ACADEMY Publishing Center

MRT
Maritime Research & Technology Journal

Volume 2 - Issue 2 - December 2023 - ISSN 2812-5622

Academy Publishing Center

MRT Maritime Research and Technology First edition 2022

ACADEMY Publishing Center

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MRT Volume 2, Issue 2 (December 2023)
eISSN: 2812-5622
pISSN: 2812-5614

MRT Maritime Research and Technology

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Ranking the Factors Applied in Simulation Training Leading to Better Traffic in Alexandria Port Using AHP

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Received on: 06 March 2023 Accepted on:22 June 2023 Published on: 17 July 2023

ABSTRACT

Purpose: *There is a risk of collisions in daily life and these risks are doubled in the shipping industry. The focus of this study is to identify the factors that lead to ships' collisions by prioritizing them. These factors are vessel traffic, marine pilots, fairway traffic, navigation aids, and ship berthing.*

Methodology: *The data were collected from 30 experts and decision-makers in the maritime industry. The Analytic Hierarchy Process (AHP) method analyzed the data to know the preferences.*

Findings: *The results revealed that vessel traffic is the first item that causes ships' crashes, then marine pilots, fairway traffic, navigation aids and ship berthing, respectively.*

Key-words:
ships' collisions, vessel traffic, fairway traffic, navigation aids, ship berthing, marine pilot simulator.

1. INTRODUCTION

Currently, the majority of the world's products is transferred by the ocean which is more than 90 percent. About 8 million tons of products were carried every year by container ships, tankers, and bulk carriers (Fruth and Teuteberg, 2017). In year 2013, ship shipping was increased to 9.5 billion tons, while in 2015 this process has been raised to 20.5 million twenty-foot equivalent units (TEUs), regardless of the economic crisis that occurred in 2009. The maritime industry increased twice in comparison with the global commercial local goods (Harrison and Boske, 2017). In the last decades, the maritime industry became a vital way of connection and transportation all around the world. By increasing maritime traffic, the world endured this suboptimal growth that has increased risk (Sousa, 2018).

The increase in shipping industry is positively correlated with the rising in world's request, thus it is a well-established truth that most marine transportation is relatively frequent. In other words, particular points of interest (POIs) are connected to only a restricted number of roadways such as ports or stationary locations (Willett et al., 2018).

With every maritime traffic increase, there is an increase in ship crashes, privateering offensive, and terrorism threats. Although the updated computer-based systems and the new navigational technology are frequently placed on vessel crossings, a large proportion of accidents still occur (Willett et al., 2018). Since traffic is going on, collisions between vessels are the main functional hazard in the maritime industry. Although updated computer-based systems and new navigational technology are frequently placed on vessel crossings, a large proportion of accidents still occurs (Hou et al., 2020; Van Gelder et al., 2020).

More than 80% of maritime transportation accidents and collisions are said to be due to human factors, according to various marine accident surveys. Therefore, the influence of human factors on these accidents is continuing to be crucial (Hou et al., 2020). According to that, many prior studies started to search for different reasons that affect the safety of the navigation and lead to ships' collisions, which are represented in; vessel traffic where some of the literature review were dedicated to understand the semi-continuous spatial statistical analysis using ais data for vessel traffic flow characteristics (Kim, 2021); marine pilots as some of the previous studies contributed to analyzing the term of maritime pilot training and certification, besides conducting a comparative study between several countries regarding marine pilot (Kalulu, 2018); fairway traffic where some of the literature review investigated the Ship collision frequency estimation in port fairways in order to understand the fairway traffic through conducting a case study (Weng and Xue, 2015); navigation aids where a specific portion of the literature review contributed to understanding the effects of urban form and navigational aids on wayfinding behavior and spatial cognition (Yu et al., 2021); and finally ship berthing as several previous studies were dedicated to solving continuous berth allocation problems (Yuan et al., 2017).

Based on these studies, the current research aimed to investigate the role of these five factors (Vessel Traffic (VT), Marine Pilot (MP), Fairway Traffic (FT), Navigation Aids (NA) and Ship Berthing (SB)) on the ships' collisions and apply analysis of Analytic Hierarchy Process (AHP) method to know the ranking of each of these five variables. According to that, the contribution of the study is represented in testing different factors that affect ships' safety as well as trying to rank them according to their strength. This point represents the main contribution as there are no previous studies that have merged these five factors before or have measured their effect on maritime safety.

This paper is divided into seven sections, where each section achieves a particular purpose of the research. Starting with section one, it presents the introduction of this paper. Section two presents the literature review, where previous studies that had examined the same variables are discussed. Section three is research methodology. Section four presents the data analysis and the outcomes of the AHP. Section five shows the discussion of the concluded results. Moreover, section six is the conclusion of the research, where the benefit of the current research is shown. Ending with the seventh section, which represents the limitation of this research and the suggestions for the future research.

2. LITERATURE REVIEW

The relationships between the research variables are examined in the parts that follow. This study sought to ascertain how to prioritize the preferences of maritime traffic based on the simulation models that impacted the security and risk level in the maritime industry. Five key variables are presented to determine the optimal service standard that the port should adhere to to achieve a safer navigational path. These factors are; Vessel Traffic (VT), Marine Pilot (MP), Fairway Traffic (FT), Navigation Aids (NA) and Ship Berthing (SB). Therefore, the relationship between these factors and the way to safer way of navigation are shown in the next subsections.

Vessel Traffic

By describing how the freight field is one of the oldest fields in traffic. Nowadays maritime traffic has become one of the major fields in traffic at extremely high pressure for efficacious and secure functions on land not in the harbor functions. With increasing requests, there is a development in technology in all fields generally and in the maritime industry especially. Vessel Traffic Service (VTS) is one of the newest technological services in the maritime industry to raise the safety and efficiency of harbor functions. A support service for cargo ships passing by ports or over challenging terrain is called VTS (Praetorius and Hollnagel, 2014). Numerous forms of VTS have been implemented in recent years to increase safety, especially in areas with high traffic density and vital maritime settings (Yang et al., 2023). In locations with peak traffic intensity, the VTS has been found to have a favorable impact on both administrative surveys and project evaluations (Praetorius and Hollnagel, 2014). VTS is accepted as one of the aspects that could affect the safety of navigation based on the aforementioned points.

Different studies discussed this point, such as; Park and Bang (2016), Hoogendoorn et al. (2019), Qiu et al. (2020), and Srše et al. (2021) proved a strong correlation between the improvement of vessel traffic service and maritime traffic and safety. In addition, Hoogendoorn et al. (2019) assured that the amount of vessel traffic was positively related to vessel traffic. Qiu et al. (2020) revealed that vessel number and speed were the most effective factors in vessel traffic services and the adoption of rotational shifts can help in maritime traffic. Similarly, Srše et al. (2021) indicated a relationship between the vessel sizes, the hazard distance, and the traffic flow standard deviation. These can be used to develop a broad model of vessel traffic flow as well as to judge the architecture of hypothetical rivers and the safety of navigation. Accordingly, the current study can assure of the importance of VTS on maritime traffic and its benefits that are related to vessel amount, speed and size as well as the hazard distance.

On the other hand, Dahlman et al. (2015) aimed to study how vessel traffic systems engaged integrity and dynamic traffic movements and how these services uplifted traffic fluency. Results showed that the VTS domain is highly complicated and that the two systems that were simulated have quite diverse services to identify the impact on the systems' monitoring, response, and anticipatory capabilities. When making plans for and carrying out modifications inside the VTS domain, it is crucial to keep this in mind. Although VIS has many benefits for maritime safety, it still represents a complicated system that requires lots of training in order to deal with it.

Real-time multi-vessel collision assessment, which integrates a multi-vessel collision risk index model and Density-Based Spatial Clustering of Applications with Noise (DBSCAN) for locating groups of encountering vessels was investigated by Jin et al. (2017). The results showed how effectively and efficiently encounter vessels within each cluster can be identified and ranked according to their collision risk, allowing operators to prioritize encounter vessels for further risk assessment automatically. This framework can thereby lessen the number of fatalities and property losses while enhancing the security and safety of vessel traffic transportation.

Studies also mentioned artificial intelligence and it supports the safety of navigation in the presence of VIS. Ye et al. (2019) and Goh et al. (2019) had mentioned this point, where Ye et al. (2019) indicated that when VIS is compared to the current Traffic Signal Revealing System, the average waiting time for vessels is reduced by roughly 22 minutes. By shortening travel times, this will boost the waterway's capacity while also greatly enhancing the effectiveness and precision of the scheduling of ship traffic. While Goh et al. (2019) revealed the importance of traffic pattern knowledge for a variety of domain applications and how it is a requirement for the increasingly common knowledge-based forecasting methodologies. The results also highlighted how crucial it is to research maritime traffic and how artificial intelligence may be used to address it. Regarding this point, it is important to mention that artificial intelligence is a significant factor that will support the navigation process but at the same time, the human pilot role should not be neglected.

Marine Pilot

Today's pilots provide one of the most critical services to the maritime business. It is nevertheless crucial for ships traveling to high-risk waters to have a pilot on board. Today's pilots combine the latest cutting-edge nautical technology with their extensive local expertise. The rate of technological development makes it challenging for pilots to stay up to date with such cutting-edge equipment. New ship designs necessitate new maneuvering techniques, yet marine pilots are obliged to operate them without prior training, putting them and others in danger. These changes necessitate specialized knowledge, ongoing attention, and extremely complex decision-making (Kalulu, 2018). According to this, it is important to investigate the role of pilots in marine safety and how to prepare them to ship safely and avoid collisions.

Many studies have mentioned the importance of training and simulators in making marine pilots able to perform efficiently. Sellberg and Lundin (2017) and Sellberg (2018) demonstrated how instructions given during the simulation build on an instructor's capacity to discern how the ongoing activities in the simulator align with learning objectives. According to Sellberg (2018), the instructional goal of tying together the general and particular navigational conditions was upheld throughout all training phases, from briefing through scenario to debriefing. The findings highlighted the necessity of both in-scenario instruction and post-simulation debriefing to improve learning in a profession. The results also demonstrate how technology in the model environment enables instructors to monitor, correct, and assess students' progress toward learning goals on a continual basis.

In the same manner, Kalulu (2018) compared and contrasted Namibia's marine pilot training and certification scheme with Denmark's, as well as with international standards and best practices and revealed that there are variations in the education and training systems as well as in the rules, practices, structures, operations, and administration of the two pilotage jurisdictions. To improve the safety of persons and property at sea and in ports, the findings also indicated the need for international standards for maritime education and certification. These standards will promote the development of critical skills required for high performance and marine environment protection.

Moreover, Mateichuk et al.'s (2020) objective was to establish an efficient "Ship's Captain / Pilot" relationship that will guarantee the vessel can maneuver as effectively as possible while taking all hazards, dangers, and warnings into account. The experimental study's findings on how to efficiently foster interactions between "The Ship's Captain and the Pilot" using training technologies will aid in operationalizing fixes for problems with ship handling training and improve captains' capabilities.

The above studies have shown very clearly the importance of the simulators and training that are provided to pilots as well as the importance of training these pilots on new technology and how to use it in an effective way that represents an added value that guarantees a very safe shipping journey.

Another point related to marine pilots has been discussed in the study of Orlandi and Brooks (2018), where the study aimed to determine how 10 marine pilots' physiological and mental workloads were affected by ship handling maneuvers. From the electrocardiogram, heart rate and heart rate variability were determined. Eye tracking was used to measure pupil dilation. As berthings became more challenging and the pilots performed them in foreign ports, workload levels grew. This study concluded that the workload must be put in consideration as a main factor that affects marine pilots and their performance.

Fairway Traffic

The main purpose of fairway infrastructure is to make river navigation both safe and profitable. The fairway, along with other elements like locks, is essential to the construction of the fairway. It can be described as a specific section inside a riverbank that must be preserved by the relevant competent fairway authority (Rusu, 2015). Waterway parameters are set forth in international treaties to enable inland navigation based on the same standards. The canal system belongs to the public and must be established and maintained in accordance with these international conventions and accords by national fairways administrations (Erceg, 2018). Higher demands are placed on the capacity and safety level of coastal fairways due to the transportation sector's rapid growth and the ongoing growth of marine traffic flow (Zhou et al., 2015). Thus, the identification of fairway infrastructure and traffic represents a significant factor of navigation whether in rivers or open seas.

Studies have investigated fairway traffic and many issues that affect its safety. Weng and Xue (2015) assured that nighttime ship collision frequency was observed to be much greater than daytime ship collision frequency. Hirdaris et al. (2020) showed that remote piloting might be a safe choice on a few fairways under controlled circumstances.

Zhou et al. (2015), Cho et al. (2020a) and Cho et al. (2020b) had mentioned the importance of fairway size, as the studies showed that for a particular port quality of service, fairway size is associated with the safety level, and that the bigger the capacity of the fairway, the lower the safety level. Additionally, according to Cho et al. (2020a), the safety distance between the ship's path and structural stiffness was found to be 0.18 times for two-way traffic and 0.23 times for one-way traffic.

Also, Cho et al. (2020b) indicated that traffic distribution for each port can be taken into account while building river bridges. A similar issue is made by Park et al. (2022), who stated that it would be ideal to employ a design strategy that takes collision and stranded risk models into account when constructing new fairways or assessing those that already exist.

Another idea is discussed by Liu et al. (2022), which is related to identifying the best turnaround zone and fairway usage patterns at the same time to reduce terminal stress. A multi-objective optimization model's two optimization variables are the minimal overall scheduling time and the total waiting time. Results indicated that the entire scheduling time and the total waiting time for vessels are, respectively, reduced by around 20 minutes and an hour when compared to the operation phase. The practical approach improved turning zone and fairway accessibility in addition to substantially boosting safety and effectiveness.

Navigation Aids

The effective operation of navigational aids is another crucial element that is essential to the safety and ease of navigation of fairways following a storm (ATONs). ATONs are usually found on water and aid boats and seamen in navigating the waters. Equipment like this includes day beacons, minor lights/beacons, and buoys with or without lights. Some of these ATONs may sustain damage during extreme weather conditions (Brock et al., 2013). However, such sophisticated technology can burden navigators more and jeopardise the safe operation. To give navigators alternate data for a safer operation, advanced IT-based navigation systems are also being developed. It is vital to investigate the current drawbacks of various types of navigation equipment and prospective remedies from the navigators' point of view because it cannot be assumed that all sensor arrays offer navigators pertinent knowledge (Kwon et al., 2016).
The navigational aids represent important support that guarantee the safety of shipments. This point is studied by previous research, where different navigational aids are investigated. The Automatic Identification System (AIS) was studied by Wilhoit et al. (2014) as a cyber-physical system (CPS) that is utilized by ship pilots and authorities as an observer and navigation aid to prevent ship crashes. Findings showed how to use AIS to connect all transmitters deployed on ships and other maritime structures, including lighthouses, buoys, AIS gateways, vessel traffic services, and aircraft used for search and rescue (SAR) missions.

Artificial intelligence was also studied by Soares et al. (2014), in which the main goal was to study the navigation and collision provenance of ship handling using artificial intelligence, the results revealed that the vessel model using navigation tools profitably prevented one ship from crashing, while the other did not. This result shows the importance of navigational aids in providing safety and preventing collisions.

Through the incorporation of information display, Hareide and Porathe (2019) sought to improve the navigator's situation awareness (SA). It was proved that to enable safe navigation, it might decrease the navigator's cognitive effort while he or she is necessitated to keep vigilant awareness of what is happening outside the window. But before Maritime Augmented Reality (M-AR) is operationalized, the Technology readiness level (TRL) must be raised, and additional analysis must be done before choosing the design and the data that should be displayed in AR. Accordingly, the vigilant awareness and technological readiness awareness represent two main factors that offer safety.

Dahlman et al. (2022) aimed to study an Advanced Intelligent Maneuvering that can be used as alert during traffic to avoid ships' crashes and the benefits of navigation overall. The findings proved that participants view the decision support system as a tool for advice in visualizing potential traffic scenarios, a task that is currently problematic for most navigators.

Ship Berthing

The procedure of berthing a ship is difficult due to the growth of large ships, in particular, VLCC, cargo ships, and large container boats. Berthing energy is produced when a ship and a port structure make contact, and berthing velocity is its primary component. Additionally, berthing is a procedure in which the distance and speed gradually drops to zero for the safety of the ship and the port, whereas the needed unberthing speed is lower once the ship has left the fender. As a result, port management, pilots, and captains now prioritize keeping berthing safe. The surrounding area of the vessel must be precisely calculated regarding the berthing speed and the distance of approach during berthing. To help safe the safety of the vessel and the port, it is crucial to research ship location and surveillance close to the coastline (Chen and Li, 2021).

Hsu (2015) identified many factors that provide safety to ship berthing at harbor piers, which are worker concentration, the state of fixed support, emergency reaction, harbor strategy of improving decision-making, and berth lengths. Nguyen and Im (2019) aimed to study how to maintain ship berthing by using technology and the outcomes demonstrated that using advanced technology makes the ship's berthing support system perform effectively. On the other hand, Kang and Park (2016) examined the conditions of the ships using the final spot for more hazardous products than they could adapt. The findings revealed that a ship with a maximum limit that was three times that of the maximum berth capacity was moored at the berth. This study put a focus on the importance of capacity.

Cho et al. (2020) estimated the danger threshold of a hazardous berthing speed when the ship approached the port using a machine learning algorithm. During testing utilising the receiving operator's normal curve, the most dangerous range of berthing speed had the biggest region beneath the curve, demonstrating that the threat spectrum was properly graded. It is therefore possible to securely berth a ship because the generated models can categorise and anticipate the risk range of unsafe berthing velocity before entering a port. This is a reference to these derived models' significance. Similar to this, Anning et al. (2021) assessed the risk of berthing dangerous cargo boats. According to the results, even though the problematic container ship threat has a considerably lower likelihood under normal conditions, it still cannot be ignored and needs to be handled because of its high relative risk. According to this study, environmental and human variables play the largest roles in hazardous shipping accidents.

Cho et al. (2022) found a correlation between the type of pilot and ship berthing, identifying three categories of pilots: cautious, efficient, and hazardous. A substantial difference between the cautious and dangerous kinds was also revealed by the analysis of variance.

3. RESEARCH METHODOLOGY

To fulfill the study's purpose and goals, the data collected has been the initial step. In this study, data were gathered from experts and decision-makers in maritime industry to determine ship navigation safety in order to generate a study on the factors that affected ship's safety by prioritizing these elements. It is crucial to focus on these factors to know what the safety system lacks from experts' and decision-makers' perspectives to relieve the ship's crashes. A number of 30 experts and decision-makers in maritime industry made the sample size. This sample strategy aims to equip representatives' sample to know their opinion in ship navigation safety, then analyzing and organizing these opinions from the highest important to the least important by converting them into a number by AHP method. The methods and resources used to collect research data are detailed in the data analysis section.

4. DATA ANALYSIS

This section shows the applied AHP analysis, where data are collected from 30 experts and decision makers to identify the service attribute of a port for ship navigation safety. The analysis is presented in the following sub-sections.

Selection of the Port's Service Attribute for Safer Way of Navigation

Five factors are analyzed to identify the best service attribute that the port must follow to reach a safer way of navigation. These factors are Vessel Traffic, Marine Pilot, Fairway Traffic, Navigation Aids and Ship Berthing. Each of these factors contains a number of codes, which are shown in Table I. The following factors and codes are used in the analysis.

Table I: Factors of Port's Service Attribute for Safer Way of Navigation

Construct	Service Attribute
Vessel Traffic	VT1: The effectiveness of VTC regulators in responding to vessel enquiries
	VT2: The ability of VTC to communicate in English
	VT3: The VTC regulator warns ships of the time and location of the pilot pickup
	VT4: The VTC provides information about weather, traffic, and geographical features of the port
Marine Pilot	MP1: The marine pilot indicates an appropriate location to embark
	MP2: The marine pilot has a professional piloting ability
	MP3: The ability of marine pilot to communicate English language
	MP4: The service attitudes of the marine pilot
Fairway Traffic	FT1: The fairway and anchorages are occupied by fishing boats.
	FT2: The management of vessel traffic in the fairways
	FT3: The procedures used by small boats to prevent collisions with inbound and outbound vessels
	FT4: The measures taken by the port administration to stop small boats from blocking fairways

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.093

Construct	Service Attribute
Navigation Aids	NA1: The layout of the anchorages and fairways
	NA2: The harbor's landmarks and lighthouses
	NA3: The lighted buoy used to indicate the difference between the inbound and outbound lanes
Ship Berthing	SB1: the quantity of tugboats needed to help berth and unberth the ships
	SB2: The horsepower of the tugboat helps vessels in berthing and departing
	SB3: The tugboat driver's qualifications to help vessels berth and leave
	SB4: The measures mooring boats take to help vessels berth and depart

Ranking the Preference of the Main Five Factors

The ranking is identified through making a pairwise comparison matrix, decision matrix and the weight of the five factors. The values of the factors constructed from the responses are shown in Table II.

Table II: Values of Main Factors

Dimen-sions	VT	MP	FT	NA	SB
VT	1.00	0.26	0.34	0.45	0.68
MP	3.84	1.00	0.99	1.69	2.39
FT	2.92	1.01	1.00	1.12	2.06
NA	2.22	0.59	0.89	1.00	1.52
SB	1.47	0.42	0.48	0.66	1.00
SUM	11.46	3.28	3.70	4.92	7.66

From Table II the criteria weight (CW) and weighted sum vector (WSV) are calculated, where they are used to calculate the consistency of the numbers that are checked by calculating the λmax Random Consistency value (RC), Consistency Index (CI), and Consistency Ratio (CR) as shown in Table III.

Table III: CW and WSV Values of the Main Five Factors

CW	WSV
0.55	2.73
1.98	9.72
1.62	8.29
1.25	6.31
0.80	4.04

λmax= (WSV1/CW1) + (WSV2/CW2) + (WSV3/CW3) + (WSV4/CW4) + (WSV5/CW5) / no. of criteria

= ((2.73/0.55) + (9.72/1.98) + (8.29/1.62) + (6.31/1.25) + (4.04/0.80)) /5 = 5.0155491

CI= (λmax – no. of criteria) / (no. of criteria – 1)

= (5.0155491-5)/4 = 0.0038773

CR= CI / Random Consistency Index

= 0.0038773/1.12 = 0.0034708

It is concluded that CR value is < 0.1. Thus, the values are acceptably consistent. After that the pairwise comparison of the five factors is done as shown in Table IV. From Table IV that indicates pairwise comparison, the decision matrix is obtained. MP is the first in ranking followed by FT. The third rank is NA, while the fourth is SB and the final rank is VT.

Table IV: A Pairwise Comparison Matrix for Main Five Factors

	GM	W
VT	0.49	8.81%
MP	1.73	31.25%
FT	1.47	26.59%
NA	1.12	20.31%
SB	0.72	13.04%
Sum	5.53	100.00%

Ranking the Preference of Vessel Traffic

The ranking is identified through making a pairwise comparison matrix, decision matrix and the weight of vessel traffic. The values of the factors constructed from the responses are shown in Table V.

Table V: Values of Vessel Traffic

Dimen-sions	VT1	VT2	VT3	VT4
VT1	1.00	0.32	0.39	0.79
VT2	3.14	1.00	1.20	2.61
VT3	2.58	0.83	1.00	2.07
VT4	1.27	0.38	0.48	1.00
SUM	8.00	2.54	3.07	6.47

From Table V the criteria weight (CW) and weighted sum vector (WSV) are calculated, where they are used to calculate the consistency of the numbers that are checked by calculating the λmax Random Consistency value (RC), Consistency Index (CI), and Consistency Ratio (CR). However, Table VI shows CW and WSV Values of Vessel Traffic.

Table VI: CW and WSV Values of Vessel Traffic

CW	WSV
0.62	2.50
1.99	7.94
1.62	6.51
0.78	3.12

ʎmax= ((2.50/0.62) + (7.94/1.99) + (6.51/1.62) + (3.12/0.78)) /4 = 4.0004574
CI= (4.0004574 - 4)/3 = 0.0001525
CR= 0.0001525 / 0.9 = 0.0001694
It is concluded that CR value is < 0.1. Thus, the values are acceptably consistent.
After that the pairwise comparison is done as shown in Table VII. From the table of pairwise comparison, the decision matrix is obtained. VT2 is the first in ranking followed by VT3. The third rank is VT4, while the fourth is VT1.

Table VII: A Pairwise Comparison Matrix of Vessel Traffic

	GM	W
VT1	0.56	12.46%
VT2	1.77	39.55%
VT3	1.45	32.44%
VT4	0.70	15.55%
Sum	4.48	100.00%

Ranking the Preference of Marine Pilot

The ranking is identified through making a pairwise comparison, decision matrix and the Marine Pilot weight. The values of the factors constructed from the responses are shown in Table VIII.

Table VIII: Values of Marine Pilot

Dimen-sions	MP1	MP2	MP3	MP4
MP1	1.00	0.24	0.29	0.45
MP2	4.17	1.00	1.15	1.84
MP3	3.47	0.87	1.00	1.41
MP4	2.22	0.54	0.71	1.00
SUM	10.85	2.66	3.14	4.70

From Table VIII the criteria weight (CW) and weighted sum vector (WSV) are calculated and they are used to calculate the consistency of the numbers, as it is shown in Table IX.

Table IX: CW and WSV Values of Marine Pilot

CW	WSV
0.49	1.97
2.04	8.09
1.69	6.76
1.12	4.52

ʎmax= ((1.97/0.49) + (8.09/2.04) + (6.76/1.69) + (4.52/1.12)) /4 = 4.001986392
CI= (4.001986392 - 4)/3 = 0.0006621
CR= 0.000662131 / 0.9 = 0.0007357
It is concluded that CR value is < 0.1. Thus, the values are acceptably consistent. After that the pairwise comparison is done as shown in Table X. From the table of pairwise comparison, the decision matrix is obtained. MP2 is the first in ranking followed by MP3. The third rank is MP4, while the fourth is MP1.

Table X: A Pairwise Comparison Matrix of Marine Pilot

	GM	W
MP1	0.42	9.26%
MP2	1.72	37.90%
MP3	1.44	31.67%
MP4	0.96	21.18%
Sum	4.54	100.00%

Ranking the Preference of Fairway Traffic

The ranking is identified through making a pairwise comparison, decision matrix and the Fairway Traffic weight. The values of the factors constructed from the responses are shown in Table XI.

Table XI: Values of Fairway Traffic

Dimen-sions	FT1	FT2	FT3	FT4
FT1	1.00	0.40	0.48	0.87
FT2	2.50	1.00	1.24	2.23
FT3	2.07	0.81	1.00	1.59
FT4	1.16	0.45	0.63	1.00
SUM	6.73	2.66	3.35	5.69

From Table XI CW and WSV are calculated, where they are used to calculate the consistency of the numbers in Table XII.

Table XII: CW and WSV Values of Fairway Traffic

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ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.093

CW	WSV
0.69	2.75
1.74	6.96
1.37	5.48
0.81	3.25

λmax= ((2.75/0.69) + (6.96/1.74) + (5.48/1.37) + (3.25/0.81)) /4 = 4.0039573
CI= (4.003957267 - 4)/3 = 0.001319089
CR= 0.001319089 / 0.9 = 0.001465655
It is concluded that CR value is < 0.1. Thus, the values are acceptably consistent. After that the pairwise comparison is done as shown in Table XIII. From the table of pairwise comparison, the decision matrix is obtained. FT2 is the first in ranking followed by FT3. The third rank is FT4, while the fourth is FT1.

Table XIII: A Pairwise Comparison Matrix of Fairway Traffic

	GM	W
FT1	0.64	14.91%
FT2	1.62	37.74%
FT3	1.28	29.74%
FT4	0.76	17.61%
Sum	4.29	100.00%

Ranking the Preference of Navigation Aids

The ranking is identified through making a pairwise comparison, decision matrix and the Navigation Aids' weight. Values of the factors constructed from the responses are shown in Table XIV.

Table XIV: Values of Navigation Aids

Dimensions	NA1	NA2	NA3
NA1	1.00	1.09	2.17
NA2	0.91	1.00	1.92
NA3	0.46	0.52	1.00
SUM	2.38	2.61	5.09

From Table XIV the criteria weight (CW) and weighted sum vector (WSV) are calculated and are used to calculate the consistency of the numbers which is obvious in Table XV.

Table XV: CW and WSV Values of Navigation Aids

CW	WSV
1.42	4.25
1.28	3.85
0.66	1.98

λmax= ((4.25/1.42) + (3.85/1.28) + (1.98/0.66)) /3 = 3.0001415
CI= (3.0001415 - 3)/2 = 0.0000708
CR= 0.0000708 / 0.58 = 0.000122014
It is concluded that CR value is < 0.1. Thus, the values are acceptably consistent. After that the pairwise comparison is done as shown in Table XVI. From the table of pairwise comparison, the decision matrix is obtained. NA1 is the first in ranking followed by NA2, while the third is NA3.

Table XVI: A Pairwise Comparison Matrix of Navigation Aids

	GM	W
NA1	1.33	42.18%
NA2	1.21	38.17%
NA3	0.62	19.65%
Sum	3.16	100.00%

Ranking the Preference of Ship Berthing

The ranking is identified through making a pairwise matrix, decision matrix and the Ship Berthing's weight. The values of the factors constructed from the responses are shown in Table XVII.

Table XVII: Values of Ship Berthing

Dimensions	SB1	SB2	SB3	SB4
SB1	1.00	0.31	0.43	0.89
SB2	3.24	1.00	1.41	3.17
SB3	2.31	0.71	1.00	2.24
SB4	1.13	0.32	0.45	1.00
SUM	7.68	2.33	3.29	7.29

From Table XVII the criteria weight (CW) and weighted sum vector (WSV) are calculated, where they are used to calculate the consistency of the numbers as represented in Table XVIII.

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ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.093

Table XVIII: CW and WSV Values of Ship Berthing

CW	WSV
0.66	2.65
2.20	8.83
1.56	6.26
0.72	2.86

λmax= ((2.65/0.66) + (8.83/2.20) + (6.26/1.56) + (2.86/0.72)) /4 = 4.0011487
CI= (4.001148686 - 4)/3 = 0.000382895
CR= 0.000382895 / 0.9 = 0.0004254
It is concluded that CR value is $<$ 0.1. Thus, the values are acceptably consistent. After that the pairwise comparison is done as shown in Table XIX. From the table of pairwise comparison, the decision matrix is obtained. SB2 is the first in ranking followed by SB3. The third rank is SB4, while the fourth is SB1.

Table XIX: A Pairwise Comparison Matrix of Ship Berthing

	GM	W
SB1	0.59	12.88%
SB2	1.95	42.87%
SB3	1.38	30.38%
SB4	0.63	13.88%
Sum	4.55	100.00%

Ranking of Preferences Graphically

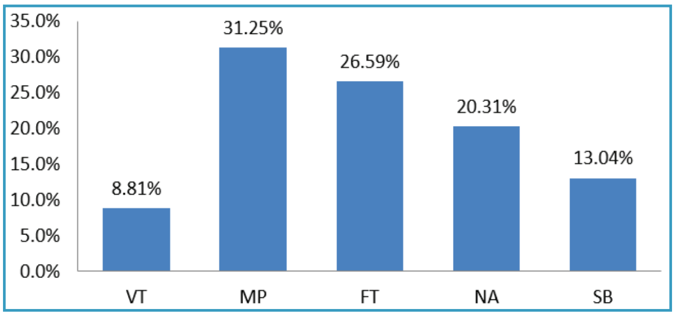

Fig. 1. Weight of the port's service attribute for ship navigation safety

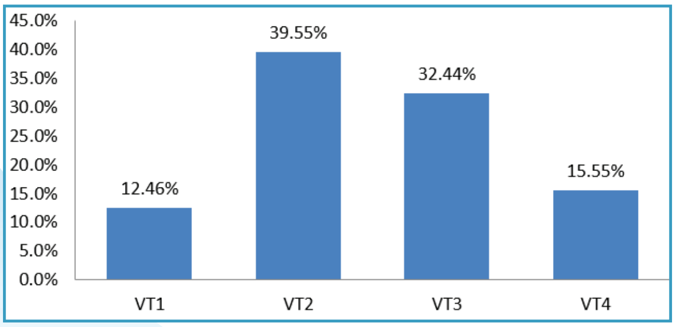

Fig. 2. Weight of Vessel Traffic

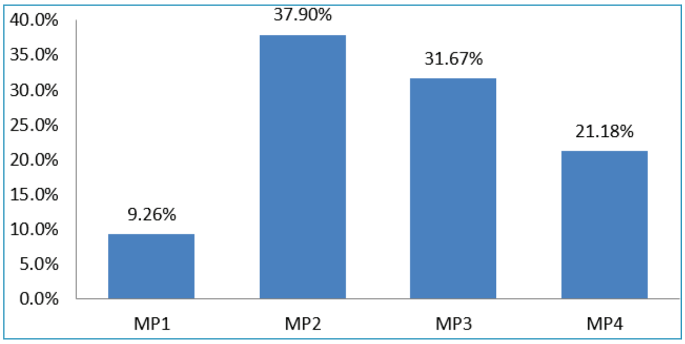

Fig. 3. Weight of Marine Pilot

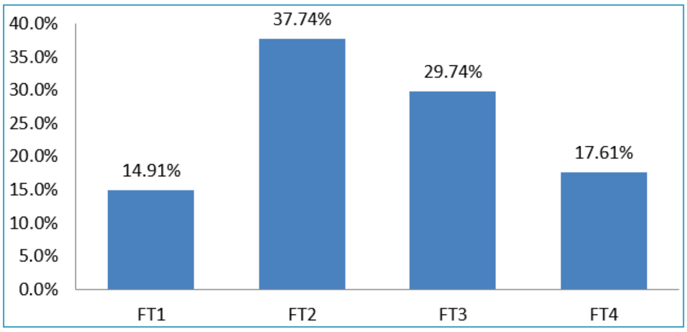

Fig. 4. Weight of Fairway Traffic

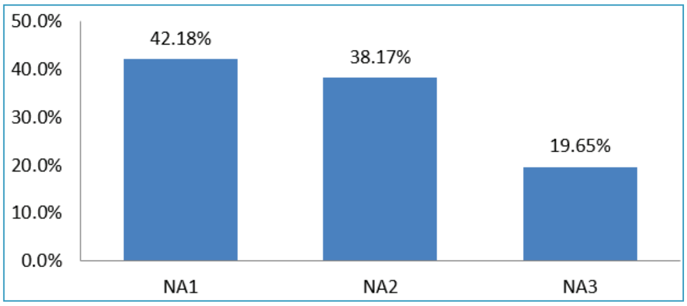

Fig. 5. Weight of Fairway Traffic

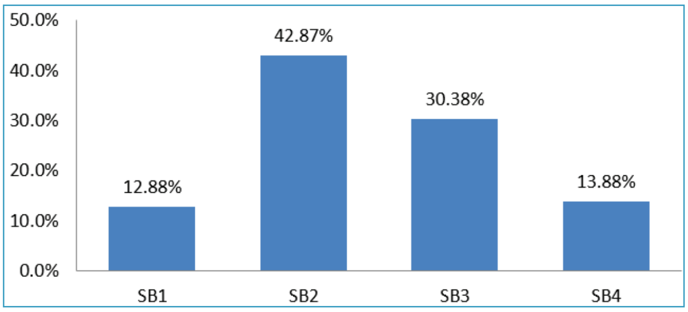

Fig. 6. Weight of Ship Berthing

DISCUSSION

The initial goal of the study is to prioritize the factors that affected ship's safety and relieve collisions by asking many experts and decision-makers to know the factors arranged from the highest to the least one. In this research there are 5 factors that affected ship's safety and asking whether these can be manipulated, will either reduce ship collisions or not. These elements were vessel traffic, marine pilot, fairway traffic, navigation aids and ship berthing, respectively.

By ranking the preferences of vessel traffic, vessel traffic is the first item affected ships' safety. Vessel container and supplemental navigation system did not deal well with measuring the distance to the port, gauging the speed and vessels' size, but for doing these measures one has to modify the vessel traffic service (VTS) to reduce the difficulty in the system and to be more simplified (Dahlman et al., 2015; Goh et al., 2019; Hoogendoorn et al., 2019; Qiu et al., 2020; Ye et al., 2019; Srše et al., 2021). These aforementioned studies were consistent with the researcher's view about maintaining vessel traffic, while there are some authors who showed that to maintain vessel traffic by vessel traffic service is to combine with other systems like the system for marine geographic or an ex-change data according to the situation as stated by Park and Bang (2016) and Jin et al. (2017)

Marine pilots came in the second level of preferences as no doubt the humans' element in every sector is important as man is the one who manages the system. In maritime industry, pilots are a very important element since if they make any mistake, this will threat the ship's safety. Marine pilots were attributed by many factors which were: simulation training as if the simulation training is simple and understandable it will be more effective; instructors' way in giving the training; how the instructor delivers the information and how the pilots can use the navigation system; also the relationship between the instructor and pilot; the mental and psychological interaction and how the pilots deal with the stress and load in work and how they are trained to maintain the stress in work during the simulation training. This in addition to behavior attributes by dealing with the risk level and trying to be safe from collisions by every possible means onboard the ship. Finally, technology training is the best way to enhance the pilots' level to professional ability to deal with every situation (Sellberg 2017; Orlandi and Brooks, 2018; Sellberg 2018; Kalulu 2018; Mateichuk et al., 2020; Fu et al., 2021) and these studies are consistent with the researcher's variables.

The third one is fairway traffic and how fairway is crucial in maritime industry. After the ship arriving at to the port, the most important step is how the ship will pass from the waterway until berthing. There are factors that impacted the fairway and caused ships' collisions which were: the width of the crossing waterway related to the ship's width, the relation between fairway size and safety level as the higher fairway level, the lower security level, the safety level between ship's structure and ships' route depends on whether the fairway is one-way or two-ways, and the schedule time for arriving and departure and how the port will manage it (Ai and Ding, 2014; Weng and Xue 2015; Zhou et al., 2015; Cho et al., 2020a; Cho et al., 2020b; Liu et al., 2022). These mentioned studies were consistent with the researcher's variables, while Hirdaris et al. (2020) and Park et al. (2022) showed that maintaining fairway should be by applying technology models as sensor to the ship and the control room to indicate that there is threat in a very simple way.

Navigation aids have some difficulties to help marine pilots in visualizing scenarios and in choosing the best one. The implementation of more lighthouses and buoys in the vessel traffic service, the calculation of the distance of port and vessel speed in each step from departure and berthing to the new port, and the sending of a simple notification with the problem were among these challenges (Wilhoit et al., 2014; Soares et al., 2014; Perera and Soares, 2017; Kwon et al., 2016; Dahlman et al., 2022). These mentioned studies were consistent with the researcher's variables.

The last preference is ship berthing. One of the critical elements in marine industry is how to maintain the berth and unberth to the ships. The berth was assigned by motions and maximum mooring line loads, the location of ship if it is close to yard or not, the speed of ships during berthing, and berth lengths are the primary safety variables influencing ship berthing at harbor piers, all these factors affected berthing and reducing safety level. (Hsu 2015; Kang and Park 2016; Nguyen and Im 2019; Cho et al., 2020a; Anning et al., 2021; Cho et al., 2022). These mentioned studies were consistent with the researcher's variables.

By reviewing all the variables that lead to maritime safety, the research's goals and purpose have been reviewed and the findings have been confirmed. Based on these results, conclusions have been reached. The recommendations made in the next section are based on the findings.

CONCLUSION

The current study concentrates on how to reduce ships' collisions by prioritize the factors that caused threat to maritime navigation safety. First, it might be helpful to think about how to reinforce the simulation maritime training to reduce risks and hazards. Future studies should focus more on improving simulation training rather than other factors including marine behaves and instructors' way with students, and the technology used to advance the education process to prepare professional pilots and relieve ships' collisions as much as one can for helping marine environment.

LIMITATIONS

The study focuses on a very limited number of experts and decision-makers, while the next research should focus on a bigger number and include in the survey pilots, software-engineers and workers as it will help in the analysis and knowing the threats from other perspectives and it will also be beneficial in the prioritization of the factors which lead to decrease the safety level.

By ranking vessel traffic as the first item that leads to ships' collisions, future studies should reinforce and confirm this study's conclusion. There is lack of research in how language enhance communication between the control room and pilots, especially the English language as it is the very common language worldwide. Also, in vessel traffic factors there is lack of research about how to advance technology to warn the ship if there is a threat. In the maritime pilots' element, the research that deals with service attitude and language is limited, while there are numerous studies that tackle the psychological behavior. In the same time, simulation training should cover service attitude also as the pilots have to be calm so as not to get into crashes. In addition, there are pilots from all over the world so we have to concentrate on which level of English they have and standardize an English accent for decreasing the misunderstanding between the control room and pilots.

In the aids to navigation (ATN), there is a gap in the research about the importance of the lighthouse, landmarks in port, and buoys to indicate the inbound and outbound lanes and how they decrease ships' crashes. The research concentrates on building more simple models to the pilots who neglect the signals and that can help and be cheap. There are also gaps in managing tugboats to help the big ships not to crowd in port. The third limitation is the qualification in general and the drivers' qualification specifically and how they will help in berthing and departing more precisely without collisions.

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Maritime Research and Technology

MRT
ISSN 2812-5622

http://dx.doi.org/10.21622/MRT.2023.02.2.108

Toward Implementing The Marine Spatial Planning Approach In The Egyptian Marine Areas

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Received on: 11 April 2023 Accepted on:01 July 2023 Published on: 20 July 2023

ABSTRACT

Purpose: *The concept of Blue Economy focuses on the sustainable utilization of maritime resources. Egypt, with its extensive coastline of approximately 3000 km, has dedicated various marine regions for both traditional activities such as shipping routes and fisheries, and newer sectors like oil and gas exploration and fish farms, leading to conflicts among stakeholders whether among users or between users and the marine environment.*

Design/Methodology/Approach: *This research paper analyses the data collected from peer-reviewed articles, identifies, and examines case studies of real-world applications of the Marine Spatial Planning (MSP) approach, and provides policy recommendations for decision-makers, stakeholders, and academic researchers interested in understanding the possibilities, challenges, and mitigation strategies associated with adopting this approach in Egypt. Due to the absence of an Egyptian MSP and limitation of domestic scientific research in this field, this paper will serve as a valuable source of information on MSP in the country.*

Findings: *The outcomes were summarized as follows: To address the limitations in implementing Marine Protected Areas (MPAs) and Integrated Coastal Zone Management (ICZM), Carbon Capturing and Storage (CCS) in Egypt, adopting the (MSP) approach is proposed as a suitable tool for managing marine ecosystems and resolving conflicts among ocean users. This approach can support decision-makers in achieving sustainable development goals (SDGs). Successful implementation of the MSP initiative in Egypt requires key conditions: stakeholder engagement from the beginning of the process, a legally-binding framework, a designated ministry, and effective monitoring and evaluation.*

Key-words:
MSP, ICZM, MPAs, CCS, SDGs.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.108

1. INTRODUCTION

The scientific name of the earth is the blue planet because both the sky and sea are blue while the economic idiom of the Blue Economy backs to a sustainable ocean economy (Hazra & Bhukta, 2022). In recent years, the blue economy notion has gained a global popularity and it is a political tool in hand decision-making to achieve strategic planning. In addition, it concerns how to utilize maritime resources in a sustainable way (Hazra & Bhukta, 2022).

The 2008 world economic crisis encouraged countries to rely on strategies and development agendas to promote their economies, so the term green economy appeared, while Small Island Developing States (SIDS) relied on their marine resources to achieve social, economic, and environmental goals. Thus, the Blue Economy notion appeared after the United Nations conference on sustainable development at Rio de Janeiro 2012 in Brazil (Kabil et al., 2022).

The Marine Ecosystem Based Management (MEBM) manages human activities in coastal and marine zones while improving and maintaining marine ecosystem services and social benefits (Gacutan et al., 2022). Moreover, it is the best way to maintain a balance between protecting the maritime environment and achieving sustainable development. Furthermore, it includes various tools such as the (MPAs) (Kriegl et al., 2021), The ICZM, MSP, and activities that support the Carbon Capturing and Storage technique (CCS) (Abd El-Hamid & Hafiz, 2022). In addition, the Ecosystem Based Management (EBM) has developed to achieve the Sustainable Ocean Governance (SOG). Additionally, MSP as an implementation tool has helped EBM to achieve significant improvements in SOG (Alam, 2020).

The MSP Definitions

The MSP approach defines by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) as "Marine spatial planning (MSP) is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process". In contrast, the first mention of the term MSP in European countries was in 2001 (Zaucha & Gee, 2019). In the last decade, the MSP approach has gained global popularity and more than 70 countries have moved toward EBM of the marine environment by adopting the MSP initiatives. It is expected that by 2030 one-third of the globe's EEZ will be regulated by the MSP. In addition, there are only two countries in the middle east namely the United Arab Emirates and Israel as a regional competitive (Patera & Pataki, 2022) See figure (1).

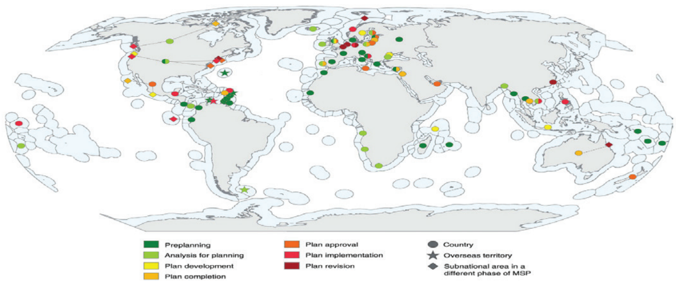

Fig. 1. World Status of the MSP Approach
Source: (Santos et al., 2019).

Egypt's Coastal Regions

Egypt is a developing coastal state with a population of approximately 107 million people and is expected by 2060 to be approximately 174 million people (Chamie, 2022). Furthermore, Egypt owns about 3000 km of coastline:1850 km along the Red Sea coast and 1150 km along the Mediterranean Sea coast (Kabil et al., 2022). In addition, coastal regions have strategic importance because approximately one-third of Egyptian people live in coastal cities; about 35 million people and about 40 % of industrial and tourism activities are located in it (Hegazy, 2021). Egypt has 13.4 million acres of marine areas and lakes. It saves about a quarter of the Egyptian food of protein annually, even though Egypt suffers from a shortage in fish production (Shehata & Eldali, 2022). Moreover, approximately 586,123 people work in the aquaculture sector, and more than one million are directly and indirectly employed in fisheries and aquaculture (Wuyep & Rampedi, 2018).

According to the Egyptian strategy and Vision 2030 toward achieving sustainable development of marine resources, applying coordinated Marine Spatial Planning in sensitive marine areas such as the Gulf of Suez is essential to manage various maritime activities such as oil and gas explorations, coastal tourism activities, shipping, ports infrastructure and development via practical planning, coordination between different sectors, and sustainable exploitation of sea resources.

On the other hand, the Blue Economy in Egypt has many challenges such as unexploited marine resources in the Red Sea such as Hurgada, Safaga, and Al Qussier in terms of marine pollution, habitat loss and the collapse of the marine ecosystem services and goods (Kabil et al., 2022). Thus, the MSP approach is an appropriate management tool in the hand of decision-makers to regulate human activities in the marine environment.

Egypt is a signatory to many conventions related to marine environment protection, and the Egyptian environmental regulations are governed by Law No.4 of 1994 and 2015 amendments. Moreover, it granted the Egyptian Environment Affairs Agency (EEAA) the authority to formulate policies and plans regarding environmental protection and to monitor the implantation of such policies and plans.

On the other hand, the current legal framework of maritime environment protection in Egypt has many defects in terms of regulations that need to be more comprehensive with a wide range of enforcement and monitoring for some environmental issues such as marine pollution, marine stakeholders' engagement including private sectors, and facilitating of people's awareness about marine environment issues (Thabit et al., 2022).

Fisheries and aquaculture are highly vulnerable sectors to climate change impacts (E-IRG, 2022), while renewable energy and oil and gas explorations are less vulnerable to climate change impacts. Moreover, the current legal framework does not adopt the MSP approach because the MSP approach is a new notion, and few people are familiar with.

Determining marine stakeholders and their disputes, their engagement in the process, and specifying an authority for their earlier engagement in the approach are rare issues with the beginning of the MSP approach. Furthermore, the MSP approach is an effective management tool to benefit of the coastal marine resources but not at the expense of the marine environment.

This paper provides decision-makers, stakeholders, and academic researchers with why the MSP is relevant to Egypt's marine regions issues, possibilities, challenges, and mitigation strategies associated with adopting the MSP approach in Egypt.

Comparison between Different Marine Ecosystem based Management Approaches in Egypt

The suitable harnessing of marine resources, reducing human activities' impacts on the marine environment, decreasing the impacts of land-based activities, and improving land-sea interactions enable countries to achieve the United Nations Sustainable Development Goals (SDGs). Moreover, to do so, a comparative analysis between MEBM approaches to attain sustainable ocean governance is struck as follows:

The Marine Spatial Planning Approach (MSP)

The concept that became MSP traced its roots to 1976, when the states were given the right to establish their Marine Protected Areas (MPAs) to safeguard the marine environment from degradation caused by human activities. In addition, the Marine Spatial Planning (MSP) approach was initially employed to enhance the management of the MPAs. Moreover, in the 1980s, Australia's Great Barrier Reef Marine Park (GBRMP) was among the best-known examples of an ocean zoning plan used in marine conservation (Johnson et al., 2020).

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO) UNESCO-IOC the MSP is defined as "the use of the sea areas to minimize conflicts between human activities and maximize benefits while ensuring the resilience of marine ecosystems" (Thenen et al., 2021). In addition, it often establishes defined zones that specify allowed uses and limitations within a specified marine region. Moreover, Egypt's Vision 2030 expressed a desire to generate more rigorous management and monitoring approaches concerning maritime environment breaches to ensure that these activities are compatible with international environmental measures, encourage sustainable approaches for fisheries to sustain ecosystems and marine biodiversity, and implement programs for improving the technological and managerial capacities of persons involved in coastal and maritime environment management.

The MSP approach links sectors, individuals, locations, coastal development, and biodiversity. In addition, it plans agendas for long-term ocean governance and is a vital instrument for identifying and operating marine areas. Moreover, it resolves conflicts between stakeholders in the marine environment, attains economic benefits for people, and at the same time safeguards marine environment protection. Besides, the MSP manages marine resources and attains a long-term blue economy (Santos et al., 2019).

The MSP has many names, including ocean zoning, ocean planning, and sea use management (Santos et al., 2019). Therefore, ocean zoning specifies and protects important regions for marine biodiversity, which is identified globally in the Convention on Biological Diversity (CBD) and the UN Agenda 2030 for Sustainable Development (Harris et al., 2022). Ocean zoning is a toolbox or technique to attain a balance between human activities such as tidal power plants and offshore wind farms and safeguard the marine environment from degradation (Lukambagire, 2019). In other words, zoning is a process for executing MSP in specified marine areas.

The main aim of using the MSP approach is to achieve the United Nations Agenda for the SDGs via managing blue economy resources to end poverty and save job opportunities for people (Harris et al., 2022).

Marine Protected Areas (MPAs)

The first national marine protected area established in Egypt was Ras Muhammed in 1983, aiming to protect the most vulnerable marine resources and promote marine ecosystem conservation (Jawad, 2021). Moreover, some national MPAs in Egypt have gained global popularity because they are tourist destinations, such as Ras Mohamed MPA, and they have national importance because of their contribution to the national GDP. In addition, Ras Mohamed MPA is assigned only for tourist diving activities, and it has high levels of control and protection against human impacts such as sewage and fishing (Nour et al., 2022).

The biggest drawback of the MPAs is the failure to address the damage to the marine environment in the adjacent areas (Madarcos et al., 2022). Moreover, there is a high concentration of macroplastics (>5mm) in the national MPAs in the Sallum Gulf as a result of the absence of regional cooperation (Hatzonikolakis et al., 2022) . In addition, the MAPs are not maintaining the entire marine ecosystem's health (Santos et al., 2018).

Integrated Coastal Zone Management (ICZM)

The ICZM concept was first introduced during the 1992 Rio de Janeiro Earth Summit in Brazil. As a result of low-lying, Nile Delta is vulnerable to climate change impacts and sea level rise (Sharaan et al., 2022). Thus, long-term sustainable management calls for implementing the ICZM approach in Egypt. In addition, the government of Egypt implemented the framework program for ICZM in 1996 to enhance readiness, build capacity, and improve coastal elasticity (World Bank Group Report, 2022).

In addition, the ICZM helps in addressing land-sea interactions to mitigate the reasons for water pollution, illogical land usage, the collapse of natural habitats, coastal erosion and flooding, climate change impacts, and SLR. Moreover, at the beginning of applying the ICZM, successful examples have been given, such as the successful exploitation of the Matrouh coastline and the coastal protection from severe impacts of climate change (coastal erosion, flooding, and sea level rise) in the low-lying coastal area in the Nile Delta.

On the other hand, the Egyptian's ICZM approach has many flaws, including the irregular and short-term nature of the coastline protection efforts and the poorly managed marine plastic waste, where Egypt generates more than 5.5 million tonnes of plastic waste yearly and Egyptian coasts are the source of some 250,000 tonnes of plastic waste dumped into the Mediterranean Sea. While the amount of plastic waste produced along Egypt's Red Sea shore is smaller than that of the Mediterranean (Habib & Thiemann, 2022).

Nowadays, Egypt witnesses severe climate change impacts such as the shoreline of flood risks in Alexandria, and the competent authority seeks to decrease the flood risks by using tough measures on the shoreline infrastructure protection such as dikes, groins, and sea walls without linking the land use plans with coastline protection development plans and without using nature-based solutions such as using hybrid protection by mixing both dikes and mangrove to increase the coastline protection by about one and a half times more than using tough measures only (Heger et al., 2022).

Recently, Egypt has cooperated with the UN development program to develop low-elevation coastline in the Nile Delta to mitigate sea level rise impacts (Sharaan et al., 2022). In addition, Egypt has adopted an initiative to plant mangroves along the Red Sea coastline to protect beaches from coastal erosion and safeguard biodiversity.

Carbon Capturing and Storage (CCS)

According to the Paris Agreement in 2016, Egypt has pledged to increase clean energy usage to decrease carbon emissions. In addition, the Egyptian strategy and Vision 2030 aim to extract renewable energy from wind farms and solar panels, which play a key role in power generation. Moreover, Egypt has an excellent opportunity for establishing CCS hubs (the blue hydrogen) to decrease the climate change impacts of carbon footprints in the Nile Delta (Abd El-Hamid & Hafiz, 2022), from the new exploration of gas fields in the Mediterranean and the Gulf of Suez, and industrial areas in Alexandria and Suez.

Nowadays, Egypt constructs renewable energy sources such as solar panels and wind farms are utilized to obtain green hydrogen through the electrolysis of water, a process which breaks water down into hydrogen and oxygen. While establishing the CCS is costly, it requires a strict regulatory framework and capacity improvement for modern technology (Esily et al., 2022). In addition, Egypt has not yet ratified MARPOL Annex VI.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.108

Adoption of MSP Approach Procedures

The first step in making the MSP process successful is bridging the gap between dominant economic growth without adversely impacting social and ecological aspects. In addition, the MSP initiatives have already obtained government approval and are currently in effect in 22 countries, accounting for about 27% of the world's (EEZs). Moreover, these include cases where MSP covers the majority of domestic waters in countries such as Belgium, Germany, the Netherlands, and China. While the MSP only covers a small area under national jurisdiction in countries such as the United States, Canada, and Croatia.

The IOC-UNESCO gives a methodological framework for the MSP approach, which contains 10 steps to adopt the MSP (See Figure 2) that can be used in any geographical atmosphere (Pennino et al., 2021):

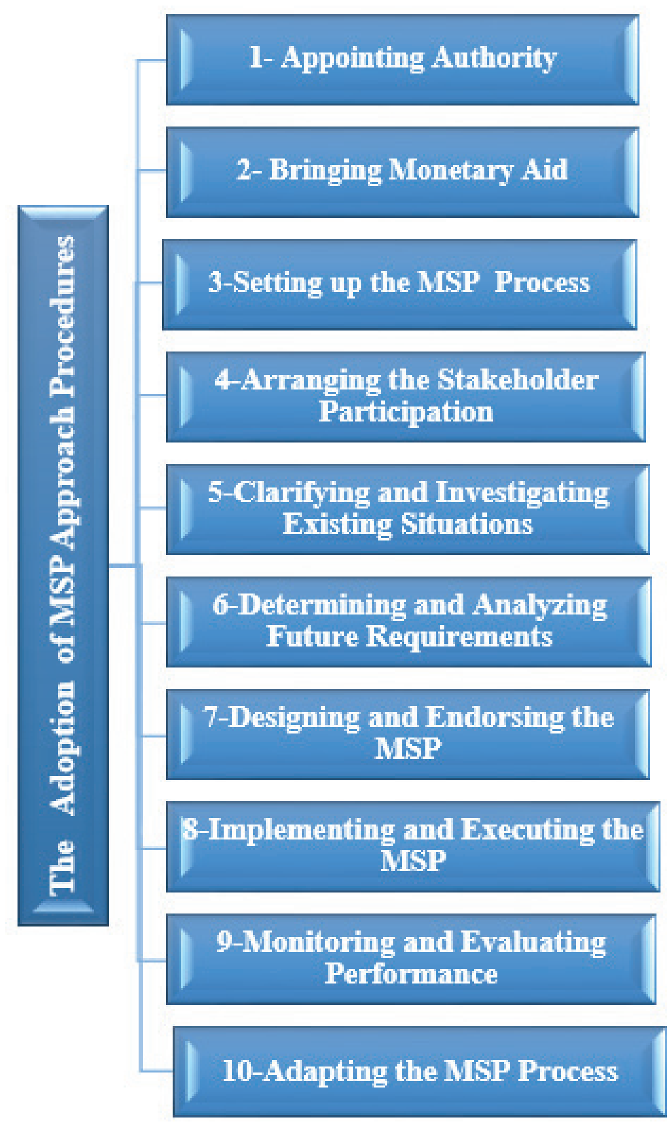

Fig. 2. Adoption of MSP Approach Procedures
Source: (Pennino et al., 2021).

Features and Advantages of the MSP Approach Implementation in Egypt

The MSP approach is characterized by collecting socio-economic and ecological targets in one management technique. In addition, it is a mix between science and management. Furthermore, scientific-based management refers to taking appropriate decisions based on available knowledge about the ecosystem and its dynamics in order to accomplish comprehensive integrated management, which aims to conserve the ecosystem's services and goods of human activities. Moreover, it is a comprehensive and proactive approach dealing with uncertainties and long-term agendas to manage marine resources sustainably, which is why the MSP depends on science and knowledge. (Ryabinin et al., 2019).

The MSP approach deals with time and space to protect biological communities and breeding lands (Ehler et al., 2019). Thus, it attains the EEAA's goals of protecting and safeguarding the marine environment from pollution. The MSP approach is an appropriate tool for managing ocean areas in Egypt because its distinctive biodiversity benefits the country's economy, promotes human welfare and offers regulating and supportive functions. It supports a diverse range of terrestrial and aquatic life forms as well as ecosystems. Egypt is home to a wide variety of ancient plant, animal, and microorganisms. So, the long-term plan could recover endangered or threaten marine species and take appropriate action to prohibit damaging human activities (sewage, heavy metals, shipping routes, and tourists activities) that disturb the marine habitat in the Gulf of Suez (Mohamed et al., 2023).

PRINCIPAL STAGES OF THE MSP APPROACH

The IOC-UNESCO has identified the main stages of the MSP (See Figure 3). Furthermore, for an effective development of the MSP, stages, steps, and tasks should be achieved successfully (Santos et al., 2019)
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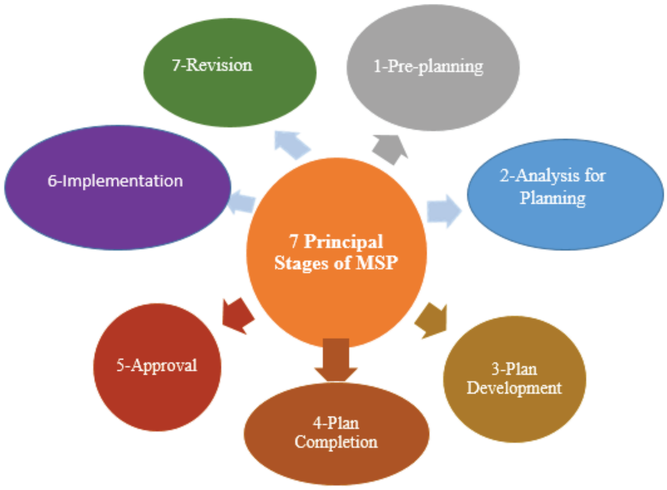

Fig. 3. 7 Steps of Effective Development of the MSP Approach
Source: (Santos et al., 2019).

Possibilities of Implementing the MSP Approach in Egypt

Egypt has coastlines on the Red Sea and the Mediterranean (Amin et al., 2020). Furthermore, Egypt has the River Nile, and marine areas are suitable breeding grounds for different kinds of fauna and flora. In addition, the Red Sea is a safe refuge for about 209 kinds of coral reefs, and it attracts about 14 million tourists annually, providing about 12 percent of the Egyptian GDP.

The Suez Canal is the link between Europe and Asia, with about 12 percent of the world's seaborne trade passing through it annually (World Bank Group Report, 2022). Furthermore, Egypt's marine areas are divided into traditional areas, such as shipping routes and fisheries and new areas, such as oil and gas explorations, renewable energy, and fish farms.

Egypt seeks to exploit its marine resources to achieve economic growth, especially after many reasons have led to the collapse of the Egyptian economy in the last decades, such as poor planning in the past, the 2008 world economic crisis, COVID-19 (Soliman, 2023) (Batini & Li, 2023), and the Russia-Ukraine war in 2022. Therefore, managing the marine resources under a well-structured MSP approach will enable Egypt to achieve the SDGs and safeguard the marine environment.

The country would secure the necessary funding and resources for implementing the MSP approach, where the majority of governments that implement the MSP rely on direct budgetary allocations from general taxes or fees tokens. Alternative sources of funding can include, among others, grants from foundations, funds from the private sector, collaborations with non-governmental organizations, and grants and donations from international and multinational organizations (Alder et al., 2022).

About 70 countries use MSP as a tool to manage their marine territories. Successful examples include Australia's Great Barrier Reef Marine Park zonation, Germany's North and Baltic Seas plans, and Rhode Island's Special Area Management Plan. Currently, 22 countries have approved the MSP (Johnson et al., 2020).

Egypt has put much efforts into achieving the environmental targets outlined in its 2030 Vision. However, some barriers hinder Egypt from implementing the MSP approach, including financial arrangements and a lack of private sector interest in investing in the marine sector. Moreover, environmental data are scarce due to a lack of enforcement of some environmental regulations and inadequate environmental monitoring along the Egyptian coasts; for instance, marine pollution of some heavy metals near Hurgada, Safaga, Alqusier, and Marsa Allam on the Red Sea (Nour & Nouh, 2020).

THE MSP APPROACH IMPLEMENTATION REQUIREMENTS IN EGYPT

Delimitation of the Egyptian Maritime Borders

The East Mediterranean has nine countries with about 17 maritime boundaries. Additionally, the Suez Canal has gained the East Mediterranean strategic importance due to its key role in facilitating international seaborne trade. In addition, the Eastern Mediterranean has political concerns because of the traditional Arab-Israeli conflicts and the historical Turkey-Greece-Cyprus conflicts. Furthermore, at the beginning of the 2000s, according to estimated figures, the East Mediterranean region had about 122 trillion cubic feet of oil and gas reserves, thus, the Eastern Mediterranean region has transformed to an economic region (Ketenci & Sevencan, 2021).

According to the 1982 UNCLOS Convention, the coastal states have exploitation rights over living and nonliving marine resources in an area extending to 200 nm from the baseline., while delimitating maritime borders in the East Mediterranean is quite complex because the distance between the opposite two countries is less than 400 nautical miles. Furthermore, according to the equidistance principle of the UNCLOS

1982 convention which regulates marine boundaries, a state's marine boundaries must follow a median line that is equidistant from its neighbours' shores. Egypt signed two agreements, the first with Cyprus in 2003 and the second with Greece in 2020, as a result of new explorations of gas fields and as a result of the memorandum between Libya and Turkey about demarcating their maritime borders in 2019 (Koukakis, 2022) (See Figure 4).

Fig. 4. Egypt and Greece, Equidistance Principle 5 Points (a,b,c,d,e).

On the other hand, Egypt's Red Sea maritime borders are not delimited with any of the Red Sea countries; only Egypt signed an agreement with Saudi Arabia (Tiran and Sanafir Islands) in 2016, but they are still not delimited yet.

Adoption and Implementation of Satisfactory Lawful and Policy Foundations

There is no mention of adopting the MSP initiatives in the EEAA agenda, and there is no clear strategy or set of rules for the MSP approach initiative's implementation in Egypt. As part of the national blue economy strategy, a coordinated MSP is also a priority in the Gulf of Suez to coordinate and manage multiple activities such as oil extraction, coastal tourism, maritime transport, and port infrastructure through effective planning, coordination, and sustainable use of marine resources.

Coordination and Integration amongst Various Sectors

The MSP approach is a new concept (Papageorgiou, 2016), and only a few developed countries have already implemented it. That is why there is a need to establish a specialized entity responsible for applying the MSP approach. In addition, blue growth is the driving force behind implementing the MSP approach and coordination between various marine sectors is required to bring new ideas for solving issues and increase the exchange of information between different sectors (Alder et al., 2022).

The institutional capacity in Egypt is centralized in a few institutions, such as the ministry responsible for addressing climate change impacts, the Ministry of Environment, and the Ministry of Petroleum, which is responsible for energy efficiency (World Bank Group Report, 2022). While, The MSP's primary goal is to improve cooperation between various sectors, stakeholders, and government institutions in order to enhance ocean governance (Finke et al., 2020) .

Availability of Data and Information to Maritime Resources

The MSP approach is based on science and management. Therefore, decision-making uses strong and trustworthy evidence when dealing with marine spatial policies, while this evidence is generated from a mixture of the most reasonable functional data utilized with the appropriate means for management options (Alder et al., 2022). Moreover, the availability of data plays a vital role in taking appropriate decisions by competent authorities in dealing with marine issues, but the availability of data is limited in Egypt and depends on people's knowledge (Negm, 2022). Thus, the final condition has yet to be fulfilled as competent authorities do not have enough information and limited data regarding marine issues (El-Magd et al., 2021).

LEGAL REGIME FOR THE MSP APPROACH IN EGYPT

The analysis of UNCLOS and other international and regional conventions results in the finding that international law permits coastal states to engage in MSP, subject to many limitations. In addition, the UNCLOS divides the ocean into jurisdictional zones including territorial water, contiguous zone, exclusive economic zone, and continental shelf, and it is not necessary to implement the MSP in each jurisdictional zone. However, the state's right decreases with distance from the shore, and third parties have rights to lay pipelines, cable, and shipping. Moreover, some developed nations, including the UK, Germany, and the Netherlands, have firmly incorporated MSP into their national law systems. In addition, Germany was the first country to extend the federal spatial planning act from the land to the EEZ (Drankier, 2015).

Environmental matters in Egypt are governed by Law No. 4 of 1994 as amended in 2015. This law entitles the Egyptian Environment Affairs Agency (EEAA) to design and prepare the general policy for protecting and promoting the environment and review the implementation of such plans.

Discharging marine pollutants are not allowed for ships in Egypt's territorial waters. Additionally, the environmental law imposes severe fines on those who violate the regulations and offers incentives to those who implement the environmental protection provisions. While, commercial ships and tankers, oil rigs and other sources of marine pollution have breached the environmental law, due to the absence of satellite monitoring and aerial surveillance in the northern Red Sea region (Elbeih et al., 2020).

The environmental law provisions demand a licence to exploit any marine resources inside Egypt's territorial waters and exclusive economic zone (EEZ). Moreover, if the competent authority is convinced that the permitted processes will not harm marine resources and the environmental impact assessment EIA is approved, authorization is given. In addition, the marine regions regulations specify the specific requirements that must be met for the permission to be granted.

This law demands the implementation of protection standards in the region to guard marine living and non-living resources against indiscriminate exploitation, depletion, or demolitions where reservation areas in the Economic Zone are clarified under the Marine Areas Regulations.

The main targets of the marine environment regulations are to mitigate and prevent pollution. Moreover, the rules of marine environment protection could be extended to include both the protection of the marine environment and the development of the MSP approach because the MSP approach's regulatory system controls human impacts on the marine environment in marine areas either those under national jurisdiction or those beyond national jurisdiction (UNEP-WCMC, 2019).

Egypt showed dedication to establishing environmental sustainability priorities at the national and international levels, but environmental sustainability is still challenging to achieve and calls for a long-term commitment requiring concerted efforts. Egypt created the national committee for sustainable development to carry out the National Environmental Action Plan (NEAP), which sets the country's environmental priorities.

The EEAA can be the driving force behind the development of the MSP approach in Egypt because in some countries, such as Australia and Poland, the environment and energy sector is responsible for its implementation. On the other hand, the current legislative framework for marine environment protection in Egypt has many defects and does not include the MSP approach. While, there are some remedial actions to promote the current legislative framework via establishing a new legislation that is entirely dedicated to the MSP, following the South Africa approach, or by modifying current legislation to accommodate the MSP (Finke et al., 2020). In addition, establishing the MSP initiatives in Egypt should be delegated to a nominated authority via an institutional body.

In order to better support the MSP strategy and make its execution easier, there is a need for a clear legal framework to deal with environmental challenges in marine regions that have been increased from baseline to EEZ. In addition, a regional collaboration is needed to govern surrounding marine areas in light of their social, economic, and environmental conditions. However, it is difficult to reach a joint decision due to differences in national objectives, governance, transparency and regulations. These discrepancies may be mitigated by encouraging stakeholders to share trustworthy data and using technologies for data collection in order to identify future advancements in the marine sectors and spatial requirements. When feasible, regional states may also modify their laws while still acknowledging their differences.

CHALLENGES IN IMPLEMENTING THE MSP APPROACH IN EGYPT

Implementation of the MSP in Egypt faces some current and upcoming challenges (See Figure 5), and they need effective solutions for marine resources sustainability.

Fig. 5. Major Challenges in Implementing the MSP
Source: (UNEP-WCMC, 2019), (Santos et al., 2018).

ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.108

STAKEHOLDERS' ENGAGEMENT IN THE MSP IN EGYPT

According to UNESCO, for a successful MSP approach, the stakeholders and their conflicts must be determined. The MSP approach cannot commence without the stakeholders' engagement and the stakeholders are persons or organizations that are involved in or influenced directly or indirectly by activities related to the exploitation of marine resources. One of the three fundamental groups listed below can be used to classify stakeholders (See Figure 6) (Perry, 2019). Moreover, the aim of stakeholders' engagement is to enhance the desired outcomes of the MSP approach through scientific-based decisions and to enhance the efficiency of management levels.

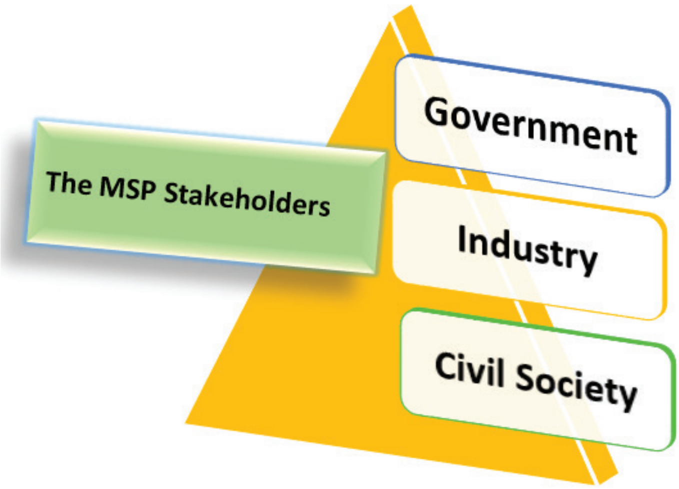

Fig. 6. The MSP Stakeholders
Source: (Perry, 2019).

Civil Societies

The civil society includes people, academics, and non-governmental organisations. Additionally, their involvement in all MSP stages is crucial, especially during stage zero or the pre-implementation, to ensure that social-level plans and political objectives are compatible (Lukambagire, 2019).

NGOs

The NGOs have knowledge and expertise regarding marine environment protection and management, so their engagement in the MSP process can bridge the knowledge gap in developing countries regarding the development and implementation of the MSP approach and mitigate conflicts between stakeholders (government, civil society, and marine industries).

Moreover, the representatives of the NGOs are concerned about the people's needs and their future visions, so they provide the government with feedback about potential decisions and alternatives when setting the MSP plan. In addition, there are some NGOs which actively work in marine environment protection in the Red Sea such as HEPCA (Hurgada Environmental Protection and Conversation Association).

The Government

The government develops and implements the MSP process. Moreover, the government saves funds for the MSP process and detects the desired goals when setting the long-term or short-term agenda. Furthermore, citizen benefits and environmental protection are the government's responsibility. The government's role in the MSP approach is to identify the stakeholders and arrange meetings or seminars to encourage them to be involved in the MSP approach. There are two types of conflicts: user-to-user conflict and user-to-marine environment conflict. Therefore, stakeholders' engagement in all MSP stages is essential to resolve these issues. While, potential barriers that government could face, such as finances constrain the government's capacity for planning and implementing the MSP. However, with financial and technical support from foreign partners, government professionals and experts will be encouraged to dedicate their attention and time to MSP as a financed activity.

Industry Stakeholders

Commercial stakeholders include shipping, fisheries, aquaculture, renewable energy, and exploration of oil and gas. Also, industry sectors are crucial to the MSP planning process since they have significant influences on commercial activities in marine zones. Furthermore, their participation in the MSP is crucial for providing the government with essential economic data, demonstrating the scope and breadth of the industry, and aiding in attaining people's welfare and the marine environment conservation (Eliasen et al., 2021). Moreover, they present advice to the government that helps it take appropriate decisions and develop alternative visions (Zaucha & Gee, 2019).

Despite the planners' best efforts, commercial stakeholders can refuse to participate, and they have a preference to look for direct and quick profits and work on entirely different timetables than the MSP process. Since the MSP is an iterative approach that takes time, this emphasizes the necessity to promote the MSP process to the business community well before the planning starts (Eliasen et al., 2021).

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ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.108

DATA MANAGEMENT FOR THE MSP APPROACH

Available Data in Egypt

The Egyptian Environmental Affairs Agency (EEAA) provides data related to marine regions and stakeholder engagement. Furthermore, some sectors keep and save their data, such as fisheries, aquaculture, marine environment protection, and oil and gas. This, in addition to the Environmental Information System (EIS) used by the EEAA to gather, organize, store, and analyse environmental data. Additionally, it is used for different objectives, for example environmental management and protection.

The MSP Data Management

According to UNESCO-IOC/European Commission (2021), before starting any data collection or subsequent reviews for MSP, the scale of planning must be determined because it directly affects the type and resolution of the data needed. Moreover, the scale of the plan should also consider the following four aspects: the political-administrative structure of neighbouring territories; the distribution and dynamics of marine ecosystems; the international legal framework controlling marine waters; and a variety of maritime human activities such as fish farms shipping lines, and oil and gas explorations.

The World Bank (WB), FAO, IMO, UNESCO, and other regional or specialised United Nations organizations are just a few examples of sources from which data can be gathered. Furthermore, the necessary information can be acquired through sources including academic publications, professional scientific judgement, governmental sources, local knowledge, and real-field measurements. Moreover, several technologies are available today, such as online web-mapping or decision-support tools like SeaSketch that helped marine planning in Canada and Adobe GeoPDF in the Seychelles.

However, developing new marine data systems can be costly and time-consuming. Moreover, in cases where data are scarce, participatory mapping might be a useful and less expensive starting point. Even when plenty of data are available, participatory mapping is typically still necessary.

There are three main types of spatial information that are relevant for the MSP process: the geographic and biological distributions for a specific species or biological community, information regarding human activities in space and time, and ambient physical characteristics related to the ocean (bathymetry, currents, and sediments).

Monitoring and Evaluation

Monitoring and evaluation are crucial to building management skills during the MSP process. So, the MSP process includes creating a body for these tasks. Since then, they have been instrumental in improving the adaptability and efficiency of the (GBRMP)'s MSP implementation (Alam, 2020). In addition, there are two types of monitoring: long-term and short-term. The long-term is useful in sustaining marine resources and addressing the cumulative impacts of unexpected consequences such as climate change and eutrophication. However, it is expensive. While people who work in the fishing, tourism, and petroleum industries can benefit from short-term monitoring of the MSP process (van den Burg et al., 2023).

According to Schwartz-Belkin and Portman (2023), policies that depend on geospatial technologies such as Global Position System GPS, Geographic Information System GIS, and remote sensing in monitoring could be more precise and comprehensive and these monitoring tools such as:

1- Remote Sensing Satellite: it provides large-scale and current data on sea surface height, temperature, salinity, and colour of ocean water which are translated into suspended solids, turbidity, and chlorophyll-a concentration. Moreover, it is used to classify shallow benthic ecosystems like coral reefs and seagrass meadows and to identify regions suitable for aquaculture. Moreover, Visible Infrared Imaging Radiometer Suite (VIIRS) can identify night time fishing, and monitor light pollution. Synthetic Aperture Radar (SAR) satellites offers 24-hour observations regardless of the amount of light or weather. Moreover, it detects objects on water surfaces, for instance ships.

2- Vessel Monitoring Systems (VMS): VMS is a system used only in commercial fisheries sectors to identify, position, and movement of fishing vessels to the nation's fisheries regulatory authorities. In addition, it prevents unauthorized use of commercial fishermen's fishing grounds by other fishers, the VMS data is private. Moreover, VMS transmits a position signal once per 1-2 hours, while, the Automatic Identification System (AIS): the position, course, and speed of the vessel are all included in the AIS message. Furthermore, depending on the ship speed, the

AIS messages are sent every 2 to 3 minutes. The AIS signal travel between ship-to-ship or ship-to-shore within VHF radio range. Moreover, Satellite- AIS (S-AIS) the detection of S-AIS signals have the advantage that they go beyond the VHF range. The European Commission requires all fishing ships more than 12 meters to install VMS and all ships more than 15 meters to install AIS on board. Moreover, the IMO requires installing AIS on all passenger ships and cargo ships engaged in international voyages with a gross tonnage of more than 300. Therefore, data from vessel tracking can be used to identify conflicts and compatibilities with other human activities and environmental concerns.

3- Animal bio-telemetry: tiny tags are attached to the marine species and they track marine species' positions, movements, and transmission of data to distant sites, As a result, they monitor marine species without human interference or modifications. Moreover, delineating conservation zones is made easier and more accurate with the help of telemetry data. Therefore, combining telemetric data with vessel-tracking data can provide a better understanding of the interactions between marine mammals and humans.

4- Passive Acoustic Monitoring (PAM): it monitors marine mammals in all weather conditions and quantifies deep water foraging. Moreover, it targets specific animals for their seasonal habitat, reproduction, and fish population. While, Passive eco-acoustic monitoring detects all physical parameters, biological, and geophysical (wind, rain, and wave). It also compares between marine species in or out the marine protected area over time. Moreover, it identifies all noise from human activities such as seismic surveys or shipping.

5- Active Sonar (Sound Navigation and Ranging): acoustic sonar is used to determine the water's depth and the bottom type (sand, mud or gravel). In addition, it is used extensively to identify fish groups underwater and to keep dolphins away from fishing nets as well as for habitat mapping and exploration, nekton detection, and other purposes. In contrast, passive acoustics are used to find acoustic signals omitted from the marine environment and to monitor fish populations.

6- Unmanned air and sea vehicles: unmanned platform carries Sonar, hydrophones for recording sound, cameras, or sensors for environmental data collection. Moreover, Aerial Unmanned Vehicles AUVs, such as gliders, are equipped with hydrophones to identify marine mammals' communication, and they can monitor and give warning of the location of wildlife. While in Egypt there is no VMS to monitor about 5000 fishing boats (Kamal, 2020) and using the Remote sensing and GIS for monitoring marine habitat and shoreline changes in the Red Sea (Darweesh et al., 2021) and shoreline changes in the Mediterranean (Hammad et al., 2022).

THE BENEFITS OF APPLYING THE MSP APPROACH

According to Alam (2020), the benefits of applying the MSP approach are:

1- It offers an integrated process for managing human activities in the ocean to protect economic, environmental, and social interests. By assigning space and regulating human activities, for instance, the strategic goal behind the Barents Sea Integrated Management Plan is to promote oil and gas production (Bambulyak et al., 2022).

2- It permits various human activities to discover marine resources while maintaining a high environmental protection standard.

3- It provides a strategic and proactive strategy, which enhances maritime management in different socioeconomic, environmental, and administrative ways.

4- It emphasises coordinated networks of institutions at the local, national, and international levels.

5- It provides a foundation for deciding where certain activities can or cannot occur inside a specific zone.

CASE STUDY

The Great Barrier Reef Marine Park (GBRMP) is the world's largest marine ecosystem, with a surface area of 344,400 km2. The GBRMP is also equal to approximately 10% of the total area of coral reefs around the globe. However, in the 1970s, mining, oil drilling, and pollution caused by oil spills and shipping routes caused severe damage to the coral reefs. Thus, the Great Barrier Reef Marine Park Act 1975 (the Act) was established. After that, the Act nominated the Great Barrier Reef Marine Park Authority (GBRMPA)

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.108

to handle management plans such as prohibiting damaging activities and prioritising management and preservation techniques. The GBRMP has adopted the MSP via zoning plans (See Figure 7) to reduce numerous disputes and effectively manage a large marine ecosystem. Moreover, the GBRAP is divided into eight zones, each with a particular set of guidelines for permitted and forbidden activities. In addition, zones may also refer to how activities are conducted, such as fishing activities via commercial or recreational fishing.

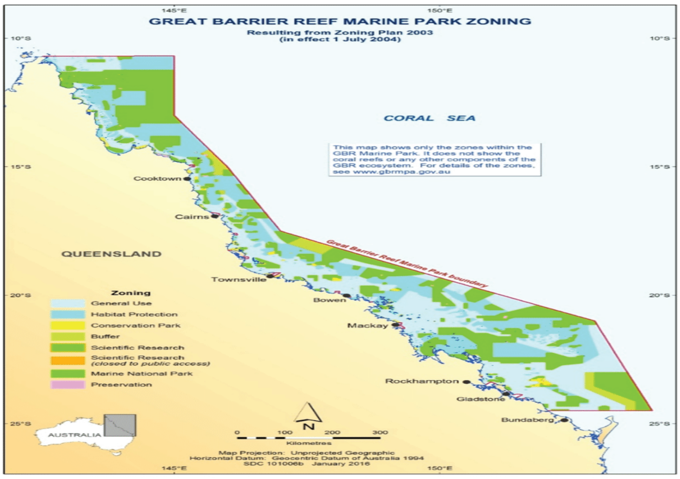

Fig. 7. the Eight Zones of the GBRMP
Source: (Bode & Day, 2020).

However, the effective implementation of the MSP needs political and financial support, participation of stakeholders from the outset of the process, and the availability of data (Alder et al., 2022).

Climate change impacts, particularly ocean acidification, runoff, overfishing, and coastal development, all of which cause severe damage to the GBRMP ecosystem. Thus, new tools are required to thoroughly understand the spatial and temporal dynamics of marine species and ecosystems in order to apply EBM in the GBRMP. These instruments include telemetry, modelling, genetic techniques, geographical analysis, remote sensing, and quantitative analysis (Hassan & Alam, 2019). However, due to the disparities in socioeconomics conditions and marine ecosystems, the GBRMP management plan cannot be immediately used in other countries (Flannery & McAteer, 2020).

Moreover, the MSP is being implemented in some developing countries such as Seychelles for three main reasons: to develop the Blue Economy, address climate change adaptation, and enhance the percentage of protected marine waters to 30%. However, there are scepticism and concerns that may exist regarding the MSP approach's implementation because, in actuality, it is more focused on fundamental ideas in ecosystem management than it is on environmental challenges.

On the other hand, the Gulf of Suez (GOS) extends for 300 kilometres. Moreover, this region has abundance of coral reefs and marine life adds to its economic significance. In addition, 85 percent of Egypt's total crude oil production comes from the GOS, the country's principal source of crude oil. However, the marine environment, coral reefs, islands, coastal regions, and beaches in Egypt are seriously threatened by shipping activities and offshore oil and gas development and production (Abdallah & Chantsev, 2022). Therefore, applying the MSP approach in such sensitive marine areas will solve the conflicts between stakeholders of various sectors, and achieve sustainable ocean governance. Furthermore, protecting marine species and biodiversity that benefits people in the Gulf of Suez is necessary for a sustainable blue economy.

DISCUSSION AND RECOMMENDATIONS

For the practical and operational implementation of MSP in Egypt, it is better to promote existing plans rather than construct a new special authority. However, MSP is a continuous and comprehensive approach that should be evaluated regularly depending on its outcomes. The MSP must be evaluated every five years in most conditions to examine the desired outcomes in different ways and assure the engagement of stakeholders in the planning process from the beginning.

The MSP approach is like ICZM regarding incorporation between different sectors such as marine protection, aquaculture, fisheries, the army, oil and gas exploration, and renewable energy, so they are not designated for only a single sector. Moreover, they deal with human activities, mitigate their impacts, and resolve conflicts either between users or between users and the marine environment (Santos et al., 2019). While the marine area covered by the ICZM is limited and does not cover open-seas areas, territorial waters, or the EEZ,

The MSP approach is a tool like the MPAs dealing with the future sustainability of the marine environment. Moreover, their plans depend on climate change impacts, government policy and agenda, economic growth, and marine stakeholders.

Sound governance is an essential part of succeeding in the MSP process. Thus, the institutional framework must support the MSP approach via a strong legislative policy for it to be a continual process. Moreover, a marine zoning plan is important in specifying marine regions for economic benefits or conservation.

Some recommendations that can help decision-makers in Egypt manage the maritime borders excellently are:

- Installation of a dedicated authority for the MSP: it is a way to change the current laws via modifying or a new interpretation of the existing legislations to provide a foundation for the MSP. Moreover, in some countries, such as Australia and Poland, the implementation of the MSP is charged by the Ministry of Environment and Energy, so in Egypt, the EEAA can be the driving force behind implementing the MSP.
- Coordination among multi-sectored bodies especially offshore marine activities such as fishing, wind farms, and shipping lanes.
- Improving institutions' and individuals' competence in marine research will raise public awareness and support MSP implementation.
- Regional collaboration or mutual strategic environmental assessment is needed to identify and address transboundary issues.
- Ensuring a mediation mechanism is available if it becomes necessary to resolve disputes over an area of common interest.
- The formation of a technical and scientific committee to offer guidance and technical support for decision-making, and to review procedures on issues essential to the MSP process.
- The scientific and technological committee could serve as a data repository, guaranteeing the quality and availability of data for the appropriate stakeholders.
- Stakeholders can participate in the MSP process through meetings, seminars, conferences, or consultations.
- Political will may mitigate the lack of financial, technological, and human capacity. Countries' supporting of MSP procedures will ensure the long-term sustainability of the process. If more money is required, it can be obtained from alternative sources.

CONCLUSION

a. In conclusion, the discovery of oil and gas fields in the early 2000s has transformed the Eastern Mediterranean region into an economically significant zone. This prompted the Egyptian government to delineate maritime borders with Cyprus in 2003 and Greece in 2020, underscoring the need for efficient ocean management to harness its blue economy.

b. The MSP approach offers an effective strategy of action for attaining the SDGs, including ending poverty and creating jobs for young people, and marine environment conservation. It serves as a multidimensional management tool for decision-makers, offering a way to address conflicts between users and the marine environment.

c. However, Egypt has yet to fulfil the requirements for implementing the MSP approach in its marine zones. Despite considerable efforts by the EEAA to implement international and national environmental laws, a dedicated authority is necessary to apply the MSP approach in the Egyptian's marine areas successfully.

d. Effective implementation of the MSP initiative hinges on sound policy and a robust institutional framework to resolve disputes among ocean users. Engagement of stakeholders from the outset, demarcation of critical marine areas, and continuous monitoring and evaluation of marine ecosystem components are all integral components of this approach.

e. While ICM is typically applied to marine areas within 2 km of the shoreline, MSP can be extended to broader regions like the EEZ and even ABNJ. In contrast to MPAs, which fail to address the damage to the marine environment in adjacent areas, and the high-cost CCS tool, MSP aims to use the oceans more sustainably and ensure resource efficiency.

f. As such, proactive adoption of the MSP approach is critical to achieving the SDGs and preserving marine resources for future generations.

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Assessing the Role of Green Technologies in Reducing Environmental Footprint of Ports

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Received on: 30 June 2023 Accepted on:09 August 2023 Published on: 05 September 2023

ABSTRACT

Purpose: *The issue of port sustainability has become an increasingly prominent topic of concern for governments, international agencies, and business sectors worldwide. Ensuring that port development does not compromise the integrity of the environment and instead fosters sustainable growth is of paramount importance. Recently green technologies conceders as important tool that support port sustainability and development.*

Design/Methodology/Approach: *This study examines the deployment and influence of green technologies on port sustainability, using a quantitative analysis of survey responses collected among a varied array of stakeholders across Egyptian ports, survey questions verify green technology application, evaluate environmental consequences, operational costs, competitiveness, and obstacles, enhancing quantitative analysis with qualitative research insights; coupled with a detailed qualitative case study of the Port of Rotterdam, a port internationally known for its effective use of green technologies. The analysis underscores the transformative capacity of green technologies in attaining notable environmental improvements and enduring cost efficiencies, notwithstanding the challenges associated with initial investment hurdles.*

Findings: *Drawing insights from the experiences of the Port of Rotterdam, the study brings to light the obstacles of intricate regulations and technological constraints, accentuating the need for simplified policy measures, consistent innovation, and an accommodating infrastructure. The study encourages a comprehensive strategy, dynamic stakeholder cooperation, and stringent scrutiny for the effective integration of eco-friendly technologies, offering valuable perspectives that can steer Egyptian ports and the broader maritime sector towards an ecologically sustainable future.*

Key-words:
green technologies, port, port sustainability.

1. INTRODUCTION

Ports are essential in facilitating global commerce and economic expansion, functioning as critical junctions in supply chains. However, the swift expansion and intensification of harbor activities have led to substantial environmental issues, including air and water contamination, energy utilization, and greenhouse gas emissions. port development and sustainability has become an increasingly prominent topic of concern for several sectors worldwide. Ensuring that port development does not compromise the integrity of the environment and instead fosters sustainable growth and development is of crucial significance. The achievement of sustainability necessitates collaborative efforts to reduce greenhouse gas (GHG) emissions through the utilization of green technologies, fuels, and operational practices. This objective can be realized through the combined efforts of industries and government support.

These environmental effects present threats to both human health and ecosystems, emphasizing the necessity for sustainable harbor management practices. As a response to these challenges, the integration of green technologies in port operations has surfaced as a promising solution to diminish the environmental footprint of ports (Wu et al., 2020). green technologies comprise a broad array of solutions that foster environmental sustainability, including renewable energy systems, energy-efficient infrastructure, emission control technologies, waste management solutions, and sustainable transportation methods.

Embedding these technologies into harbor operations can mitigate adverse environmental impacts, enhance resource efficiency, and spur the transition towards more sustainable practices. Although the potential of eco-friendly technologies in harbor management is acknowledged, there's a need to evaluate their role and effectiveness in reducing the environmental footprint of harbors. This study endeavors to address this gap by conducting a detailed analysis of the role of eco-friendly technologies in harbor sustainability. The literature review uncovers a burgeoning body of research on eco-friendly technologies within the context of harbor management.

Prior studies have delved into the categorization and explanation of various eco-friendly technologies relevant to harbors (Żukowska, 2020). Moreover, case studies have displayed successful instances of eco-friendly technology incorporation in harbors, emphasizing the environmental benefits and challenges tied with their adoption (Wu et al., 2020). A comparative analysis will be undertaken to appraise the environmental impact of eco-friendly technologies in harbors. This comparison will measure the environmental performance and economic viability of harbors employing eco-friendly technologies against those that do not (Alamoush et al., 2022; Argyriou et al., 2021). By quantifying the disparities in environmental indicators between these two categories, crucial insights can be gleaned about the effectiveness of eco-friendly technologies in reducing the environmental footprint of harbors.

Case study examination will delve deeply into harbors that have successfully implemented eco-friendly technologies. These case studies will present valuable lessons and practical instances of eco-friendly technology integration in harbor operations (Arof et al., 2021). By dissecting the environmental performance data and economic factors linked with the adoption of eco-friendly technologies in these harbors, a comprehensive understanding of their advantages and challenges can be attained (Vega-Muñoz et al., 2021; Schneider et al., 2020; Samadi et al., 2018). The findings of this study will augment the knowledge base on green technologies in port management, providing insights into their role and efficacy in reducing the environmental footprint of harbors. Suggestions will be put forth to stimulate the integration of green technologies and foster sustainable practices in the maritime sector. Ultimately, this study aims to endorse the development of environmentally responsible and economically feasible harbor management strategies that harmonize the demands of global commerce with the priority of environmental sustainability.

2. LITERATURE REVIEW

The significant contribution of the maritime sector to global emissions, and by extension, the environmental footprint of ports, has been well-documented in contemporary literature (Kramel et al., 2021; Hossain et al., 2021; Wan et al., 2021). These studies lend substantial weight to the adoption of green technologies as a viable strategy for reducing these emissions and promoting sustainability.

The prospect of transforming ports into "green gateways" through the implementation of green technologies has been extensively discussed (Gruchmann, 2018; Wu et al., 2020). These researchers contend that through the adoption of renewable energy sources, waste management systems, and green logistics strategies, ports can not only mitigate their environmental impacts but also enhance competitiveness and stimulate economic opportunities.

On the issue of specific green technologies in port operations, there is consensus among researchers that emission control technologies like scrubbers and selective catalytic reduction systems can have a significant impact in reducing air pollutants (Alamoush et al., 2022). Additionally, researchers JSadiq et al., (2021) and Iris, (2021) advocate for the use of renewable energy systems, such as wind turbines and solar panels, in ports as an effective measure to cut greenhouse gas emissions.

However, the barriers to the adoption of green technologies, such as high upfront costs, technological constraints, and organizational resistance, are also consistently highlighted in the literature (Zhen et al., 2020; Sun et al., 2019). Both studies underscore the need for supportive policies, technical advances, and cultural shifts within the maritime sector to circumvent these challenges.

The Port of Rotterdam has consistently received praise in academic circles for its effective implementation of green technology (Lim et al., 2019; Bergqvist & Monios, 2019; Shi et al., 2018). Both studies applaud the port's all-encompassing strategy towards sustainability, fruitful collaborations with stakeholders, and forward-thinking methods in tackling regulatory and technological obstacles. In brief, the general agreement in the scholarly literature, as outlined by American Psychological Association (APA) citation and referencing, endorses the capability of green technologies in harbor management to reduce environmental footprint, boost operational efficiency, and heighten economic competitiveness. At the same time, the literature accentuates the widely recognized hurdles that must be overcome for successful execution.

Moshiul et al. (2021) underscores the necessity of integrating both the design of the ship and the supporting port infrastructure to effectively reduce the pollutant emissions of maritime transport, suggesting that without considering the entire system, the environmental benefits of individual green ships could be compromised. Vicenzutti and Sulligoi (2021) highlighted the increasing scholarly interest in green shipping practices (GSP) within the international maritime industry, with a noticeable rise in research trends from 2007 to 2019, emphasizing that GSP is essential for future maritime transport sustainability. Through extensive real-world data experimentation, they not only verify the efficacy of their proposed model but also offer valuable managerial insights. Such focused studies are instrumental in highlighting the challenges and opportunities for green technology adoption in the maritime sector (Zhen et al., 2020).

3. METHODOLOGY

This research employs a blend of methodological approaches, with the aim of yielding a well-rounded understanding of how green technologies are put into practice and the impacts they have within port management. The methodology includes a quantitative analysis of survey responses collected from a diverse group of 30 stakeholders across various ports. This is coupled with a detailed qualitative case study of the Port of Rotterdam, a port internationally known for its effective use of green technologies.

The purpose of the survey questions is to verify the application of green technologies, evaluate their environmental consequences, understand their implications on operational costs and competitiveness, and identify the primary obstacles faced during their adoption. The outcomes of this quantitative analysis are then enhanced with insights drawn from the qualitative research.

The Port of Rotterdam case study offers a comprehensive view of the real-life deployment and influence of green technologies in a major port. This case study explores the port's progress in environmental enhancement and the economic benefits resulting from the utilization of these technologies. It also discusses the collaborations and partnerships that have driven the successful implementation of green technologies and outlines the regulatory, policy, and technical challenges encountered along the way.

The study utilizes both primary and secondary data. The primary data is gathered from the survey responses, while secondary data comes from academic articles, reports, and publications relating to the subject, including in-depth evaluations of the green initiatives at the Port of Rotterdam. This methodological diversity ensures the validity and strength of the findings, offering invaluable insights for ports worldwide on their path towards sustainability.

4. ANALYSIS AND RESULTS

The present study employs a quantitative approach to analyze survey data collected from a sample of 30 stakeholders affiliated with different ports. The respondents' diverse occupational backgrounds enhance the comprehensiveness of the researchers' investigation into the implementation and effects of green technologies in port management. Approximately 20% of the respondents were Port Managers/Directors, providing strategic perspectives on the adoption of these technologies. Environmental Managers/Officers, comprising around 15% of the responses, brought a focus on environmental impact and compliance to the analysis. Operations Managers or Supervisors constituted about 25% of the sample, shedding light on the practical aspects of integrating green technologies into daily port operations. Logistics and Supply Chain Managers made up 15% of the survey, offering insights into the influence of green initiatives on supply chain efficiency. Maintenance or Engineering Managers, accounting for another 15%, shared their experiences regarding the technical implementation and challenges of these technologies. Finally, the input from Financial Managers or Controllers, representing 10% of the respondents, allowed for a deeper understanding of the economic feasibility of employing green technologies. This broad array of job roles within port operations helped generate a well-rounded overview of green technologies' role in reducing the environmental footprint of ports. Complements the findings from the qualitative research.

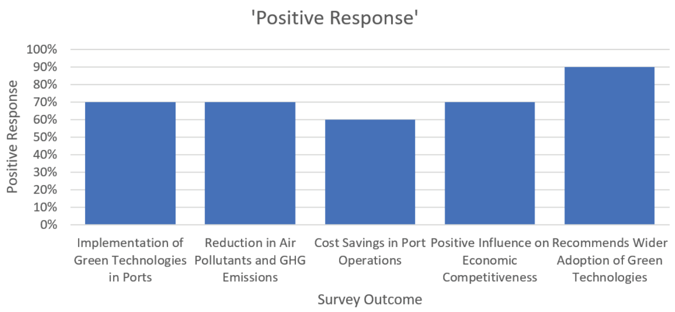

Fig. 1: The implementation and effects of green technologies in port management
Source: Author

From figure 1 most respondents (approximately 70%) confirmed the implementation of green technologies in their ports, and about 70% reported a reduction in air pollutants and greenhouse gas emissions. While a substantial proportion of respondents (about 60%) acknowledged cost savings in their port's operations, approximately 70% stated that the adoption of green technologies positively influenced their port's economic competitiveness. A significant majority (90%) recommended wider adoption of green technologies in port management.

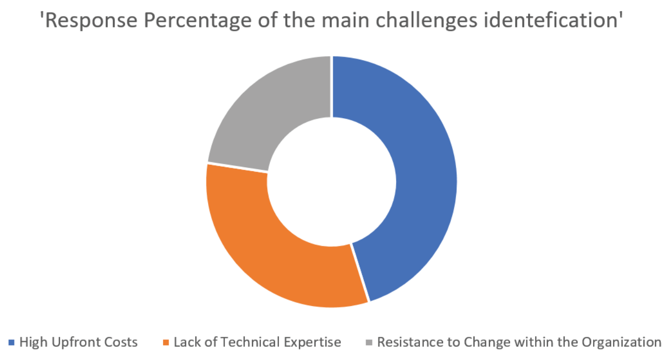

Fig. 2: The main challenges to apply port green technologies
Source: Author

Notably, the survey results as shown at the above diagram (Figure 2) in align with the main challenges identified in the qualitative analysis. High upfront costs were the most cited barrier (70% of respondents), followed by a lack of technical expertise (50%) and resistance to change within the organization (35%). These findings underscore the necessity of addressing these challenges to foster wider adoption and successful implementation of green technologies in ports.

In brief, the findings from both qualitative and quantitative research underline the significant potential of green technologies in reducing the environmental footprint of ports. They highlight the need for continued investment, supportive policy measures, and a proactive approach to overcoming challenges and barriers. The study suggests that through adopting green technologies, ports can not only achieve significant environmental benefits but also enhance their operational efficiency and economic competitiveness.

Additional understanding is obtained from the case study focusing on the Port of Rotterdam, which stands as a successful model of green technology application. The environmental repercussions of this transition are noteworthy, with stakeholders observing marked enhancements in air quality and notable decreases in greenhouse gas emissions. Stakeholders further emphasize the economic practicality of green technologies at the Port of Rotterdam, pointing to long-term cost reductions and improved operational efficiencies that more than compensate for the upfront investments.

Green Technologies in Port Management: An Exploration of Economic and Environmental Impacts at the Port of Rotterdam

This investigation undertakes a thorough exploration of the function and effects of green technologies within port management. The case study revolving around the Port of Rotterdam, globally recognized for its effective embrace of green technologies, plays a key role in this study.

The environmental impact of green technologies has been remarkably impressive, as illustrated by the Rotterdam example. The port's stakeholders have recorded significant enhancements in air quality, largely thanks to the use of emission control systems like scrubbers and selective catalytic reduction mechanisms (Alamoush et al., 2022). Further, investment in renewable energy resources such as wind turbines and solar panels has resulted in notable decreases in greenhouse gas emissions, reinforcing the port's dedication to sustainability objectives (Molavi et al., 2020).

In terms of economic viability, the Port of Rotterdam shows that while initial expenditures on green technologies can be hefty, they ultimately yield considerable long-term cost savings and operational efficiencies. For example, the adoption of energy-efficient infrastructure and renewable energy sources has led to reduced energy usage, subsequently lowering energy expenses over the long run (Greenberg et al., 2019). The port's commitment to environmental sustainability has also elevated its reputation, drawing businesses that prioritize eco-friendliness and creating new economic possibilities (Arof et al., 2021).

The case study also highlights the importance of stakeholder cooperation in the successful deployment of green technologies. The partnerships forged among the port authorities, technology providers, and local communities at the Port of Rotterdam have been instrumental in advancing sustainable practices. Early engagement with stakeholders, fostering of partnerships, and proactive promotion of the environmental benefits of green technologies have all served as significant drivers of the port's sustainability agenda (Samadi et al., 2018).

The Port of Rotterdam serves as a notable illustration of a port that has successfully adopted environmentally sustainable port activities. These initiatives encompass the adoption of energy-efficient lighting, the implementation of an effective energy management system, and the utilization of contemporary waste treatment methods. The port has made investments in advanced technology, including RFID reader systems for container tracking and electrically driven cranes. The implementation of these efforts has resulted in a 14% reduction in carbon dioxide emissions by the port since 2016. The Port of Rotterdam is now engaged in an energy transition initiative that is grounded on four fundamental pillars: efficiency and infrastructure, the establishment of a new energy system, the development of a new raw material and fuel system, and the promotion of sustainable transport. The primary objective of this endeavor is to achieve a significant reduction of 55% in CO_2 emissions by the year 2030, ultimately aiming to attain carbon neutrality by 2050 (Port of Rotterdam Authority, 2023).

However, the study does recognize that challenges exist, particularly in navigating complex regulatory and policy frameworks and the need for continual technological advancements. The experience of the Port of Rotterdam demonstrates that these obstacles, while substantial, can be effectively managed through a combined approach of continued investment, supportive policies, and proactive strategies.

In summary, this research underlines the transformative potential of green technologies in reducing the environmental impact of ports, while concurrently enhancing operational efficiency and economic competitiveness. Drawing upon the case study of the Port of Rotterdam, the study promotes an integrated approach towards sustainability, emphasizing the value of stakeholder collaboration, public-private partnerships, and regular monitoring and evaluation for the successful implementation of green technologies across the maritime sector.

5. CONCLUSION

The adoption and effective implementation of green technologies within port management have emerged as pivotal strategies for reducing environmental footprints and promoting sustainability. By undertaking a comprehensive qualitative and quantitative analysis, this study provides invaluable insights into the advantages, challenges, and lessons accrued from the implementation of green technologies, with a particular focus on the Port of Rotterdam.

The positive environmental impact of green technologies, specifically in improving air and water quality while reducing greenhouse gas emissions, is markedly evident in the findings. Aided by emission control technologies such as scrubbers and selective catalytic reduction systems, the Port of Rotterdam has managed to significantly diminish air pollutants, hence improving air quality (Alamoush et al., 2022). Similarly, renewable energy investments in wind turbines and solar panels have facilitated a significant shift towards cleaner energy sources, contributing to a marked reduction in greenhouse gas emissions (Molavi et al., 2020).

Economically, the adoption of green technologies within the Port of Rotterdam illuminates their feasibility and subsequent financial advantage. While the initial investments are substantial, long-term cost savings and operational efficiencies realized through energy-efficient infrastructure and renewable energy sources become evident (Schneider et al., 2020). Such savings not only bolster the port's economic competitiveness but also attract environmentally conscious businesses, thereby promoting sustainable growth and development (Arof et al., 2021).

Despite the notable gains, the implementation of green technologies is not devoid of challenges. The complexity of regulatory and policy frameworks, coupled with technological limitations and high upfront costs, pose significant barriers that warrant address. Streamlining regulatory and permitting processes, alongside the development of supportive policies, is crucial for facilitating the widespread adoption of green technologies (Sun et al., 2019). Concurrently, ongoing research and development efforts are imperative to improve the efficiency, scalability, and affordability of green technologies (Sun et al., 2019).

In summary, this study underscores the pivotal role and efficacy of green technologies in promoting sustainable port management. The Port of Rotterdam case study validates that an integrated approach, stakeholder collaboration, and continuous monitoring form the bedrock of successful implementation. Recommendations for widespread adoption of green technologies revolve around the streamlining of regulatory frameworks, fostering stakeholder collaboration, and encouraging investment in research and development.

The insights from this study have far-reaching implications for port management and sustainability practices globally. Ports can reap significant environmental improvements and economic benefits by adopting green technologies, subsequently enhancing their reputation as sustainable entities. The lessons gleaned from the Port of Rotterdam's experience provide robust guidance for other ports embarking on similar green technology initiatives.

In essence, the Port of Rotterdam serves as a benchmark in showcasing how ports can significantly reduce their environmental impact through the adoption and effective implementation of green technologies. By espousing sustainable practices and fostering stakeholder collaboration, ports globally can contribute towards a greener and more sustainable maritime industry future.

6. RECOMMENDATIONS

The rapid evolution of green technologies in port management, as highlighted by this study, underscores its pivotal role in achieving environmental sustainability and adopting economic efficiency in port operations. Drawing from the vital insights of diverse stakeholders across Egyptian ports and the compelling case of the Port of Rotterdam, a multi-pronged strategy is evident:

1. Investment Priority: Initial capital expenditure might seem hefty, it promises significant returns through decreased operational expenses, heightened economic competitiveness, and improved environmental conditions. As such, ports should focus on long-term benefits rather than immediate costs, directing resources to the broad adoption of green technologies.

2. Capacity Building: Addressing the lack of technical expertise is paramount. Regular training programs and workshops can bridge the knowledge gap, enabling stakeholders to leverage the full capacity of these technologies.

3. Embracing Change: Organizational resistance can be eased by refining a culture of continuous learning and innovation. Awareness campaigns highlighting the tangible benefits of green technologies can drive acceptance and smooth integration.

4. Robust Stakeholder Collaboration: The Port of Rotterdam's success underscores the essence of collaborative efforts. Building and raising partnerships with technology providers, local communities, and other port stakeholders can amplify the effectiveness of sustainable initiatives.

5. Policy Reforms: Governments and international maritime bodies should introduce and revise policies that favor the adoption of green technologies, including financial incentives and simplified regulatory frameworks.

6. Case Study Replication: The Port of Rotterdam serves as a beacon of sustainable excellence. Ports worldwide can emulate their strategies, adjusting them in line with local perspectives and challenges, to replicate their success.

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Maritime Research and Technology
MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.133

Maritime Accident Analysis Using Modified HFACS-MA

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Received on: 25 July 2023 Accepted on:17 August 2023 Published on: 03 September 2023

ABSTRACT

Purpose: *In a previous endeavor, the authors discussed Human Reliability Assessment (HRA), Human Error Identification (HEI), and accident analysis as the most well-known methods of accident investigation. A general overview of the various analytical models and methodologies was given, outlining the key concepts behind each category, and choosing the HFACS-MA spell out to serve as a starting point for any research in this field. This particular model is a qualitative analytic model that examines both active and latent failures revealed in maritime accident reports.*

Design/Methodology/Approach: *In this paper, a comparative study is presented among three versions of the HFACS-MA model; a benchmarking was made with a US government DoD-HFACS version in order to compare the codes inside each version to ensure the integration of all safety standards. Accordingly, the most suitable version was singled out. The modified Maritime Human Factors Analysis and Classification System (HFACS-MA) was carefully examined as a qualitative analytic model to evaluate active and latent failures stated in the contact accident report, identifying human error as the primary cause. This was done as an example of how the modified (HFACS-MA) may be applied to maritime accident analysis.*

Findings: *The HFACS-MA version developed by Kim et al. (2011) and modified by Kang (2017b) was further modified in the current work by adding one extra code to it, that is Equipment Design and Specification code (i.9).*

Key-words:
Accident investigation, Human errors, Maritime accident analysis, Maritime Human Factors Analysis and Classification System model.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.133

1. INTRODUCTION

The Human Factors Analysis and Classification System (HFACS) model was developed by Shappell and Wiegmann (2000) and modified in (2003) based on Reason's idea of latent and active failures (1990) to provide a better understanding of the causes of naval aviation accidents. Many researchers have used the HFACS tool to assess the actual and latent conditions that contributed to the accidents. Given the previous success of HFACS, which was developed in the aviation field and has been modified and optimized in a variety of industries, it appeared reasonable to apply the HFACS framework to identify active and latent failures within maritime accidents in the hope of achieving similar results Yang et al. (2019). In a previous paper (Youssef et al. 2023) the most well-known models of examining human error were discussed and the HFACS was found most suitable for maritime accident analysis, The interested reader is advised to consult Youssef et al. (2023) for further details. As indicated in Figure 1, there are four levels of HFACS: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences.

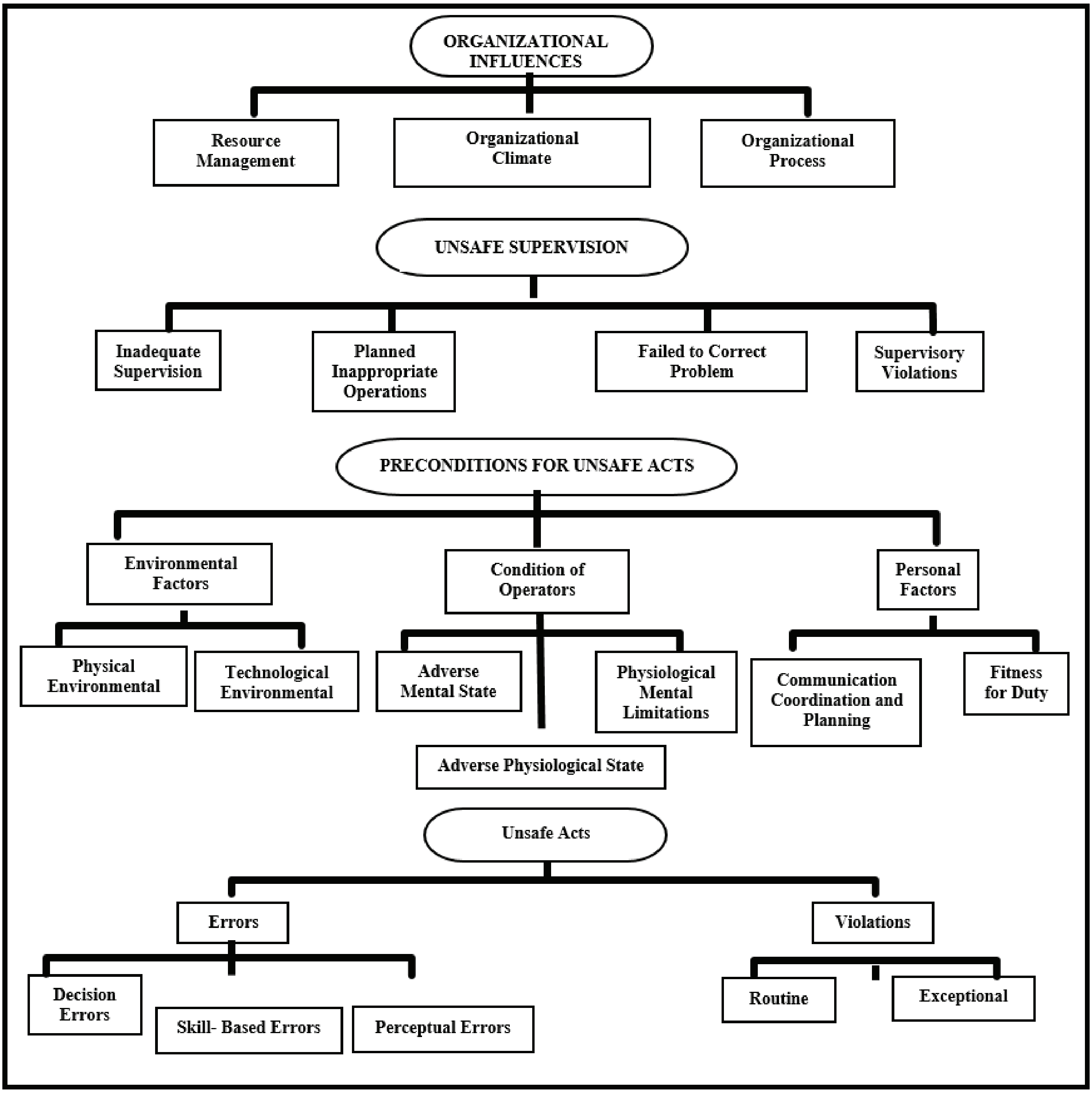

Figure 1. HFACS Framework (Shappell and Wiegmann, 2003)

Hulme et al. (2019) examined HFACS application in different fields through July 31, 2018. After searching four databases (PubMed, ScienceDirect, Scopus, and Web of Science), a total of (690) articles were identified. After removing (197) duplicates and examining the remaining (493) titles and summaries, a total of (43) HFACS studies were singled out; (14) studies were published between the years 2000 and 2009 (9 years), and (29) studies between 2010 and July 31, 2018 (8 years and 6 months). Utilization of the HFACS model in studies approximately doubled over almost the same period, as shown in Table 1. They also noted that more than (60%) of the studies used HFACS in a modified form to analyze how a network of interacting latent and active factors contributed to the occurrence of an accident.

Table 1: Illustrating Wide Interest in HFACS

S/N	Study	Field	Accidents
1	Wiegmann & Shappell (2001)	Aviation	119
2	Gaur (2005)	Aviation	48
3	Dambier & Hinkelbein (2006)	Aviation	239
4	Li & Harris (2006)	Aviation	523
5	Reinach & Viale (2006)	Rail	6
6	Tvaryanas et al. (2006)	Aviation	221
7	Shappell et al. (2007)	Aviation	1020
8	Baysari et al. (2008)	Rail	23
9	Gibb & Olson (2008)	Aviation	124
10	Lenne et al. (2008)	Aviation	169
11	Li et al. (2008)	Aviation	41
12	Tvaryanas & Thompson (2008)	Aviation	48
13	Baysari et al. (2009)	Rail	19
14	Celik (2009)	Maritime	1
15	Patterson & Shappell (2010)	Mining	508
16	Wang et al. (2011)	Maritime	2
17	Hale et al. (2012)	Construction	26
18	Lenne et al. (2012)	Mining	263
19	Chauvin et al. (2013)	Maritime	27
20	Chen et al. (2013)	Maritime	1
21	Hooper & O'Hare (2013)	Aviation	288
22	Li & Harris (2013)	Aviation	523
23	Wang et al. (2013)	Maritime	1
24	Akhtar & Utne (2014)	Maritime	93
25	Akyuz & Celik (2014)	Maritime	1
26	Batalden & Sydnes (2014)	Maritime	94
27	Daramola (2014)	Aviation	42
28	Gong et al. (2014)	Aviation	2
29	Kim et al. (2014)	Nuclear	38
30	Yunxiao & Yangke (2014)	Mining	107
31	Madigan et al. (2016)	Rail	74
32	Wong et al. (2016)	Construction	52
33	Akyuz (2017)	Maritime	1
34	Al-Wardi (2017)	Aviation	40
35	Fu et al. (2017)	Mining	1
36	Theophilus et al. (2017)	O&G	11
37	Verma & Chaudhari (2017)	Mining	102
38	Yıldırım et al. (2017)	Maritime	257
39	Yoon et al. (2017)	Nuclear	1
40	Zhan et al. (2017)	Rail	1
41	Zhou & Lei (2017)	Rail	407
42	Mirzaei Aliabadi et al. (2018)	Mining	295
43	Zhang et al. (2018)	Mining	94

Source: (Hulme et al. 2019)

Over time, several versions of the HFACS model appeared, as shown in Table 2, indicating that this model has been repeatedly adapted to suit the fields of application and address deficiencies in a manner commensurate with the fields of application.

Table 2: Listing Different HFACS Versions

S/N	Version	Application	Developer	No. of levels
1	DoD HFACS	U.S. Department of Defense Aviation mishaps	US DoD (2005)	4
2	Analytical HFACS	Shipping accidents	Celik and Cebi (2009)	4
3	HFACS-ADF	Australian Defense Force aviation safety	Olsen and Shorrock (2010)	5
4	HFACS-MSS	Maritime machinery space fire and explosion	Schröder-Hinrichs et al.(2011)	5

5	HFACS-MA	Maritime accidents	Kim et al. (2011)	3
			Chen et al. (2013)	5
			Wang et al. (2020)	5
6	HFACS-Coll	Maritime collisions	Chauvin et al. (2013)	5
7	HFACS-Ground	Maritime groundings	Mazaheri et al. (2015)	5
8	HFACS-FCM	Maritime fire prevention	Soner et al. (2015)	5
9	HFACS-OGI	The Oil and Gas Industry	Theophilus et al. (2017)	5
10	HFACS-PV-BN	Maritime accidents for passenger vessels	Uğurlu et al. (2020)	5
11	HFACS-FV	Fishing vessel accidents	Zohorsky (2020)	4
12	HFACS-PV&FFTA	Maritime accidents for passenger vessels fire and explosion	Sarıalioğlu et al. (2020)	5
13	HFACS-OGAPI	Domestic and overseas oil, gas, chemical, and power plants	Yang and Kwon (2022)	5

Source: (Zohorsky, 2020; Youssef et al., 2023)

Modified Maritime Human Factors Analysis and Classification System (HFACS-MA)

Youssef et al. (2023) selected the HFACS-MA to analyze maritime accidents based on an extensive review of the literature. Three maritime versions are available, as follows:

Version I: Kim et al. (2011) combined the HFACS framework with six "human factors" presented in the IMO Casualty Investigation Code (Res.A.884 (21)), (1999) and the Generic Error Modelling System "GEMS" framework by Reason (1990), on three different levels: (i) Organizational Influences, (ii) Preconditions for Unsafe Acts, and (iii) Unsafe Acts.

Version II: Chen et al. (2013) developed a prototype of a specific Human and Organizational Factors framework (HOF) for maritime accident investigation and analysis, consisting of five different levels: (i) External Factors, (ii) Organizational Influences, (iii) Unsafe Supervision, (iv) Preconditions (SHEL), and (v) Unsafe Acts.

Before the framework can be extensively utilized in practice, they assessed the HFACS-MA and noted that various modifications are required. For instance, a specific HOF framework with specific categories should be established for maritime accidents. This is comparable to the US DoD (2005) version (7.0) and is helpful for investigators to identify the human factors involved in maritime accidents. Also, how to assess the weight or significance of the HOFs identified in an accident or the aggregate demographics of many accidents needs to be incorporated. Third, a protocol for exchanging data between organizations and countries is urgently needed. Organizations or government agencies will find it easier to gather and distribute their causal HOFs data if a standard framework-based data exchange protocol (or something equivalent) is available.

Version (III): HFACS-MA framework developed by Wang et al. (2020), in five levels, and used to analyze three maritime accidents. They indicated that some improvements are needed before the framework can be widely used in practice, including: (i) Some of the materials used in this study came from news articles; (ii) One of the research's drawbacks is the lack of data resulting from the translation barrier of the local language in Korea and Thailand while gathering evidence, which restricts the breadth of conclusions that authors could make; and (iii) many concerns about the three incidents remain unanswered despite the data being analyzed by four safety experts, such as the path of each catastrophe and the risk assessment of human components. Therefore, this version was also waived.

The authors compared the coding methods of the HFACS-MA versions after analyzing many studies such as DoD HFACS version (7.0), (U.S. Department of Defense, 2022), the new HFACS-MA version framework, by wang et al. 2020, and in masters' theses and Ph.D. dissertations that were published in high-impact scientific journals in several different countries such as the U.S., the U.K., Europe (European Union, 2021), and Sweden, (SJÖFS, 2021).

The HFACS-MA version by Kim et al. (2011) code was compared to the DoD HFACS version (7.0) code as a benchmark, as it is a government model used in the US Department of Defense and compared to the HFACS-MA by Wang et al. (2020) code, as it is a new software product uses HFACS-MA model, U.S. Air force safety center (2022).

2. RESULTS AND DISCUSSION

The aforementioned comparison and benchmarking prosses ended up with the following findings:

(i) The DoD HFACS version (7.0) consists of (4) levels, divided into (17) sub-categories, and consisting of (109) codes; the codes are provided U.S. Department of Defense (2022).

(ii) As mentioned above, the HFACS-MA version by Kim et al. (2011) was reviewed by Kang (2017b) in (3) levels, consisting of (111) latent causal factor codes without adding active codes Level (3) Unsafe Acts.

(iii) The HFACS-MA version by Wang et al. (2020) consists of (5) levels, divided into (24) sub-categories; the author's codes are provided.

(iv) The DoD HFACS version (7.0) describes in level 1, Organizational Influences, in subcategory (Policy & Process Issues), the issues Purchasing or Providing Poorly Designed or Unsuitable Equipment, code (OP007) (Lower et al., 2018. This code was ignored or eliminated in the HFACS-MA model by Kang (2017).

(v) The HFACS-MA version by Wang et al. (2020), describes in level 1, External factors, in the subcategory (Flaws in design), this issue is an obstacle to making full use of the equipment to perform tasks. This code was also ignored or eliminated in the HFACS-MA version by Kang (2017).

(vi) As a result of this comparison, the authors coded Level (3) Unsafe Acts, in (4) sub-categories, distributed into (5) codes, then the authors modified and added one code to the HFACS-MA version by Kim et al. (2011) that was examined by Kang (2017b) to improve the accuracy of the data being analyzed from maritime accident investigations by adding a code in level (2) / Organizational Influences / Management / Supervision / Equipment Design & Specification, code i.9, bringing a total of (117) codes.

For all those reasons the authors choose to use the HFACS-MA version by Kim et al. (2011), instead of using HFACS-MA versions by Chen et al. (2013) or Wang et al. (2020).

3. CONCLUSION AND RECOMMENDATIONS

The purpose of this paper was to identify active and hidden factors in the current investigation report. The modified HFACS-MA tool was used to analyze the contact investigation report, as an applicable example, resulting in the finding of (5) human error cause factors in maritime accidents. The relational analysis between active and latent failures has aided the understanding of accident patterns from the latent factors of the organizational system through the latent factors of onboard to the unsafe acts of seafarers.

The authors have (i) coded Level (3) Unsafe Acts, in (4) sub-categories, distributed into (5) codes; (ii) modified and added one code to the HFACS-MA version by Kim et al. (2011) that was examined by Kang (2017b) to improve the accuracy of the data by adding a code in level (2) / Organizational Influences / Management / Supervision / Equipment Design & Specification, code i.9, bringing a total of (117) codes, and (iii) found a (1) human causal factor influenced by the newly added code Equipment Design & Specification, code (i.9).

For the maritime industry sector the authors recommend that (i) When drafting maritime accident reports, the responsible organization/company should consider language/format to avoid data gaps caused by the translation barrier of the local language; consequently, it is advisable to write the report in two languages (the native language of the reporter and English); (ii) Activating the data exchange protocol for maritime accident reports between organizations and countries; (iii) Continuity of training; (iv) Law enforcement supervision, and (v) To analyze the data within the Egyptian Gulf of Suez, it was recommended that the article adopted by an Egyptian government agency in order to provide data/reports of maritime accidents, and then apply the results of this article to the data that were extracted from the Egyptian Gulf of Suez using the modified HFACS-MA.

For the academic research, the authors recommend that (i) Establishing a database for all human error-based maritime accidents is advised to be supervised by IMO to enhance maritime scientific research related to accident analysis; (ii) The HFACS-MA version of the HFACS model can also be used to study maritime accidents in the Gulf of Suez, provided that sufficient data on accidents in this vital area are available, and (iii) In this study, the authors played the role of the accident analysis expert; therefore, it is recommended that more than one expert play this role and that the different results, if any, be aggregated through consensus analysis.

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A Review on Simulation Based Training on Autonomous Ships and Protection of Egyptian Maritime Security

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Received on: 19 June 2023 | Accepted on: 22 August 2023 | Published on: 05 December 2023

ABSTRACT

Purpose: *Autonomous ships are gaining more and more favor in the maritime sector as a result of their ability to boost productivity while simultaneously lowering costs and boosting levels of safety. However, the proliferation of autonomous ships brings with it new worries about cybercrime, piracy, and other challenges to maritime safety and security. Protecting marine security is of the highest significance in Egypt since the Suez Canal is an essential transportation route for international business.*

Design/Approach/Methodology: *This research study investigates the function that training plays in improving both the general security of autonomous ships that operate in Egyptian seas as well as the cyber security of such ships.*

Findings: *This research summarizes the findings of the available literature on training for autonomous ships and maritime security. The paper also evaluates this literature. According to the findings of the research, even though there is a rising knowledge of the significance of training for autonomous ships, there are substantial gaps in training programs and resources in Egypt. This is even though there is a growing awareness of the value of training for autonomous ships. The findings of the research are summarized in a set of suggestions for boosting Egypt's marine security and the quality of its training programs.*

Key-words:
Autonomous Ships, Maritime Security, Cyber security, Simulation Based Training.

INTRODUCTION

It is anticipated that the deployment of autonomous ships in the maritime sector would provide considerable advantages in terms of increased efficiency, decreased costs, and increased levels of safety. However, the deployment of autonomous ships gives rise to new worries about cybercrime, piracy, and other dangers to maritime safety and security. Protecting marine security is of the highest significance in Egypt since the Suez Canal is an essential transportation route for international business. This research study investigates the function that training plays in improving both the general security of autonomous ships that operate in Egyptian seas as well as the cyber security of such ships.

With the Suez Canal acting as an essential connection between Asia and Europe, Egypt is an essential participant in the international marine sector. Over twelve percent of annual worldwide commerce is estimated to go through the Panama Canal, making it one of the busiest shipping channels in the world (Khalifa and Salem, 2019). Because of the canal's significance to international commerce, there is a greater chance that it will be the target of security risks including piracy, terrorism, and smuggling. The use of autonomous ships brings up additional problems about cyber security, in addition to the previously mentioned conventional security risks.

Autonomous ships are a relatively new technology that is undergoing fast development and have the potential to revolutionize the shipping sector. These vessels navigate and carry out their operations at sea without the assistance of humans by using cutting-edge technology such as artificial intelligence. The deployment of autonomous ships has the potential to boost productivity while simultaneously lowering costs and raising levels of safety. On the other hand, the widespread use of autonomous ships brings up new worries about cyber security. The risks associated with cyber security include the possibility of being hacked, infected with malware, and experiencing various types of cyber-attacks. These dangers have the potential to endanger the ship's safety as well as the security of its crew and its cargo. The crew has to have proper cyber security training in order to reduce these risks and guarantee that they can react correctly in the case of a Cyber-attack (Ghaderi, 2019).

The adoption of autonomous ships raises concerns regarding the emergency safety and security of the vessel, its crew, and its cargo, in addition to cyber security threats. Effective training in emergency response is vital to guarantee that the crew can react effectively to crises and reduce the risk of harm or loss of life. This training is essential because it helps ensure that the crew can respond appropriately to emergencies.

Given the essential significance of maritime security to the Egyptian economy and the possible hazards connected with the adoption of autonomous ships, there is an urgent need for effective training programs to strengthen the cyber security and overall security of these boats (Ben Farah et al., 2022). This requirement has been exacerbated by the fact that the adoption of autonomous ships is expected to increase in the near future. These training programs need to be thorough, up-to-date, and relevant to the shifting dangers that face marine security. In addition, the many stakeholders in the marine sector need to collaborate in order to guarantee that effective coordination is maintained throughout the process of developing and implementing these programs. Egypt can contribute to the sustained expansion and economic success of the global maritime sector if it improves the training programs and resources that are now available. In doing so, Egypt can assist to guarantee the safe and secure operation of autonomous ships inside its territorial waters (Ash and Scarborough, 2019; Ampah et al., 2021).

Therefore, the purpose of this research is to conduct a literature review on training for autonomous ships and maritime security, as well as provide the findings of a survey that asked Egyptian maritime stakeholders about their views on the significance and usefulness of training for autonomous ships. The purpose of the research is to determine where Egypt's training programs and resources are lacking, and then to give suggestions for how those programs and Egypt's maritime security should be improved.

LITERATURE REVIEW

The introduction of driverless ships is a technology that is undergoing fast development and has the potential to bring about a sea change in the shipping sector. The deployment of autonomous ships has the potential to boost productivity while simultaneously lowering costs and raising levels of safety. However, the proliferation of autonomous ships brings with it new worries about cybercrime, piracy, and other challenges to maritime safety and security as listed in MSC 106/INF.20. MSC 106/INF.20 lists some of the safety risks that could come with using driverless ships, such as cyber security risks, communication problems, and the chance of a ship colliding with another. Also, MSC 106/INF.20 talks about how Maritime Autonomous Surface Ships (MASS) might affect the marine workforce, such as by changing job roles and making it necessary to learn new skills and get new training. The paper stresses how important it is to give sailors and other people who work on driverless ships the right training and licensing to make sure the ships run safely and efficiently.

Protecting marine security is of the utmost importance in Egypt because of the importance of the Suez Canal to international commerce. This literature review takes a look at the research that has already been done on how to train autonomous ships and improve maritime safety. The purpose of the evaluation is to give suggestions for strengthening training programs and increasing marine security in Egypt, as well as to identify any gaps that exist in Egypt's training programs and resources. The research that has already been done on how best to train autonomous ships and ensure safety at sea is analyzed in this literature study. The study indicates that while there is a rising understanding of the necessity of training for autonomous ships, there are still substantial gaps in training programs and resources. This is even though there is a growing knowledge of the importance of training.

The significance of cyber security in relation to autonomous ships has been the subject of several studies in recent years. The risks associated with cyber security include the possibility of being hacked, infected with malware, and experiencing various types of cyber-attacks. These dangers have the potential to endanger the ship's safety as well as the security of its crew and its cargo. The crew must have proper cyber security training in order to reduce these risks and guarantee that they can react correctly in the case of a cyber-attack.

In the context of autonomous ships, Crespo et al. (2019) places a strong emphasis on the significance of cyber security. The research sheds light on the dangers that might arise from cyber-attacks on autonomous ships as well as the need to receive adequate training in cyber security. Accordingly, cyber security training for autonomous ships need to center on techniques for detecting and counteracting cyber-attacks, as well as on the most effective methods for protecting the ship's information systems and data.

A study on the present state of the art in autonomous shipping and marine cyber security was carried out by Kovanen (2021). This research underscores the necessity for good cyber security training for autonomous ships. This training should include instruction on the most recent technological advancements and best practices for cyber security. Moreover, it is recommended that experienced cyber security specialists provide training on cyber security for autonomous ships. Additionally, the training should be adapted to meet the unique requirements of the ship and its crew.

Other research has focused on the significance of education and training for marine safety on a global scale (Chapsos, 2016). Smuggling, piracy, and terrorist attacks are all examples of dangers to maritime security. These dangers have the potential to have substantial repercussions on both the economy and society, in nations such as Egypt, where marine commerce is an essential component of the economy. Effective training for marine security may assist in minimizing these risks and ensure that crew members can react effectively in the event of an incident. Training can also help to ensure that crew members are able to respond appropriately.

Upadhyaya (2018) carried out a comprehensive analysis of the dangers, difficulties, and potential answers regarding maritime security. According to the findings of the research, adequate training for marine security is very important. This training should include topics such as emergency response, piracy, and terrorism. Furthermore, training programs have to be comprehensive, current, and adapted to the particular requirements of the vessel and the people serving on it.

A study of the regulatory and legal problems related to autonomous shipping and marine security was carried out by Zhang and Roe (2019). According to the findings of the research, robust training programs for autonomous ships are desperately needed. These programs should include instruction on topics such as cyber security, emergency response, and piracy. Additionally, various stakeholders in the maritime sector, such as training providers, regulators, and ship owners, should work together to establish training programs.

Guidelines for the categorization of autonomous ships have been prepared by the International Association for Classification Society (IACS, 2020). These recommendations emphasize the need of competent training for autonomous ships, particularly training that covers topics such as cyber security, autonomous systems, and emergency response procedures. According to the standards, training programs should be established in conjunction with various stakeholders in the maritime sector, and they should be adapted to meet the requirements of the ship and the individuals serving on it.

The IMO has produced standards and recommendations on the education and certification of seafarers, including those who operate aboard autonomous ships. In its standards, the IMO emphasizes how important it is for autonomous ships to have adequate training, which should include training on topics such as cyber security, emergency response, and piracy (IMO, 2021a). The guidelines also indicate that training programs should be designed in consultation with stakeholders in the maritime sector and should be adapted to the individual requirements of the ship and its crew (IMO, 2021b). This is one of the recommendations that are included in the guidelines.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.140

Marine Insight (2021) is an online resource that is geared at the marine business and gives information on the most recent trends and advancements that have occurred in the sector. There are articles on the website that discuss autonomous ships as well as the future of the maritime industry. The website emphasizes the significance of proper training for autonomous ships, including training in cyber security and emergency response, as well as training on the most recent technological developments and industry standards.

An investigation of marine transportation was carried out by the United Nations Conference on Trade and Development (UNCTAD) in the year 2019. The significance of the marine sector to the economy of the whole world is brought to light by the findings of this research, as is the need for efficient training programs to guarantee the safe and sound operation of ships. According to the findings of the research, training programs have to be comprehensive, current, and adapted to the particular requirements of the vessel and the people serving on it.

Existing research emphasizes the significance of good training for autonomous ships and maritime security; yet there are still substantial gaps in training programs and resources despite the fact that these issues have been brought to light. These deficiencies include the absence of training programs that are both comprehensive and current, the absence of collaboration amongst stakeholders in the formulation and execution of training programs, and the absence of funding for training programs. In addition, there is a need for the development of training programs that are adapted to meet the particular requirements of the ship and the crew, and that also take into consideration the growing dangers to maritime security.

METHODOLOGY

Search Strategy

The researcher employed a systematic strategy to perform a complete literature evaluation, which included scanning a range of electronic databases, including Google Scholar, Scopus, Web of Science, Science Direct, and other relevant sources. He ensured that his search was comprehensive and inclusive by utilizing a variety of databases, gathering a wide range of papers regarding "Egyptian Marine Protection and Training on Autonomous Ships.» The researcher utilized a mix of keywords and related phrases, such as "autonomous ships," "maritime security," "cyber security," "training," "Egypt," "Maritime Safety Committee (MSC)," and others, to narrow his search. He attempted to gather the most relevant and up-to-date information on the issue by using these precise phrases, to ensure that his evaluation was complete.

Inclusion and Exclusion Criteria

The studies were screened based on their relevance to the research question. The inclusion criteria for the studies were that they should focus on training for autonomous ships and/or maritime security and should include information on training programs and resources. The exclusion criteria were that the studies should not be relevant to the research question or should be duplicates of other studies.

Data Extraction and Analysis

The studies that met the inclusion criteria were reviewed in depth to extract relevant information on training programs and resources for autonomous ships and maritime security. The extracted information was organized into themes and analyzed to identify gaps in training programs and resources, and to make recommendations for improving training programs and enhancing maritime security.

The analysis of the studies was conducted using a content analysis approach. This involved organizing the extracted information into categories and themes and identifying patterns and trends in the data. The analysis also involved comparing the findings of different studies to identify areas of agreement and disagreement.

RESULTS AND DISCUSSION

While searching the literature, a total of 58 papers that qualified for inclusion were discovered. The studies were published between the years 2010 and 2021, and they addressed a broad variety of subjects connected to the education of crew members aboard autonomous ships and the protection of maritime infrastructure. The studies were assessed using a method known as content analysis, and the findings are summarized in the following paragraphs.

Training Programs and Resources for Autonomous Ships

The studies that were looked through brought to light the significance of having efficient training programs and resources for autonomous ships (Komianos, 2018). The following are some of the most important topics that should be taught in training programs:

- Navigation and operation of ships operating on their own,
- Performing service and repairs on unmanned

vessels,

- Risk assessment and management,
- Preparedness for unexpected events and responses to emergencies, and
- Collaboration and open lines of communication

There are several resources that need to be made accessible to assist training programs. These resources include simulators, training manuals and materials, and access to experienced staff.

Based on the findings of the examined research, it has been identified that Egypt's training programs and resources for autonomous ships exhibit some deficiencies. A lack of comprehensive and current training programs was one of these gaps, as was a lack of coordination amongst stakeholders in the formulation and execution of training programs and a lack of funding for training programs (Gouda, 2016). According to the research, training programs should be designed to address these gaps, and resources should be made available to assist the creation and implementation of these training programs. The studies also advised that these training programs be produced.

Table I. Summary of Training Programs and Resources for Autonomous Ships

Theme	Description	Gaps	Recommendations
Training Programs	Navigation and operation of autonomous ships, maintenance and repair, risk assessment and management, emergency response and contingency planning, and communication and teamwork	Lack of comprehensive and up-to-date training programs, lack of coordination between stakeholders and lack of resources	Develop comprehensive and up-to-date training programs, coordinate the development and implementation of training programs between stakeholders, provide resources for training programs
Resources	Simulators, training manuals and materials, access to experienced personnel	Lack of resources	Provide resources to support the development and implementation of training programs

Cyber Security

Cyber security was another topic that was brought up in the research, and it emphasized how important it is for autonomous ships and marine safety (Bolbot et al., 2020; Sharma and Kim, 2022). In addition, autonomous ships face a number of cyber security vulnerabilities, including the following:

- Unauthorized access to the ship's databases and computer systems,
- Malware and viruses,
- Attacks that deny access to a service, and
- Attacks using spoofing and phishing techniques.

Based on the findings of the investigations, it was advised that training programs for autonomous ships should include cyber security training, and that resources should be made available to assist cyber security training. Furthermore, the regulatory framework for autonomous ships must be expanded to incorporate provisions for cyber security.

Table II. Summary of Cyber Security

Theme	Description	Recommendations
Cyber security	Unauthorized access to the ship's systems and data, malware and viruses, denial of service attacks, spoofing and phishing attacks	Integrate cyber security into training programs, provide resources to support cyber security training, include cyber security in the regulatory framework

Coordination and Collaboration

According to the studies that were analyzed, coordination and cooperation among the many stakeholders is essential for the creation and execution of training programs and resources for autonomous ships as well as maritime security (Ichimura, 2021; Tijan et al., 2021). There are a number of different parties that ought to have a say in the development of training programs and resources. These parties include ship-owners, ship operators, training providers, and regulatory bodies.

Additionally, there is also a need for coordination and cooperation among the many stakeholders in the process of developing and implementing training programs and resources. According to the findings of the research, the various stakeholders should collaborate in order to design comprehensive and current educational programs and resources that are adapted to meet the particular requirements of the ship and the members of its crew.

Table III. Summary of Coordination and Collaboration

Theme	Description	Recommendations
Coordination and Collaboration	Involvement of ship-owners, ship operators, training providers, regulatory authorities, as well as coordination and collaboration between stakeholders.	Create a systematic communication strategy that includes frequent meetings, conferences, and information sharing sessions for all parties involved in order to establish regular communication channels. This will improve cooperation by facilitating the sharing of ideas, updates, and comments.

Regulatory Framework

The relevance of the regulatory framework for autonomous ships and maritime security was also stressed in the papers that were evaluated (Komianos, 2018; Li and Fung, 2019; Mallam et al., 2020). There are various regulatory problems that need to be fixed, including the following:

- The establishment of certification and guidelines for autonomous ships,
- Insurance and legal responsibility,
- Regulatory frameworks for cyber security, and
- Cooperation and coordination on the international level.

A complete regulatory framework that tackles these challenges and gives direction for the design and operation of autonomous ships should be devised.

Table IV: Summary of Regulatory Framework

Theme	Description	Recommendations
Regulatory Framework	Certification and standards for autonomous ships, liability and insurance, cyber security regulations, international cooperation, and coordination.	Need for a comprehensive regulatory framework.

Automation in the Navy

Since World War one, the navy has incorporated automation. The majority of modern naval ships are highly automated, according to recent studies by Barrett et al. (2019) and Cordle & Cotter (2019). The automation adoption in the navy has had both favorable and unfavorable effects. It was stated that better communication between designers of automation systems and navy personnel currently in service will help to offset these negative consequences by reducing the likelihood of the introduction of automation systems that are ineffective for their intended use. Prior to their deployment on autonomous ships, new recruits, and existing serving naval officers have focused on receiving adequate training, as their arrival frequently results in the reallocation of functions. The serving personnel transition training is essential before their deployment in highly automated littoral warfare ships, according to Cordle & Cotter's (2019) suggestion. Additionally, Barrett et al. (2019) argue in favor of preparing autonomous ships brand-new naval recruits.

Autonomy, which means independence and self-governance in Greek, is derived from the terms "auto" and "nomos," which both imply law. So, in a strict sense, an autonomous system is one that has the capacity to change the predetermined, programmed course of action that the system's inventor has established. A former executive of Ford Motor Company created the word automation, which was derived from autonomy. The phrase automation was conceptualized as "the execution by a machine agent (typically a computer) of a function that was previously performed by a human" in the literature, which is where it first appeared. These authors assert that a function no longer qualifies as automation when it has been fully and permanently transferred from a human to a machine. According to this definition, an autonomous system is one that is incapable of deviating from its pre-programmed operations (Vagia et al., 2016).

According to Man et al.'s (2015) study, which primarily focuses on human factor issues linked to the ships operation from shore control centers (SCCs), future SCC operators would need training in terms of their cognitive skills to appropriately handle every information displayed on screens in SCCs. Man et al. (2015) fell short of going farther and putting out any framework for the improvement of cognitive abilities of future ship operators from SCCs. The other studies stress the necessity of coordinating seafarers' training with technical advancements in MASS, but they do not precisely describe the kind of training that will be required or suggest a structure for enhancing seafarers' future skill sets. However, Nguyen (2018)'s survey of maritime experts indicates that future seafarer training would prioritize:

- Computer-depending and Simulator-depending training,
- The Virtual Reality technology and simulation use, which also permits to seafarers to practice and train on board,
- Personalized training that is absolutely tailored to the individual requirements,
- Competencies of STEM (engineering, technology, science, and math) introduced for all technical industries,
- Recent knowledge in managing people and leadership, associated with management in the sector,
- The young seafarers' Preparation for life at sea, and
- Training those who, as marine engineers, port officers, or electro-technicians, will operate future autonomous ships and their propulsion systems either remotely or onboard.

The characteristics of the sailors who will man the ships of the future imply that they may have both non-seafaring and seafaring backgrounds. Future mariners will be trained using simulations extensively. The precise facilities that will be required for training upcoming ship operators are still mostly unknown (Mallam et al., 2020).

Resource Unavailability leads to Piracy

Maritime piracy, which is fundamentally a kind of illegal behavior, differs from other forms of criminal activity since it happens in areas of the high seas outside of any nation's territorial authority. Piracy flourishes in lawless areas. This lack of effective government and unrestrained natural resource exploitation, notably energy and fisheries, hurts the economy. Somalia is the most famous example of how failing fisheries and coastal ecosystems have fueled piracy. Foreign fishing fleets with bigger, more effective ships and operations drove Somali fishermen out of the richest fishing grounds. The fishermen joined together with local militias, who filled the governance void, in order to engage in ship hijacking for ransom since they were facing the loss of their livelihood and the absence of an efficient administration to deal with foreign incursions (Kantharia, 2019).

Military or maritime law enforcement power can be used to combat piracy in the short term, but this tactic only offers temporary relief to crews and ships and does not address the deeper, systemic problems that support piracy. As an illustration, consider the international naval forces deployment to the Horn of Africa to protect commercial ships and quell piracy. Since the roots of piracy are not being properly addressed, the effect over time decreased the shipping attacks, but the withdrawal of those naval forces is likely to lead to a revival of piracy. In order to address these root causes and systemic problems, it is important to strengthen the law rule, provide viable economic alternatives to piracy, and ensure that international assistance is delivered in a targeted and efficient manner (Jin and Techera, 2021).

Focus on Cargo Security Enhancement

The ISPS Code introduction has significantly, though not solely, shaped the focus on vessel and port security since September 11, 2001, or 9/11, when terrorists launched coordinated assaults against the US. In the future, port and vessel security will probably move to a focus on ships and ports as conduits within the supply chain rather than as targets due to the sustained and anticipated maximization in the volume of global cargo and the concentration on "Just-in-Time" delivery of commodities. This is a result of growing concern over the secure and safe transportation of commodities. "Just-in-Time" delivery is a supply chain idea to lessen the need for cargo warehousing and storage. There may also be fewer "moves" inside a supply chain in some circumstances, which eliminates some transfers across logistics providers. Although the idea is meant to cut costs, the fact that it depends on on-time deliveries makes supply chains more susceptible to disruption.

The following are some of the elements that will aid in the transition from vessel and port security to cargo and supply chain security:

- The ISPS Code clearly defines the criteria for port and ship security, although the Code concentrates on ports and ships as terrorist aims rather than as hubs for nefarious activities, cargo theft, or the contraband flow, including the Weapons of Mass Destruction potential introduction;

- There is more cargo in the system since global trade keeps growing extremely quickly;
- The global supply chain is becoming more and more dependent on "Just-in-Time" delivery, which increases its sensitivity to disruption and the potential severity of its effects; and
- Large volumes of personal, financial, and freight information are also progressively flowing digitally, which raises the possibility of integrated security concerns (Physical, cyber, and operational).

The ISPS Limitations (Edgerton, 2021)

Following the 9/11 terrorist attacks, the ISPS Code was created and went into effect globally in 2004. The Code was created with an emphasis on preventing attacks of terrorist on ships and ports rather than on the ships and ports use as conduits for illicit activities, contraband, or people since at the time, protecting essential infrastructure was a top priority. Access some cargo and control-related issues were addressed, but little attention was paid to cargo security. (CBP) US Customs and Border Protection launched new initiatives to focus on cargo security, including the placement of CBP personnel at the busiest container ports worldwide, under the auspices of the US container security initiative (CSI), to act as liaisons and coordinate the screening of cargo headed for the US in addition to the expansion of voluntary, incentivized programs of cargo security like Customs-Trade Partnership Against Terrorism, which the US implements.

Furthermore, the ISPS code did not specifically address cyber security because it was introduced prior to the rapid improvements on the internet, information technology, and the shipping sector. Although the Code mentions information protection, it imposes no rules or criteria for it.

The ISPS Code is therefore not intended to adequately address issues of cargo security and developing cyber security difficulties specific to the industry, despite the fact that it is still current and very successful at defending ships and ports from assault.

While this literature review has provided valuable insights into the training programs and resources for autonomous ships and maritime security in Egypt, there are several limitations that should be acknowledged as follows:

1. Limited research on autonomous ships in Egypt,
2. Limited information on the effectiveness of training programs,
3. Limited information on the costs of training programs,
4. Limited information on the impact of autonomous ships on maritime security,
5. Limited information on the regulatory framework for autonomous ships in Egypt,
6. Limited research on the integration of cyber security into training programs, and
7. Limited focus on small-scale autonomous ships.

CONCLUSION

The development of autonomous ships has the potential to completely transform the shipping sector, but at the same time, it presents a number of important issues for maritime education and safety. The purpose of this literature review was to investigate the previous research that has been conducted on the subject of training for autonomous ships and maritime security, with a particular emphasis on Egypt. The goal of the assessment was to identify any gaps in training programs and resources and to give suggestions for strengthening training programs and increasing maritime security in Egypt. Specifically, the evaluation focused on Egypt's maritime security.

Following the evaluation, many important topics were recognized as ones that need to be included in training programs. These include the navigation and operation of autonomous ships, maintenance and repair, risk assessment and management, emergency response and contingency planning, as well as communication and collaboration. The evaluation determined that several resources, including simulators, training manuals and materials, and access to experienced staff, should be made accessible to assist training programs.

Accordingly, there are a few deficiencies in the training programs and resources available for autonomous ships in Egypt. These deficiencies include a lack of comprehensive and current training programs, a lack of coordination between stakeholders in the development and implementation of training programs, and a lack of resources for training programs. This evaluation makes a number of recommendations, one of which is that training programs that address these gaps should be established, and that resources should be made available to assist the creation and implementation of these training programs.

In addition, the evaluation emphasizes the significance of cyber security, coordination, and teamwork, as well as the legislative framework for autonomous ships and marine safety. It is recommended that training programs for autonomous ships should include cyber security training, and that resources should be made available to assist cyber security training. The study concludes with the recommendation that the regulatory framework for autonomous ships should include cyber security considerations. In addition, the assessment highlights the significance of coordination and cooperation among the many stakeholders in the process of developing and implementing training programs and resources for autonomous ships as well as maritime security. Based on the findings of the study, the stakeholders should collaborate in order to establish training programs and resources that are both thorough and up to date, as well as resources that are suited to the particular requirements of the ship and its crew. In conclusion, the study emphasizes how important it is to have a legal framework in place for autonomous ships and to maintain maritime safety. A complete regulatory framework is recommended to be constructed as a result of the evaluation. This framework should handle problems such as certification and standards for autonomous ships, liability and insurance, cyber security rules, as well as international collaboration and coordination.

RECOMMENDATIONS

Based on the findings of this evaluation of the relevant literature, a number of suggestions are available for the creation of educational programs and resources pertaining to autonomous ships and maritime security in Egypt, including the following:

- Create instructive programs that are both thorough and up to date,
- Make available resources for educational program,
- There is a need for coordination between various stakeholders in the process of developing and implementing training program, and
- Cyber security education should be included in educational programs for ships that operate on their own. Training in cyber security needs to be supported by resources that ought to be made accessible. It should also be included into the regulatory framework for autonomous ships, and finally
- Create an all-encompassing regulatory structure.

LIMITATIONS

This literature review is based on research that was published in English; thus, it is possible that relevant studies that were published in other languages were not included in the study. This is one of the limitations of the review. In addition, the review was restricted to research that was published between the years 2015 and 2022, therefore it is possible that some pertinent studies were missed. In addition, the study was restricted to just electronic resources, therefore it is possible that pertinent research that was not indexed in these databases was overlooked.

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Utilizing Of The Quality Function Deployment (Qfd) To Analyze The Effects Of Using Autonomous Vessels On Maritime Shipping Factors

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Received on: 06 August 2023 Accepted on: 10 October 2023 Published on: 12 December 2023

ABSTRACT

Purpose: *The maritime sector has seen a significant digital shift and technical advances related to the design and development of unmanned ships. Autonomous cargo ships, also known as maritime autonomous surface ships (MASS), are crewless vessels that transport either containers or bulk cargo over navigable waters with little or no human interaction. Applying third and fourth generation of full autonomous vessels will be expected to improve maritime navigation in the future.*

Design/ Approach/ Methodology: *This paper attempts to give a complete view of the development of autonomous vessels by exploring the long-term effects of using unmanned or fully autonomous vessels on regulations, technologies and shipping industries that reflect the new paradigm in the shipping industry. The effects of Maritime Autonomous Surface Ship (MASS) implementation of the maritime shipping factors were analyzed based on a Quality Function Deployment (QFD) Decision model that demonstrates global maritime shipping behavior through implantation of MASS.*

Findings: *The research paper results indicated the most important factors and criteria, in order of importance, in the recent trends in the development of autonomous vessels. The safety requirements in operating ports, cyber security from hacking risks, legal approval and ethical issues, cost implications, and maritime recruitment are some of the most important factors to consider, adopting such technological development for maritime shipping.*

Key-words:
QFD-Port selection criteria, Multicriteria decision making, Task oriented weighting, Intelligent decision support, Autonomous ships, Maritime Autonomous Surface Ships (MASS).

INTRODUCTION

Recently, technology is moving forward as a step related to cyber-physical systems and autonomy as part of the "fourth generation of shipping". Given the demands of the shipping industry and the needs of shipping lines, the previous research offers several reasons for the use of autonomous vessels such as: the need for better crews' working environment onboard for mitigating the risk of future shortage of seafarers, reducing transportation costs, the global effort of reducing emissions, improving the safety in shipping, saving shipping voyage time and, shipping line and ports reputation.

On the regulatory side, IMO (2017) decided to initiate a Regulatory Scope Exercise (RSE) to determine the safe and environmentally sound operation of MASS. RSE will be complex as it will affect all activities of the maritime industry, including security and safety, interactions with ports, pilot life in response to incidents and the marine environment.

In terms of technology, by using the recent Information and Communications Technology systems (ICT), ships will be structured with advanced automatic control, communication, capabilities, and interface systems, and they will be operated remotely as land-based or offshore service centers. Unmanned or autonomous ships are currently used for aerospace, military, and scientific activities.

On the industrial side, there are various classes of remote or unmanned systems in other transportation modes such as the train, automobile and aircraft industries, as autonomous vehicles were already under development. Turning back to the maritime industry, MASS is expected to change shipbuilding, instrumentation, equipment, and port infrastructures (Ghaderi, 2019).

In this paper, the maritime shipping factors that might be affected by application of autonomous ships in global maritime shipping routes are presented. In addition, all main and sub factors that may be affected from autonomous ships application in the maritime shipping are ranked to clarify the priority of these factors in their order of importance, since the previous research in this field is lacking in detail, in exploring the long-term effect of using autonomous ships on the maritime shipping market in a scientific computational manner.

The main goal of the paper is to investigate the application of full autonomous (unmanned) ships on the maritime shipping industry, to assess the feasibility of applying this technology soon, and the seriousness of being considered as a real competitor to conventional shipping.

Effects of Utilizing Autonomous Surface Ship on Maritime Shipping Industry Factors

Regulation Effects Reviews

Although autonomous surface vessels are a relatively new technology, they are still subject to the same international laws and regulations as any other vessel. These laws and regulations are in place to ensure the safe operation of any kind of vessel, even in seabed regions beyond the purview of any national jurisdiction.

Although some regulations for staffed vessels may be compatible and appropriate for unmanned and autonomous ships, such as some clauses of the International Code of Safety Management (ISM), they are also mandatory standards and characteristics of unmanned vessels in international withdrawals and regulations (Lang, 2020). As the maritime industry develops more advanced vessels with intelligent capabilities, the International Maritime Organization (IMO) is reviewing regulations for autonomous vessels, defined as a Regulatory Scope Exercise (RES) on autonomous vessels (Komianos, 2018).

Effects of MASS on Shipping Industry Reviews

In the past century, the maritime industry has been dependent on the knowledge and experience of the ship's crew. Recently, artificial intelligence, automatic control, and autonomous technology to repair marine transportation have been replaced by unmanned ships. Furthermore, MASS will have effects on shipbuilding, port infrastructure, construction, and design, including services and interfaces. With the expected automation, the components of land freight will be transformed, port selection criteria, port infrastructure and cargo handling will be altered due to land logistics and the transport chain (DNV GL, 2018).

Effects of MASS on Marine Technology Reviews

Autonomous ships feature technology like remote flying objects or autonomous vehicles that use an array of physical sensors to control autonomous operations (Lloyds Register & QinetiQ, 2020).

Ten years ago, providing internet access to crew members and travelers was difficult and expensive. In recent years, maritime has embraced different technologies for generic communications. Commercial cell phones with 3G or 4G networks can connect ships to shore up to 30 kilometers offshore. Instead of the secluded lifestyles that restrict them from accessing the maritime sector, crew members with access to the internet may have a competitive edge in developing their knowledge of ships (Burmeister et al., 2019).

The first challenge to develop technology for autonomous vessels is to demonstrate that remote and staffed systems meet the minimum safety requirements as a manned vessel system and ensure that the Shore Control Center (SCC) is provided with adequate situational awareness (Porathe et al., 2021). The implementation of MASS technology will have a range of beneficial and detrimental effects on safety. The goal is to increase the dependability of autonomous and unmanned ships' safety in comparison to conventional ships (Taufer, 2019).

Main Factors Considered on MASS

Security

As the operation of autonomous vessels becomes increasingly reliant on data technology and communication information systems both on board and on shore, the risk of cyber-attacks becomes a significant concern. Compared to conventional ships, autonomous vessels are at a greater risk of cyber-attacks due to the ability to control activities remotely. Hackers can target and compromise communication links to gain direct control of the vessel's processes.

Due to the increased reliance on software and communication systems for ship control, autonomous ships are more vulnerable to cyber threats. Additionally, new security issues will be confronted as malicious activity increases and new technologies, like the Internet of Things (ITO), are developed, making it more crucial than ever to safeguard networks, data, and systems (DNV GL, 2020).

MASS might alter how criminal, hacking, and terrorist actions are organized. The implementation of autonomous ships soon is supposed to reduce the number of casualties, including cases of hostages and kidnappings by pirates and armed robbery. On the other hand, unmanned vessel hijacking of any type of cargo is increasing along with the inherent risks that lead to criminalities such as illegal transportation of goods, containing both drugs and weapons.

Jobs and Training

The maritime industry is growing rapidly, and it can be challenging to find suitable skilled seafarers to meet the demand. Additionally, the idea of autonomous ships has raised concerns about potential job loss, as artificial intelligence and autonomous systems are expected to replace some roles traditionally performed by humans.

However, this trend will be followed by the chance to start a new career and generate employment, which will require particularly highly qualified crews and operators with knowledge of technology and IT systems. The use of automation can help compensate for the anticipated worker shortage. Many offshore activities will become SCC onshore because of the remote activity and autonomous operations, allowing employees who find careers on land and offshore more appealing to join the transportation business. Additionally, because MASS is managed from land it could cause maritime accidents due to the difficulties of remaining on board for an extended period (Kim et al., 2020).

Safety

Automation can improve environmental safety, as it can address human deficiencies such as fatigue, information overload, attention span, and a natural bias pertaining to the likelihood of incidents (Porathe et al., 2021). According to a United States Coast Guard (USCG) investigation, between 75 and 96 percent of maritime accidents were due to human error. Burnout, a lack of standards and maintenance, a lack of knowledge and information, and poor communication abilities were to blame for these incidents (Hinrichs et al, 2021).

Therefore, risk assessment is a useful tool for making pertinent design decisions and may be used to demonstrate the primary degree of risk. The complexity of the autonomous marine system leaves a gap in the availability of pertinent information, expertise, experience, and data. Given the multitude of uncertainties in episodic, probabilistic, and hazardous circumstances, it can be challenging to fully estimate the amount of risk to MASS as a result (Rodseth, 2021).

Research Stages Implementation

The research is structured in the manner described as: **Step1:** Reading and analyzing literature; recent relevant literature must be reviewed in this stage. **Step 2:** Based on the results of Step 1, the three main axes to examine the effects of applying autonomous shipping should be conducted from the perspective of maritime transport stakeholders who are integrated into the global logistics chain. In this phase, questionnaires that will ask the target group a series of questions are carefully prepared. **Step 3:** Questionnaires will be received by the target group. After replies have been received, the findings of the surveys will be examined, and important information will be extracted and concluded using statistical procedures. **Step 4:** At this point, QFD will be applied to obtain results for this subject, i.e., building the QFD HOUSE and determining the relative relevance of criteria. **Step 5:** The focus at this point will be the house of quality (HOQ) of Quality Function Deployment (QFD). The model findings will be interpreted, and the research findings will be sought after. **Step 6:** Study findings will be summarized, any limitations will be discussed, and suggestions for more research will be made.

Structured Communication Technique

The Delphi method has been used in the research paper as a popular tool in information systems research for identifying and prioritizing the critical maritime factors that will be affected by applying autonomous shipping technology for managerial and technical decision-making.

The research adopted a systematic approach to conduct a "Delphi survey method as structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts" for structuring a group communication and meeting with maritime experts and different shipping stakeholders, that was essential for collecting opinions and judgments analytically (experts' opinion depended on real data and the previous knowledge of future autonomous technology application) to estimate the correlation relation between the maritime shipping customer needs as voice of customers (VOC) and each maritime factors and port criteria that expected to be affected from full automation technology.

The research provides rigorous guidelines for the process of selecting appropriate experts for the study and gives detailed principles for questionnaire design that ensure a valid study. The research used questionnaires distributed to stakeholders in maritime shipping to obtain original data and then used some basic statistical methods (average, and quartile). To find out the sample size, the following steps were applied:

1- Designate margin of error **(E= 0.05)**

2- Determine how confident you can be; in case of E= 0.05 **(Z score = 1.96)**

3- Define population size (Maritime Shipping Stakeholders Estimation) **N = 260**

4- Define the standard of deviation (In case of uncertainty of population size) **P= 0.5**

5- Finalize sample size $n = \frac{P*(1-P)*(Z)^2/(E)^2}{1+ P*(1-P)*(Z)^2/(E)^2\, N}$

Given this result, the questionnaires were distributed to 225 dynamic shipping clients, yielding 155 functional answers, the survey participants involved cargo carriers, port management, freight forwarding, ship manufacturing companies and some other stakeholders, volume distribution of investigated customers shown in **Figure 1.**

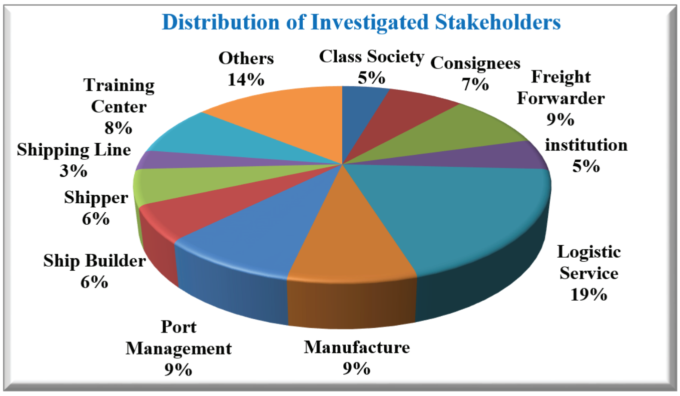

Figure 1. Volume distribution of investigated customers

Quality Function Deployment (QFD) Concept

Quality function deployment (QFD) is a method to transform user demands into service design quality to deploy the functions forming quality, to deploy methods for achieving the design quality subsystems and component parts, and to specify elements of the manufacturing process according to the Quality Function Deployment website. QFD aids in translating the Voice of the Customer (VOC) into new goods and services that meet customer demands. In the current report, QFD will be examined to comprehend how it functions, to point out both the advantages and the disadvantages, and to talk about its potential applications (Shillito et al., 2013).

QFD is founded on gathering and translating customer requests into specifications and individual features, and then process plans, production and service necessities are developed. Figure 2 demonstrates each of the sections contained in "the House of Quality (HOQ)". Each segment contains crucial information that is unique to that section of the QFD analysis. In fact, the procedure is flexible and the order in which the HOQ is completed depends on the research team. Typically, the matrix is completed by a specifically created team who follows the logical sequence provided by the letters A to F. HOQ is a qualitative and subjective tool for translating the client's requirements into technical features (Terninko, 2017).

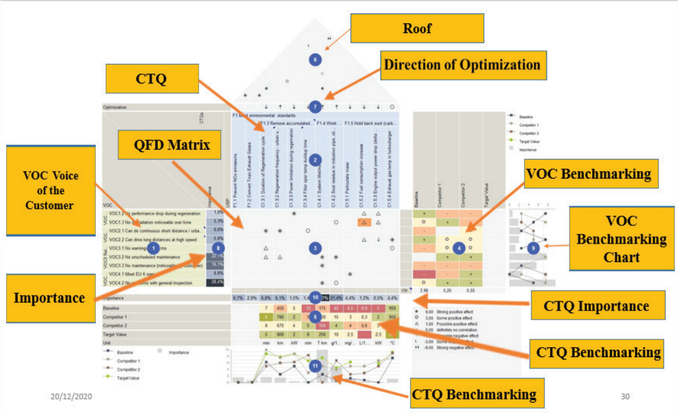

Figure 2. The House of Quality (HOQ) overview

Results and Discussion

Voice of Customer Importance Evaluation

The VOC defines the direction that should be taking. Collecting the VOC should occur throughout the autonomous technologies service development cycle. It should take place before the final concept is defined, while the service is in development and after the service has been launched. One of the most effective ways to gather VOC is through a customer focus group.

Table 1: VOC Importance Evaluation

Customer needs		importance evaluation
The need for better crews	VOC 1	7.73
Reduce transportation costs	VOC 2	8.15
The global effort of reducing emissions	VOC 3	1.98
Improving the safety in shipping	VOC 4	6.34
Saving shipping voyage time	VOC 5	4.61
Shipping line and ports reputation	VOC 6	4.38
Improving the cyber security	VOC 7	7.26
Delivery of cargo undamaged condition	VOC 8	4.52

Table 1 (importance evaluation) and Figure 3 show in detail the average of the voice of customers in order, it was clear that the largest average (VOC2) (8.15) and the lowest average (VOC3) (1.98).

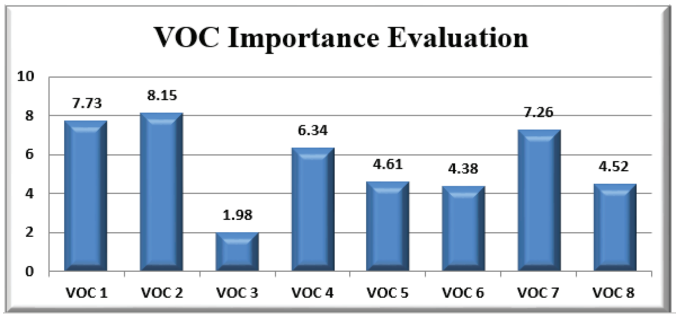

Figure 3. VOC Importance valuation

Maritime Shipping Initial Criteria

Global and local laws and practices, as well as a distillation of prior experience, regulate the maritime transportation industries, technology, and regulations. These might lose significance with time, particularly when innovative technologies are involved. Autonomous surface shipping is one example of such innovation in the marine sector. The enormous range of design solutions clearly outstrips the capacity of prescriptive restrictions. Furthermore, prescriptive laws may become out of date if best practice is changing, such as with developing technologies or shifting paradigms surrounding ship operations. These regulations reflect the best engineering practice at the time they were enacted. To characterize the issues, make solution suggestions, and outline future research paths in risk assessment of autonomous, QFD applied to explore the effects of deploying autonomous shipping technology on marine shipping major factors.

Table 2 shows in detail the empirical finding of applying QFD on Marine shipping factors relative to the customer needs. As shown QFD table illustrates the need for better crews VOC1, improving the cyber security VOC7 and reducing transportation costs VOC2, and ranking the highest percentage; that means mentioned requirement in order have the highest important relative to the Marine shipping factors, in the time that global effort of reducing emissions VOC3 rank the lowest percentage; which means that VOC3 is the least important relative to the Marine shipping factors.

Also, Table 2 illustrates that individual criteria monitor and control system (SCC) C14, the International Regulations for Preventing Collisions at Sea C6 and Automation Safety System C16 in order rank the highest percentage, which means the mentioned criteria have the highest importance relative to customer needs. At the same time, the table reflects that individual criteria international convention of Bills of lading C8 rank the lowest percentage, which means C8 is the least important relative to customer needs.

MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.151

Table 2: Maritime Shipping Initial Criteria

Customer Needs	Importance	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	QFD	%
		Marine Shipping Factors																							
VOC 1	7.73	7.90	8.31	8.72	8.52	4.52	8.66	3.28	2.66	4.45	4.03	5.00	6.45	7.48	8.66	7.41	8.24	4.17	4.17	7.28	5.21	5.90	5.21	1053.33	17.53
VOC 2	8.15	4.59	3.28	4.03	7.21	5.71	6.55	6.83	6.07	3.62	3.62	3.55	5.76	6.66	7.21	7.83	7.48	4.10	4.10	6.45	6.52	6.24	6.66	1010.78	16.82
VOC 3	1.98	3.76	3.41	2.86	1.76	8.66	2.59	2.38	2.10	1.41	1.34	1.34	1.62	4.52	4.45	1.55	4.31	1.62	1.90	5.07	8.03	5.76	7.83	155.27	2.58
VOC 4	6.34	7.76	8.17	7.97	8.45	4.24	8.52	3.97	3.14	7.07	6.93	7.00	7.90	8.24	8.24	7.41	8.45	5.69	5.34	7.83	7.69	6.93	7.83	981.83	16.34
VOC 5	4.61	6.24	4.38	3.90	2.24	1.48	8.59	5.76	5.00	6.31	5.83	5.62	7.62	7.83	8.03	5.41	7.48	3.83	4.17	7.14	5.21	5.76	4.93	565.49	9.41
VOC 6	4.38	5.62	4.66	6.24	7.00	7.48	8.59	5.34	4.72	3.48	3.83	3.90	5.28	6.72	7.41	7.76	7.76	3.90	3.97	7.28	5.76	5.69	5.90	561.47	9.34
VOC 7	7.26	6.79	5.41	4.93	1.97	1.41	8.10	2.17	1.69	8.45	8.66	8.59	8.52	8.72	8.86	9.00	8.66	7.97	7.90	8.38	5.21	7.14	5.14	1043.27	17.36
VOC 8	4.52	6.71	6.14	6.14	5.86	2.07	9.00	7.57	6.43	5.36	5.21	5.50	7.00	7.79	8.00	6.43	7.36	4.14	4.00	7.50	7.93	6.71	8.07	637.64	10.61
QFD		288.2	257.2	265.4	263.4	184.8	356.2	210.8	179.1	241.5	237.4	244.9	301.8	337.4	356.8	324.6	351.4	216.3	215.4	328.0	281.0	285.5	282.0	6009.08	100.00
%		4.80	4.28	4.42	4.38	3.08	5.93	3.51	2.98	4.02	3.95	4.08	5.02	5.62	5.94	5.40	5.85	3.60	3.58	5.46	4.68	4.75	4.69		

C1 Regulatory scoping exercises on autonomous ships (RES)
C2 International Safety Management (ISM) Code
C3 Standards of Training, Certification and Watch keeping for Seafarers (STCW)
C4 International Conventions for the Safety of Life at Sea (SOLAS)
C5 International Conventions for the Prevention of Pollution from Ships (MARPOL)
C6 the International Regulations for Preventing Collisions at Sea
C7 Ship Stability Strength and Loading Principles
C8 International Convention of Bills of Lading
C9 Automatic control communications
C10 Interface systems
C11 Information connection technique
C12 Decision support system
C13 Operation system on board
C14 Monitor and control system **(SCC)**
C15 Cyber security system
C16 Automation safety system
C17 Enterprise grates connectivity
C18 Big data capability
C19 Automation operations
C20 Ship builder and manufactures
C21 Equipment and devices required
C22 Ship building structure

QFD of Marine Shipping Factors Main Indicator with Respect to Initial Criteria and Voice of Customer (VOC)

The relative relation between Marine shipping factors and the maritime stakeholder's voice as customer needs is represented graphically; Figure 4 illustrates the impact of applying autonomous shipping and technologies on this sector by applying QFD.

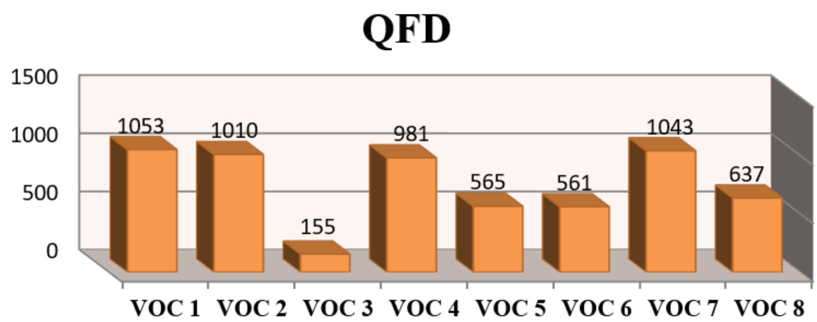

Figure 4. (A3) Marine shipping factors (QFD)

Table 2 on Marine shipping factors indicator and Figure 4 show in detail (A3) Marine shipping factors (QFD) (VOC1)(1053.33), (VOC2) (1010.78), (VOC3) (155.27), (VOC4)(981.83), (VOC5)(565.49),

(VOC6)(561.47), (VOC7)(1043.2), (VOC8)(637.64). The largest value is the need for better crews (VOC1)(1053.33) and the lowest value global effort of reducing emissions (VOC3)(155.27).

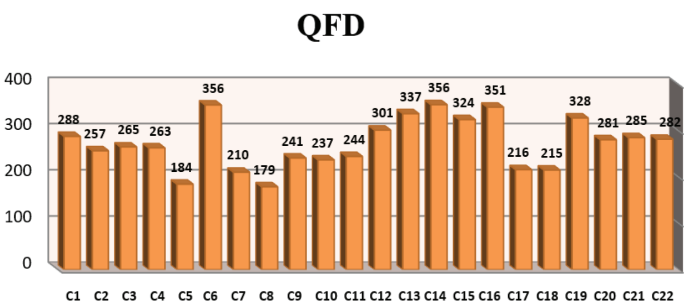

Figure 5. (A3) Marine shipping factors (QFD)

Table 2 on Marine shipping factors indicator and Figure 5 show in detail A3 Marine shipping factors (QFD) that values of variables ranged from (C1) to (C22). It is obvious that the largest value is Monitor and control system (C14) (356.8) and the lowest value is Convention of Bills of Lading (C8) (179.1).

Marine Shipping Factors Sub Indicators

In this section, the individual marine shipping factors of autonomous shipping were divided to sub indicators (B's) groups by finding the mean averages of the individual criteria (C's) for each group, to facilitate the analysis and comparison process with the same sub indicators of regular shipping.

Table 3: Marine Shipping Factors Sub Indicators

Customer Needs	Marine Shipping Factors		
	B1 (C1- C8) Marine regulation	B2 (C9- C16) Marine technology	B3 (C17- C22) Marine industry
VOC 1	6.57	6.47	5.32
VOC 2	5.53	5.72	5.68
VOC 3	3.44	2.57	5.03
VOC 4	6.53	7.66	6.89
VOC 5	4.70	6.77	5.17
VOC 6	6.21	5.77	5.41
VOC 7	4.06	8.68	6.95
VOC 8	6.24	6.58	6.39

CONCLUSION

a- The research findings contend that global effort of reducing emissions rank the lowest percentage, which means it is the least important relative to maritime shipping factors. Consequently, the main effects of applying full autonomous shipping third and fourth generation appear obviously on some critical marine shipping factors criteria (highest average from applying QFD on the statistical result) that is illustrated in Table 2 as follows:

(1) Monitor and control system C14

(2) International Regulations for Preventing Collisions at Sea C6

b- The Effects on Marine Shipping Factors are as follows:

(1) In terms of international regulations, the weight **Regulatory scoping exercises on autonomous ships (RES) C1** in (HOQ) result reflect that RSE has been accepted into the Maritime Safety Committee (MSC) work program to determine how to address the safe and environmentally sound operation of MASS in IMO instruments. Amending all relevant conventions will take a lot of work and a long time.

(2) In terms of technology, the weight of **Monitor and control system (SCC) C14** in (HOQ) result, explained that MASS must be monitored and controlled remotely by SCC operators by an intelligent alarm system that receives necessary and critical information via satellite. The systems and sensors required for MASS and SCC must be identified and developed, and their synergistic effects must be closely reviewed.

(3) In terms of maritime shipping industry, the weight of **Shipbuilder and manufactures C20 and Shipbuilding structure C22 in result** reflects that the manufacturers and other shipping stakeholders realized that they should have a high degree of redundancy and durability to avoid failures. The MASS will have an impact on ship design, shipbuilding, port infrastructure including services and interfaces.

Recommendations for Future Research

a- To enhance the capabilities of applying QFD as decision tools in future maritime research, the integration of other quality engineering techniques into QFD should be considered to increase its efficacy.

b- Further research needs to prove that the technology will improve competency, reduce physical exertion, and create more shore-side jobs, to prove that the application of this technology will be a real contributor to the future shipping industry.

c- The amount of autonomy should be defined in any further research as early as possible to cut costs and guarantee that business demands and safety hazards are identified and handled.

d- Further studies should demonstrate that the purpose of applying this advanced technology is to enhance the lives of people in the maritime domain and not just reduce operational fees and to reduce the expected resistance to this autonomous technology and any AI innovation.

Recommendations for Autonomous Ships Application

a- Updating the International Maritime Organization (IMO) Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) must be mentioned in the future research of applying autonomous shipping that is based on decision making tools.

b- Due to the "uncharted areas" of "unknown and unexpected risks, the future effects of maritime shipping elements and implementation barriers" that the current research has been exploring, as well as the highest level of consideration shown for all pertinent stakeholders, improved information dissemination, and information flow, the short periods should be continuously considered on the technology's viability along with the level of risk presented by the proposed system compared to the conventional shipping system and any legal restrictions.

c- As for maritime employment, the potential proliferation of unmanned ships is sparking further discussions about the future of offshore business opportunities. According to an autonomous shipping customer survey, technical innovations would provide several opportunities for seafarers to work nearer to their homes and "engage in more complex and high-level tasks" where "routine and more risky activities" are automatic. On the other hand, the maritime trade is expected to grow and this is sure to create more job opportunities.

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Maritime Research and Technology
MRT
ISSN 2812-5622
http://dx.doi.org/10.21622/MRT.2023.02.2.161

Acceptability of the e-Learning Module in Seamanship (Trim, Stability, and Stress)

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Received on: 12 October 2023 Accepted on: 02 December 2023 Published on: 12 December 2023

ABSTRACT

Purpose: *The acceptability level, strengths, and weaknesses of the Seamanship e-learning module were ascertained by this survey research study. It was found that the students and the experts found the e-learning module in Seamanship to have high acceptability in general and in terms of appearance, learning activities, evaluation procedure, ease of use, and usefulness. According to students, the strengths of the e-learning module in Seamanship were that it is: accessible, convenient, easy to understand, informative, relevant, has sufficient content, user-friendly, has several varied sources available, self-paced, well-organized, efficient, and systematic. Meanwhile, its weaknesses include the need for internet access, incomprehensive discussion of the contents, unreliable/unstable site, lack of human interaction, lack of hands-on experience, difficulty in using the site, misaligned lesson content and quizzes, excessive screen time, and availability of gadgets.*

Findings: *It is recommended that the e-learning module in Seamanship may be improved based on its strengths and weaknesses. Future researchers may conduct similar studies on other subject areas, look into longitudinal research or determine the effectiveness of the e-learning module.*

Key-words:
acceptability, e-learning module, information and communication technology, learning materials.

INTRODUCTION

Keeping up with new technological breakthroughs is one of the most frequently stated reasons why education needs to change. Nowadays, the internet is not only available through computers but also in our pockets in the form of smartphones which manifold faster than the first computer developed (De Bruyckere et al., 2016).

E-learning is one educational innovation that has responded to the quick advancements in technology. Education through the use of electronic devices and digital material is referred to as "electronic learning" or "e-learning." It includes anything from online universities to conventional classes with basic technology included. In addition, e-learning can come in a variety of formats. PowerPoint presentations and instructive films might be used in a conventional environment. The Classroom Performance System (CPS), on the other hand, offers a fully digital learning environment. Another popular type of e-learning is online education, where a lot of colleges and institutions let students use Moodle or other virtual learning environments to submit assignments, finish exams, and take part in online conversations. According to Christensson (2015), credits obtained for courses or subjects online are typically equal to those obtained in a regular classroom. In higher education, e-learning is a big part of the teaching process. It offers sophisticated methods that support the teacher's ongoing requirement to draw out and utilize each student's cognitive abilities to the fullest (Khazaal, 2015).

Numerous studies back up the use of online learning. The results of Harandi's (2015) investigation have validated that e-learning is among the factors influencing students' motivation during class. Furthermore, Afolabi (2017) discovered in her research that students scored very well on the achievement exam given to them and had a favorable opinion of the usage of Open Educational Resources (OER) in online learning.

This study illustrates the e-learning theory. E-learning, according to Clark and Mayer (2016), combines instructional techniques and content with the aim of promoting individual learning. This includes instructor-led instruction at a set time, known as synchronous e-learning, and learning intended for self-study that is available on demand, or asynchronous e-learning. Even though e-learning appears appealing, they stress that the advantages of technology still rely on how they are applied. It must, therefore, be appropriate for and consistent with human cognitive learning processes and be based on instructional design concepts. Furthermore, it has been suggested by Mayer et al. (2015) that students can learn effectively if teachers use educational technologies to construct assignments that reduce superfluous cognitive load and control relevant and intrinsic load at levels that suit them. Thus, early evaluative assessment of e-learning content is seen to be crucial for establishing a framework for subsequent tool enhancements, according to Martinez-Torres et al.'s (2008) study.

E-learning modules in a variety of areas, for both general and professional courses, have been developed recently by instructors at John B. Lacson Foundation Maritime University (Arevalo), Inc. It has not yet determined whether using the online learning module in Seamanship is acceptable. Hence, this study was carried out.

This study sought to ascertain the degree of acceptability of the Seamanship (Trim, Stability, and Stress) e-learning module for the school-year 2021-2022. This study aimed to give a more in-depth analysis and interpretation of the usual descriptive information that quantitative data can give. Specifically, this study sought answers to the following questions:

1. What is the level of acceptability of the e-learning module in Seamanship as a whole and in terms of (a) appearance, (b) learning activities, (c) evaluation procedure, (d) ease of use, and (e) usefulness as perceived by the students?

2. What is the level of acceptability of the e-learning module in Seamanship as a whole and in terms of (a) appearance, (b) learning activities, (c) evaluation procedure, (d) ease of use, and (e) usefulness as perceived by the experts?

3. What are the strengths and weaknesses of the e-learning module in Seamanship as perceived by students and experts?

METHODOLOGY

Research Design

A survey research design was used in this study. Survey research, according to Jhangiani et al. (2015), is a quantitative and qualitative method distinguished by two key features: using self-reports to measure variables of interest and giving careful consideration to sampling. It is an adaptable method that can be used to investigate a broad range of fundamental and practical research issues. Despite the fact that statistics are frequently used to examine survey data, many research issues may call for the use of qualitative analysis. Additionally, Ponto (2015) notes that a variety of approaches to participant recruitment, data collection, and instrumentation are possible with survey research. It might be as simple as approaching people on the street with a few targeted questions or as complex as conducting a multi-instrument study that is both valid and reliable.

Respondents

Of the 600 students enrolled in the school-year 2021-2022, 286 Bachelor of Science in Marine Transportation (BSMT) students who took Seamanship in the first semester were the respondents. Cluster random sampling was used to select them. To further assess the degree of acceptability of the e-learning module in Seamanship, five experts in the fields of maritime education, ICT, and learning material creation were purposefully chosen as respondents.

Instrument

A 32-item researcher-made acceptability questionnaire was utilized in this study. The questionnaire consisted of two parts. Part I was a 4-point Likert-type questionnaire with options for the responses as strongly disagree, disagree, agree, and strongly agree. It was further divided into five categories: (1) appearance, (2) learning activities, (3) evaluation procedure, (4) ease of use, and (5) usefulness. In each of the items, strongly disagree corresponded to 1 point, disagree was 2 points, agree was 3 points, and strongly agree corresponded to 4 points. Part II was an open-ended questionnaire that is composed of two questions. Both the students and experts were allowed to answer the second part of the questionnaire in whatever language they were comfortable with. Research and IT specialists evaluated the acceptance questionnaire, which underwent a pilot test with a reliability level of 0.97 using Cronbach alpha.

Data Collection

Before answering the acceptability questionnaire, the students were allowed to access the e-learning module online. The researchers asked permission from the Administrator to use the university's computer laboratory so that students could access the module. The questionnaire was administered personally by the researchers. Results were tallied and tabulated. The quantitative data came from the first part of the questionnaire, while the qualitative data were taken from the second part.

Data Analysis

To examine the information acquired, both quantitative and qualitative methods of data analysis were applied. Mean and standard deviation were employed in the quantitative section. Means were employed to assess the overall acceptability of the Seamanship e-learning module and its acceptability in terms of appearance, learning activities, evaluation procedure, ease of use, and usefulness. The scale shows the mean scale, descriptive rating, and indicators for the acceptability in the e-learning module for Seamanship.

Table 1. Mean Scale, Descriptive Rating, and Indicators for Interpreting the Acceptability of the e-Learning Module in Seamanship

Mean Scale	Descriptive Rating	Indicators
3.51 – 4.00	Very High Acceptability	The e-learning program was deemed excellent overall by the experts and students, and very few adjustments were necessary.
2.51 - 3.50	High Acceptability	Although the e-learning module still needs a few to a moderate number of adjustments, the students and experts thought it was very good overall.
1.51 - 2.50	Low Acceptability	The e-learning module's general features were deemed adequate by professionals and students, although they still require extensive improvements.
1.00 – 1.50	Very Low Acceptability	The e-learning module's general elements were deemed inadequate by the experts and students, and they require a thorough revision and overhaul.

The homogeneity or heterogeneity of the expert and student responses was assessed using the standard deviation. Thematic analysis was employed for the qualitative portion. Thematic analysis is a technique used to examine and present themes or patterns found in the collected qualitative data (Braun & Clarke, 2006). The recurrent themes in the descriptive answers to the second section of the acceptability questionnaire were determined using this method in the study.

RESULTS AND DISCUSSION

Acceptability of the e-Learning Module in Seamanship

Table 2 shows the level of acceptability of the students and experts towards the e-learning module in Seamanship in general and in various aspects. This study found that the students generally view the e-learning module in Seamanship as having "high acceptability" (M=3.31, SD=0.39). Furthermore, the results also show that it has also "high acceptability" in terms of appearance (M=3.29, SD=0.44), learning activities (M=3.38, SD=0.40), evaluation procedure (M=3.32, SD=0.44), ease of use (M=3.24, SD=0.44), and usefulness (M=3.30, SD=0.41).

On the other hand, results show that, overall, the e-learning module in Seamanship has "high acceptability" (M=3.35, SD=0.56), according to the experts. Furthermore, the findings of the study also show that it also has "high acceptability" in terms of appearance (M=3.37, SD=0.61), learning activities (M=3.50, SD=0.57), evaluation procedure (M=3.17, SD=0.46), ease of use (M=3.33, SD=0.61), and usefulness (M=3.40, SD=0.50). These results have resemblance to the research conducted by Encarnacion et al. (2021). According to their research, every parameter that they are evaluating has received higher ratings from both instructors and undergraduate program participants. Teachers attributed the better scores to well-designed instructional materials and highly interactive, engaging discussions. Students attributed the higher ratings to well-designed course materials, online assessment, and student-centered activities.

Table 2. Level of Acceptability of e-Learning Module in Seamanship According to Students and Experts

Category	Students			Experts		
	M	*Descriptive Rating*	*SD*	*M*	*Descriptive Rating*	*SD*
Overall	3.31	High Acceptability	0.39	3.35	High Acceptability	0.56
Appearance	3.29	High Acceptability	0.44	3.37	High Acceptability	0.61
Learning Activities	3.38	High Acceptability	0.40	3.50	High Acceptability	0.57
Evaluation Procedure	3.32	High Acceptability	0.44	3.17	High Acceptability	0.46
Ease of Use	3.24	High Acceptability	0.44	3.33	High Acceptability	0.61
Usefulness	3.30	High Acceptability	0.41	3.40	High Acceptability	0.50

Note. 1.00-1.50 – Very Low Acceptability; 1.51-2.50 – Low Acceptability; 2.51-3.50 High Acceptability; and 3.51-4.00 – Very High Acceptability.

Strengths of the e-Learning Module in Seamanship

All the experts have voluntarily given their responses about the strengths of the e-learning module, while only 139 of the 286 students have responded. Giving feedback is voluntary and observes the privacy of the respondents using the Privacy Notice Form (PNF) and Informed Consent Form (ICF)

Students' Point of View

The strengths of the e-learning module in Seamanship, according to students, are as follows: accessible, convenient, easy to understand, informative, relevant, has sufficient content, user-friendly, has several varied sources available, self-paced, well-organized, and efficient.

Accessible

Of the 139 students who responded, 71 students responded that the e-learning module in Seamanship is accessible. Students elaborated that they can access the module anytime if they have internet connection. A study has shown that one of the positive aspects of e-learning is the accessibility provided by the online environment (Gherheș et al., 2021).

Convenient

There were 20 students who expressed that it is convenient. Generally, the students could get the lesson, activities, and quizzes even in the comfort of their homes. This demonstrates that students can access these courses whenever it is most convenient for them by using the e-learning module (Encarnacion et al., 2021). Studies have even demonstrated that students view the convenience of staying at home as one of the benefits of online learning (Gherheş et al., 2021).

Easy to understand

There were also 20 students who found the e-learning module in Seamanship easy to understand. According to students, it enables them get experience in the maritime field through concise explanations and simply understood examples. Despite the lack of in-person interaction, the topics were clearly discussed and the explanations were easy to follow. In the study by Setiyani et al. (2020), the results were fairly low when they conducted an initial test on student knowledge because some had trouble understanding the learning material. However, after the digital module was developed according to the students' needs, their responses to digital teaching materials became "very good."

Informative

Twelve students found the module informative. They identified the abundance of knowledge that may be learned from the Seamanship e-learning module as a great asset. Similar findings were made in the study by Keskin and Yurdugül (2022), which showed that the instructional talks were the most crucial element of the e-learning process. Furthermore, according to Ivanii et al. (2020), the essence of competency heavily emphasizes theoretical preparedness. For this reason, both traditional and online learning must have information-rich debates and content.

Relevant

Eleven students stated that the e-learning module in Seamanship is relevant. It contains information that is relevant to their future professions and will serve as a foundation for deeper learning in the present and future. This is similar to the study of Hamid et al. (2021), one of the aspects that they checked is the relevance of the module as a part of the content validity. It was found that the experts agreed that all materials were relevant.

Sufficient content

Eleven students also said that it has sufficient content. All aspects of the topics were given enough information. Similarly, the study of Pham and Tran (2020) found that the content and design of online courses were among the five factors that had a significant impact on the acceptability of e-learning. Thus, the content and design of the e-learning courses should be reviewed and updated to be suitable for an online environment.

User-friendly

There were nine students who shared that the e-learning module in Seamanship is user-friendly. The students could easily access and navigate all of the lessons and activities that were prepared. Regarding these, Pham and Tran's (2020) study noted that perceived utility and simplicity of use were two of the main factors contributing to e-learning's acceptability.

Several varied sources available

There were also nine students who said that the e-learning module provides several or varied sources. They can find more information on the internet and store it on their phone for later use or in the event of a bad or nonexistent internet connection. Encarnacion et al. (2021) claimed that the incorporation of technology allowed students to feel at ease utilizing a variety of devices, and that web-based resources allowed them to expand their knowledge and find new concepts.

Self-paced

Nine students said that it is self-paced, meaning students can learn at their own pace. They can advance at their own speed. If there was anything they missed during their virtual session, they could use it as a reviewer. Also, it helps them study independently, realize some things, and gain knowledge on their own. This demonstrates that students can learn through online courses at their own speed, which will support their development as self-directed learners (Encarnacion et al., 2021).

Well-organized

Seven students stated that the e-learning module is well-organized. The sources and the topics were easy to find and instructions were easy to follow. Based on a study, learners appreciated the range of resources offered in a well-structured way (Encarnacion et al., 2021). Therefore, the e-learning system administrator(s) should consider enhancing the LMS's design and incorporating certain cutting-edge features that will make it more practical and helpful for both instructors and students (Pham & Tran, 2020).

Efficient

Four students said that the module was efficient. It saves them time and money and makes it possible to cater to individual needs. Similarly, e-learning was acknowledged as an efficient, effective, and novel teaching and learning platform upon its acceptance, implementation, and delivery in Tanzania's higher education institutions (Almas et al., 2021). According to a study by Bachri et al. (2021), e-learning may even have lower expenses for academic staff, students, and universities through less commute time, cheaper transportation, and possibly lower parking costs. Table 3 summarizes the themes of the strengths of using the e-learning module in Seamanship from the students' point of view.

Table 3. Summary of Strengths on the Use of the e-Learning Module in Seamanship from Students' Point of View

Strengths (in themes)	f	%	Rank
Accessible	71	51	1
Convenient	20	14	2.5
Easy to understand	20	14	2.5
Informative	12	9	4
Relevant	11	8	5.5
Sufficient content	11	8	5.5
User-friendly	9	6	8
Several varied sources available	9	6	8
Self-paced	9	6	8
Well-organized	7	5	10
Efficient	4	3	11

Experts' Point of View

Of the five experts, three of them said that the e-learning module in Seamanship is accessible. The students could access the lessons anytime and anywhere. The study of Encarnacion et al. (2021) explained that teachers may have a favorable opinion of e-learning because it relieves them of extra work, like duplicating course materials, because students may access and use the learning resources. Meanwhile, experts also said the module could help students learn better. These results are consistent with the study of Encarnacion et al. (2021), which found that e-learning greatly advanced students' abilities to analyze and solve problems, complete online tests, and turn in assignments and projects. Additionally, experts said online learning is an efficient way to carry out the lessons. This aligned with the findings of Al-Anezi and Alajmi's (2021) study, which indicated that teachers perceived e-learning technology as an efficient tool in teaching and learning.

Weaknesses of the e-Learning Module in Seamanship

Students' Point of View

Only 129 of the 286 students have responded to the weaknesses of the e-learning module in Seamanship. The weaknesses of the e-learning module in Seamanship, according to students, are as follows: need for internet access, incomprehensive discussion of the contents, unreliable/unstable site, lack of human interaction, lack of hands-on experience, difficulty in using the site, misaligned lesson content and quizzes, excessive screen time, and requires the availability of gadgets.

Need for Internet Access

There were 61 students who said that the need for internet access is the weakness of the e-learning module in Seamanship. It is highly-dependent to the internet connection which varies from student to student thus, making it unfair for them. This situation hindered learning that extended beyond the classroom and could affect students' academic performance (Maphalala & Adigun, 2021).

Incomprehensive Discussion of the Lessons

According to 35 students, the module has an incomprehensive discussion of the lessons. Some of the information is not in the e-learning module and needed further explanation. These demonstrate the need for learning resources that might motivate learners more. In addition to being able to modify established learning theories for the digital era, educators and course designers ought to be able to apply connectivism's tenets to the creation of engaging instructional materials (Bismala & Manurung, 2021).

Unreliable/unstable site

There were 34 students who commented that the weakness of the e-learning module is the unreliable or unstable site. The e-learning platform itself keeps on failing. There were times that students tried to answer some quizzes, and the platform crashed. At times, the server cannot handle many users logging in at the same time. Like the research conducted by Lu et al. (2020), it was demonstrated that poor infrastructure has a negative impact on learning psychology, the teaching process, and the efficacy of course assessment. The LMS system and information storage services are just a couple of the components make up the infrastructure.

Lack of Human Interaction

According to 21 students, the e-learning module lacked human interaction. It may cause social isolation because students do not see their teachers and classmates face-to-face. Interaction is very limited. Similarly, the study of Al Rawashdeh et al. (2021) revealed that most students said that although e-learning makes it more likely for them to interact virtually with their teacher and other students, it also means that they spend more time in front of their devices—laptops, cellphones, and tablets—which causes them to become more socially isolated. This was corroborated by a study by Müller et al. (2021), which found that due to the little interaction, even teachers were worried about their own knowledge of student engagement and learning. Teachers believed they rarely knew how their students were actually performing, despite constant efforts to encourage contact. The study of Gherheş et al. (2021) found that, despite all of e-learning's benefits, in-person interaction was still necessary for learning. Lu et al. (2020) emphasized that an important and indispensable factor even in e-learning is the teacher. Since teachers' reputations, approaches, expertise, and knowledge aid students in achieving the best outcomes during their learning and research processes. The study's findings even demonstrated that the instructor has a bigger impact than the actual course.

Lack of Hands-on Experience

There were 18 students who said that the lack of hands-on experience is another weakness. Some of the topics are better understood if they have practical application or real-time access like in the face-to-face classes. It is difficult for them to apply the concepts they have learned because they do not have the equipment needed at home. A comparable drawback identified in the study of Gherheş et al. (2021) was the absence of real-world applications. This demonstrates that not all academic subjects can benefit long-term from e-learning. Furthermore, Müller et al. (2021) pointed out in their research that it can be difficult to transfer face-to-face learning experiences—which are typically more applied and practical—to online activities. It is nearly impossible to incorporate activities like role plays, discussions, field trips, and experiments into online learning. The absence of these opportunities would disadvantage students. Hence, Afghani (2021) suggested that there is potential for enhancing the execution of e-learning activities in subjects that often require greater hands-on experience. The intention is to provide the students with opportunity to practice, explore, and observe in ways that are similar to in-person interactions.

Difficulty in Using the Site

There were four students who said that the weakness of the e-learning module was the difficulty in using the site. They found that using the new LMS was quite difficult and the old LMS was better. It was harder for the students to find the activities and assignments. In fact, if there are modifications to the e-learning platforms, teachers and students need to be informed and taught again for e-learning to succeed. When teachers and students require technical assistance, it should be given to them as soon as possible (Maphalala & Adigun, 2021; Afghani, 2021).

Misaligned Lesson Content and Quizzes

There were four students who noted the misaligned lesson content and quizzes. Students said that there were times when the time the lessons or module given are far off from the quizzes and activities given. This needs to be prioritized and improved. Keskin and Yurdugül (2022) made sure that the formative assessment resources, discussion topics, and information were given in accordance with the objectives of each chapter. The e-assessment experiences were determined to be significant interaction experiences. In the end, their study's findings demonstrated that, in addition to content interactions, online assessments and discussion forums play a complimentary role in creating a successful e-learning environment.

EXCESSIVE SCREEN TIME

Three students commented that excessive screen time had become the e-learning module's weakness. Too much exposure to blue light from phones and other gadgets, which a module can be accessed, causes eye strain. It was established that these students' concerns regarding excessive screen time were legitimate. Excessive screen time, or using a computer for more than two hours a day, has been linked to high blood pressure, raised serum cholesterol, and overweight or obesity in young people. Furthermore, screen-time habits developed during youth may persist throughout adulthood. However, if e-learning is eventually implemented, it might not be practicable for youngsters to follow the suggestion to limit their daily screen time to no more than two hours (Herrick et al., 2014).

Requires Availability of Gadgets

There were two students who said that the availability of gadgets is a weakness. E-learning indeed requires constant availability of gadgets and internet connection. Inequalities in student learning are frequently caused by problems with internet access and device availability. Educators have noted that although e-learning is highly lauded for its ability to serve all students, there are questions over whether this really happens when the majority of instruction takes place online. A camera, a computer that is suitable for learning, and a sufficiently fast and reliable internet connection are examples of technology that some have questioned if all students will have access to (Müller et al., 2021).

Other Responses Not Included in the Themes

Other students commented that the e-learning module might allow cheating. They observed that it is easy for online students to share answers knowing there is nobody watching. This matter was also brought up in Müller et al.'s study (2021). For written examinations and exams, they decided to use a variety of open-book assessment formats. To guard against dishonesty, it was also advised that students concentrate on higher-order learning and practical application. Some educators, however, continued to have doubts about the validity of the exams, so they used the Zoom teleconferencing software to do proctoring. Table 4 summarizes the weaknesses in the use of the e-learning module in Seamanship according to students.

Table 4. Summary of Weaknesses in the Use of the e-Learning Module in Seamanship from Students' Point of View

Weaknesses (in themes)	f	%	Rank
Need for internet access	61	47	1
Incomprehensive discussion of the lessons	35	27	2
Unreliable/unstable site	34	26	3
Lack of human interaction	21	16	4
Lack of hands-on experience	18	14	5
Difficulty in using the site	4	3	6.5
Misaligned lesson content and quizzes	4	3	6.5
Excessive screen time	3	2	8
Requires availability of gadgets	2	2	9

Experts' Point of View

Two of five experts said that the need for internet access is a weakness of the e-learning module in Seamanship. Without internet connection, the e-learning module cannot be accessed and used. Aside from the need for internet access, experts also said that technology issues are also a weakness because not every student and teacher is tech-savvy. Self-motivation is necessary, as is an individual's assessment of the need for learning, which could result in problematic outcomes and slow learning progress. In contrast, Encarnacion et al. (2021) discovered that students are more driven to learn on their own and do their coursework responsibly when they use e-learning.

CONCLUSIONS

During the pandemic, e-learning has become the norm. Because learner satisfaction has been shown to have a statistically significant impact on students' intention to continue with e-learning, it is crucial to evaluate students' acceptability and satisfaction with e-learning (Bashir, 2019).

The researchers were able to assess their e-learning module in Seamanship using the study's findings, and overall, it was determined to be highly acceptable in general and in terms of appearance, learning activities, evaluation procedure, ease of use, and usefulness for both students and the experts. Therefore, it can be said that the e-learning module is appropriate for usage in the classroom. This is in line with the findings of the Encarnacion et al. (2021) study, which considered e-learning as a viable online tool to support efficient instruction and high-quality learning. Moreover, they concluded that e-learning might influence education in the future by bringing the traditional classroom online. Teachers and students felt that e-learning had an impact on teaching and learning since its use had risen, particularly during the pandemic. Using open-ended questions, the study also identified the benefits and drawbacks of the Seamanship e-learning module. While the weaknesses—such as the need for internet access, the incomprehensible discussion of the contents, and the unstable/unreliable site—provide room for improvement, the strengths—such as accessibility, convenience, and relevance—would indicate which areas and features of the e-learning should be retained and further supported.

RECOMMENDATIONS

It is suggested that the e-learning module in Seamanship be used going forward based on the analysis and study outcomes. Second, the teachers, course developers, the in-charge of the e-learning modules and LMS administrators may continue to support the e-learning module in Seamanship by maintaining its strengths. Third, the teachers, course developers, the in-charge for the e-learning modules, and LMS administrators may focus on addressing and improving the weaknesses of the e-learning module. They may find ways to lessen the module's dependence on internet access. The teachers and course developers may enhance the content of the module by providing a more detailed and comprehensive discussion of the lessons and aligning the content and its activities. Teachers may also find mechanisms to reduce the probability of cheating. The in-charge for the e-learning modules, and LMS administrators may find ways to make the site more reliable and stable, and more user-friendly. Finally, researchers in the future might carry out comparable studies on different topics, investigate longitudinal studies, or assess the effectiveness of the e-learning module.

ACKNOWLEDGMENT

This research was funded by the Commission on Higher Education (CHED) through the Institutional Development and Innovation Grant (IDIG) Project.

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