater risk of dropping out. Furthermore, if their responses are linked with high school grades and the total number of points obtained in the final state exam, it is clear that a student with a mid-grade score of less than 3.52 and with a lower average number of points are dropping the most. The analysis indicates that the highest dropout rate is at the PTJM study. The students stated out that the main reason for dropping out is the transition to another study. The fact that they couldn't enroll in the desired study is also one of the reasons for a student dropping out. From the analysis, it is evident that these students generally come from other schools that are not close to technical or maritime areas, or that they enroll in university only to meet their parent's expectations. Hence, the choice of study can be related with the student's background and family tradition.

Regarding duration of the study, the longest study duration is noticed on PN, PEIT, and BS. This could be connected to the fact that during the study period, these students usually start their internships on-board.

The obtained results of our research show that higher education institutions, especially the one where this research was conducted, should be aware at the earliest stage of the need to determine the profile of students with a potential risk of dropping out of school. Machine learning predictive modeling is of great benefit in systematically determining the risk of dropping out and diagnosing the cause depending on the level of risk. In this study, a random forest model combined with selected features obtained by fusion of different feature selection algorithms showed excellent performance in multi-class classification and student dropout prediction. Faculty Management together with Quality Assurance System should consider the possibility and need of building a dropout early warning and support systems for at risk students using the predictive models.

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Identification and reduction of seafarers’ cognitive and behavioral fatigue impacts for effective MET policy development

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Abstract: The analysis of the interviews, conducted among the crewing agencies representatives, active seafarers and cadets, review of the instruments, developed by the International Maritime Organization (IMO), evaluation of the accidents’ database, collected by the International Transport Workers' Federation (ITF) display fatigue as one of the leading factors greatly influencing upon the seafarers and effectiveness of their performance, especially due to the COVID-19 pandemic. Therefore, the aim of the proposed paper is to share the results of the implemented research, related with identification of cognitive and behavioral markers prioritization and inclusion of fatigue detection and decrease into Maritime Education and Training (MET) policy development aimed at improvement of seafarers’ performance and safety of navigation.
Keywords: fatigue; cognitive, behavioral impact; reduction

1. Introduction

Fatigue is a threat significantly influencing the safety of navigation and considerably damaging both mental and physical health of seafarers. According to the International Transport Workers' Federation (ITF) data, fatigue results in no less than 25% of the whole number of casualties-resulted accidents at sea [1].

Therefore, both the International Maritime Organization and the International Labour Organization pay special attention to fatigue prevention issues. The applicable regulations of the International Convention on Standards of Training Certification and Watchkeeping for Seafarers (STCW), 1978, as amended, the International Safety Management (ISM) Code, the Maritime Labour Convention (MLC), 2006, and the IMO Assembly resolutions provide a background for fatigue reduction. The above-mentioned instruments are aimed to apply the principles of minimum safe manning, to arrange watchkeeping schemes ensuring the balance between minimum rest and the safe watches periods, to provide occupational safety and health, suitable hygienic conditions at cabins and recreational spaces on board, etc. The analysis of the seafarers’ interviews, based on the mentioned above resolutions, also displays fatigue as one of the leading factors, greatly influencing the seafarers and effectiveness of their performance, especially due to the COVID-19 pandemic.

2. Fatigue causing factors detection

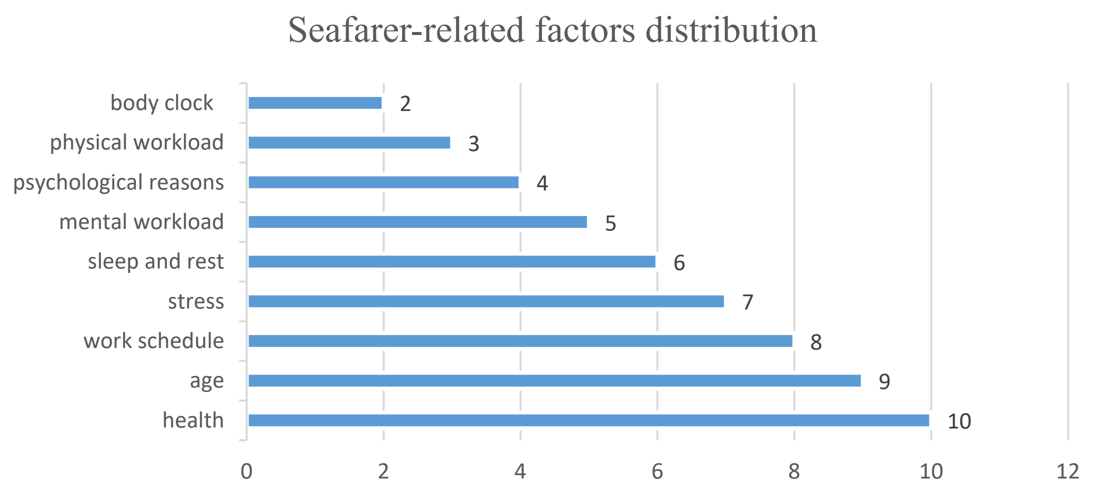
The researches, dealing with fatigue related issues, are generally focused on the following matters, such as the prevention and management of fatigue among seafarers [4], health and safety in seafaring [5], studies of the international regulations on labor health and safety among seafarers involved in fishing [6], review of measuring methods of seafarers’ fatigue, sleepiness and sleep behavior [7].

Thus, as the first step of our research, identification of the main factors, causing fatigue among the seafarers was conducted on the basis of the IMO developed resolutions [2].

The interview analysis resulted in detection of the chain of interrelated seafarer-vessel-environment factors, mainly causing and strengthening fatigue among the interviews’ participants.

The seafarers were also asked not only to name the main fatigue causing factors, but also to range fatigue causing sub-factors in priority sequence.

The interviewed seafarers arranged the following priority sequence of the seafarer-related factors, mainly causing fatigue on board:

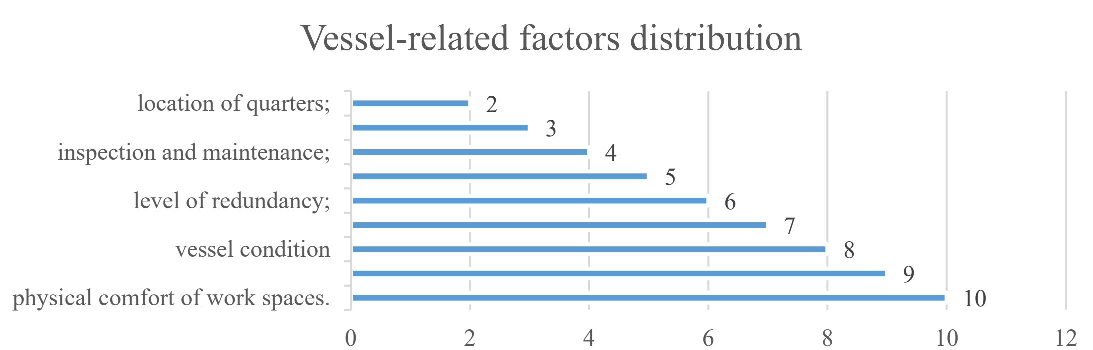


	health	age	work schedule	stress	sleep and rest	mental workload	psychological reasons	physical workload	body clock
priority	10	9	8	7	6	5	4	3	2

priority

Table 1. Prioritization of seafarer-related factors.

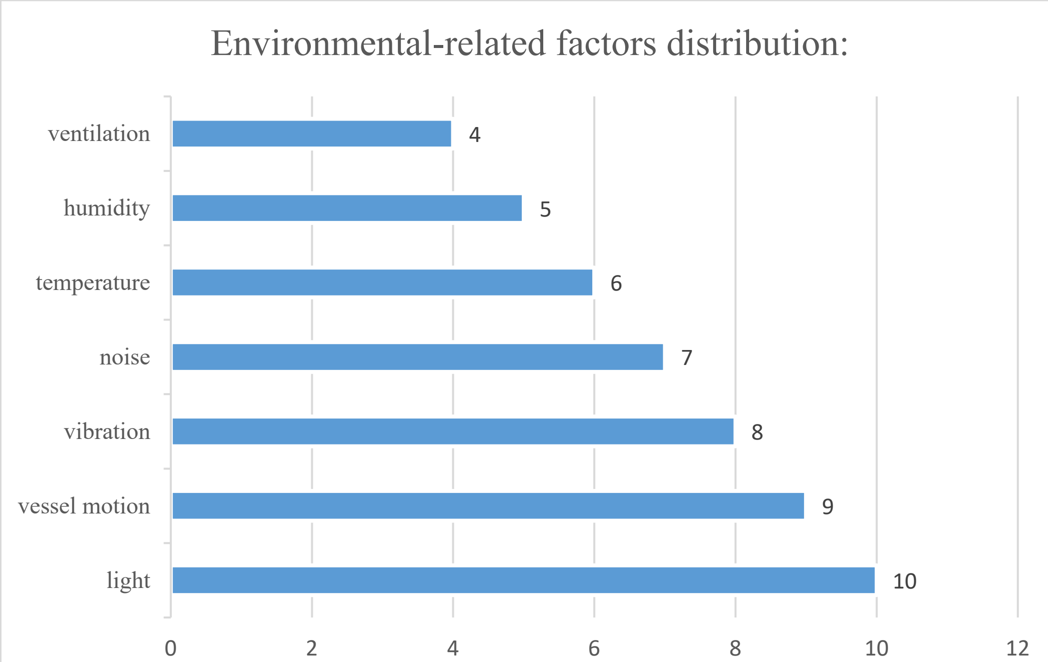
According to the interviewed seafarers, the following priority sequence of the vessel-related factors was arranged:



	physical comfort of work spaces.	equipment design and reliability;	vessel condition	level of equipment automation;	level of redundancy;	physical comfort in accomodation spaces;	inspection and maintenance;	vessel design	location of quarters;
priority	10	9	8	7	6	5	4	3	2

Table 2. Prioritization of vessel-related factors.

Thus, according to the interviewed seafarers, the following priority sequence of the environmental-related factors mainly causing fatigue on board:



	light	vessel motion	vibration	noise	temperature	humidity	ventilation
■ priority	10	9	8	7	6	5	4

Table 3. Prioritization of environmental-related factors.

3. Detection of physical, cognitive and behavioural markers of fatigue

At the next step of the research development, markers of fatigue influences on physical, cognitive and behavioural performance of the seafarers are presented.

Physical effects of fatigue are typically displayed by uncontrolled wish to sleep, often followed by sluggish eyelids closure, irritated eyes, sudden napping, and difficulties keeping awake.

Physical markers are characterized by impediment of hand-eye coordination and slow speech with difficulties to apply a correct word. Other physical markers include headaches, faintness, difficulties with breathing, digestion, sleeping, and appetite.

Naturally, physical effects present a risk to seafarers' safe and effective performance, but at the same time, they are relatively easy for detection and identification.

In their turn, behavioural mood and attitude shifts are presented with the markers of unusual manner of ineffective communication, increased irritation and decreased tolerance.

Therefore, the seafarers feel depression, ignore dangers and are prone to risky decision. Lost motivation often results in habitual negligence and reckless disregard.

Thus, behavioural effects present a considerable risk for safe shipping, but may be detected by the crew members of fatigue suffered seafarers, who can't evaluate their own ineffective performance.

Therefore, mentioned above physical and behavioural signs and markers may be more or less easily and clearly detected and recognized, but cognitive signs are quite difficult to be identified, therefore they present significant safety problems.

The conducted interviews' analysis resulted in prioritization of three following fatigue caused cognitive problems detection and ranging of their effects.

1. Difficulties with concentration, presented with the following prioritization:

- Decrease habitual vigilance
- Gaps in attention
- Problems with multitasking
- Inability to ensure a chain of activities
- Prioritization of a single-task
- Mainstreaming of a simple task, ignoring more significant ones
- Reduction of solving compound tasks
- Application of habitual unsuccessful actions

2. Reduced decision making has also been detected as the critically dangerous impact of fatigue, followed with:

- Inability to evaluate importance of the situation
- Improper assessment of distance, speed, and time
- Taking risky decisions
- Unusual uncertainty

3. Decreased memory results in:

- Brain fade
- Problems with remembering the chain of actions and procedures
- Problems to fix the series of assignments or its components
- Problems with assignment or its components completion

Slackening of cognitive processes is also detected through slow responds to routine or emergency situations.

Conclusion

Consequently, fatigue, its symptoms and results present a vivid threat for safe shipping. It shall be taken into consideration that behavioral and especially cognitive impacts of fatigue are difficult to be detected and identified by untrained person suffering from fatigue.

So, it is not enough to deliver currently recommended trainings, mainly covering general fatigue related issues, but prospective fatigue-resistant policy of Maritime Education and Training, in line with Global Maritime Professional concept development, shall plan the ways to educate persons involved in safe shipping provision with appropriate skills of fatigue identification, prevention, detection, and management.

Thus, fatigue-resistant industry shall ensure a circle of fatigue-resistant seafarers, companies, vessels and the environment.

Fatigue resistant company shall constantly track fatigue signs and take appropriate corrective measures.

Fatigue resistant seafarer shall be able to detect not only his or her own, but also colleagues' physical, behavioral and cognitive signs of fatigue, be able to apply the modern trends of fatigue reduction, including self-massage and breathing techniques in line with traditional measures of fatigue reduction.

Fatigue resistant MET shall not only identify but also shall predict and provide a long-range fatigue resistance policy, including analog ship handling in expected augmented and mixed reality and operation of unmanned vessels in near future.

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Helping Accelerate the Global Maritime Professional Body of Knowledge up the S-Curve of Innovation

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Abstract:
In a visionary effort to help guide maritime education and training (MET) institutions in readying their students for an evolving future resulting from an information revolution, the International Association of Maritime Universities (IAMU) released the inaugural edition of Body of Knowledge for Global Maritime Professionals (GMP BoK) in 2019. It was intended that the GMP BoK be a "living resource" that is revised and improved periodically. In that light, we have reviewed the GMP BoK using a use case analysis. Specifically, we examined the essential GMP competency of academic research using a generic MET institution. From this analysis, we observed two categories of potential improvements: product enhancements and product extensions. In the end, this use case analysis uncovered a potential need for additional flexibility within future editions of the GMP BoK as well as a need for future product extensions (e.g., companion versions – one that focuses on instructional/learning methods and another that focuses on learning assessment).

Keywords: Global Maritime Professional, Innovation, Alignment, Product Enhancement, Product Extension

1. Introduction

In maritime education and training (MET) institutions in readying their students for an evolving future resulting from an information revolution. The GMP BoK was meant to address the overarching purposes articulated in the original Agreement of IAMU and in subsequent statements (i.e., as emphasized in the 2014 Tasmanian Statement and clarified in the 2016 Haiphong Statement) to develop a well-prepared global maritime work force. As noted in the Forward to the GMP BoK, the intent was to provide a2019, the International Association of Maritime Universities (IAMU) released its inaugural edition of the Body of Knowledge for Global Maritime Professionals (GMP BoK). This visionary effort was intended to help guide:

"shared description of a global maritime professional, an articulation of competencies required to master the new maritime work environment, a set of recommended learning outcomes, and suggestions for curriculum development" [GMP BoK p. vii].

The GMP BoK built upon the research of those attempting to universalize maritime education and training with the understanding that a collective global and unified MET system is not only beneficial to an industry that is, by its very nature, multinational, interdependent, and fragmented, but also more efficient and innovative. As is now commonly recognized, such an undertaking suffered because of the complex nexus of national rules and regulations, diverse accrediting bodies, and particular missions and visions of individual MET institutions around the world. The GMP BoK successfully circumvented many of the issues that plagued earlier attempts for curricular unification by emphasizing outcomes, rather than standardized curricula (i.e., model courses, syllabi, lesson plans, standardized exams and the like). Such an orientation was crucial to establish the multi-tiered construct by focusing on the desired end result, and not on the means by which that result was attained.

Beside the substantive work done on universalization of MET prior to the publication of the GMP BoK, since 2019 more scholarship has been devoted to the application and analysis of this framework. Even with the disruption of intellectual activity brought about by a global pandemic, maritime educators began to apply the GMP BoK framework to various programs – see e.g., Benton's "The Application of the Global Professional Framework on an MET Program" (2021); Bolmstem's "Maritime Innovation Management – A Concept of an Innovative Course for Young Maritime Professionals" (2021); Mednikarov's "Current Trends in the Maritime Profession and their Implications of the Maritime Education" (2021); Loginovsky's "Global Maritime Professional: University Course of Risk Assessment" (2021); Baylon's "Sustainable Development in Maritime Education and Training (SDiMET) Towards Global Maritime Professionals (GMP) Development" (2021), and many others.

Thus, while the problem of the standardization of the acquisition of knowledge and skills has been probed for some time, the critical application, reception, and interrogation of the GMP BoK itself is relatively new. Within this nascent body of work, there are parallel (and overlapping) trajectories – one strand that seeks to apply the framework to an existing program in order to see how that program aligns with the standards and outcomes of the GMP BoK, and another strand that seeks to critique the methodology of that framework. This is, of course, the nature of intellectual work, and we are cognizant of the fact that an appraisal of the efficacy of the framework may be premature in that the data surrounding the application of the framework on current programs has not matured. However, we also feel that an analysis of the work – with criticism wholly meant to be constructive – is consonant with the spirit with which the BoK was created:

"The Body of Knowledge is not intended to be a singular, static document, but rather a living resource that adapts and evolves so as to be a key resource for all stakeholders" [GMP BoK p. 65].

We offer possible adaptations and revisions to the GMP BoK with the knowledge that we have not yet fully exhausted the potential inherent in this inaugural edition. There is much that can be learned from further applications of the current model that many maritime institutions are still considering. Rather, this analysis is meant to provoke ways of thinking about the future of the GMP project – as thought experiments to increase the utility of the framework for both the specific institution using it as an assessment tool and for the collective organization of institutions desirous of a shared objective.

In the following sections, we begin first with a theoretical turn from conceiving the GMP BoK not merely as a pedagogical tool, but as a *technology* so we can historicize its evolution and better see where it lies in on the spectrum of adoption. From this perspective, attention is then given to the learning outcomes themselves. It will be argued that a turn from Bloom's classic taxonomy toward that of Anderson and Krathwohl may provide for a more robust classification. This will be explored by reviewing the same case study used in the GMP BoK. By using this context, a simple use case analysis will be performed. Finally, the authors will suggest some ideas for future editions and volumes of the GMP BoK. All this is presented by way of suggesting improvements to a framework that has already proven to be useful in fostering debate on how to educate maritime professionals in a dynamic and volatile globalized industry.

2. Reconceptualizing GMP BoK as Technology

While the GMP BoK is indeed an important pedagogical tool and framework, it may also be viewed as a *technology*[5]. In this case, the technology of the GMP BoK is the application of pedagogical knowledge (particularly that which is evidence-based) to enhance the state of MET systems for creating global maritime professionals. Most technological innovations follow a predictable pattern of growth and adoption, commonly referred to as the S-curve of innovation (see Figure 1), where the horizontal axis represents the time horizon and the vertical axis represents some adoption. Like other incipient technologies, the GMP BoK lies at the bottom of the S-curve of innovation (i.e. point A) where growth and adoption are slow. The goal of most technological innovations is to climb the S-curve and

[5] According to Oxford Dictionary of English Languages, the first listed definition of technology is "the application of scientific knowledge for practical purposes, especially in industry." It is much broader than the common understanding of technology as "machinery or equipment" (the second listed definition).

realize exponential growth and adoption (i.e., point C). In general, the S-curve of innovation follows the notions of diffusion of innovation as it pertains to markets as follows:

A. Early Market (prior to any recognized adoption except "innovators")
B. Early Adoption (where adoption is driven by "early adopters")
C. Mass Adoption (where adoption is driven by first and early then "late majority" of adopters)
D. Late Adoption (where adoption continues with "laggard adopters")

Additionally, after the late stages and technology or product maturity, adoptions begin to decline as the adopters seek other alternatives. At this point, new technologies or products are released to extend adoptions into another S-curve of innovation (the bottom of which is represented with the dashed line in Figure 1).

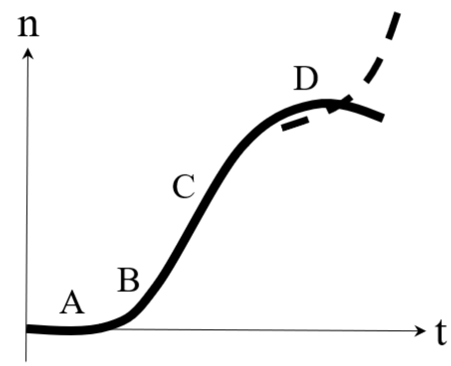

Figure 1: S-Curve of Innovation/Adoption

However, when a technology is in early stages (i.e. at points A or B like the GMP BoK), it is unclear if adoption will be sufficient to initiate mass adoption. In these cases, additional effort and expense (such as through positioning and promotion) are unlikely alone to yield advancement up the S-curve of innovation. Instead, continuing improvements (or product enhancements and extensions[6]) of the GMP BoK will be needed to enable significant growth and adoption. In this spirit of continuous improvement, this paper will now explore opportunities for enhancing and extending the GMP BoK.

3. Use Case Analysis

It is often instructive to test a technology using a specific use case. While use case analysis if frequently used in designing products and their requirements, they may also be applied retroactively to determine effectiveness and usefulness of that product from the user perspective. In this case, we will examine the technology of the GMP BoK from the perspective of a user using the foundational competency of "academic research" as the object of the case study. In other words, we will consider a fictitious MET institution program and use the GMP BoK to help identify relevant learning outcomes. However, we will also take the opportunity to explore potential product/technology enhancements and extensions along the way.

The GMP BoK provides an implementation framework (Figure 2) that employs a four-step procedure for extracting learning outcomes.

[6] Product enhancements are typically viewed as improvements or additional features to existing products; whereas, product extensions are often entirely new, but related products that build upon the brand and adoption of existing products in the same category (e.g., introduction of Vanilla Coke).

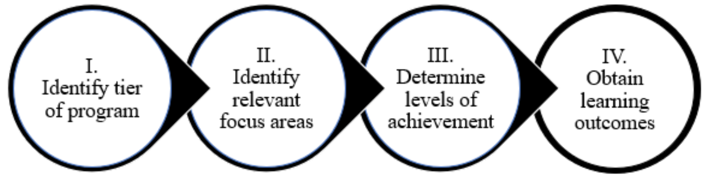

Figure 2: GMP BoK Implementation Framework (adapted from GMP BoK p. 52)

I. *Identify tier of program*. In this step, program administrators identify which tier most closely matches the type(s) of program(s) they are offering. In this use case analysis, we will consider the example of a first academic degree with an operational level competency (i.e., ***GMP Tier A***).

The four tiers match many of the types of programs currently offered at MET institutions, particularly within the IAMU membership. However, unless the definition of global maritime professionals is intended to exclude ratings, there could ostensibly be other tiers that might include seafarers who possess operational or management level certifications without academic degrees. Likewise, there may be global maritime professionals working in non-seafaring roles that would have academic degrees (particularly advanced degrees) without the requirement for operational or management level certification. Additionally, the tiers are largely based on the context of today. Assuming the regulatory framework is responsive to the emerging technologies, consider the case where future ships are fully autonomous and operated remotely. The notions of operations and management may become blurred and potentially other competencies may emerge, making the tiering structure obsolete.

Based upon these observations, several questions emerge:

- Should additional tiers be added?
- Should professional certification and education be decoupled?
- Should additional flexibility be provided within the tiers?

II. *Identify focus areas which correspond to the program*. In this step, program administrators review the objectives of the program to be delivered and identify which of the 28 focus areas apply. As was demonstrated in the GMP BoK, this use case analysis will consider the fundamental competency of ***academic research***.

In the broader context, resulting from a preliminary survey, the focus areas represent a snapshot in time. As the pace of change remains unabated and even accelerated in certain areas, the nature of the focus areas will need be responsive and changing. For example, looking at 2020 Future of Jobs Report by the World Economic Forum, many of the top 15 skills for 2025 are reflected in the focus areas (e.g., #3 complex problem solving, #4 critical thinking and analysis, #6 leadership and social influence, and #11 emotional intelligence), while others are not (e.g., #2 active learning and learning strategies, #7 technology use/monitoring/control, #14 systems analysis and evaluation). In the autonomy example introduced earlier, it would seem many of these future skills would be requisite. As recognized within the GMP BoK, these focus areas should be continually examined and updated periodically (perhaps every five years). Furthermore, it might be beneficial to provide an option to allow program administrators to use the framework to explore focus areas not listed.

Based upon these observations, several questions emerge:

- How often should the competencies of a GMP be reviewed?
- How far into the future should the competencies be predicted?
- Should there be an option for program administrators to include competencies not listed or envisioned by the GMP BoK?

III. *Determine the Levels of Achievement*: In this step, program administrators determine which levels of achievement are identified for their program tier (step 1) and focus areas (step 2). By examining Tables 1,

2, and 3 (cognitive, affective, and psychomotor domains respectively); program administrators look up which levels of achievement (column header) applies to specific focus areas (row header) based upon identified program tiers (table body).
In this use case, for Tier A programs, the ***cognitive process dimensions of remembering, understanding, and applying*** were identified (see Figure 2 on p. 53 of the GMP BoK) and the ***receiving, responding, and valuing categories of the affective domain*** were identified for Tier A programs (see Figure 3 on p. 54 of the GMP BoK). There were ***no psychomotor aspects*** associated with academic research (see Figure 4 on p. 54 of the GMP BoK). While there is some ordering to each of the domains (e.g., increasing complexity of the cognitive processes for the cognitive domain), it seems insufficient to consider these dimensions as "levels of achievement." As noted in the revision to Bloom's taxonomy for cognitive objectives (Anderson & Krathwohl, 2001), higher order dimensions (such as evaluating and creating) are often used to achieve objectives in lower order dimensions (e.g., remembering and understanding). Similarly, it does not seem reasonable that tier assignment would be strictly progressive and non-overlapping. For example, while the affective dimensions are primarily sequential, it would seem that internalization may be the ultimate objective of learning is such a domain for any tier program, and not reserved for Tier D programs. Considering the "principle of parsimony" which indicates that models should be as simple as possible, it is understood why such a mapping has been devised, but perhaps a note could be provided that the identified "levels of achievement" are illustrative and program administrators may desire to include additional dimensions or categories based upon their specific circumstance and context.

Based upon these observations, several questions emerge:

- What unintended impacts might result from considering the categories of a taxonomy as linear sequence of levels of achievement?
- Is there an effective way to allow gaps and overlaps within and between program tiers?
- How might program administrators deviate from the illustrative tables?

IV. *Obtain required learning outcomes*: In this step, using mapping from step 3, program administrators use tables 4, 5, and 6 (cognitive, affective, and psychomotor domains respectively) to obtain required learning outcomes.
The use case analysis will now examine the learning outcomes that resulted for *academic research* at Tier A programs. Given that *remembering, understanding, and applying* were the given cognitive process dimensions for a Tier A program in academic research, the following objectives were indicated (Figure 5):

- ***Identify different methods.***
- ***Describe processes required for conducting academic research.***
- ***Explain rationale, procedures, and implications of academic research.***
- ***Prepare clear hypotheses.***
- ***Conduct a literature review.***
- ***Cite sources appropriately.***
- ***Employ appropriate quantitative and qualitative methods.***
- ***Conduct research.***
- ***Report results.***

While this is a substantial list, by its nature, it will be incomplete. For example, it is not exhaustive of the learning outcomes needed for academic research. Outcomes such as the following appear missing and may be included:

- Recognize four levels of measurement. (Remember)
- Evaluate suitability of particular methods for given data. (Evaluate)
- Design the research. (Create)

Note that the second and third additional objectives listed above are higher order and would be entirely appropriate for a Tier A program, even though these cognitive process dimensions were not indicated in step 3.

Similarly, for the affective domain, a series of learning outcomes focused on ethics have been prescribed. While ethics is a necessary value for academic research, it is not sufficient. Attitudes, emotions, and values such as curiosity or tenacity might be equally (or more) necessary for conducting academic research. Finally, depending upon the type of research, if experimentation is involved, a certain form of dexterity or psychomotor competency might be required (e.g., to manipulate an apparatus, to demonstrate a movement protocol, to retrieve physical data). The point here is that it would not be possible to distill *academic research* competencies into a dozen or so outcomes because each type of research is context dependent. Again, this would indicate a need to note that the outcomes are illustrative and not intended to be a complete representation. Further, if this case study is representative, it would seem each focus area (and the associated outcomes) would benefit from additional work. Perhaps the concept is that the GMP BoK framework is viewed as a beta-release and that each implementation will yield enhancements to incorporate in the future.

Taken together, the use case analysis has uncovered (or perhaps highlighted) several potential product enhancements for future revisions of the GMP BoK, which might help accelerate this technology up the S-curve of innovation. The next section will now focus on a specific set of product extensions that were identified in the use case analysis.

4. Additional discussion

The GMP BoK clearly states its focus is exclusively on learning outcomes:

"Further action on the determination of curricula (syllabi, learning activities, assessment methods) to achieve these learning outcomes, rests with the different member Universities" [GMP BoK p. 5].

However, as was the case with learning outcomes, there is a clear need for additional guidance as it pertains to selection of learning activities and assessment methods. While MET institutions and communities have started to focus more exclusively on outcomes (e.g., IMO development of action verb taxonomy for model courses, or IAMU development of the GMP BoK), more work needs to be done regarding how the outcomes are put into practice (i.e., the types of instruction and learning used to achieve those outcomes, the means of assessing whether and how well the objectives were achieved). There is a long history of aligning learning outcomes, instructional (learning) activities, and learning assessment (e.g., Wiggins, Wiggins, & McTighe, 2005; Biggs, 2003, 1999; Spady, 1994; Tyler, 1951). Often these three elements are considered interrelated parts of a larger whole (Figure 3).

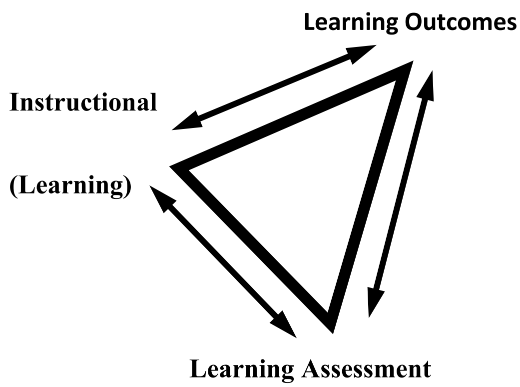

Figure 3: Illustration of Coherence

Even if the proper learning outcomes are appropriately identified, this does not ensure they will be achieved (without the corresponding design of aligned learning activities and learning assessment methods). As a result, there is an important opportunity to *extend* the product of the original GMP BoK. The GMP BoK has already adopted Bloom's revised taxonomy for the cognitive domain – which represents a spectrum of objective categories. While the revised categories of *cognitive processes* were adopted, the corresponding second dimension of *knowledge* was not included in the GMP BoK. This may be for reasons of complexity. However, objectives are typically stated as a verb (i.e., action which is representative of the cognitive process) in combination with a noun (i.e., object which is representative of the type of knowledge to be obtained). For example, using the learning objective from the use case analysis, one objective of academic research is to:

"Identify (verb or cognitive process) different methodologies or methods… (noun or knowledge)."

In the revision to Bloom's taxonomy, Anderson and Krathwohl (2001) present a "taxonomy table" where the six cognitive processes are listed across the top and the four knowledge types are listed down the side, creating a 6 x 4 matrix. Each learning objective is then placed into one of the 24 different positions on the taxonomy table. Similarly, instructional designers and instructors may locate instructional (learning) activities into any one of the 24 positions on the taxonomy. Likewise, the learning assessment methods may be placed on the taxonomy table. The benefit of using the taxonomy table in this way is that alignment (and also misalignment) becomes immediately apparent. For a more complete description of how this alignment can be examined using taxonomy tables, readers are encouraged to read the paper entitled "Proposing a Validation Tool for IMO Model Courses to Evaluate Alignment of Outcomes, Activities, and Assessment" in these proceedings.

By mapping each outcome, activity, and assessment is such a way using the taxonomy table provided in the revision to Bloom's taxonomy, alignment may be examined and even ensured. Applying such an analysis to MET courses and the requisite lesson plans would demonstrate a strong commitment to outcomes-based education. However, in order to effectively perform this mapping, it would be highly beneficial for program administrators and faculty at MET institutions to have additional resources such as a volume of the GMP BoK devoted to instructional methods (or learning activities) and another volume devoted to learning assessment. These two additional volumes of the GMP BoK (i.e., product extensions) would not be an insignificant undertaking, but would represent a considerable advancement in the technology for the MET community.

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Proposing a Validation Tool for IMO Model Courses to Evaluate Alignment of Outcomes, Activities, and Assessment

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Abstract: Whether informed by backward design, constructive alignment, outcomes-based education, or even essentials formulated decades earlier, there appears to be strong convergence that there should be coherence among learning objectives and/or outcomes, learning (or instructional) activities, and (learning) assessment. The maritime education and training (MET) community has widely adopted this coherence model and it is being implemented to various degrees. Recently, the International Maritime Organization has taken another step in developing its outcomes-based training policies by adopting verb taxonomies to develop learning outcome statements for model courses. However, there is evidence some IMO model courses may lack alignment between their stated overarching aim and their learning domain coverage as a recent analysis of Model Course 1.20 (Fire Prevention and Firefighting) has shown. Using the validation method developed by Cambridge Assessment, this study evaluates the alignment of domain coverage for IMO model course 1.21 (Personal Safety and Social Responsibility). Since the safety culture literature and conservation literature indicate that affect is an important determinant of pro-safety and pro-environmental behaviors, it was anticipated that this model course would have a substantial portion of affective domain coverage evidenced in its learning outcomes. However, it was found that this course has a preponderance of declarative knowledge and mental procedure outcomes and few affective, psycho-motor procedures, and interpersonal skills. Additionally, this study explored coherence between learning outcomes and instructional methods using existing frameworks as well as coherence between learning outcomes and assessment methods using existing frameworks. The authors will make the case that a method for validating coherence among learning objectives and/or outcomes, learning (or instructional) activities, and (learning) assessment is needed in the MET community – as has been done in the IMO's sister organization International Civil Aviation Organization.

Keywords: Alignment, Outcomes Assessment, Model Course, STCW, Maritime Education & Training

1. Introduction

Scholars have long made the case that there should be coherence among learning outcomes, instructional (or learning) activities, and learning assessment. For example, Spady (1994) described outcomes-based education as a form of education where "everything in an educational system" is focused and organized "around what is essential for all students to be able to do successfully at the end of their learning experiences." Biggs (2003, 1999) coined the term "constructive alignment" and emphasized that there should be "coherence between assessment, teaching strategies, and intended learning outcomes in an educational program." Wiggins, Wiggins, and McTighe (2005) proposed "backward design" as a method for achieving coherence. In backward design, desired results are identified first, then identifying which evidence will be acceptable to demonstrate achievement of the desired results, and finally learning experiences and instruction are planned. However, this idea of coherence is not new; decades earlier, Tyler (1951) introduced basic principles of curriculum and instruction that included the notion of coherence. This is often represented as a trio of interrelated elements (Figure 1).

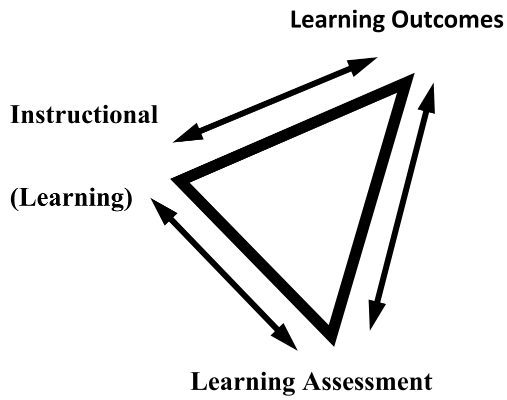

Figure 1: Illustration of Coherence

Maritime education and training (MET) institutions have widely recognized the importance of outcomes-based education. In fact, the recent publication of the Global Maritime Professional (GMP) Body of Knowledge (BoK) provides a framework for identifying relevant learning outcomes. However, proper outcomes identification alone does not ensure the outcomes will be achieved. It is also necessary to ensure instructional (or learning) activities and learning assessment are also aligned to the outcomes.

Therefore, this paper will propose a method for examining alignment between outcomes, activities, and assessment. Using a previously demonstrated method (Szwed, Hanzu-Pazara, & Manuel, 2021), it will first examine coherence with learning outcomes through mapping content/domain coverage. Then, it will more generally explore how alignment can be evaluated across an entire course (learning outcomes, learning activities, and learning assessment). Finally, it will present a framework for applying the notion of coherence model courses and more generally to any MET course.

2. Domain Coverage of Representative Model Course

Even before alignment can be considered, instructors and instructional designers must ensure an appropriate selection of learning outcomes to guide a development and delivery of the course, and assessment of learning. A course evaluation process developed by Cambridge Assessment (Suto, Greatorex, & Vitello, 2020) was found suitable for validating learning domain coverage in IMO model courses (Szwed, Hanzu-Pazara, & Manuel, 2021). That study evaluated the IMO's foundational model course in firefighting (MC 1.20) and found an imbalance between aims of the course and domain coverage (i.e., 75% of course was devoted to transmitting information, despite the action-orientation of firefighting). This study extends that work by examining the IMO's foundational course in health, safety, and the environment (MC 1.21). The method for mapping learning domain coverage followed the same five-step method (contained in Figure 2).

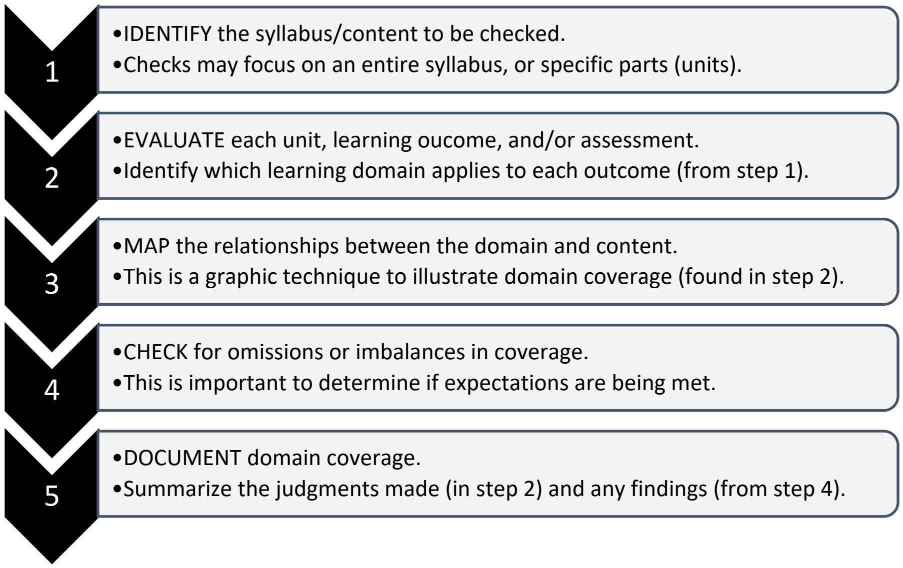

Figure 2: Method for Mapping Learning Domain Coverage

2.1 Step 1

This study examined the baseline training for health, safety, and environment (HSE). Specifically, the study examined the IMO Model Course 1.21 Personal Safety and Social Responsibilities (2016 edition – electronic). This model course was selected because it is the essential HSE training needed by all seafarers (and prospective seafarers) prior to employment on sea-going ships[7]. The model course is broken down into seven primary competencies:

1. Introduction
2. Comply with emergency procedures
3. Take precautions to prevent pollution of the marine environment
4. Observe safe working practices
5. Contribute to effective communication on board ship
6. Contribute to effective human relationships on board ship
7. Understand and take necessary actions to control fatigue

2.2 Step 2

This study evaluated each of the 147 knowledge, understanding, and proficiency performance criteria contained in the IMO safety, health, and environment course (as specified in the detailed teaching syllabus – Part C of the model course). Each evaluator[8] judged whether an outcome was an informational task, mental procedure, psychomotor procedure, or interpersonal procedure.

2.3 Step 3

Domain coverage was tabulated for each of the seven competencies and for the course overall. In contrast to the previous study of the IMO model course in firefighting, this study only reported the percentage of outcomes devoted in each domain for each of the seven competencies. We did not attempt to determine how the approximate time (as specified in the course outline – Part B of the model course) was allocated to each outcome.

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[7] A number of other courses relate to more specific aspects of safety e.g., firefighting and survival at sea.

[8] The two authors served as evaluators in this study. Both have extensive experience with MET (maritime education and training), knowledge of outcomes assessment and taxonomies, and some direct knowledge with HSE.

2.4 Results

Table 1 provides a mapping of competency/content to the learning domain affiliated with the performance criteria within the competency.

Table 1: Breakdown of Learning Outcomes Allocated to each Competency (IMO Model Course in HSE) with Mapping to Relevant Learning Domain

Competence/Content	Information	Mental Procedure	Psychomotor Procedure	Interpersonal Procedure	Approx. Time (hours): Lectures & Demos (Hours)	Practical Work (Hours)
Introduction	1.4%				**1.0**	
Comply with emergency procedures	6.1%		1.4%		**1.5**	**0.5**
Take precautions to prevent pollution of the marine environment	15.6%				**4.0**	
Observe safe working practices	25.9%	0.7%	0.7%		**3.5**	**0.5**
Contribute to effective communication on board ship	15.0%	0.7%		2.0%	**2.0**	**1.0**
Contribute to effective human relationships on board ship	14.3%				**2.5**	
Understand and take necessary actions to control fatigue	16.3%				**1.5**	
	96.4%	**1.4%**	**2.1%**	**2.1%**	**18.0**	**2.0**

Virtually all of the outcomes (140 of 147) were devoted to transmission of information. It should be noted, however, that there were psychomotor and/or interpersonal procedure outcomes in each of the three competency areas with time devoted to practical work (which would seem to imply psychomotor and/or interpersonal procedures, as well as mental procedures). In addition to the Cambridge Assessment method for examining domain coverage in the syllabus, this study also examined action verb usage in the development of the performance criteria (which serve as detailed learning outcomes). Figure 3 provides an illustration of how often specific verbs were used in the 147 knowledge, understanding, and proficiency performance criteria contained in the IMO SE model course.

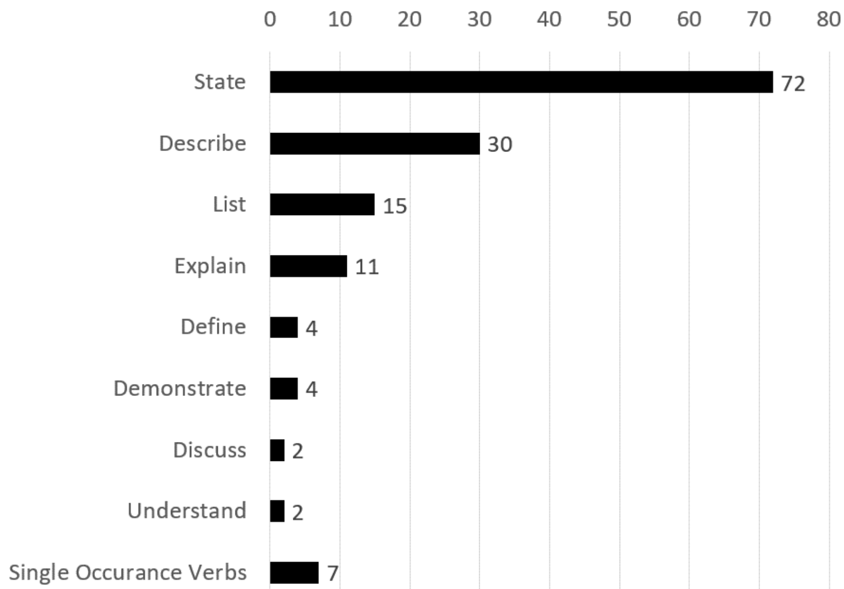

Figure 3: Frequency of Action Verb Usage in IMO Model Course in HSE

2.5 Discussion

There appears to be an imbalance between the overarching objectives stated in the course outline and the learning objectives provided in the detailed teaching syllabus. Five of the seven primary competencies have action-orientation: comply, take, observe, and contribute (in two different contexts). However, as noted in Table 1 and Figure 2, a preponderance of the objectives is crafted to transmit information or declarative knowledge. This imbalance aside, the overarching aim of the course is to prepare seafarers for the transition from shore to sea and alert them to the vastly different living and working environment. However, when it comes to HSE, learning that is affective, behavioral, and interpersonal has been found most effective to ensure a lasting change in perspective (e.g., Oltedal & Lützhöft, 2018; Schultz, 2011). Additionally, further examination of individual lesson plans for each module with practical work would be necessary to determine if the few outcomes devoted to them are sufficient.

3. Aligning Outcomes, Activities, and Assessment

This section will examine a method for constructive alignment.

3.1. A Taxonomy for Teaching, Learning, and Assessing

Perhaps the most widely used taxonomy of educational objectives is Bloom's taxonomy (1956) for the cognitive domain – which represents a spectrum of objective categories (i.e., knowledge, comprehension, application, analysis, synthesis, and evaluation). In 2001, Anderson and Krathwohl updated and revised Bloom's taxonomy. One of the notable revisions was the inclusion of two dimensions (cognitive processes and knowledge). Generally, objectives are stated as a verb (i.e., action) in combination with a noun (i.e., object). They noted that the verb described the intended cognitive process, while the noun generally described the knowledge students were expected to acquire or construct. For example, from the model course examined (see Section 2), the third objective in the second competence states that the trainee is expected to: "Describe (verb or cognitive process) procedures (noun or knowledge) adopted on board to minimize marine pollution."

In their book, Anderson and Krathwohl (2001) provide a "taxonomy table" where the cognitive process dimension is listed across the top and the knowledge dimension is listed down the side. There is a separate column for each of the six categories in the cognitive process dimension (i.e., remember, understand, apply, analyze, evaluate, and create) and there is a separate row for each of the four categories in the knowledge dimension (i.e., factual knowledge, conceptual knowledge, procedural knowledge, and meta-cognitive knowledge). A learning objective could be placed in any one of the 24 different combinations of the cognitive process dimension (6 categories) and the knowledge dimension (4 categories). The example learning objective above from the IMO model course might be placed in the "remember" category for cognitive processes and the "procedural knowledge" category of knowledge. Heer (2012) developed a useful guide for employing the two-dimensional framework of Bloom's revised taxonomy (see link provided in reference).

Anderson and Krathwohl (2001) also present a series of vignettes of actual learning scenarios to illustrate how to use taxonomy table to illustrate alignment/coherence, or lack of it. By placing the learning objectives, instructional (or learning) activities, and assessments on a series of taxonomy tables, (mis)alignment becomes apparent. To simplify the display of this concept, we will introduce the following notation:

- Objective[9] – a dot will be placed in the center of each box pertaining to each of the objectives.
- Activity – the upper half triangle of each box will be shaded for each of the instructional activities.
- Assessment – the lower half triangle of each box will be shaded for each assessment.

The following completed taxonomy table (see Figure 4) illustrates the alignment analysis for the "Nutrition" vignette, which is a real curricular unit that was analyzed by a team of experts. This vignette demonstrated moderate alignment as evidenced by the coverage of the shaping and the proximity to the objectives. If there had been strong (or perfect) alignment, each box with a dot would have been fully shaded. You are encouraged to refer to the source for a complete description of the analysis.

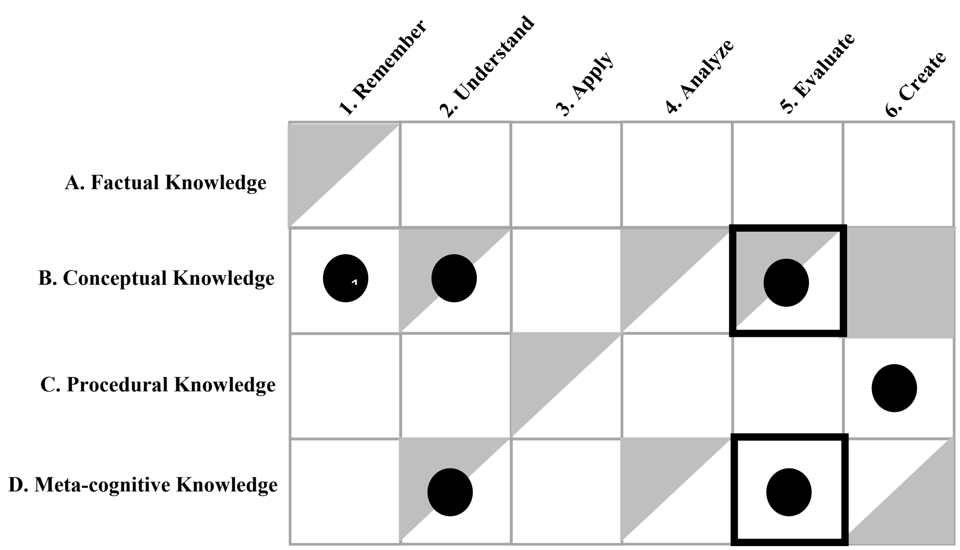

Figure 4: Alignment Mapping of Objectives, Activities, and Assessments for Sample Learning Module

By mapping each outcome, activity, and assessment is such a way, it is possible to observe instances of gaps or overlaps in the intended treatment of the subject/learning, as well as (mis)alignment. Applying such an analysis to model courses and the requisite lesson plans would demonstrate a strong commitment to outcomes-based education. This taxonomy table scheme could be used as an advanced tool for validating model courses. The part that is notably absent is the tacit knowledge of the experts who evaluated the vignettes:

[9] While Bloom's work used the word "objectives", a more recent emphasis on "learning outcomes" is perhaps appropriate given the increased prominence of outcome-based education in maritime education and training.

- What types of instruction are well suited to the different learning objectives?
- What types of assessment are well suited to the different learning objectives?

Unfortunately, the answers to these two questions are not codified into any singular source or resource. Instead, various attempts have been made to address these questions. The next two sections will highlight some of those attempts.

3.2. Aligning Instructional (or Learning) Activities to Outcomes

A search was conducted to identify sources of matching or aligning instructional methods to learning objectives, but an apparent strain of literature did not immediately emerge. Instead, several examples were found that either explicitly or implicitly illustrated such matches.

Nilson (2001) provided a table of 17 teaching methods and which specific categories in the cognitive dimension (e.g., six cognitive process categories within Bloom's taxonomy) they were most effective in developing. For example, lectures were considered most effective for developing (declarative) knowledge. Whereas, an interactive lecture also supported development of comprehension (and possibly all others depending upon features of interactive lecture). In contrast, a teaching method like roles plays and simulation would be effective at developing application, analysis, and evaluation (i.e., the higher order categories of the cognitive process dimension). While Nilson's book (and table) were created before the revised Bloom's taxonomy was published, it is envisioned that such a matrix could be used for selection of instructional method to best align with identified learning outcomes. This table would be helpful in that it contained a wide variety of typical classroom and field-oriented teaching methods. Also, it might be used retrospectively to evaluate alignment/coherence.

Another more recent attempt at matching instructional strategies to knowledge types called the "Instructional Strategies Framework" was proposed by Wallcott, Fiorella, and Malone (2013). This framework was prepared to inform development of training, which would be highly relevant to model courses. While it viewed training as having three phases (i.e., prior-, during-, and post-training), the during-training instructional strategies included three main classes of training events: presentation, guidance, and practice (which were further subdivided). Each of these indicated the appropriate level of expertise of the training (e.g., novice, journeyman, and expert) as well as the knowledge type (e.g., declarative, procedural, conceptual, and integrated). These knowledge types are similar in nature to the found in the knowledge dimension of Bloom's revised taxonomy (Anderson & Krathwohl, 2001). For example, signaling (presentation), worked out examples (guidance), and distributed practice (practice) were identified as effective for supporting development of declarative knowledge. In contrast, distributed practice (practice) and cognitive apprenticeship (guidance) were considered effective for supporting development of integrated knowledge. This framework would be helpful in that it grouped instructional strategies and provided underlying instructional principles as well as supporting research.

Weston and Cranton (1986) published an article about selecting instructional strategies. In general, these were summarized as being in one of four different categories of instruction: a. Instructor-centered, b. Interactive, c. Individualized, and d. Experiential Learning Methods. For each of the learning domains (i.e., cognitive, affective, and psychomotor), they identified (or matched) appropriate instructional (or learning) methods to each category within each dimension. For example, in the affective domain, among several others, it suggested lecture and discussion for receiving, discussion and simulation for responding, simulation and projects for valuing, projects and field experience for organizing, and field experience and independent study for characterizing. The four summary categories presented would be useful for creating a framework for classifying instructional methods. A similar categorization approach was proposed for the Saskatchewan educational system (1991) and it included five groupings of instructional strategies: a. direct instruction, b. indirect instruction, c. experiential learning, d. independent study, and e. interactive instruction. There are similarities and overlaps between the two frameworks. We propose a typology that uses two dimensions to define the categories of instructional strategies and methods. First, it appears both of these categorizations include some notion of locus for responsibility – we have defined these as: teacher-centric, learner-centric, and shared-responsibility. Additionally, since both of the categorizations include what appears to be instructional strategies found in the classroom and those from experiential learning, we propose a dimension for where the learning takes place: classroom environment, performance environment (which is especially important for professional training), and a simulated environment (since this is a key context within MET). Figure 5 illustrates how instructional methods may be placed in each of the resulting intersections of this typology.

		Locus of Responsibility	
Learning Environment	***Teacher-centric***	***Shared Responsibility***	***Student-centric***
Classroom	Lecture	Case Study	Independent Research
Simulated	Simulation Exercise	Laboratory	Role Play
Performance	Drill & Practice	Field Study	Internship

Figure 5: Typology of Instructional Methods/Strategies based on Locus and Learning Environment

It could be envisioned that cognitive outcomes could be developed across any combination of locus and environment, that affective outcomes would best be learned on the portion with more student-centrism, and that affective outcomes would best be learned in simulated and performance environments. However, until such time as a study has been performed or a theory has been proposed that measures or assesses goodness of fit between the category of each learning outcome and proposed instructional (or learning) methods and strategies, we will focus on assessing the coverage of fit (from the taxonomy tables) as described earlier.

3.3. Aligning Learning Assessment to Outcomes

Similarly, it would be beneficial to evaluate alignment between learning outcomes and learning assessment methods. Here too, there is an apparent gap in the literature. There have been a few attempts to create a classification scheme to develop coherence. For example, in the context of business schools (mainly in an effort to demonstrate suitable learning assessment for accreditation purposes), Rubin and Martell (2009) provided a classification of assessment methods for learning outcomes in each main learning domain (cognitive, affective, and skills-based or psychomotor). In their example, they suggested exams were effective at assessing verbal (declarative) knowledge, concept mapping as effective at assessing knowledge organization, and case scenarios as effective at assessing cognitive strategies. For affective outcomes, the indicated attitude could be assessed indirectly through self-reporting and that motivation could be assessed directly through observation (e.g., time on task, team engagement, etc.). In a similar effort, Shannon et al. (2000) devised a scheme for matching assessment methods to outcomes in their context of engineering education. However, since the matrix of outcomes and methods was nearly fully covered, it was determined this matching scheme was less useful and mainly pointed toward a need for further research – which we agree with. There are also several resources that provide matches to classroom (formative) assessment techniques rather than summative assessment techniques. While interesting in concept, it seems this idea of matching assessment to outcomes is less well-developed than matching methods to outcomes. Therefore, we propose assessing the coverage of fit (from the taxonomy tables) as described earlier.

4. Conclusions

After evaluating the objectives of two foundational model courses (namely MC 1.20 and MC 1.21), it appears more focus might be devoted to ensuring learning outcomes adequately cover the intended domains of learning. Specifically, it would be beneficial that affective aspects, psychomotor procedures, and interpersonal procedures are adequately represented in the outcomes (as indicated by overarching objectives), in addition to the more traditional cognitive aspects (e.g., information and mental procedures). It would seem that in addition to the two-dimensional revised Bloom's taxonomy for cognitive aspects of learning, other taxonomies should be referenced to ensure affective, psychomotor, and interpersonal aspects of learning were suitably considered. Examples could be drawn from any number of taxonomies as illustrated in Figure 6.

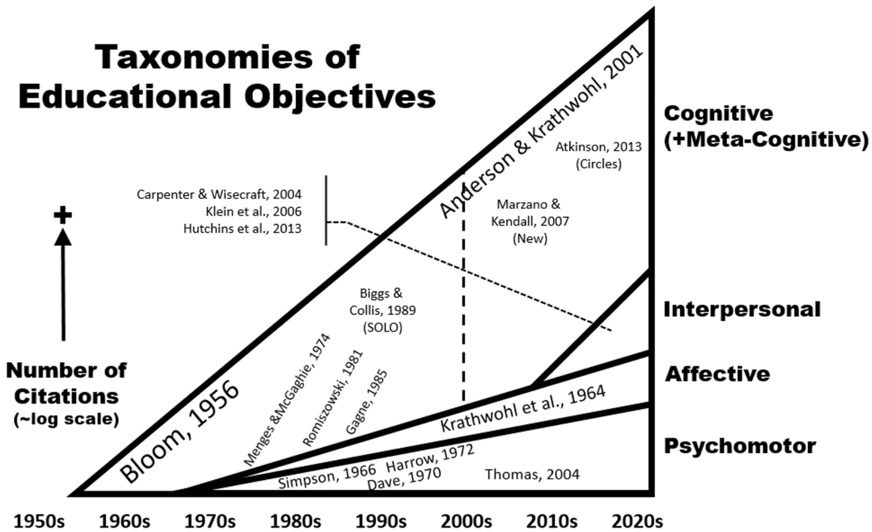

Figure 6: Developmental Progression of Taxonomies of Learning Objectives/Outcomes

However, even more importantly, the concept of alignment (or coherence) might be more formally established in the IMO model course framework. At present, the greatest focus is on learning objectives (stated as competencies for knowledge, understanding, and proficiency). Model courses provide a sample lesson plan, but learning (or instructional) activities are left to instructors and instructional designers. Further, the model courses provide general assessment concepts, but limited discussion of how best to align specific assessment to instructional (or learning) activities and the learning objectives they are intended to deliver. As a result, no alignment can be guaranteed. Using a framework such as the taxonomy tables (Anderson & Krathwohl, 2001), much more intentional alignment course be achieved in design and/or validation of IMO model courses.

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Empowering teachers in Maritime Education and Training (MET) through gender-equality training: A bottom-up approach for the implementation of current legislation

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Abstract: An increasing awareness of gender equality in the maritime sector is notable in recent years. While it is a good step forward, gender equality is often integrated into a diversity management agenda for leaders, but it is unclear how to apply the philosophy of gender equality in Maritime Education and Training (MET) led by teachers. It is evident that top-down approaches for the implementation of gender policies are often insufficient to achieve gender equality because they may fail to provide tools for an effective application and to recognize and consider the autonomy of practitioners who can actively contribute to gender equality with their work in different useful manners. The paper argues that bottom-up approaches can become an efficient method for the incorporation of gender mainstreaming by increasing the participation of practitioners and actively involving them in transforming their attitudes, practices and work methods. A balance between top-down and bottom-up approaches seems a desirable option as it combines the efficiency and leadership of the top-down approach with the collaborative advantages that come from the whole team. Finally, the paper addresses the role of the IAMU community to work together for gender equality in the context of MET.

Keywords: Maritime Education and Training (MET); gender mainstreaming; bottom-up approach; gender equality strategy

1. Introduction

In recent years, there has been an increasing awareness of gender equality in the maritime sector. Notable examples have been the World Maritime Day 2019 theme of “Empowering Women in the Maritime Community", set by the International Maritime Organization (IMO), and its follow-on action proclaiming an International Day for Women in Maritime, to be observed on 18 May every year. In addition, numerous initiatives and campaigns are arising within maritime organisations as the benefits of a gender-balanced workforce become more evident. All these actions serve to enhance efforts to achieve the United Nations Sustainable Development Goal 5 (SDG5) on gender equality and so promote the recruitment and retention of women, while trying to raise their profile within the maritime industry at the same time. Although these endeavours constitute a good step forward to strengthen the commitment towards gender equality in the maritime community, they do not always seem to obtain the needed results. One of the reasons behind this is that gender equality is often discussed and treated as a stand-alone issue, without the necessary and meaningful contextualisation that would be desirable.

Women make up half of the world population, yet they are dramatically underrepresented within the historically male-dominated maritime industry. According to the BIMCO and ICS (2021), the percentage of female STCW certified seafarers is estimated to be only 1.28% of the global seafarer workforce, which means 24,059 women out of 1.89 million seafarers currently serving the world merchant fleet. Although this represents an increase as compared with the 2015 report and, therefore, a positive gender trend, the female workforce representation in the sector continues to be scarce. The report warns that the industry must significantly increase training and recruitment levels in order to avoid a serious shortage in the supply of officers by 2026. This officer shortfall can constitute a good opportunity to recruit more women for the maritime industry but, unfortunately, it is mirrored by an even worse shortfall of female students in MET. A study by Barahona-Fuentes et al. (2020), which examines the evolution of female student enrolment in different MET institutions between 2009 and 2018, concludes that there is no significant rising tendency in any of the universities analysed over that decade. In addition, the same study observes that gender equality promotion policies are still scarce or inexistent and have a limited effect on female enrolment figures. This raises the question of how the gender equality agenda can be implemented not only in the maritime industry but also in MET. To meet the increasing demand of seafarers, sea careers and MET must be promoted with a special emphasis on female recruitment and retention as maritime female students are an important asset to meet the industry's demand. This paper argues that the implementation of gender equality policies from a bottom-up perspective, thus complementing the more traditional top-down approaches, can constitute an effective way to achieve better results.

2. Defining top-down and bottom-up approaches in relation to policy implementation

Traditionally, public policy implementation literature has been split between two major schools, top-down and bottom-up. Top-down theorists consider policy designers as the central actors and focus on factors that can be controlled at central level whereas bottom-up theorists emphasise target groups claiming that policy is actually conducted at local level. However, as implementation research evolved, this dual conflict model has been followed by different attempts aiming at reconciling them (Matland 1995).

Top-down approaches treat implementation as an administrative process that begins with the objectives authoritatively set by policy-makers from which implementation will follow naturally in a linear fashion. Their main emphasis is on the designers of the policy and those aspects that can be handled from top positions while expecting a general benefit. Therefore, in top-down approaches, the number of actors involved is quite limited and so is the extent of change as policy implementation depends on lower-level institutions, to which policy designers hand the responsibility over. In addition, the expertise of local implementers is usually not only ignored but also seen as an impediment towards implementation (Abas 2019).

Bottom-up models developed as a reaction to top-down approaches, which ignored the key role of final implementers. These models focus on the actors involved in the final implementation arguing that policies are made at local level (Matland 1995). Due to their emphasis on target groups, a benefit of these approaches is the understanding of contextual factors within the implementing environment as actors and their goals, strategies and activities need to be understood for a successful implementation as well as the difficulties encountered in meeting the stated goals (Cerna 2013). In addition, bottom-up approaches assume that the formulation and implementation are a single integrated process (Matland 1995) and look for strategies to create a network that allows connections between local actors, decision-makers and top policy-makers (Sabatier 2005). Nevertheless, bottom-up models have not eluded criticisms, either. Firstly, it is considered that policy control should be exercised by those authorised by votes or position to do so and, secondly, these models are said to overemphasise local implementers autonomy (Matland 1995).

A combined approach emerged drawing on the strengths of both approaches. Policy implementation occurs thanks to the interaction of a wide range of stakeholders at different levels (Cerna 2013). Therefore, as they are all equally important, the combination of approaches seems a natural option for a successful policy implementation. However, some authors suggest that implementation may vary according to policy areas and the content and type of policies (Suggett 2011), that is, the context and scope of the policy affect the design and strategies of the implementation plan. Other competing theories also emerged within the field of policy implementation such as the network theory (stemming from the bottom-up approach), the game-theory or the agent theory as more sophisticated ways of theorising about implementation (Cerna 2013). The debate as to the most appropriate policy implementation framework is still open as implementation research studies are a relatively new scientific field, which is continuously evolving. Hence, analysing each particular context and its needs, as well as the scope of the implementation, seems a good strategic response to provide the best solution and address any possible implementation problems and concerns.

3. Implementation of gender equality policies in MET institutions: top-down versus bottom-up approaches

This paper analyses the potentialities of collaborative bottom-up strategies in relation to the implementation of gender equality policies in MET institutions as an alternative and complement to more traditional top-down approaches. In order to do so, existing cases of gender legislation implementation are discussed and later some examples of effective bottom-up goal implementation methods in the maritime sector are provided to assess the opportunities they offer for gender regulations.

3.1. Gender policy implementation in MET institutions

Different research findings emphasise the importance of increasing gender awareness in the MET curricula, with well-defined guidelines and good practices, in order to enhance the incorporation of female students and, thus, future female seafarers in the shipping industry. A study conducted by Barahona Fuentes et al (2020) gathered data concerning the figures of female student enrolment and graduation in sixteen MET institutions over a decade (2009-2018). The research discovered that despite all the international gender-equality legislation efforts, specific female student policies were still limited or inexistent in most MET institutions. This led to an equally insufficient implementation of such policies and low numbers of female students in the vast majority of institutions. Another research by Böstrom and Österman (2015) examined how gender equality is addressed in the curricula of tertiary maritime education in the five top-ranked countries according to the Global Gender Gap Index in 2013, revealing a lack of clear strategies on behalf of MET institutions for these matters. The authors conclude that, beyond the formalisation of gender-inclusive policies, additional tools for operationalising them are needed in order to successfully integrate them as part of the curricula. Otherwise, gender policies tend to be inefficiently used for improving gender equality. Further, the revealing IAMU research project to increase gender and cultural awareness in MET evaluated these issues in relation to human factors, shipping companies, ship management practices and MET institutions. The project report acknowledges the important role of MET institutions to increase gender and cultural awareness in their curriculum and instruction and so motivate women to join the shipping sector (Dragomir et al 2018).

Although significant research has been carried out on the difficulties and obstacles that deter the attraction and retention of women in the maritime industry (Kitada 2021; MacNeil and Ghosh 2017; Mackenzie 2015), much less is known about how to bring about an effective change in MET institutions, which constitute the source of supply of future maritime professionals. The role of MET institutions is crucial in molding future gender-sensitive seafarers, but this challenge entails more far-reaching actions than the issue of gender-inclusive policies and legislation. It is evident that top-down approaches for the implementation and enforcement of gender policies are often insufficient to achieve gender equality. Hence, a more collaborative approach would need to be applied to achieve an improved access and rate of female students to tertiary MET studies. The design of clear proactive measures together with the involvement of the different stakeholders in educational institutions may help towards a more effective implementation of gender policies. In line with this, recognizing and considering the autonomy of practitioners who can actively contribute to gender equality with their work in different useful manners can also constitute an important asset to meet the desired gender-equality in MET institutions, which would have at the same time a significant positive correlation with female participation in the maritime sector.

3.2. Bottom-up implementation methods in the maritime sector: an opportunity for gender legislation

The maritime sector is a strongly legalised area due to its numerous international regulations. Traditionally, most legislative implementations have followed top-down approaches but bottom-up ones are not new in this area. In fact, there are several examples of such, that appear to be successful. For example, Sampson and Zhao (2003) report that multinational crew developed “bottom-up English” as a common means of onboard communication in addition to the IMO Standard Marine Communication Phrases (SMCP), which were developed by IMO to facilitate effective communication on board (top-down implementation method). Another bottom-up example is from maritime innovation training where social learning methods empower international students undertaking the MSc programme at the World Maritime University to collaborate, innovate, and take actions on specific maritime challenges to achieve sustainable development (Bolmsten and Kitada 2020). On a global scale, IMO has been for many years adopting regional and national approaches to empower women in the maritime sector through its Women in Maritime Associations (WIMAs) which are active agents to work with the IMO member States to achieve the global goal (IMO 2021). IMO also recently undertook an exercise to evaluate gender equality in activities by using the Participatory Gender Audit methodology developed by the International Labour Organization (ILO), which communicates with various levels of organisational hierarchy. All these bottom-up examples show how to create good synergies between global and local institutions while empowering practitioners for the inclusive culture of sustainable shipping.

It is evident that this partnership between top-down and bottom-up approaches can be an effective alternative to implement goals and regulations, because increased participation and active involvement of practitioners help in transforming their attitudes, practices and work methods to achieve goals. Another example of this is illustrated by an innovation project to incorporate gender mainstreaming in teaching developed by Barcelona School of Nautical Studies. So as to incorporate gender mainstreaming in all Catalan Universities, the Catalan University Quality Assurance Agency (AQU) published the *General framework for the incorporation of the gender perspective in university teaching* (AQU 2018). In line with this, the Governing Council of the Universitat Politècnica de Catalunya (UPC) approved the incorporation of the new transversal competence on gender perspective to all bachelor's and master's degrees taught at the university. To comply with this mandate, the Commission for Gender Equality of the Barcelona School of Nautical Studies developed an innovation teaching project for the creation of a web platform with resources for the incorporation of the gender perspective in their Nautical, Marine and Naval engineering bachelor and master's degrees.

This innovation teaching project intended to design solutions that could help teachers develop the necessary abilities to transform their curricula in a more gender-sensitive way. Therefore, the project included not only the provision and development of gender-equality resources and materials but also the delivery of specific gender-sensitive teacher training. This teacher training would serve to make teachers reflect on gender-equality issues and feminist pedagogies and to empower them to transform their teaching in different manners. The different course activities were aimed at aiding teachers assess and detect gender inequalities and so avoid the use of bias or stereotypes, modify course contents and examples in a more gender-sensitive way by including women as role models and balanced references, use more inclusive language and develop more gender-sensitive teaching methods and assessment. The feedback received from the teacher-training activities was used to refine the valuable materials developed so that they could be included in a repository on the project platform as a guide and example for other MET teachers.

This gender-equality training constitutes a further example to illustrate how bottom-up approaches are a valuable method to implement governmental and institutional legislation. Incorporating gender mainstreaming in MET is a challenge that can be overcome with creative solutions. In this particular case, this gender-focused training became an efficient attempt to contribute towards this challenge by actively involving practitioners in changing their attitudes, practices and work methods. In addition, this initiative served not only to empower the teaching staff at Barcelona School of Nautical Studies to transform their teaching but also to create a sense of community by working together towards bridging the gap in maritime education.

4. Discussion and conclusion

The traditional top-down legislation implementation approaches in the maritime sector have been essential to regulate a vast number of maritime affairs. Authority figures have defined goals and ways to achieve them, which have then been filtered to lower levels in the organisational hierarchy to be applied. Nowadays, the urge to implement the gender agenda impulses more creative and varied methodologies to achieve the desired goals. Combining different methodologies, namely, top-down and bottom-up approaches has contributed to obtaining more effective results, as the examples provided in the paper suggest. This combination of strategies increases the involvement of all the stakeholders and generates better synergies between them while contextualising and adapting gender legislation to each unique environment.

In addition, bottom-up approaches may serve to give a voice to lower levels of the organisational hierarchy, usually women, with respect to the implementation of goals and regulations. Women's voices and experiences will help the maritime community to better understand their needs and perspectives and so address issues that may have been neglected or underestimated so far. In the light of this, new considerations developed at lower levels may be gradually integrated into the higher-level framework of decision-making to design more efficient policies to enhance gender equality.

MET institutions may benefit from bottom-up methodologies in relation to the implementation of gender equality legislation in different ways. Fostering knowledge-based actions at lower levels may not only encourage practitioners to actively participate in the implementation of such policies but also enhance the participation of women, usually occupying a higher percentage of lower-level positions. Further research would be required to see if the use of bottom-up methodologies that give women a voice may also help to reverse the present male dominance in senior and leadership positions as a result of this women empowerment. If so, this could constitute a successful way to increase women's promotion to senior positions in MET institutions with its corresponding salary increase to help reduce the present pay gap.

Concerning the incorporation of gender mainstreaming in teaching in MET institutions, bottom-up approaches are a good opportunity to encourage and empower MET teachers to develop a more gender-sensitive training in their routine of work. This way, they are not passive receptors of decisions made at a higher level in the organisational hierarchy but actors actively involved in assuming responsibilities and making decisions in their particular context. In addition, teaching and training non-experts becomes necessary to build knowledge to avoid gender biases, stereotypes and patriarchal practices in teaching, while formulating new methodologies and practices to engage more female students in MET and so help to bridge the existing gender gap. Finally, it becomes crucial to disseminate all these actions and practices so that they can spread and grow within the IAMU community to work together for gender equality in the context of MET.

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The role of simulator and co-teaching for developing student's thinking and speaking interactive skills

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Abstract: Maritime English is a key tool for a future seafarer to ensure safety while performing delegated duties not only at sea but in the shore-based maritime industry. It is one of the core requirements of IMO presented in STCW Convention. To work out such skills in Maritime English at the operational level requires a lot of hard and systematic work, especially for non-native English-speaking seafarers.

So, the aim of the research given in the presented paper is to find the proper ways for our students to increase the knowledge of their professional, Maritime English language and communicative skills. The paper presents one of the ways how to reach the goal. On the bases of our teaching experience of Professional Maritime English, co-teaching and a simulated environment created by the simulator during the classes assist us in developing not only student professional Maritime English language thinking and speaking interactive skills but also developing critical thinking skills and mustering professional competencies.

Keywords: co-teaching, simulation, skills, competence.

1. Introduction

Maritime English proficiency is a mandatory tool for a future seafarer to ensure safety not only at sea but in the shore-based maritime industry. The maritime English skills at the operational level are one of the core requirements of IMO (International Maritime Organization) and STCW (Standards of Training, Certification, and Watchkeeping for Seafarers).

After completing graduation, the students have to write and respond to both formal and informal emails, prepare reports, and interact with colleagues, as officers, they need to acquire knowledge and skills to operate international ships and communicate to the port authority in English. Therefore, the students need to improve their proficiency in English at universities.

The students must be provided with sufficient proficiency in Maritime English and the Maritime English terminology for implementing different kinds of jobs and communication onboard the vessel around the world. Maritime English language is the key tool for safety at sea, therefore, it is vitally important for cadets to practice speaking English daily and master it.

English language teachers' big challenge is to improve cadets' maritime English skills so that they can communicate effectively onboard the vessel. The BSMA (Batumi State Maritime Academy) students have a lack of confidence in using English due to a lack of practice in English. They generally learn English in class and do not practice English outside the class, which makes them difficult to use English in interaction.

So, speaking fluently and accurately is the student's main concern and the English language teacher's aim is to create an interactive classroom atmosphere to enable learners to practice the language.

The interaction in the classroom improves students' oral production and their ability to communicate spontaneously using the English language in different interactive situations. Classroom interaction and fluent speech have been a matter of great interest for many researchers of second and foreign languages. There are a lot of studies in the field of language teaching, which deal with the importance of classroom interaction. The interaction is identified with the process of language learning.

Language teaching depends both on the teacher's teaching strategy and methodology, and also on students' ability to speak confidently in their native and foreign languages. According to Bygate's ideology, foreign language Teachers' aim is to prepare learners to be able to use the language, therefore, teachers need to be creative in designing the classroom`s activities. The teacher must choose a strategy in the teaching process, which brings success or failure in language learning. [2]

Knowledge of grammar, and vocabulary is not enough, it must be used in action. Using language in action, speaking, writing, and listening, is a skill, which teachers must enhance apart from the knowledge of the student. Knowledge without skill is less effective, and non-fulfilled.

Language teachers for developing speaking skills must use both: motor-perceptive skills, and interaction skills. In maritime English, Motor-perspective skill is identified as learning of English language through dialogues, IMO SMCP (Standard Maritime Communication Phrases), case studies, grammar forms, learning a language in the frame, and whether the interaction skill gives the student a choice, this is a skill of using knowledge and basic motor-perceptive skill to achieve communication. Interaction skill involves making decisions such as: what to say, how to say, what is right, and what is wrong.

Communication – is sharing and exchange of information. It is the ability to transmit and receive messages. In maritime English classes communication is done through words, actions, signs, objects or a combination of all these, where the classroom is a communication environment and the English language is a tool that is used for communication. Very important is also to train students speaking and listening skills with the help of GMDSS (Global Maritime Distress and Safety System) and portable VHF (Very High Frequency) Radios "Walkie Talkie" equipment, for seafarers it is a big challenge to communicate via this system because it is really very hard to communicate easily without training.

The use of simulators in maritime education and training is an essential component for developing seafarer competencies in the following courses such as NAVIGATION, CARGO HANDLING, ECDIS (Electronic Chart and Information System), ARPA (Automatic Radar Plotting Aids) RADAR, GMDSS, SHIPS HANDLING, SHIPS MANUVRING, BRIDGE RESOURCE MANAGEMENT, ENGINE CONTROL ROOM, etc. Simulator classes enable students to dive deeply into future professional challenges, understand and learn essentially difficult operations, and train themselves in right and quick decision making, they also develop students' internal and external communication skills.

Research shows, as we mentioned above, that language teaching greatly depends on: teaching strategy, interactive class atmosphere, motor-perceptive skills, and interaction skills. The student's motor-perceptive skill is developed in his/her first two years of education when he/she grabs general knowledge regarding maritime navigation and marine engineering and learns general vocabulary, terms, and IMO SMCP both regarding deck department and engine department. From the third year of education at university learners learn conventions, principles of operations, and emergency performed on board the vessel or at sea, by the way, they are introduced to simulator classes, where their motor perceptive skill is transformed into interactive skill, that means, that backed on their knowledge, students can use their theoretical knowledge in action.

2. Co-teaching and simulated lesson plan strategy

The language teaching strategy is the teacher's choice, which greatly depends on the teacher's knowledge, experience, and creativity with the help of which he/she organizes the interactive class atmosphere, which later develops students' fluent speaking skills.

As a simulator is an essential component for developing seafarer's competency in different marine affairs, we offer to use simulator classes for developing student's navigator skills and English-speaking interactive skills, where students more realistically would be involved in making decisions using professional knowledge and a maritime English in more realistic ship atmosphere. The simulator classes create the best classroom atmosphere where students' motor-perceptive skills (lower thinking skills) are effectively transformed into interactive (higher thinking) skills. A wide range of tasks, performed by the student on simulators, gives the possibility to break the language in the frame, where each new task on the simulator is a new challenge, where the student uses his/her motor-perceptive skill in real action, according to the topic and the situation.

For planning, managing, and implying the simulator class-based lesson, Bloom's taxonomy assists trainers to identify the intellectual level at which individual students are capable of working. It classifies thinking levels from simple to complex, therefore cognitive complexity grows at every level. Lessons build on Blooms Taxonomy are focused on developing students' performance from simple to complex (Figure 1):

Figure 1. Bloom's Taxonomy

We offer the model of the lesson which could be used on major numbers of simulators, as an example, we can show how it could be implemented in one of the course lessons such as "Bridge Resource Management" which would be planned and implemented by the Bridge Recourse Management course instructor and maritime English language co-teacher based on Blooms Taxonomy chart, which will enhance cadets competency of Bridge Resource Management, and develop English language communication skills under the stress. The simulator class scenario, lesson plan, monitoring of task execution, and assessment of students' competency are performed by the class trainer. The class brainstorming activities over the topic are provided by the English language Co-teacher, who later controls, and assesses the students' English language communication skills.

The lesson is divided into the following stages:

Stage one: Bridge Recourse Management simulator class instructor prepares the exercise for class: "Man Overboard" scenario. In the lesson plan, the instructor highlights the objective of the exercise, describes the exercise, shows the performance criteria, what should students demonstrate, and how to prove his/her knowledge of the given case. Then trainer gives the details of the assessment criteria, and finally total exercise results and comments.

Stage two: The role of the English language Co-teacher is to brainstorm with students with different activities over the topic" Man Overboard" (MOB), and then remind students of essential vocabulary, terms, and IMO SMCP which later facilitate their task performance during the presentation.

The lesson starts with the following brainstorming activities which engage student memory, thinking, and problem-solving skills in action:

Task1**:** The group work. Arrange the actions of man overboard according to the consequence.

The teacher divides the group into group A and group B and gives students the list of jumbled immediate actions, which they should arrange consequentially in three minutes.

1. Wheel over to the same side of MOB
2. Mark and note the position by pressing MOB on ECDIS or GPS (Global Positioning System)
3. Throw a life ring to the person MOB buoy

4. Sound three prolonged blasts on the ship's whistle Inform master
5. Note wind speed and direction
6. Post lookouts
7. Stand by engines
8. Inform other vessels in the vicinity
9. Prepare recovery equipment
10. Establish communication between bridge, deck, and rescue boat.

After three minutes students demonstrate their task and read the list. The teacher corrects mistakes if they occur.

Task2**:** Group work. The teacher shares the LSA (Life Saving Appliances) presentation to students where they should Match the LSA word list with pictures orally (time needed 2 minutes) (Figure 2).

Figure 2. LSA word list with pictures.

Task 3: The teacher shares three diagrams of navigational maneuvers and asks a student to guess individually the name of each of them. (Time needed 2 minutes) (Figure 3):

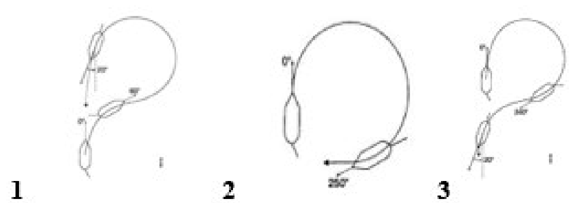

Figure 3. Diagrams of navigational maneuvers.

Task 4: The teacher tries to elicit what are the advantages of Williamson Turn? (Time needed 2 minutes).

Students demonstrate their knowledge, and they try to list Williamson's turn Advantages such as:

Advantages of Williamson turn are: Vessel makes a good original track line; This turn is good in reduced visibility; It is a simple maneuver.

Stage 3: After the brainstorming class instructor conducts a briefing to a group and delegates the roles to cadets such as:1. Master, 2. Watch Officer, 3. Back-Up Officer,4. Helmsman,5. Supervisor.

The instructor himself will take the role of the following: 1. Pilot, 2. Port Control, 3. MRCC (Maritime Rescue Coordination Center)

The students should use and follow “Pre-Arrival CL”, “Pilot CL”, and “Contingency CL MOB” Checklists.

Stage 4: Trainer introduces Scenario:

1. Date 04 Jan 2022; UTC – 12:00 / 15:00LT
2. Vessel – “LCC TANKER” Product Tanker; Freeboard – 10.5Mtrs; Location – Bosporus North Entrance.
3. Weather condition – Wind WSW 5, Sea SW 4, Swell 2, visibility 5NM.
4. Vessel proceeding to PBA, “Kavak Pilot” Confirmed Pilot boarding takes place in position 41° 15.1′ N, 029° 07.92′ E 7.0KT, With Boarding Speed 6KT, Heading 200Degress at PBA.
5. “Kavak Pilot” listens/works on VHF Channels 16, 11, and 71.
6. Vessel intends to Pick Up the Pilot at an agreed position to enter Bosphorus North Entrance
7. Passage Plan agreed with all bridge teams and approved with the master.
8. All Equipment in working condition.

Stage 5: Students are executing tasks, where they should create a plan of action and then perform it in a limited period. The role of the English language teacher is to supervise students' communication skills, the target vocabulary they use for the topic, and pronunciation, to make some notes which later would be discussed by the teacher. The role of the trainer **is more complicated, he is the role player, the case supervisor, and the assessor. The team should create a plan of action close to all requirements.**

Stage 6: At this stage of the lesson backed on the result of lesson monitoring, the trainer and English language teacher assess students’ following abilities (Table 1 and Table 2):

Table 1. Assessment of a student’s abilities.

Trainer’s ASSESSMENT CRITERIA:			Evaluation Scale	
Max 5 Score	**Max 5 Score**	**Max 10 Score**	**Max 10 Score**	**Max 10 Score**
Knowledge of Procedures, Familiarisation with Check Lists	**Ability to Act in Emergency, Follow procedures**	**Ability To Coordinate And Command in Emergency**	**Ability to Report and communicate with external parties**	**Ability to Report and Establish Internal communication**

Table 2. Assessment of a student’s abilities.

English language teacher’s ASSESSMENT CRITERIA:			Evaluation Scale	
Max 5 Score	**Max 5 Score**	**Max 10 Score**	**Max 10 Score**	**Max 10 Score**
Knowledge of target vocabulary, good pronunciation	**Ability to use IMO SMCP in an Emergency situation.**	**Ability To Coordinate And Command in Emergency, language fluency**	**Ability to Report and communicate with external parties, language fluency**	**Ability to Report and Establish Internal communication language fluency**

Stage 7: At the final stage the trainer and language teacher conduct a debriefing, where they discuss the advantages and disadvantages of the performed job. Teachers highlight students’ mistakes regarding the proper management of the emergency procedure and language used for communication and give them advice and instructions on how to improve it if it is necessary.

So, by the completion of the course, a student will be able to:

1. Act in the situation of MOB executing different roles;
2. Perform Williamson Turn procedure;
3. Coordinate internal and external communication of rescue operation;
4. Coordinate communication with Shore facilities;
5. Report procedures and time logging.

According to Blooms Taxonomy 6 level chart, our lesson plan is oriented for learners to demonstrate the following abilities (Table 3):

Table 3. Bloom's Taxonomy evaluation and analysis.

Remember	The learner can remember or recall the information about the emergency case "MOB"
Understand	The learner can explain the idea of the concept.
Apply	The learner can use the information according to the case and establish correct action and maneuverings.
Analyze	The learner can differentiate what to do, and use, how to act. Which orders and phrases to use.
Evaluate	The learner can make quick decisions in dynamically developed emergency situations
Create	The learner can create a new product, correct the scenario for safe and prompt action, and generate new ideas and thoughts.

The presented lesson model depicts learners moving from the lower level of Bloom's taxonomy to the higher one. Each level is followed by the higher, more challenging one (Figure 4).

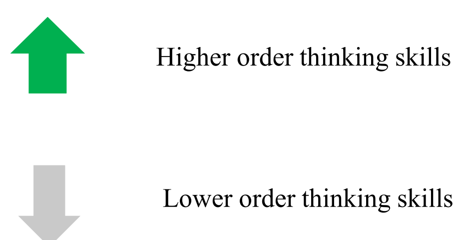

Figure 4. Thinking skills evaluation.

In conclusion, after analyzing and discussing the simulator class lesson strategy, teaching tools, methods of teaching, and assessment, we tried to highlight all advantages of the simulator class teaching atmosphere, which will positively affect students' higher-order thinking and speaking skills. A wide range of tasks, performed by the student on simulators, break the language in the frame, and a new task on the simulator is a new challenge, where the student backed on his/her motor-perceptive skill moves to a higher level of thinking, to the top of the Blooms taxonomy "Creation", where the learner independently formulates his/her speech, makes a quick decision, transmit and receive the information. Proper communication is the key to safety at sea. Simulator class trainer and English language co-teacher on such lessons look like the RCC-rescue coordinating Centre, which gives students emergency cases and problems, which students should treat and tackle properly and in a short period of time.

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A Comparative Study of Ship Risk Profile According to Port State Control Regime: A Case Study of Turkish Straits

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Abstract: The implementation and supervision of international regulations are crucial to ensure maritime safety. Port State Control (PSC) regimes make a great contribution to this by inspecting the safety standards and compliance with international regulations of ships arriving at ports. In PSCs, due to a lack of personnel for inspection and an excess number of ships to be inspected, risky ships are selected by ship risk profile and inspected, and substandard ships are detected. In this study, detention data along with non-conformities of PSC were combined with ships' data passing through the Turkish Straits to compare the PSC regime's effect on the navigational safety of a narrow waterway passage. Furthermore, exploratory analysis has been provided in order to reveal the maritime traffic structure of the Turkish Straits regarding PSC measures. The results have offered promising evidence that PSC regime implementation provides a valuable indicator to discriminate ship risk profile for narrow waterways.

Keywords: Maritime safety; Narrow waterways; Ship Risk Profile; Port State Control; Turkish Straits

1. Introduction

Maritime safety is crucial considering 90% of world trade is being carried out by maritime transportation (AGCS 2021), and is being ensured by putting international regulations and measures into practice. The supervision of international regulations and measures is just as vital as the implementation of those. Whereas the implementation and supervision of international regulations are primarily the responsibility of the flag state, these controls and inspections are carried out by the classification societies or inspectors authorized on behalf of the flag state (IMO 2017). However, due to the nature of the maritime environment, the fact that ships cannot frequently visit the ports of flag states and that there are not enough resources/personnel in flag states for ships that implement Flag of Convenience (FOC) has caused weaknesses in ensuring and inspecting the safety standards of ships. These resulting vulnerabilities have brought PSC to life (Heij et al. 2011). PSC regimes make a great contribution to the implementation and supervision of international regulations by inspecting the safety standards and compliance with international regulations of ships arriving at ports in support of Flag State Controls (FSC) (IMO 2017). In PSCs, due to a lack of personnel for inspection and an excess number of ships to be inspected, risky ships are selected by ship risk profile and inspected, and substandard ships are detected (Paris MoU 2021). Once the historical data of these inspections are evaluated, it is revealed that there are significant improvements in the establishment of life, property, and environmental safety (Li et al. 2008). PSC is the last safety step, which is generally accepted as a measure to consolidate the old maritime safety net created by FSCs and classification societies (Emecen Kara 2016).

In this study, detention data along with non-conformities of PSC were combined with ships' accident data passing through the Turkish Straits to compare the PSC Regime effect on the navigation safety of a narrow waterway passage. Then, in respect of maritime safety, a comparative study was conducted between ships passing through the Turkish Straits that had accidents and those that did not in order to reveal the significance of PSC audits. Furthermore, exploratory analysis has been provided in order to reveal the maritime traffic structure of the Turkish Straits regarding PSC measures. The results have provided promising evidence that PSC results/indicators have a significant effect on the navigation safety of narrow waterways. The correlation between PSC data and ship accidents has been revealed to provide insights into future studies.

Within the scope of the aforementioned information, this study is organized as follows. In Section 2, the literature review and info about the Turkish Straits are expressed. Data examination is introduced in Section 3. In Section 4, results are assessed. In the last section, the conclusion is presented. Sailing Plan (SP)-1 reports data between the years 2005 and 2021, which are reported by ships passing through the Turkish Straits, and the accidents data that occurred in Straits between the years 2004 and 2021 were obtained from the Turkish Directorate General of Coastal Safety. In addition, Paris MoU, Tokyo MoU, Mediterranean MoU, and Black Sea MoU detention data were extracted from the website of the relevant MoU.

2. Background

2.1 Turkish Straits

The Turkish Straits, composed of the Istanbul Strait, the Canakkale Strait, and the Sea of Marmara, are among the riskiest and most congested narrow waterways in the world with their unique structure in the aspect of navigational safety. Given that the Turkish Straits connect the Mediterranean and the Black Sea, its importance in world trade is apparent. The increasing ship sizes and traffic density in parallel with world trade on this waterway has escalated existing risks in the Straits (Köse et al. 2003), and safety measures have become highly necessary. Due to this need, many measures and regulations are continuously being put into practice. Therefore, academic studies are concentrated on safety in these waters as well.

Whilst the current state of the Turkish Straits is reviewed, it can be seen that the straits are being monitored by Turkish Straits Vessel Traffic Service (TSVTS) in order to mitigate accident risks, and a variety of precautions are taken by evaluating meteorological conditions, sea states, and traffic density. In addition, ships passing through straits are obliged to follow the traffic separation scheme and to inform TSVTS with SP-1 reports, which contain a wide variety of data about ship characteristics.

2.2. Literature Review

Maritime accidents are more common in ports, inland waters, or narrow waterways than on open seas (Ozbas 2013) and PSC plays an important role in mitigating sub-standard ships in the waterways. Therefore, studies on PSC focusing on maritime safety specific to narrow waterways are crucial. A literature review on PSC inspections was conducted by Yan and Wang (2019), and after examining 43 articles, it is declared that the introduction of PSC has helped to improve maritime safety, especially by reducing accident risks. This fact has been demonstrated once again by this study and made PSC's efficiency apparent.

In the study by Sage (2005), it has been stated that the sub-standard ship risk profiles set by the targeting factors used by the Paris MoU and the risk situation of the sea area where the ship is located, can be utilized in the identification of high-risk ships. With the help of this, high-risk vessels could be followed more precisely and proactive measures can be taken effectively by VTSs in order to mitigate possible accident risks or the consequences of accidents. Degré (2007) put forward the necessity of applying the ship risk profile in a risk-based way with a statistical approach including accident risk as a new targeting method by the Paris MoU. As a regional study, maritime risk assessment of the Istanbul Strait regarding the risk level of ships' flags according to Black Sea MoU data was conducted by Emecen Kara (2016). In parallel with these studies, a static ship risk profile model was introduced with a probabilistic approach using the ship risk profile parameters of the Paris MoU by Dinis et al. (2020). In addition, it has been stated that environmental, geographical, and other dynamic risk factors related to navigation can be added to the model developed in the sea region.

As abovementioned, PSC inspections escalate maritime safety. However, the PSC impact on narrow waterways has not been evaluated in studies related to PSC. In this study, a comparative analysis of the data on narrow waterways, specific to the sea region, was conducted with the PSC data.

3. Data Examination

Sea regions are unique due to the complexity of the maritime environment, and international regulations and measures can be introduced specifically for the region. The Turkish Straits are one of the most important narrow waterways in terms of regulations and measures introduced specifically to the region. In this respect, data on ships passing through the Turkish Straits between the years 2005-2021 and marine accidents in the Straits between the years 2004-2021 were obtained. As PSC data, Tokyo MoU between the years 2000-2021, Black Sea MoU between the years 2002-2021, Paris MoU between the years 2009-2021, and Mediterranean MoU between the years 2016-2021 were acquired from related MoU websites. General information regarding ship passages from the Turkish Straits has been provided in Figure 1.

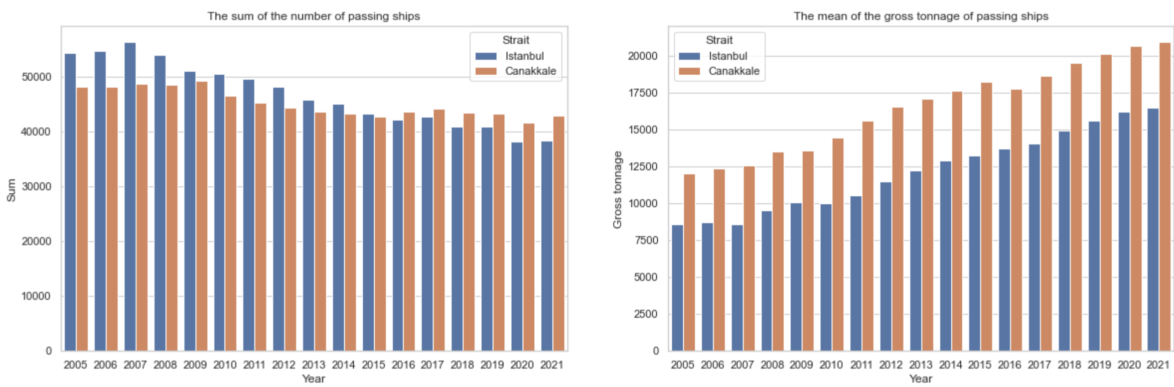

Figure 1. Ships passing through the Turkish Straits between the years 2005-2021.

In Figure 1, it is seen that the number of ships passing through the Turkish Straits has decreased over the years, but the gross tonnage of the ships passing through the Straits has highly increased compared to the decreasing number of ships passing. Considering the unique geographical structure of the Turkish Straits and current traffic density in the Straits, there is a serious increase in the size of ships and that poses potential accident risks. While reviewing PSC detention data with ships passing through the Turkish Straits, it is noticed that detention and deficiency number increased proportionally similarly (see Figure 2) and the yearly ratio of ships with detentions passing through the Turkish Straits increased as well (see Figure 3).

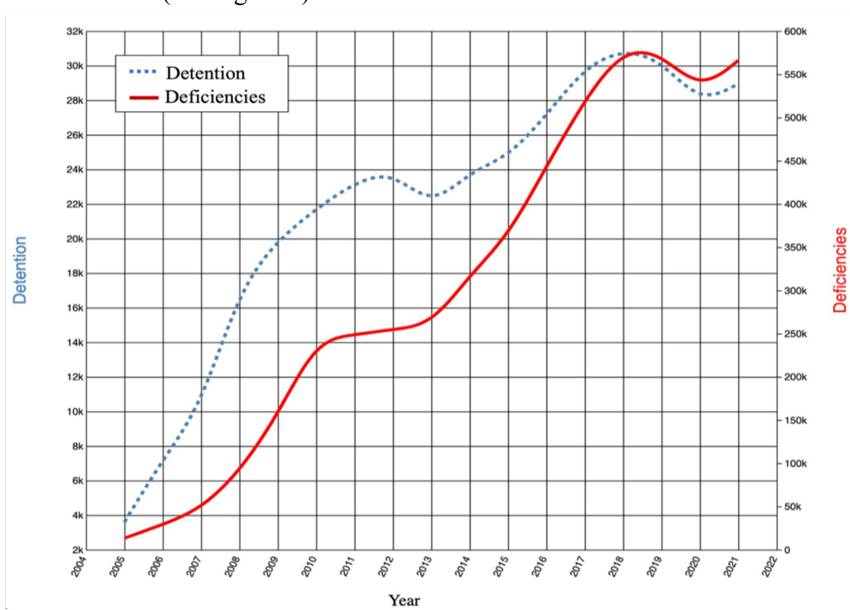

Figure 2. The deficiency and detention number of ships passing through the Turkish Straits

Length, gross tonnage, draft, flag, and pilot on board were selected as ship characteristics from the Turkish Straits data. Ship flag and pilot on board data are not numerical. To transform these data into numerical data, the pilot on board was assigned as “0” when false and “1” when true, and for ship flag categorization, the relevant year Paris MoU excess factor was used. Latter, the number of deficiencies and detention data from the PSC data were merged with the Straits data. Data cleaning is conducted; ship types are categorized as Tanker, Cargo, Container and Passenger ships, and other types of ships are excluded. Ship data passing through the Turkish Straits with PSC data and ship accident data in the Turkish Straits with PSC data are demonstrated respectively in Table 1 and in Table 2.

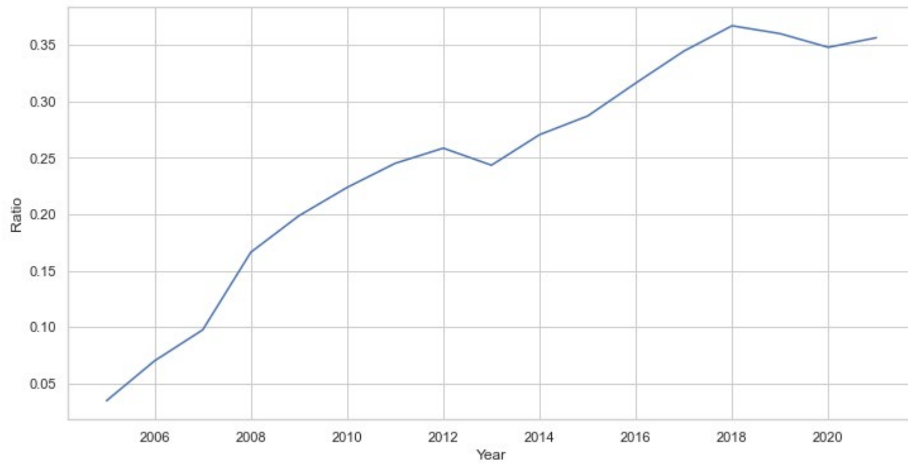

Figure 3. The ratio of ships with detentions passing through the Turkish Straits (non-dimensionalized)

In Table 1, duplicated data of ships passing through the Turkish Straits are dropped according to passage year, IMO number, and detention sum. Whilst examining data in Table 1, it is detected that the mean age of the ships passing through the straits is 16,25, the mean flag factor is -0,35 which indicates that ships, passing through Straits, are above the standard safety level (White flag), the mean detention number is 0,59, and the mean deficiency number is 4,11.

Table 1. Ship data passing through the Turkish Straits between the years 2005-2021.

	Count	**Mean**	**Std**	**Min**	**25%**	**50%**	**75%**	**Max**
Length	119414	157.27	57.05	34.84	108.40	151.55	189.99	399.99
Gross Tonnage	119414	20585.92	22549.24	142.00	3952.00	12226.00	29688.00	232618.00
Age during Passage	119414	16.25	11.65	0.00	6.00	14.00	25.00	60.00
Pilot on Board	119414	0.73	0.44	0.00	0.00	1.00	1.00	1.00
Draft	119414	6.94	2.73	3.01	4.90	6.50	8.40	19.28
Flag Factor	117741	-0.35	1.57	-2.00	-1.42	-0.86	0.00	10.60
Deficiency Number	119414	4.11	12.32	0.00	0.00	0.00	2.00	265.00
Detention Number	119414	0.59	1.31	0.00	0.00	0.00	1.00	20.00

In Table 2, owing to the fact that marine accidents are rare events, duplicated data of ship accident data in the Turkish Straits are dropped according to date of accident, and IMO numbers. While analyzing data in Table 2, it is noticed that the mean age of the ships passing through the Straits is 26,55, the mean flag factor is 0,98 which indicates that ships, passing through the Straits, are below the standard safety level (Gray flag), the mean detention number is 0,87, and the mean deficiency number is 8,08.

Table 2. Ship accident data in the Turkish Straits between the years 2004-2021.

	Count	**Mean**	**Std**	**Min**	**25%**	**50%**	**75%**	**Max**
Length	719	119.55	46.41	30.80	84.38	113.35	143.08	299.94
Gross Tonnage	719	8659.24	12945.10	148.00	1995.00	3712.00	9912.00	104729.00
Age during Passage	719	26.55	11.38	1.00	20.00	28.00	34.00	75.00
Pilot on Board	719	0.04	0.19	0.00	0.00	0.00	0.00	1.00
Draft	574	5.73	2.71	1.80	3.70	5.02	7.20	18.42
Flag Factor	699	0.98	2.16	-1.78	-0.55	0.44	2.27	12.68
Deficiency Number	719	6.08	15.73	0.00	0.00	0.000	5.00	202.00
Detention Number	719	0.87	1.57	0.00	0.00	0.000	1.00	12.00

Eventually, a comparison analysis was conducted on both the data in Table 1 and Table 2. As a prerequisite, the Levene test for checking variance equality, and the Shapiro-Wilk test as a normality test were applied to both data. According to the results, the variance of the data was not equal, and due to sample sizes, the variables were not well fitted to normal distribution. Notwithstanding these shortcomings, Welche's T-test was selected as a proper test and was conducted to descriptive statistics of data.

4. Results and Discussion

Whilst assessing the results, it is observed in Figure 1 that the size of ships passing through the Turkish Straits is increasing significantly even though the number of ships passing is decreasing less in comparison. This poses a serious potential hazard in the case of the occurrence of an accident. In addition to that, deficiency and detention numbers act correlatedly as depicted in Figure 2. The ratio of ships with detentions, which indicates these ships are sub-standard and vulnerable to accident occurrence, passing through the Straits in Figure 3 is approximately 0,35 for the last 5 years. These imply that potentially sub-standard ships prone to accident risk are passing through the Straits as well.

Comparing data of ships passing through the Turkish Strait in Table 1 with accident data in the Straits in Table 2, it is apparent that PSC data (Flag factor, detention number, and deficiency number) of accident data is significantly higher. This situation indicates that PSC data can be used as ships' factors prone to accident risk in maritime safety risk assessment in the Turkish Straits. In addition, the mean age of ships in accident data is older than expected. Contrary to expectations, the mean length of ships in accident data (Table 2) is less than the ship passage data (Table 1). When the data is thoroughly inspected, it is evaluated that this situation may be related to the building of new ships in larger sizes by the effect of new technological and economic developments, and needs.

Table 3. Welch’s t test results

	Statistics	p-Value
Length	21.710	0.000
Gross Tonnage	24.504	0.000
Age during Passage	24.196	0.000
Pilot on Board	10.583	0.000
Draft	93.253	0.000
Flag Factor	-16.379,	0.000
Deficiency Number	-3.354	0.001
Detention Number	-4.865	0.000

The results of Welch’s test have been presented in Table 3. As can be seen from the results, most of the features of accident and ship passage data are significantly different. Particularly, deficiency number and detention number results have shown that PSC regime implementation provides a valuable indicator to discriminate ship risk profiles.

In the example of the Turkish Straits, maritime authorities are utilizing the ship characteristics such as ship length, ship age, draft, etc. for determining ship risk profile. In this study, it is observed that the flag factor, deficiency and detention number may also be employed in ship risk assessment.

5. Conclusion

In this study, it is aimed to reveal the maritime traffic structure of the Turkish Straits, which is one of the most dangerous narrow and congested waterways in the world, with its economic and geopolitical importance, regarding PSC measures. Understanding the maritime traffic structure in the Turkish Straits may provide insight into risk assessment approaches in narrow waterways and congested waters, and determine what needs to be done for safe passage with the help of the PSC data. It has been seen that PSC data is a valuable indicator to determine risky ships for the narrow waterways in example of the Turkish Straits. For further studies, taking into account other features such as geographical and meteorological features could provide more insightful results for risk assessment in narrow waterways.

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